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ACRONYMS AND ABBREVIATIONS

AFEP	anadromous fish evaluation program
AWS	auxiliary water system
BACI	before-and-after control impact
BGS	behavioral guidance structure
BIA	Bureau of Indian Affairs
BKD	bacterial kidney disease
BLM	Bureau of Land Management
BOR	Bureau of Reclamation
BPA	Bonneville Power Administration
CBFWA	Columbia Basin Fish and Wildlife Authority
CEQ	White House Council on Environmental Quality
CFD	computational fluid dynamics
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeter
Corps	U.S. Army Corps of Engineers
CR	Columbia River
CREP	Conservation Reserve Enhancement Program
CRI	Cumulative Risk Initiative
CRiSP	Columbia River Salmon Passage (model)
CRITFC	Columbia River Inter-Tribal Fish Commission
CROHMS	Columbia River Operational Hydromet Management System
CTWSRO	Confederated Tribes of the Warm Springs Reservation of Oregon
CWA	Clean Water Act
CWT	coded-wire tag
D	differential delayed mortality
DGAS	dissolved gas abatement study
EDT	ecosystem diagnosis and treatment
EFH	essential fish habitat
EIS	environmental impact statement
EM	delayed mortality of nontransported fish
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESBS	extended-length submersible bar screen
ESP	extended streamflow prediction (model)
ESU	evolutionarily significant unit
FCRPS	Federal Columbia River Power System
FDA	Food and Drug Administration
FELCC	firm energy load carrying capacity
FERC	Federal Energy Regulatory Commission
ft/s	feet per second

FGE	fish guidance efficiency
FLUSH	Fish Leaving Under Several Hypotheses (model)
FPE	fish passage efficiency
FPOM	Fish Passage Operations and Maintenance Coordination Team
GBT	gas bubble trauma
GIS	geographic information system
HCP	Habitat Conservation Plan
HGMP	hatchery and genetic management plan
I-5	Interstate Highway 5
ISAB	Independent Scientific Advisory Board
ISG	Independent Scientific Group
IWUA	Idaho Water Users Association
JFT	Juvenile Fish Transportation Program
kaf	thousand acre-feet
kcfs	thousand cubic feet per second
km	kilometer
kV	kilovolt
LCR	Lower Columbia River
LCREP	Lower Columbia River Estuary Program
m	meter
m^3/s	cubic meters per second
mm	millimeter
Maf	million acre-feet
MCR	Middle Columbia River
MDEQ	Montana Department of Environmental Quality
mg/l	milligrams per liter
MGR	minimum gap runners
MOP	minimum operating pool
MOU	memorandum of understanding
msl	mean sea level
MW	megawatt
NEPA	National Environmental Policy Act
NFH	National Fish Hatcheries
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NRC	National Research Council
NWFSC	Northwest Fisheries Science Center
NWPPC	Northwest Power Planning Council
O&M	operations and maintenance
ODFW	Oregon Department of Fish and Wildlife
OWRD	Oregon Water Resources Department
PATH	Plan for Analyzing and Testing Hypotheses
PDO	Pacific Decadal Oscillation

PFMC	Pacific Fishery Management Council
PIT	passive integrated transponder
PNCA	Pacific Northwest Coordination Agreement
ppm	parts per million
PSC	Pacific Salmon Commission
PUD	Public Utility District
QA	quality assurance
QAR	quantitative analysis report
QC	quality control
Rkm	river kilometer
RM	river mile
RPA	Reasonable and Prudent Alternative
R/S	recruits per spawner
RT	radio-tracking
RSW	removable spillway weir
SAR	smolt-to-adult return rate
SIMPAS	simulated passage (model)
SOI	Southern Oscillation Index
SR	Snake River
STS	submersible traveling screen
TDG	total dissolved gas
TMDL	total maximum daily load
UCR	Upper Columbia River
UCUT	Upper Columbia United Tribes
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UWR	Upper Willamette River
VARQ	variable (VAR) outflow (Q)
VBS	vertical barrier screen
VSP	viable salmon population
WDF	Washington Department of Fisheries
WDFW	Washington Department of Fish and Wildlife
WRI	Willamette Restoration Initiative

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1.0 OBJECTIVES

The Endangered Species Act (ESA) (16 USC 1531-1544), amended in 1988, establishes a national program for the conservation of threatened and endangered species of fish, wildlife, and plants and the habitat on which they depend. Section 7(a)(2) of the ESA requires Federal agencies to consult with USFWS and NMFS, as appropriate, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or to adversely modify or destroy their designated critical habitats.

This document is the product of an interagency consultation pursuant to Section 7(a)(2) of the ESA and implementing regulations found at 50 Code of Federal Regulations (CFR) Part 402. It consists of four actions:

- The Federal agencies that operate, or market power from, the Federal Columbia River Power System (FCRPS), namely the Bonneville Power Administration (BPA), the U.S. Army Corps of Engineers (Corps), and the U.S. Bureau of Reclamation (BOR) (collectively the "Action Agencies"), reinitiated consultation with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) to consider the effects of actions related to FCRPS configuration, operations, and maintenance on species listed as threatened or endangered under the ESA.

- BOR is also consulting on the continued operation and maintenance of 19 of its projects in the Columbia River basin (Table 1.0-1).[1] Two of those projects, the Columbia Basin Project and the Hungry Horse Project, include facilities that are also part of the FCRPS. Several of the remaining 17 BOR-owned projects in the basin include power plants and/or provide flood control benefits, but these power plants (and their associated dams and reservoirs) are not operated or coordinated as part of the FCRPS, nor do these project facilities provide system flood control. All 19 BOR projects are authorized to provide water for irrigated agriculture, and all except the Hungry Horse Project do so at present. While the configuration, operation, and maintenance of the FCRPS and the operation and maintenance of the BOR's 19 projects are separate agency actions, they are similar in that all have hydrologic effects on the flows in the mainstems of the Columbia and Snake rivers. However, this biological opinion does not attempt to apportion the

[1]Because of ongoing negotiations in a general adjudication of water rights under way in Idaho, BOR could not adequately define its proposed action to facilitate consultation for its 11 irrigation projects in the Snake River basin. Since discussions are continuing, BOR has indicated that the proposed action may be different from those measures set forth in its December 21, 1999, biological assessment. Accordingly, BOR has asked to extend the consultation on these 11 projects pending a revised proposed action and analysis of effects (see BOR 2000d). NMFS has agreed to extend the current consultation with regard to BOR's projects in the Snake River basin and to exclude those projects from this biological opinion. BOR anticipates providing the necessary additional information, and NMFS anticipates issuing a supplemental biological opinion on these projects before water from these projects is needed for irrigation use in the 2001 growing season.

Table 1.0-1. BOR irrigation projects in Columbia River basin.

Project	Location	Subbasin or Stream
Upper Columbia River (Upstream of Snake River Confluence)		
Hungry Horse	Western Montana, north of Flathead Lake	South Fork Flat Head River
Bitter Root	Western Montana, south of Missoula	Bitterroot River
Missoula Valley	Western Montana, north of Missoula	Clark Fork River
Frenchtown	Western Montana, north of Missoula	Clark Fork River
Dalton Gardens	North Idaho, north of Coeur d'Alene	Spokane (Hayden Lake)
Avondale	North Idaho, north of Coeur d'Alene	Spokane (groundwater)
Rathdrum Prairie	North Idaho, northwest of Coeur d'Alene	Spokane (groundwater)
Spokane Valley	Eastern Washington, east of Spokane	Spokane (groundwater)
Columbia Basin	Central Washington	Columbia River
Chief Joseph[1]	North-central Washington, from Canadian border to Wenatchee	Okanogan and Columbia rivers
Okanogan	North-central Washington, near Okanogan	Okanogan River
Yakima	Central Washington, near Yakima	Yakima River
Lower Columbia (Downstream of Snake River Confluence)		
Umatilla	Northeast Oregon	Umatilla and Columbia rivers
Crescent Lake Dam	Central Oregon west of Bend	Deschutes River
Crooked River	Central Oregon, north of Bend	Crooked River
Deschutes	Central Oregon, north of Bend	Deschutes River
Wapinitia	North-central Oregon, south of The Dalles	Deschutes River
The Dalles[1]	North-central Oregon, near The Dalles	Columbia River
Tualatin	Northwest Oregon, west of Portland	Tualatin River (Willamette River)
Snake River		
Minidoka	Southern Idaho and western Wyoming from Twin Falls Idaho to Jackson Lake, Wyoming	Snake River
Palisades	Eastern Idaho, on Wyoming border	Snake River
Michaud Flats	Southern Idaho, near Pocatello	Snake River
Little Wood River	South-central Idaho, north of Twin Falls	Little Wood River
Boise	Southwest Idaho, near Boise	Boise and Payette rivers
Mann Creek	Southwest Idaho, northwest of Boise	Weiser River
Owyhee	Eastern Oregon and southwest Idaho, near Ontario, Oregon	Owyhee and Snake rivers
Vale	Eastern Oregon, west of Ontario	Malheur River
Burnt River	Eastern Oregon, south of Baker City	Burnt River
Baker	Eastern Oregon, near Baker City	Powder River
Lewiston Orchards	West-central Idaho, near Lewiston	Clearwater River

Note: Shaded (Snake River) areas are not included in this biological opinion. The Arnold Project in central Oregon was also removed from this biological opinion based on comments from BOR that this is not a Federal project and was erroneously included in its biological assessment.
[1]Chief Joseph Dam and The Dalles Dam are owned and operated by the Corps, but have associated irrigation works that are owned and operated by BOR.

relative contribution of the FCRPS and BOR projects to the current status of the evolutionarily significant units (ESUs).[2]

- NMFS is also consulting internally on its issuance of a Section 10 permit for the Corps' Juvenile Fish Transportation Program (JFT). The FCRPS operation necessarily includes the JFT, which requires an enhancement permit issued by NMFS pursuant to ESA Section 10(a)(1)(A).

- NMFS is also consulting internally on its issuance of Section 10 permits for certain of the research, monitoring, and evaluation actions essential to the implementation of this biological opinion. Not all are included, because not all are sufficiently defined to identify the proposed methodologies and, from that, the estimated levels of take. As additional studies and study plans are developed in accordance with this biological opinion, NMFS anticipates the need for additional Section 10 research permits and additional review of the issuance of those permits under Section 7(a)(2).

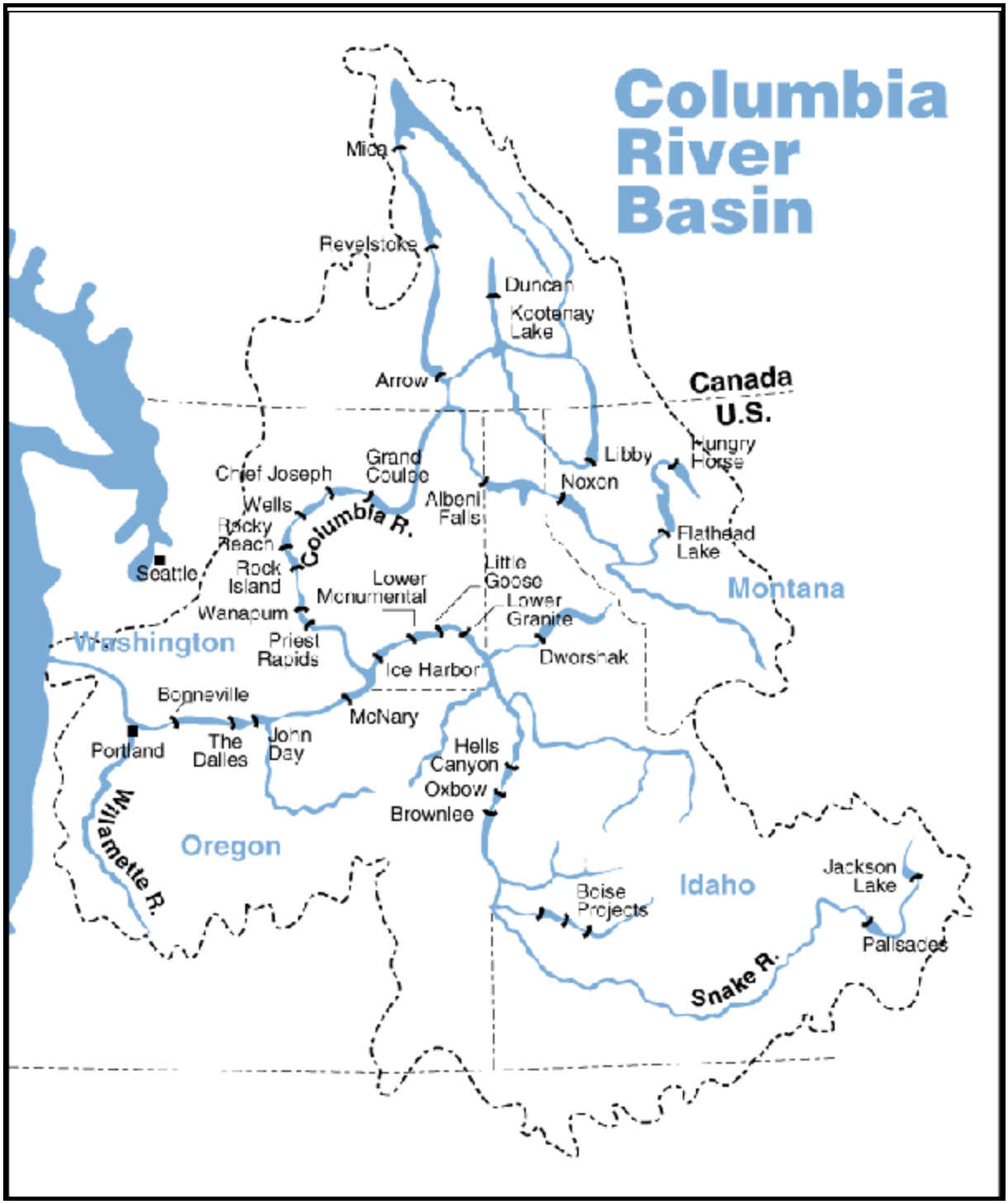
The action area encompasses the mainstem Columbia and Snake rivers from Chief Joseph Dam and Hells Canyon Dam down to and including the estuary and plume (nearshore ocean) of the Columbia River (Figure 1-1). With respect to the FCRPS projects, this biological opinion considers the effects of the existing configuration, continued operation, and maintenance of the 14 sets of dams, powerhouses, and associated reservoirs known collectively as the FCRPS and operated as a coordinated system for purposes of power production and flood control on behalf of the Federal government. The facilities that constitute the FCRPS are Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor dams, powerplants, and reservoirs in the Snake River basin; Albeni Falls, Hungry Horse, Libby, Grand Coulee, Banks Lake (features of the Columbia Basin Project), and Chief Joseph dams, powerplants, and reservoirs in the upper Columbia River basin; and McNary, John Day, The Dalles, and Bonneville dams, powerplants, and reservoirs in the lower Columbia River basin. Some of these dams and reservoirs are also operated for other purposes as authorized by Congress (e.g., navigation, irrigation, fish and wildlife, and recreation). These operations are inseparable from those for power generation and flood control. They are included in the scope of this consultation, except where activities are separate Federal actions under other authorities (e.g., Clean Water Act [CWA] Section 404).

With respect to the 19 BOR projects, formal consultation on the full scope of these proposed operations is being accomplished as follows:

1. This biological opinion considers the aggregate effects of all 19 BOR projects on streamflows in the mainstem Columbia and Snake rivers (these effects result from

[2]Throughout this biological opinion, NMFS uses ESU to define anadromous salmon and steelhead populations either listed or being considered for listing under the ESA. An ESU is a population that 1) is substantially isolated reproductively from conspecific populations, and 2) represents an important component of the evolutionary legacy of the species. The term ESU may include portions or combinations of more commonly used definitions of stocks within or across regions.

Figure 1-1. Map of the Columbia River basin, including major facilities that make up the Federal Columbia River Power System.



reservoir storage and releases, diversions and withdrawals, consumptive uses, and return flows). It also considers the effects of using some of these projects and other sources to provide instream flow in the Columbia River downstream of Chief Joseph Dam. Effects considered include the frequency of attainment of the flow objectives established in the 1995 FCRPS Biological Opinion[3] and 1998 Supplemental FCRPS Biological Opinion.[4]

2. This biological opinion also considers all the known operational effects of the BOR projects upstream of Chief Joseph Dam. The only known effects of these projects on listed salmon and steelhead result from the cumulative hydrologic effects of their operations on streamflows in the Columbia River downstream of Chief Joseph Dam.

3. BOR is also consulting on any additional effects of its projects located downstream of Chief Joseph Dam in the Columbia River Basin, except for the Columbia Basin Project. BOR has already prepared biological assessments, or, as appropriate, is preparing supplemental biological assessments to address any additional effects of such projects, such as effects on tributary habitat, tributary water quality, or direct effects on salmon survival (impingement, entrainment in diversions, false attraction to return flows), through project-specific consultations designed to supplement this biological opinion. Because mainstem flows are addressed in this biological opinion, these supplemental consultations will address effects of mainstem flows only to the extent to which consultation reveals additional effects on the mainstem flow regime that are not considered in this 2000 FCRPS Biological Opinion. The schedule for these supplemental consultations is undetermined at this time pending receipt of additional information from BOR.

4. The Columbia Basin Project, features of which are located both upstream and downstream of Chief Joseph Dam, diverts water from and returns it to the mainstem Columbia River above McNary Dam (with most of the project water diverted from the Columbia River above Chief Joseph Dam, but all return flows occurring below Chief Joseph Dam). Its storage and diversion operations are integral to the operation of Grand Coulee Dam. All the project's effects on listed salmon and steelhead occur in the mainstem. For these reasons, the BOR initiated consultation specifically on the operation and maintenance of all the Federally owned lands and facilities of the project (whether such operation and maintenance is performed by BOR or by others pursuant to agreements with BOR). This 2000 FCRPS Biological Opinion, therefore, considers all the known operational effects of the Columbia Basin Project, not just its contribution to cumulative hydrologic impacts on streamflows in the Columbia River, even though some

[3]"Biological Opinion—Reinitiation of Consultation on 1994–1998 Operation of the Federal Columbia River Power System and Juvenile Transportation Program in 1995 and Future Years" (NMFS 1995a).

[4]"Supplemental Biological Opinion—Operation of the Federal Columbia River Power System Including the Smolt Monitoring Program and the Juvenile Fish Transportation Program: A Supplemental to the Biological Opinion Signed on March 2, 1995" (NMFS 1998).

of the project's features are downstream of Chief Joseph Dam in the Columbia River basin.

This consultation considers whether the effects of these actions are likely to jeopardize the continued existence of 12 listed species of Columbia Basin Project salmonids and cause the destruction or adverse modification of their designated critical habitat. The 12 species are as follows:

- Snake River (SR) spring/summer chinook salmon (*Oncorhynchus tshawytscha*; listed as threatened on April 22, 1992 [57 FR 14653]); critical habitat designated on December 28, 1993 [58 FR 68543], and revised on October 25, 1999 [64 FR 57399]

- Snake River (SR) fall chinook salmon (*O. tshawytscha*; listed as threatened on April 22, 1992 [57 FR 14653]); critical habitat designated on December 28, 1993 [58 FR 68543]

- Upper Columbia River (UCR) spring chinook salmon (*O. tshawytscha*; listed as endangered on March 24, 1999 [64 FR 14308]); critical habitat designated on February 16, 2000 [65 FR 7764]

- Upper Willamette River (UWR) chinook salmon (*O. tshawytscha*; listed as threatened on March 24, 1999 [64 FR 14308]); critical habitat designated on February 16, 2000 [65 FR 7764]

- Lower Columbia River (LCR) chinook salmon (*O. tshawytscha*; listed as threatened on March 24, 1999 [64 FR 14308]); critical habitat designated on February 16, 2000 [65 FR 7764]

- Snake River (SR) steelhead (*O. mykiss*; listed as threatened on August 18, 1997 ([62 FR 43937]); critical habitat designated on February 16, 2000 [65 FR 7764]

- Upper Columbia River (UCR) steelhead (*O. mykiss*; listed as endangered on August 18, 1997 [62 FR 43937]); critical habitat designated on February 16, 2000 [65 FR 7764]

- Middle Columbia River (MCR) steelhead (*O. mykiss*; listed as threatened on March 25, 1999 [64 FR 14517]); critical habitat designated on February 16, 2000 [65 FR 7764]

- Upper Willamette River (UWR) steelhead (*O. mykiss*; listed as threatened on March 25, 1999 [64 FR 14517]); critical habitat designated on February 16, 2000 [65 FR 7764]

- Lower Columbia River (LCR) steelhead (*O. mykiss*; listed as threatened on March 19, 1998 [63 FR 13347]); critical habitat designated on February 16, 2000 [65 FR 7764]

- Columbia River (CR) chum salmon (*O. keta*; listed as threatened on March 25, 1999 [64 FR 14508]); critical habitat designated on February 16, 2000 [65 FR 7764]

- Snake River (SR) sockeye salmon (*O. nerka*; listed as endangered on November 20, 1991 [56 FR 58619]); critical habitat designated on December 28, 1993 [58 FR 68543]

1.1 RELATION TO OTHER BIOLOGICAL OPINIONS

This 2000 FCRPS Biological Opinion supersedes all previous opinions NMFS has issued concerning the FCRPS. This includes the 1995 FCRPS Biological Opinion and the supplemental opinions NMFS issued on May 14, 1998, December 9, 1999, and February 4, 2000. Further, NMFS and USFWS have coordinated this multispecies opinion and the opinion USFWS is issuing on the effects of hydrosystem operations on Columbia River basin species within its jurisdiction, dated December 2000. The two agencies intend the recommendations and requirements of these opinions to be mutually consistent. They represent the Federal biological resource agencies' recommendations of measures that are most likely to ensure the survival and recovery of all listed species and that are within the current authorities of the Action Agencies.

1.2 SECTION 10 PERMITS

1.2.1 Section 10 Permits for Juvenile Transportation Program

In 1999, the Corps Walla Walla District applied to NMFS for a new Section 10 permit for the JFT. As an interim measure, NMFS extended the Corps' existing Permit 895, under authority of Section 10 of the ESA and NMFS' regulations governing ESA-listed fish and wildlife permits (50 CFR Parts 217 through 227), to be valid until December 31, 2000, or until replaced by the new permit. The extension allows the duration of Permit 895 to coincide with the completion of this reinitiation of ESA Section 7 consultation on the long-term management strategy for the FCRPS. Permit 895 authorizes the Corps' annual direct takes of the following listed fish: juvenile endangered SR sockeye salmon and juvenile, threatened, naturally produced, and artificially propagated SR spring/summer chinook salmon, SR fall chinook salmon, and SR steelhead. This take is authorized for the Corps' JFT at four hydroelectric projects on the Snake and Columbia rivers (Lower Granite, Little Goose, Lower Monumental, and McNary dams). Permit 895 also authorizes the Corps' annual incidental takes of ESA-listed adult fish associated with fallbacks through the juvenile fish bypass systems at the four dams.

With regard to three other ESUs (UCR spring chinook salmon, UCR steelhead, and MCR steelhead), NMFS has determined that any take of these species associated with the Corps' transportation activities would be incidental to operation of the juvenile bypass system under the existing requirement to suspend transportation operations at McNary Dam during the spring migration period. NMFS' estimates of incidental take for each of these ESUs is described in the incidental take statement in Section 10 of this document. Any direct take of UCR spring chinook

salmon, UCR steelhead, and MCR steelhead for the purposes of the planned transport experiment from McNary Dam will be addressed in a separate ESA Section 10 permit.

In addition, Permit 895 does not cover direct take of the following lower Columbia River ESUs: UWR chinook salmon, UWR steelhead, LCR chinook salmon, LCR steelhead, and CR chum salmon. The juveniles from all of the spawning populations in these ESUs enter the Columbia River at points below McNary Dam. Thus, they are not subject to either direct or incidental take associated with the Corps' transportation program.

1.2.2 Section 10 Permits for Research and Monitoring

Scientific research and monitoring are critical parts of the overall program to minimize take of ESA-listed anadromous fish species resulting from the operation of mainstem FCRPS projects on the Columbia and Snake rivers. These activities are necessary to satisfy the Action Agencies' responsibility for minimizing take and for ensuring that jeopardy standards will be met. While some research/monitoring activities cannot be identified in enough detail at this time to allow NMFS to estimate incidental take, others can be anticipated now. Appendix H to this biological opinion provides estimates of incidental take for each of the 12 listed ESUs for the latter group of studies.

1.3 APPLICATION OF ESA SECTION 7(A)(2) STANDARDS–JEOPARDY ANALYSIS FRAMEWORK

To achieve the objectives of this biological opinion, NMFS uses the five-step approach for applying the ESA Section 7(a)(2) standards developed in the 1995 FCRPS Biological Opinion to Pacific salmon. The steps are as follows:

1. Define the biological requirements and current status of each listed species (Section 4).

2. Evaluate the relevance of the environmental baseline to the species' current status (Section 5).

3. Determine the effects of the proposed or continuing action on listed species (methods described in Section 6.1 and applied in Sections 6.2 and 6.3).

4. Determine whether the species can be expected to survive with an adequate potential for recovery under the effects of the proposed or continuing action, the effects of the environmental baseline, and any cumulative effects, and considering measures for survival and recovery specific to other life stages (Section 8).

5. Identify reasonable and prudent alternatives (RPAs) to a proposed or continuing action when that action is likely to jeopardize the continued existence of a listed species or destroy or adversely modify its critical habitat (Section 9). Thus, this step is relevant

> only when the conclusion of the previously described analysis is that the proposed action would jeopardize listed species. The RPA will have to both reduce the mortality associated with the proposed action to a level that does not jeopardize the species, and maintain (or restore) essential habitat features so that there is no adverse modification of designated critical habitat. An analysis to determine the sufficiency of the reasonable and prudent alternative will be based on the same considerations described above.

As discussed in the 1995 FCRPS Biological Opinion, the fourth step of the application framework called for a two-part analysis. The first part focuses on the action area, delineated as the geographic extent of direct and indirect effects of the action (50 CFR Section 402.02). The effects of the action, the effects of the environmental baseline, and the cumulative effects in the action area are considered together relative to the action area biological requirements of the various listed species. The essential features of critical habitat guide in this part of the analysis.

The second part of the analysis places the action area investigation in the context of the full salmon life cycle, considering each ESU's species-level biological requirements (NMFS 1995a, pp. 13-14).

> This comprehensive analysis is necessary to fully evaluate the significance of each action under consultation to the biological requirements of the listed species in all life stages. The NMFS looks beyond the particular action area for this analysis to consider measures likely to be necessary in all life stages that, in combination, would insure that the biological requirements of the listed species will be met and thereby insure its continued existence.

For the purpose of this second part of Step 4 of the ESA Section 7 framework, to assess the effects of proposed actions while listed ESUs move toward recovery, NMFS defined the degree to which species-level biological requirements must be met (NMFS 1995a, p. 14):

> At the species level, NMFS considers that the biological requirements for survival, with an adequate potential for recovery, are met when there is a high likelihood that the species' population will remain above critical escapement thresholds over a sufficiently long period of time. Additionally, the species must have a moderate to high likelihood that its population will achieve its recovery level within an adequate period of time. The particular thresholds, recovery levels, and time periods must be selected depending upon the characteristics and circumstances of each salmon species under consultation.

Pursuant to the ESA, to fully consider the current status of the listed species (50 CFR Section 402.14(g)(2)), NMFS evaluates the species-level biological requirements of a species, subspecies, or distinct population segment level. For Pacific salmonids, NMFS evaluates species-level biological requirements as they relate to ESUs. Since 1995, NMFS has developed the viable salmonid population (VSP) concept as a tool to evaluate whether the species-level requirements of ESUs are being met (McElhany et al. 2000). Each salmonid ESU may contain multiple independent populations. VSPs are independent populations that have a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over 100 years.

The attributes associated with VSPs include adequate abundance, productivity (population growth rate), population spatial scale, and diversity. These attributes are influenced by survival, behavior, and experiences throughout the entire life cycle and are, therefore, distinguished from the more specific biological requirements associated with the action area (described in Section 5) and the particular action under consultation. Species-level biological requirements are influenced by *all* actions affecting the species throughout its life cycle and may be broader than the requirements of any specific independent population in the ESU. The action-area effects must be reviewed in the context of these species-level biological requirements to evaluate the potential for survival and recovery, relevant to the status of the species, given the comprehensive set of human activities and environmental conditions affecting the species.

Although the 1995 narrative standard, quoted above, defined the direct measurement of species-level biological requirements in terms of abundance, this definition also implicitly addresses the productivity criterion for VSPs. Given the current low abundance levels, the population growth rate must increase to reach the critical threshold or recovery abundance levels. In the long term, the population growth rate must remain high enough to maintain a stable return rate and keep populations at acceptable abundance levels. Although application of VSP by a technical recovery team may in the future suggest measurements of spatial scale and diversity, this biological opinion considers biological requirements primarily in terms of abundance and productivity.

For ESUs with multiple populations, the spatial scale and diversity criteria for VSPs are addressed primarily by specifying the number of populations that must meet species-level biological requirements, as defined above. This is considered on an ESU-by-ESU basis. The degree to which independent populations in an ESU have been delineated, and their relation to each other, can be relevant to an ESA Section 7 decision. Particularly important is the state of knowledge regarding the degree to which a mixture of independent populations in an ESU is required for the ESU to survive in the face of catastrophic events and long-term demographic processes and to maintain long-term evolutionary potential (McElhany et al. 2000). To the extent possible, jeopardy determinations should be based on evaluation of available information to determine if identified breeding units represent independent populations, as defined by McElhany et al. (2000). However, biological populations have not yet been defined for most ESUs considered in this opinion. In the case of the SR spring/summer chinook ESU, NMFS determined in the 1995 FCRPS Biological Opinion that the relevant measure is "at least 80% of the available 'index stocks.'" NMFS' proposed recovery plan for Snake River salmon (NMFS 1995c) also described "80% of available index stocks" as the percent required to meet specified abundance levels for delisting. For all other ESUs, all currently defined populations should be maintained to ensure adequate genetic and life history diversity, as well as the spatial distribution of populations within each ESU.

Step 4 of the application framework ultimately requires that NMFS determine whether the species-level biological requirements can be met considering the significance of the effects of the

action under consultation. Recovery planning can provide the best guidance for making this determination. The 1995 FCRPS Biological Opinion stated:

> Recovery plans for listed salmon call for measures in each life stage that are based upon the best available scientific information concerning the listed species' biological requirements for survival and recovery. As the statutory goal of the recovery plan is for the species' conservation and survival it necessarily must add these life-stage specific measures together to result in the survival of the species, at least, and its recovery and delisting at most. For this reason, the Recovery Plan is the best source for measures and requirements necessary in each life stage to meet the biological requirements of the species across its life cycle (p. 14).

Recovery planning will identify the feasible measures that are needed in each stage of the salmonid life cycle for conservation and survival within a reasonable time. Measures are feasible if they are expected both to be implemented and to result in the required biological benefit. A time period for recovery is reasonable depending on the time requirements for implementation of the measures and the confidence in the survival of the species while the plan is implemented. The plan must demonstrate the feasibility of its measures, the reasonableness of its time requirements, and how the elements are likely to achieve the conservation and survival of the listed species based on the best science available.

NMFS intends that it and the other Action Agencies will, as portions of recovery plans become final, incorporate applicable elements into their review and annual plans for the FCRPS described in this biological opinion. If the incorporation of such recovery plan elements could entail major changes in analyses or actions, the Action Agencies may reinitiate consultation with NMFS, and may need to undertake additional analyses to satisfy the National Environmental Policy Act (NEPA) and other requirements.

In 1995, NMFS relied on the proposed Snake River salmon recovery plan, issued in draft in March 1995. Since 1995, the number of listed salmonid species has gone from three to 12, and the need for recovery planning for Columbia basin salmonids has quadrupled. Rather than finalize the 1995 proposed recovery plan, NMFS has developed guidelines for basin-level, multispecies recovery planning on which individual, species-specific recovery plans can be founded. "Basin-level" encompasses habitat, harvest, hatcheries, and hydro. This recovery planning analysis is contained in the document entitled "Conservation of Columbia Basin Fish: Final Basinwide Salmon Recovery Strategy" (hereafter, the Basinwide Recovery Strategy [Federal Caucus 2000]). The Basinwide Recovery Strategy replaces the 1995 proposed recovery plan for Snake River stocks until a specific plan for those stocks is developed on the basis of the Basinwide Recovery Strategy. Recovery plans for each individually listed species will provide the particular statutorily required elements of recovery goals, criteria, management actions, and time estimates that are not developed in the Basinwide Recovery Strategy.

Until the species-specific recovery plans are developed, the Basinwide Recovery Strategy provides the best guidance for judging the significance of an individual action relative to the species-level biological requirements. In the absence of completed recovery planning, NMFS strives to ascribe the appropriate significance to actions to the extent available information allows. Where information is not available on the recovery needs of the species, either through recovery planning or otherwise, NMFS applies a conservative substitute that is likely to exceed what would be expected of an action if information were available.

1.3.1 Section 7(a)(2) Jeopardy Analysis Framework Applied to FCRPS

In this section, NMFS discusses the application of the statutory requirements of ESA Section 7(a)(2) to the actions considered in this consultation. Whereas the statutory standards, and the regulations that interpret them, are the ultimate determinants for this biological opinion, it has been necessary for NMFS to develop a methodology for applying those standards that uses the best scientific and commercial data available. These methods and the available science are best applied through reference to particular indicators of the essential elements of the Section 7(a)(2) standards, the likelihoods of survival and recovery.

1.3.1.1 Jeopardy Standard

Consistent with Step 4 of the Jeopardy Analysis Framework, discussed above, the mortality of listed salmonids in the different ESUs that can be attributed to the action must be below the following:

- A level that, when combined with mortality occurring in other life stages, results in a high likelihood of survival and a moderate to high likelihood of recovery

In the application of this standard, NMFS relies on all the best available scientific information. For some ESUs, this involves a great deal of modeling analysis, including simple determinative models of passage survival, the Cumulative Risk Initiative (CRI) analysis of population status, and the incorporation of both into analyses to assess the effects of alternative operations on survival from one generation to the next. For purposes of this analysis, NMFS determined that there was enough information to quantify species status and incremental survival changes resulting from actions affecting hydrosystem passage survival for 11 of the 12 ESUs. The estimates also took into account harvest levels and the Mid-Columbia Habitat Conservation Plan as provided for in the basinwide strategy (see Appendix A). Impacts of hydrosystem effects on spawning and rearing success, as well as hatchery and habitat actions affecting other life stages, were evaluated qualitatively for these 11 ESUs. The analysis for SR sockeye salmon was entirely qualitative. There is still substantial uncertainty in the resulting NMFS' projections of the likelihood of survival and recovery. As a result, NMFS relies on this analysis primarily to provide a standardized measure of risk against which to judge the significance of the action to the continued existence of the ESU. In the end, however, NMFS' determination of consistency with

ESA Section 7(a)(2) is qualitative, informed to the extent possible by standardized quantitative analysis.

1.3.1.2 Metrics and Criteria Useful for Assessing Jeopardy Standards for FCRPS

As noted above, NMFS has determined, for the purposes of this biological opinion, that there is enough information to quantitatively evaluate the likelihood of survival and recovery for 11 of the 12 ESUs. This section describes a number of metrics integral to that analysis.

1.3.1.2.1 Metrics Indicative of Survival. For the survival component of the jeopardy standard, a measurement of the risk of absolute extinction (no more than one fish returning over the number of years in a generation) within 100 years is relevant (McClure et al. 2000c). NMFS evaluates the status of the species relative to a standardized criterion of 5% probability of absolute extinction in assessing whether the species has a high likelihood of survival under the proposed action. A 100-year period captures both short- and long-term risk because a population that has a certain probability of extinction within a short time frame, such as 24 years, will have at least that probability of extinction in 100 years. NMFS also reviews a 24-year period for two reasons: 1) because the range of uncertainty around an estimate of the 100-year metric is quite large and 2) because there is potential to further modify the action in the near term through the adaptive management process (if monitoring and evaluation indicate a need for further action to avoid longer-term risks). Absolute extinction is used instead of a quasi-extinction level because of the unambiguous interpretation of this criterion, whereas quasi-extinction levels such as 20, 50, or 100 fish have different meanings for populations of different sizes and capacities in different river systems.

NMFS received many comments on this choice of an acceptable risk level in the July 27 draft. NMFS considers 5% sufficiently conservative, especially when compared to the 10% level used by the International Union for the Conservation of Nature and Natural Resources for its lowest risk category (IUCN 2000). NMFS also received comments on the July 27 draft, suggesting that higher extinction thresholds, ranging from 5 to 350 fish, be applied. NMFS reviewed an analysis of the sensitivity of conclusions to alternative extinction risk thresholds (USFWS 2000a). NMFS knows that risk increases as the threshold is raised, but continues to conclude that absolute extinction is the most biologically meaningful threshold. An extinction threshold of one fish is the only extinction threshold that has the same biological meaning regardless of which index stock or population is addressed.

This extinction criterion is used in preference to the survival threshold in the 1995 FCRPS Biological Opinion. A review by the Independent Scientific Advisory Board (ISAB 1999) considered the survival threshold ". . . insufficiently linked to the ESA considerations of probability of extinction. . . ." This approach was also criticized by a review panel (Barnthouse et al. 1994), which stated that, if the threshold represents a critical level, "it makes little sense to define persistence in terms of the frequency of years in which the populations are below the critical level. Presumably, even one such year is undesirable." If, on the other hand, the

threshold represents some less-critical level, the review panel described that level as necessarily arbitrary. The panel also noted difficulties in interpreting the particular thresholds that were eventually used in the 1995 FCRPS Biological Opinion relative to historical performance of those stocks. Botsford (1997) also noted shortcomings of the survival threshold approach.

1.3.1.2.2 Metrics Indicative of Recovery. The recovery metric stated in the 1995 FCRPS Biological Opinion is a relevant measure of the status of the species relative to the recovery component of the jeopardy standard. This recovery metric is defined as the likelihood that the 8-year geometric mean abundance of natural spawners in a population will be equal to or greater than an identified recovery abundance level. Recovery abundance levels have not been finally determined for any of the ESUs; however, the best available estimates of recovery abundance levels for five ESUs and certain component populations or index areas are shown in Table 1.3-1. For the ESUs for which the recovery abundance levels have not been proposed, until recovery levels are determined, NMFS will rely on a combination of the survival criterion and an alternate recovery criterion defined as the level of improvement needed in the productivity of the population to result in a median annual population growth rate (lambda) greater than 1.0 over 48 years. NMFS applies this alternative recovery metric because the recovery abundance level may not yet be specified, but it is certainly higher than the current abundance level. Therefore, at a minimum, a population must be increasing at least slightly to recover.

Ultimately, recovery goals for each ESU will be established using the criteria outlined in the VSP paper (McElhany et al. 2000). Until technical recovery teams formally apply VSP standards to determine recovery goals for all ESUs, NMFS relies on the following:

- Goals established during the quantitative analysis process for the UCR ESUs (Cooney 2000, Ford et al. 1999)

- Abundance goals established in the 1995 recovery plan for the SR spring/summer chinook and fall chinook salmon ESUs

Recovery time periods for each ESU must also be determined by recovery planning. The 1995 FCRPS Biological Opinion evaluated the likelihood of recovery within 48 years. It may be unrealistic to expect populations to return to recovery abundance levels within this time period. Both the 48-year and the 100-year probabilities are reviewed in assessing whether the species has a moderate to high likelihood of recovery under the proposed action.

Table 1.3-1. Interim proposed recovery levels for some Columbia River ESUs.

ESU/Population/Stock	Recovery Abundance Level	Notes
SR spring/summer chinook (at Ice Harbor)	31,440	Source: NMFS (1995c)
SR spring/summer chinook index stocks		
Bear Valley/Elk Creeks	911	Recovery goals for Snake River index stocks defined as 60% of pre-1971 abundance[1] (Source: NMFS 1995c)
Minam River	439	
Imnaha River	802	
Poverty Flats	866	
Johnson Creek	288	
Marsh Creek	426	
Sulphur Creek	283	
SR fall chinook (aggregate pop.)	2,500	Source: NMFS (1995c)
SR sockeye[2]	2,000	Source: NMFS (1995c)
UCR steelhead populations		
Wenatchee River	2,500	Source: draft report on population structure and biological requirements of UCR steelhead and spring chinook salmon (Ford et al. 1999)
Methow River	2,500	
Entiat River	500	
UCR spring chinook populations		
Wenatchee River	3,750	Source: Ford et al. (1999)
Methow River	2,000	
Entiat River	500	

Note: Recovery abundance levels refer to naturally spawning adults.
[1]Pre-1971 abundance for index stocks from ODFW (Tinus 2000).
[2]SR sockeye salmon in Redfish Lake and two other lakes in the Snake River basin.

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2.0 BACKGROUND

2.1 INTRODUCTION

On March 2, 1995, NMFS issued the 1995 FCRPS Biological Opinion. In that opinion, NMFS determined that the operation of the FCRPS, as proposed by BPA, the Corps, and BOR, would jeopardize the continued existence of threatened and endangered SR spring/summer chinook, fall chinook, and sockeye salmon and would adversely modify their critical habitat. The 1995 FCRPS Biological Opinion, therefore, set out an RPA for the operation and configuration of the hydrosystem to satisfy ESA Section 7(a)(2) requirements. The RPA prescribed measures to increase the survival of juvenile and adult salmonids and initiated the development of a long-term system configuration plan. The RPA focused on three strategies:

1. Addressing scientific uncertainties through research and data analysis
2. Requiring immediate survival improvements in the mainstem corridor through increased voluntary spill, a flow augmentation program, transportation improvements, and other measures
3. Committing to a decision on which intensive improvements, if any, would lead to the eventual survival and recovery of all listed salmonids in the Columbia River basin [At that time, only Snake River stocks were listed.]

The 1995 FCRPS Biological Opinion established a process to address the following information needs for the issues:

1. The survival of juvenile salmonids in the migration corridor
2. The effectiveness of juvenile transportation compared with inriver migration
3. The absolute return rates of transported and inriver juvenile migrants under different flow conditions
4. The effectiveness of new technologies such as surface collection
5. The cost, feasibility, and benefits of drawdown and other system alternatives

In the interim, the 1995 FCRPS Biological Opinion called for transporting all juvenile migrants collected and provided optimum inriver conditions for migrants that are not transported. The 1995 FCRPS Biological Opinion established a regional forum of Federal, state, and Tribal fish and wildlife managers to coordinate day-to-day operations during the migration season. The forum is led by the Implementation Team, which oversees the work of subgroups such as the Technical Management Team (see Section 9).

2.2 SUPPLEMENTAL BIOLOGICAL OPINIONS

On May 14, 1998, NMFS issued the 1998 Supplemental FCRPS Biological Opinion. That ESA Section 7 consultation evaluated the effects of the configuration and operations of the FCRPS on

newly listed threatened and endangered steelhead in the Upper Columbia River, Snake River, and Lower Columbia River ESUs.

In the 1998 Supplemental FCRPS Biological Opinion, NMFS determined that operating the FCRPS in accordance with the Action Agencies' proposed action, including the measures specified in the RPA of the 1995 FCRPS Biological Opinion (the 1995 RPA), would not jeopardize the continued existence of the newly listed steelhead. The 1998 Supplemental FCRPS Biological Opinion established spring flow objectives at Priest Rapids Dam to protect juvenile fish and expanded the spill program at many mainstem hydro projects, but otherwise left the decision-making process and timing for the long term as in the 1995 FCRPS Biological Opinion.

NMFS issued a second supplemental biological opinion on December 9, 1999.[1] That biological opinion evaluated and documented BOR's planned operation to comply with the 1995 RPA prescription to deliver 427 thousand acre-feet (kaf) of upper Snake River water for flow augmentation and to review the operation of all BOR projects in the Snake River system above Lower Granite Dam. Again, the architecture of the long-term, decision-making process was unchanged from that set out in the 1995 RPA.

NMFS issued a last supplemental biological opinion on February 4, 2000.[2] That opinion considered the effects of FCRPS operations on six species that NMFS listed as threatened or endangered in March 1999. NMFS determined that the 1995 RPA, as modified by the 1998 proposed action and combined with a few additional interim measures, would not jeopardize the continued existence of any of the newly listed species for the rest of the interim period. The decision-making process and timing for the long term, again, remained consistent with the 1995 FCRPS Biological Opinion.

[1] "Biological Opinion—Bureau of Reclamation Operations and Maintenance of its Projects in the Snake River Basin Above Lower Granite Dam: A Supplement to the Biological Opinions Signed on March 2, 1995, and May 14, 1998" (NMFS 1999b).

[2] "Supplemental Biological Opinion—Operation of the Federal Columbia River Power System Including the Juvenile Fish Transportation Program: A Supplement to the Biological Opinions Signed on March 2, 1995, and May 14, 1998, for the Same Projects" (NMFS 2000d).

2.3 DRAFT ENVIRONMENTAL IMPACT STATEMENT

The Corps issued a draft environmental impact statement (EIS) describing alternative configurations and operations of the FCRPS in the lower Snake River for comment during December 1999 (Corps 1999b). The draft EIS was a requirement of the 1995 RPA.

2.4 CURRENT CONSULTATION

After the Corps issued the draft EIS, the Action Agencies reinitiated consultation on the long-term configuration of the hydrosystem by submitting their final biological assessment to NMFS on December 21, 1999.[3] NMFS consulted with the Action Agencies, in coordination with USFWS, and transmitted a draft biological opinion to these agencies on May 17, 2000 (NMFS 2000a). After considering comments from the Action Agencies, as well as other Federal agencies, NMFS issued a revised draft biological opinion, dated July 27, 2000, for review by the state and Tribal comanagers and other interested parties.

2.5 MEETINGS WITH STATE AND TRIBAL REPRESENTATIVES

NMFS held a series of meetings with state and Tribal comanagers that began on February 2, 2000. The Implementation Team and the Columbia Basin Fish and Wildlife Authority (CBFWA) coordinated the meetings, which included affected agencies and Tribes that do not participate in the Regional Forum. NMFS also briefed the Northwest Power Planning Council (NWPPC) and engaged in subsequent discussions with NWPPC members. During those meetings, the comanagers and others commented on the technical elements of the proposed action and potential RPA measures.

NMFS invited consultation with the 13 Sovereign Tribes of the Columbia River basin in a letter from B. Brown. The letter, dated January 26, 2000, was faxed and mailed to each Tribal chairman. Copies were also transmitted to the Columbia River Inter-Tribal Fish Commission (CRITFC), the Upper Columbia United Tribes (UCUT), CBFWA, and NWPPC. NMFS invited each Tribe to participate in the ESA Section 7 consultation with the Action Agencies to develop the 2000 FCRPS Biological Opinion. The letter recognized that Tribal rights and Tribal trust resources could be affected by NMFS' findings and recommendations and actively solicited Tribal expertise in developing analyses of effects, biological requirements, and mitigation strategies for listed salmon and steelhead. NMFS also offered to meet individually with the Tribes on a government-to-government basis. In response to this invitation, NMFS met with the Burns Paiute, Coeur d'Alene, Colville Confederated, Kalispel, Kootenai, Confederated Salish & Kootenai, Nez Perce, Shoshone-Bannock, Shoshone-Pauite, Spokane, and Umatilla Tribes and the Yakama Nation and with representatives of UCUT and CRITFC. Dates and locations of staff- and executive-level meetings are shown in Table 2.5-1.

[3] "Multi-Species Biological Assessment of the Federal Columbia River Power System" (BPA et al. 1999)

Table 2.5-1. Consultation and conferencing with Columbia Basin Tribes on development of Draft 2000 FCRPS Biological Opinion and Basinwide Recovery Strategy.

Location	Executive-Level	Staff-Level
Washington, D.C.	1/24 and 25/2000	–
Helena, Montana	--	2/25/2000
Spokane, Washington	3/8 and 3/24/2000	2/9 and 3/16/2000
Orofino, Idaho	--	3/10/2000
Lewiston, Idaho	3/14/2000	--
Olympia, Washington	3/29/2000	--
Portland, Oregon	4/3/2000	1/13, 3/29, 4/7, 4/14, 4/17, and 6/7, 2000

NMFS met with the Tribes in a series of technical-level planning and policy-level Tribal council meetings during the comment period for the draft biological opinion issued on July 27, 2000. The purpose of the planning meetings was to identify issues that the respective Tribal governments (or their representatives) would want to discuss at subsequent policy-level meetings. The dates and locations of these meetings, and the Tribes involved, are shown in Table 2.5-2.

The Tribes asked the Federal agencies to designate a lead agency for historic preservation and to explain how cultural resource issues would be addressed. In response, the Federal Caucus discussed designating a lead agency to manage cultural resources related to Basinwide Recovery Strategy actions. The consensus was that Basinwide Recovery Strategy implementation would trigger individual agency responses to the National Historic Preservation Act (NHPA), at which point a lead agency (or agencies) would assume coordination responsibility. The Federal Caucus agreed, therefore, that a regional, multiagency, Tribal, state, and local forum should be formed to keep track of overall implementation. Beginning in late summer 2000, Federal Caucus representatives conveyed these findings to the Tribes and received comments and suggestions. The Federal Caucus will continue to consult and coordinate with the Tribes and plans to integrate a forum on historic preservation and cultural resources into the restoration programs.

Table 2.5-2. Technical and policy level meetings with the Columbia Basin Tribes on Draft 2000 FCRPS Biological Opinion and Basinwide Recovery Strategy issued on July 27, 2000.

Tribe(s)	Location	Date
Technical-Planning Meetings		
Burns Paiute, Shoshone-Paiute, and Shoshone-Bannock	Boise, Idaho	9/20/2000
Colville	Nespelem, Washington	8/22-23/2000
Coeur d'Alene and Kootenai[1]	Spokane, Washington	9/22/2000
Nez Perce[2]	–	–
Spokane	Spokane, Washington	8/15/2000
Warm Springs	Warm Springs Reservation	9/18/2000
Umatilla[2]	–	–
Yakama	Yakama Reservation	10/3/2000
Policy-Level Council Meetings		
Burns Paiute, Shoshone-Paiute, and Shoshone-Bannock	Ft. Hall Reservation	10/24/2000
Colville	Spokane, Washington	9/27/00
Coeur d'Alene and Kootenai (policy+technical)[1]	Plummer, Idaho	11/8/2000
Nez Perce[2]	–	–
Spokane	Wellpinit, Washington	9/25/2000
Warm Springs[3]	–	–
Umatilla[2]	–	–
Yakama	Yakama Reservation	10/17/2000

[1] The Kalispel and Confederated Salish and Kootenai Tribes were invited to this meeting but did not participate.
[2] The Nez Perce and Umatilla Tribes have indicated that they wish to defer technical planning and/or policy-level meetings until they have completed their reviews of the draft biological opinion and Basinwide Recovery Strategy and have submitted comments. They also have indicated that policy-level meetings would be more appropriate after NMFS has had an opportunity to review the Tribal comments. NMFS, by letter, stated that it understood the Tribal position and was prepared to meet at some future date. No date has been established.
[3] The Warm Springs Tribal staff has indicated a desire to host a policy-level consultation meeting in the future. As of this writing, no date has been established.

2.6 FEDERAL REVIEW TEAMS FOR THIS CONSULTATION

2.6.1 The Biological Effects Team

The Biological Effects Team was charged with estimating the effects of current operations and potential future configurations and operations on the survival of listed juvenile outmigrants. NMFS used this information to analyze the listed species' biological requirements in the action area (Section 6.1.1), as well as at the species level (Section 6.1.2). The team included Federal biologists and engineers representing NMFS, the Corps, and BPA. NMFS Hydro Program staff then completed the biological effects analysis.

For juvenile fish using the mainstem Columbia and Snake rivers as a migration corridor, simulation modeling is the primary method used to evaluate the effects of the proposed action on the action area biological requirements. The Biological Effects Team agreed to use NMFS' simulated passage (SIMPAS) model to evaluate the biological benefits of juvenile salmonid passage measures. SIMPAS is a fish passage accounting model that apportions the run to various passage routes (i.e., turbines, fish bypass system, sluiceway/surface bypass, spillway, and/or fish transportation) based on empirical data and input assumptions for fish passage parameters.

The Biological Effects Team reviewed and analyzed the fish passage assumptions NMFS used in earlier fish passage modeling exercises, those developed in the Plan for Analyzing and Testing Hypotheses (PATH) process, and the most recent empirical data to determine the fish passage parameters for input into the SIMPAS model. The team also used the latest compilation of fish passage information from the four white papers the Northwest Fisheries Science Center (NWFSC) recently prepared on 1) "Passage of Juvenile and Adult Salmonids Past Columbia and Snake River Dams," 2) "Predation on Salmonids Relative to the Federal Columbia River Power System," 3) "Salmonid Travel Time and Survival Related to Flow in the Columbia River Basin," and 4) "Summary of Research Related to Transportation of Juvenile Anadromous Salmonids Around Snake and Columbia River Dams" (NMFS 2000e,f,h,i).

The Biological Effects Team reviewed spill and fish guidance efficiency, spill/gas caps, turbine, spillway, sluiceway, and bypass system survival, and diel passage patterns. Those parameters were quantified for each FCRPS dam and for both spring and fall chinook salmon (considered indicator species for the spring and summer passage seasons, respectively).

As a result of the collaborative analytical effort, on March 20, 2000, the team prepared and sent out a review draft report to the 13 Tribes and other regional fisheries comanagers. The draft documented preliminary results of SIMPAS model runs incorporating current passage conditions (and alternative proposed future actions under consideration in the 2000 ESA Section 7 consultation process).

2.6.2 Hydroregulation (Modeling) Team

The Hydroregulation Modeling Team was formed by the Federal agencies during the ESA Section 7 consultation process and charged with conducting hydroregulation modeling studies to simulate alternative river operations and the costs of such operations for the Columbia River hydrosystem. The team included Federal system analysts, engineers, and biologists representing NMFS, the Corps, BPA, BOR, and USFWS. BPA assessed the effects and estimated costs of alternative future water management actions for both NMFS and USFWS biological opinion operations by using its HYDSIM hydroregulation model and a series of power market pricing and marketing models. The HYDSIM model simulates flow/reservoir management and fish spill operations on a monthly basis at FCRPS and other Columbia Basin projects to meet an array of purposes, including flood control, anadromous and resident fish protection, projected energy loads, Columbia Basin Treaty obligations, and other project-specific, nonpower requirements. Model outputs include mean monthly discharge at various project locations, including those for which NMFS has set flow objectives (Priest Rapids, McNary, Bonneville, and Lower Granite dams), as well as end-of-month reservoir elevations for the major storage projects.

More than 30 system hydroregulation studies of various operational alternatives were conducted and reviewed by the Hydroregulation Modeling Team. The Section 7 consultation team selected a final modeling scenario to analyze both the NMFS and USFWS biological opinions, including a base case study. The base case model study placed priority on meeting the reservoir operating provisions specified in NMFS' 1995 and 1998 Supplemental FCRPS Biological Opinions and the USFWS' 1995 Biological Opinion on Kootenai River sturgeon. Subsequent modeling scenarios evaluated the effects of including the VARQ modified flood control curves, deeper reservoir drafts at selected FCRPS projects, and increasing the discharge from Mica and/or Revelstoke projects during the summer. The final hydroregulation study evaluated near-term implementation of the RPA, including deeper drafts at certain FCRPS storage projects, VARQ flood control operation, biological opinion spill levels, and fall spawning flows below Bonneville Dam.

HYDSIM model output consisted of a monthly flow detail and a summary of the effect of project operations by enumerating the frequency with which the NMFS flow objectives are met on a monthly and seasonal basis at Lower Granite, Priest Rapids, McNary, and Bonneville dams. The effect of flow operations on the frequency with which storage reservoirs would achieve upper (flood control) rule curve elevation on April 10 and refill by June 30 was also summarized. See Section 9.7.1.3 for a detailed summary of hydroregulation modeling results.

2.6.3 Performance Standards Team

The Performance Standards Team was another team formed by the Federal agencies during the Section 7 consultation process. The team was composed of members from NMFS, USFWS, BPA, the Corps, and BOR. It was charged with developing a set of performance measures and associated goals or standards that NMFS and the region could use to judge the success of the

salmon recovery effort. The team began meeting in January 2000. Its work culminated in a draft report entitled, "Development of Provisional Performance Measures and Standards for Federal Hydrosystem Impacts in the Columbia River Basin," which was released to regional fishery agencies and Tribes for review on March 24, 2000. In its paper, the team developed a process for formulating performance measures in the context of three major objectives:

1. It proposed a procedure for placing hydrosystem-related performance measures and standards in the context of performance measures and standards for other, nonhydrosystem actions affecting various life-history stages.
2. It developed a suite of provisional performance measures and standards applicable to hydrosystem-related actions, including performance measures for FCRPS hydrosystem activities and for natural survival.
3. It developed a blueprint for revising the hydrosystem-related performance measures and standards in the context of mitigation measures using nonhydrosystem actions, i.e., as part of a comprehensive recovery planning effort addressing habitat, harvest, hatcheries, and hydropower.

After the report was released, NMFS built on the efforts of the team in developing and selecting population-level measures of salmon survival and recovery for each species and hydrosystem performance measures, presented in Section 1.3.1.1.

2.6.4 Water Quality Team

The Federal agencies formed the Water Quality Team during the ESA Section 7 consultation process. The team consisted of members from NMFS, USFWS, BPA, the Corps, BOR, and the U.S. Environmental Protection Agency (EPA). It was charged with development of a water quality plan for the mainstem Columbia and Snake rivers. The team also began meeting in January 2000. Its efforts culminated in a paper entitled, "Development of a Water Quality Plan for the Columbia River Mainstem: A Federal Agency Proposal." It is included in this biological opinion as Appendix B.

The water quality plan includes basinwide goals for total dissolved gas (TDG) and water temperature in the Columbia River basin. In its paper, the team outlined how a water quality plan could be developed and implemented in the basin. The team developed a water quality planning process for deciding on both structural and operational water quality measures. The strategy of the water quality plan is to identify ongoing activities and planned-for improvements in fish survival that also serve to improve water quality by reducing TDG and water temperature. The team addressed long-term structural, operational, and procedural measures for water quality improvements, as well as details concerning the process for developing a water quality plan (Appendix B).

2.7 RELATED REGIONAL FORUMS

NMFS developed its biological opinion on the effects of FCRPS operations in coordination with other ongoing Federal and regional processes. The process is described in the following sections.

2.7.1 Federal Caucus/Basinwide Recovery Strategy

The Federal Caucus includes NMFS, the Corps, BOR, BPA, EPA, the Bureau of Indian Affairs (BIA), the Bureau of Land Management (BLM), USFWS, and the U.S. Forest Service (USFS). The primary role of the Federal Caucus has been to develop a comprehensive multispecies conceptual recovery plan that describes a range of potential Federal activities that could meet ESA obligations and rebuild Columbia basin stocks (Basinwide Recovery Strategy). Non-Federal (Tribal, state, local, and private) activities are also considered in the Basinwide Recovery Strategy to the extent that they can contribute to the recovery of ESA-listed species in the Columbia River basin. Recovery options are considered and analyzed across actions affecting each life stage of ESA-listed fish: habitat, hatcheries, harvest, and the hydropower system. These options are broadly described for the purpose of engaging a regional discussion.

After the draft Basinwide Recovery Strategy was released, the Federal Caucus engaged in government-to-government consultations with 13 Native American Tribes in the Columbia River basin. In addition, more than 9,000 Pacific Northwest citizens testified in 15 public hearings. The Federal Caucus also received more than 60,000 written comments. On the basis of the feedback, the Federal Caucus is attempting to balance and respect multiple competing interests, including the needs of anadromous and resident aquatic species, Tribal trust and treaty obligations, international commitments, and the economic and cultural concerns of all citizens in the region.

The Basinwide Recovery Strategy attempts to balance these issues by recommending new, intensive measures basinwide and across the salmon and steelhead life cycle. It builds on existing measures for better balance and bolsters non-Federal decisions and actions with Federal support and funding. It recognizes the need to consider the broader cultural concerns of threatened and endangered species recovery. It links discrete actions across the ecosystem and the life stages of salmon and steelhead to connect biology and ecology basinwide. These actions will also benefit resident fish and other aquatic species.

The Basinwide Recovery Strategy serves four major purposes. First, it provides an overall, conceptual recovery strategy encompassing threatened and endangered aquatic species affected by the FCRPS. Second, it establishes a context for the new biological opinions on the operation and configuration of Federal dams issued by NMFS and USFWS. It shows how the actions called for in the hydrosystem fit with other related recovery initiatives or ongoing policies in the Columbia River basin. Third, the draft Basinwide Recovery Strategy provides a tool for engaging and informing the general public about the issues affecting salmon and steelhead, resident fish, and other aquatic species, and the policy choices under consideration in the effort to

recover them. Fifteen public hearings and seven scientific workshops were conducted after the draft was released, representing an unprecedented opportunity for the public to participate in the formation of natural resource management policies. Fourth, as a product of the Federal Caucus, the Basinwide Recovery Strategy served as an organizing tool for the Federal agencies involved to align their programs and activities to ensure maximum coordination and policy uniformity from the Federal perspective. The Basinwide Recovery Strategy is not a decision document. Its content is neither regulatory nor binding in nature. Rather, it presents a set of strategies, goals, and overall direction toward which the agencies in the Federal Caucus will commit to move their programs and policies.

In making decisions to correct the decline of anadromous fish and steelhead, as well as other listed fish and wildlife resources, the Federal Caucus will comply fully with all applicable Federal laws and executive orders. These include, but are not limited to, NEPA, ESA, CWA, and NHPA, as well as trust responsibilities applicable to the unique and longstanding relationship between the U.S. government and the region's federally recognized Indian Tribes.

2.7.2 Plan for Analyzing and Testing Hypotheses

PATH is a structured program of formulating and testing hypotheses involving the fundamental biological issues surrounding recovery of ESA-listed salmon and steelhead in the Columbia River basin. The PATH decision analysis focused on alternative hydrosystem actions that could be used to prevent the extinction of and aid in the recovery of SR spring/summer and fall chinook salmon. The work of the PATH group underlies the life cycle analyses used in this biological opinion for those ESUs.

2.7.3 Cumulative Risk Initiative

The CRI is a network of NMFS scientists working to synthesize information and provide clear, consistent, and scientifically rigorous decision support for salmonid conservation. The CRI process of the NMFS NWFSC has used matrix modeling of salmonid population dynamics to evaluate extinction risks and the sensitivity of population growth for each ESU to changes in survival in specific life-history stages as a result of management actions. In this biological opinion, the analysis was used to determine potential combinations of basinwide strategies to achieve the biological objectives related to recovery of ESA-listed species.

To involve, obtain input from, and inform both the technical scientific community and the community of policymakers, NWFSC established a series of workshops. The audience alternated between highly technical experts in specialized areas and a mix of policy and technical participants. Table 2.7-1 outlines the workshop schedule.

Table 2.7-1. CRI workshop schedule.

Date	Purpose	Level
Jul. 22-23, 1999	Technical introduction to CRI analytical approach	Technical
Aug. 31, 1999	Putting Basinwide Recovery Strategy together	Technical and policy
Sept. 29-30, 1999	Assessing productivity of habitats with respect to salmon populations	Technical
Oct. 27, 1999	Data-poor, rapid analysis assessments for other ESUs in Columbia River system	Technical and policy
Dec. 7-8, 1999	Spatial analyses	Technical
Mar. 29, 2000	Cosponsored by American Rivers	Technical and policy
Sept. 19, 2000	Recovery planning: CRI risk calculations and assessing habitat options	Technical

2.7.4 NMFS White Papers

In October 1999, NMFS synthesized existing information on salmonid passage through the FCRPS in four white papers that discussed dam passage, transportation, flow/survival relationships, and predation, respectively. The papers also characterized uncertainties associated with existing data and raised in recent analyses by regional forums. The papers were released for regional review and comment.

After the regional review, the white papers were modified to reflect comments and information from numerous reviewers and resource agencies. Contributors include the Oregon Department of Fish and Wildlife (ODFW), USFWS, Idaho Department of Fish and Game, Columbia Basin Fish and Wildlife Authority, Washington Department of Fish and Wildlife (WDFW), CRITFC, U.S. Geological Survey (USGS), Fish Passage Center, Idaho Water Users Association, Inc. (IWUA), and IDACORP, Inc. The four modified papers are now available on the NWFSC home page (web site: www.nwfsc.noaa.gov/pubs/nwfscpubs.html).

2.7.5 Quantitative Analysis

NMFS, in cooperation with other parties, is developing the quantitative analysis report (QAR) for the listed species that may be affected by the non-Federal, mid-Columbia projects (i.e., those operated by the public utility districts (PUDs) of Douglas, Chelan, and Grant counties. The QAR is a quantitative assessment of the biological requirements and likelihood of survival and recovery for endangered UCR spring chinook salmon and endangered UCR steelhead. As with PATH, much of the work of the QAR group underlies the life cycle analyses in this biological opinion for those ESUs.

2.7.6 Northwest Power Planning Council's Multispecies Framework Project/Ecosystem Diagnosis and Treatment Analysis

NWPPC's Multi-Species Framework Project is developing visions, strategies, and alternatives for recovering fish and wildlife resources in the Columbia River basin and analyzing the biological and social/human effects of alternatives. The Hydro Work Group of the Federal Caucus and the Framework Project staff jointly evaluated alternative measures for system configuration and operations and agreed to the specifications of those measures in seven Framework Project alternatives and three Federal scenarios. The joint group also coordinated the analysis of hydrosystem operations, the biological studies and evaluations, and other Federal and Framework Project tasks related to the hydrosystem.

The Framework Project will characterize a set of alternative futures for the Columbia River basin that focus on a long-term vision for the region. The Framework Project uses an analytical technique called ecosystem diagnosis and treatment (EDT) to compare the ecological effects of various alternatives and describe their economic, social, and cultural impacts. The analysis focuses on long-term conditions and emphasizes habitat actions.

3.0 PROPOSED ACTION

3.1 OPERATION AND CONFIGURATION OF FCRPS AND BOR PROJECTS

The Action Agencies have proposed, as described in their biological assessment (BPA et al. 1999), to continue current FCRPS operations that implement the 1995 RPA as supplemented, while developing measurable performance standards to guide future system improvements.

The FCRPS operates to serve an array of individual project and system purposes. Individual project purposes vary widely and may include power generation, flood control, irrigation, recreation, fish and wildlife, and other purposes defined by congressional authorizations. Systemwide purposes focus on supplying electrical energy to meet existing and projected loads, flood control, and more recently, salmon recovery.

In addition to the BOR projects in the FCRPS (e.g., certain facilities and operations at the Grand Coulee Project and Hungry Horse Dam and reservoir), the Action Agencies propose to continue current operations of the BOR's other projects, as described in the biological assessment.

Elements of the proposed action designed to enhance salmon survival are described below.

3.2 OBJECTIVES FOR SALMON AND STEELHEAD

The Action Agencies recommend that mainstem flow operations be based on the 1995 RPA as supplemented by the 1998 FCRPS Biological Opinion. For SR salmon and steelhead, the seasonal average flow objectives would range from 85 to 100 thousand cubic feet per second (kcfs) during spring (April 3 to June 20) and 50 to 55 kcfs during summer (June 21 to August 31) at Lower Granite Dam. Flow objectives in the lower Columbia River, as measured at McNary Dam, would range from 220 to 260 kcfs during spring (April 20 to June 30) and 200 kcfs during summer (July 1 to August 31). The flow objectives in any given year would be determined using a sliding scale based on forecasted runoff, as specified in the 1995 RPA. To benefit UCR steelhead, in the mid-Columbia reach the 1998 Supplemental FCRPS Biological Opinion set a further spring flow objective of 135 kcfs (April 10 to June 30) at Priest Rapids Dam.

System operators will continue to confer with NMFS and the regional fisheries comanagers to determine how to best manage in-season conditions relative to the seasonal average flow objectives. Flow management would continue to emphasize refill of headwater storage projects by June 30 in the Snake River basin and by the end of the July 4 weekend in the Columbia River basin each year (or as soon as possible after July 4 at Libby), although that priority would remain subject to in-season considerations. Reservoir drafts would be limited to 80 feet at Dworshak (elevation 1,520 feet), 10 feet at Grand Coulee (elevation 1,280 feet), 20 feet at Hungry Horse (elevation 3,540 feet) and 20 feet at Libby (elevation 2,439 feet).

For fall chinook and chum salmon spawning below Bonneville Dam, the FCRPS would be operated to use storage to augment natural flows, in an attempt to provide a flow level of 125 kcfs during early November through early April while maintaining the 1995 RPA requirement for storage projects to be at their upper (flood control) rule curve elevation on April 10 of each year. The Action Agencies recognize that in some years it may be impossible to meet both these flows and the reservoir levels in the spring, in which case priority will be on refill. As natural conditions permit, a conservative stepwise approach would allow higher flows during late fall and early winter (i.e., providing additional spawning habitat in the Ives Island area). If in-season data on reservoir operations indicate that the 1995 RPA, the 1998 Supplemental FCRPS Biological Opinion, and Vernita Bar flow requirements cannot be met by providing chum flows, the Action Agencies will confer with NMFS to modify operations.

3.2.1 Water Quality

The Action Agencies propose to continue to operate the FCRPS to reduce water temperatures during periods of juvenile and adult fish migration and to reduce the harmful effects of elevated levels of spill-generated TDG on anadromous and resident fish. Based on recommendations of the Regional Forum's Technical Management Team, flows would be released from Dworshak Dam to help reduce water temperatures in the lower Snake River for migrating fall chinook salmon and steelhead. Gas concentrations would be controlled by limiting the amount of involuntary spill at all dams, installing gas-abatement structures that reduce the generation of TDG, and taking other operational and power-marketing actions. In years of high runoff, inflows to FCRPS projects can result in forced spill or TDG levels exceeding 120%. In addition, voluntary spill to improve fish passage will be managed to 115% or 120% TDG, or as approved through variances to the 110% gas standard.

3.2.2 Specific Project Operations

3.2.2.1 Libby

Libby Reservoir would be maintained throughout fall and winter to achieve a 75% chance of reaching flood control elevation on April 10. From late spring through July, the Action Agencies would release water to achieve the goals set for white sturgeon in the Kootenai River. If the elevation of Lake Koocanusa is above 2,439 feet at the conclusion of the sturgeon operations, the Action Agencies would use water above elevation 2,439 feet to provide flows to meet salmon objectives within the turbine capacity of Libby Dam. Efforts would be made to minimize the effect of a second peak flow fluctuation below Libby until August 31 for the benefit of resident fish species. The Action Agencies would consider the Technical Management Team's recommendations for Libby operations, along with others (including the NWPPC's) in making final operating decisions.

3.2.2.2 Hungry Horse

Hungry Horse Dam would be operated during the fall and winter months to achieve a 75% chance of refill to its April 10 upper rule curve. Hungry Horse Dam would also operate to meet a year-round minimum instantaneous streamflow of 3,500 cubic feet per second (cfs) in the Flathead River near Columbia Falls to protect instream habitat for native resident fish populations, including ESA-listed bull trout. Using water supply forecasts, the Action Agencies would operate the project to refill no later than the end of the July 4 weekend. The Action Agencies would draft the project to 3,540 feet to assist in meeting the summer anadromous fish flow objective at McNary Dam, as coordinated through the Technical Management Team. Because a selective-withdrawal, water-temperature-control structure has been installed at Hungry Horse, the Action Agencies would plan water releases to try to meet state-recommended water temperature guidelines during the period June through October.

3.2.2.3 Grand Coulee

Grand Coulee Dam would be operated according to the 1995 RPA and the 1998 FCRPS Supplemental Biological Opinion. The Action Agencies would operate the project during January through April 10 to ensure an 85% confidence of refill to flood control elevation. BOR would limit winter drafts to elevation 1,265 feet, 1,260 feet, 1,250 feet, and 1,240 feet at the end of December, January, February, and March, respectively (except when deeper drafts would be needed for flood control or power emergencies). Beginning in April, Grand Coulee would be operated to refill to full pool (elevation 1,290 feet) by the end of the July 4 weekend. From April 10 through August 31 of each year, releases would be made to augment flows for anadromous fish, as coordinated by the Technical Management Team. The reservoir would be drafted as low as 1,280 feet elevation by August 31 during average and above-average water conditions. After Labor Day weekend, the Action Agencies would try to refill Lake Roosevelt by the end of September to elevation 1,283 feet or higher for kokanee spawning needs. Water would also be released from Grand Coulee to meet an average daily minimum flow requirement of approximately 30 kcfs or higher as needed to meet minimum flows at Priest Rapids Dam. The Priest Rapids minimum flow is the higher of 36 kcfs or the Vernita Bar flow requirement during the December-through-May period. The Action Agencies would continue to coordinate with regional interests to develop operations that minimize the potential stranding of post-emergent fall chinook in the Hanford Reach.

3.2.2.4 Albeni Falls

The typical maximum reservoir operating range for this project, which controls water surface elevations in an upstream natural lake, is from elevation 2,051 to 2,062.5 feet. The reservoir would be drawn down beginning on Labor Day for power generation and flood control purposes and would typically achieve its lowest elevation between November 15 and 20 of each year. Variations in lake level after November 20 would be controlled to within 1 foot to protect established kokanee spawning areas. Experimental operations have occurred for the last several

winters to examine the relationship between winter lake levels and kokanee spawning. During winter 2000, a lake elevation of 2,053 feet was monitored to evaluate potential effects on resident species and lake productivity. Before this experimental operation, Albeni Falls was drafted farther, to elevation 2,051 feet, during winter operations. Under the Action Agencies' current activities, operations during January through March 31 would allow for some fluctuation in reservoir elevations for power production and flood control, but the elevation could not drop below the last minimum water level established in December. From April through June, the reservoir would refill. During the summer months, the fluctuations would be maintained within a 0.5-foot limit (i.e., between 2,062- and 2,062.5-foot elevation).

3.2.2.5 Dworshak

Dworshak Dam would continue to be used to augment flows in the Snake River for the intended benefit of juvenile and adult summer-migrating salmon and steelhead from April through August. Dworshak would be full by June 30 and would draft to its August 31 draft limit of elevation 1,520 feet (80 feet from full pool) to provide water to meet anadromous fish flow objectives. The project would be operated to release a minimum of 1,300 cfs between September and April to enhance the probability of refill to the flood control rule curve elevation by the beginning of April. Because Dworshak Dam has a temperature control outlet facility and a multilevel outlet, cool water would typically be released during July or August to reduce water temperatures in the lower Snake River.

3.2.2.6 BOR's Snake River Projects

In the July 27, 2000, Draft FCRPS Biological Opinion, the proposed action included the continued operation and maintenance of BOR's 11 projects in the Snake River basin (Table 3.2-1). The Department of Justice, BOR, and NMFS have been engaged in negotiations with the state of Idaho and Idaho water interests to settle Federal and Tribal water claims in the Snake River basin as part of the general adjudication of water rights taking place in Idaho District 1 Court. Termed the Snake River Basin Adjudication, this process will define the water rights under Idaho law of all parties having interests in Snake River basin water within Idaho's boundaries. To date, agreement has not been reached. Since discussions are continuing, BOR has indicated that the proposed action for its 11 irrigation projects in the Snake River basin may be different from those measures set forth in its December 21, 1999, biological assessment. Accordingly, BOR has asked to extend the consultation on these 11 projects pending a revised proposed action and analysis of effects. Because all BOR projects upstream of Hells Canyon Dam, including those in Oregon, have similar and additive effects on listed fish, NMFS and BOR agree that it would be best to consult on these projects simultaneously. Therefore, at BOR's request, NMFS has agreed to extend the current consultation with regard to BOR's projects in the Snake River basin and to exclude those projects from this biological opinion. BOR anticipates providing the necessary additional information, and NMFS anticipates issuing a supplemental biological opinion on those projects before water must be delivered from the projects for irrigation use in the 2001 growing season.

Table 3.2-1. BOR projects in Snake River basin.

Project	Location	Subbasin or Stream
Minidoka	Southern Idaho and western Wyoming from Twin Falls Idaho to Jackson Lake, Wyoming	Snake River
Palisades	Eastern Idaho, on Wyoming border	Snake River
Michaud Flats	Southern Idaho, near Pocatello	Snake River
Little Wood River	South-central Idaho, north of Twin Falls	Little Wood River
Boise	Southwest Idaho, near Boise	Boise and Payette rivers
Mann Creek	Southwest Idaho, northwest of Boise	Weiser River
Owyhee	Eastern Oregon and southwest Idaho, near Ontario Oregon	Owyhee and Snake rivers
Vale	Eastern Oregon, west of Ontario	Malheur River
Burnt River	Eastern Oregon, south of Baker City	Burnt River
Baker	Eastern Oregon, near Baker City	Powder River
Lewiston Orchards	West-central Idaho, near Lewiston	Clearwater River

3.2.2.7 Columbia River Treaty and Non-Treaty Storage

To improve the likelihood of achieving salmon flow objectives in the mainstem Columbia River, the Corps and BPA propose to continue to negotiate mutually beneficial agreements with BC Hydro annually for use of their Columbia River Treaty storage and non-Treaty storage in Canada. Under Treaty operations, these actions include 1 million acre-feet of storage for salmon flow augmentation in the Columbia River, stored above the Detailed Operating Plan Treaty Storage Regulation levels from January to April 15 and then released from May through July, and storage exchanges between Libby and Canadian reservoirs, which would reduce potential adverse effects of salmon flow augmentation drafts on recreation, resident fish, and power in the U.S. and Canada. Under the Non-Treaty Storage Agreement, both BPA and BC Hydro store water in Mica Reservoir during May and June for release in July and August. BPA releases all its May/June stored water during July and August for salmon flows, whereas Canada releases half of its May/June stored water during July and August and the other half at its discretion.

3.2.3 Spill for Fish Passage

Spill is an action to reduce turbine-related mortality of juvenile salmon and steelhead at lower Snake and Columbia River hydroelectric projects. Spill will be at the levels recommended in the 1998 Supplemental FCRPS Biological Opinion, assuming that waivers are obtained from the states of Oregon and Washington to exceed their 110% TDG state water quality standards. The Action Agencies would continue to provide spill for fish passage, but not to exceed TDG levels allowed under the standard or any modifications to it.

3.2.4 Juvenile Fish Transportation

Juvenile salmonids would be collected at several dams on the lower Snake and Columbia rivers and transported downstream by truck or barge to release points below Bonneville Dam in an effort to improve survival over that experienced by inriver migrants. The Action Agencies would continue to provide spill levels that spread the risk between transported and inriver migrants. Spring migrants would not be transported from McNary Dam. Generally, summer juvenile migrants (those collected after the June 20 planning date) would be transported from all four transport facilities. Spill would be limited during that period so that more of the run would approach the powerhouse and be diverted by screens into collection facilities. Once collected, nearly all would be transported by barge or truck to below Bonneville Dam and released.

3.2.5 Minimum Operating Pool (MOP)

Some mainstem run-of-river FCRPS reservoirs on the lower Snake River and John Day Reservoir on the Columbia River would be lowered during the spring and summer migration periods to increase water velocity (intended to increase the migration rate and survival of salmonid smolts). Three of the lower Snake River facilities (Little Goose, Lower Monumental, and Ice Harbor dams) would be operated within 1 foot of the MOP from April 3 until adult fall chinook begin to enter the Snake River, as recommended by the Technical Management Team. Lower Granite Dam would be operated within 1 foot of the MOP from April 3 through November 15 of each year. After November 15, all four reservoirs would be operated within their normal 5-foot operating ranges. McNary, The Dalles, and Bonneville reservoirs would be operated within their normal ranges. From April 20 to September 30 each year, John Day Reservoir would be operated within a 1.5-foot range above elevation 262.5 feet, as long as irrigation withdrawal remained unaffected and additional space was not needed for flood control. The pool elevation would be raised if irrigation pumping problems occurred.[1] During the fall and winter months, all four lower Columbia River projects would be operated within their normal operating range, with the exception of temporary flood control storage at John Day, if needed.

3.2.6 Peak Turbine Efficiency Operation

Under the current action, the Action Agencies would operate turbines at the eight FCRPS mainstem Snake and Columbia River projects at a high efficiency (within 1% of peak operating efficiency) to reduce the mortality of fish passing through turbines. Operations outside this range would be limited and most likely implemented at the recommendation of the Technical Management Team to abate supersaturated levels of TDG. Specifics of turbine operations that would achieve 1% efficiency are contained in the Corps' annual Fish Passage Plan.

[1]It has been determined that John Day Reservoir cannot be operated at its MOP elevation of 257 feet during the juvenile fish migration season, because of adverse effects on irrigation pumping.

3.2.7 Fish Passage Facilities

3.2.7.1 Juvenile Fish Bypass

Juvenile fish bypass would be provided at Corps mainstem hydroelectric projects by a variety of methods, including screened turbine intakes with bypass/collection facilities at Lower Granite, Little Goose, Ice Harbor, Lower Monumental, McNary, John Day, and Bonneville dams; ice and trash sluiceway passage at The Dalles Dam; and/or spill for fish passage. Surface bypass technology is under evaluation at Lower Granite, Bonneville, and John Day dams. Juvenile fish bypass facilities would be operated continuously during the fish passage period from April through November. All juvenile fish bypass systems would be operated and maintained based on criteria in the Corps' Fish Passage Plan. The plan would be reviewed and updated annually after coordination with the regional fisheries agencies and Indian Tribes and in coordination with NMFS. In-season changes to operating criteria and maintenance schedules may be recommended by the Technical Management Team.

3.2.7.2 Adult Fish Passage

All the mainstem FCRPS hydroelectric dams in the Columbia/Snake migration corridor have fish ladders and associated auxiliary water supply and powerhouse collection facilities. The adult fish passage period would be March through November at Bonneville, The Dalles, and John Day dams and March through December at McNary and the four lower Snake River projects. Criteria for the operation and maintenance of adult passage facilities would be also contained in the Corps' Fish Passage Plan. Adult salmonids (and other species) would be counted at each mainstem dam, with the schedule varying according to location and time of year.

3.2.8 Other Activities

A number of research studies covering various aspects of juvenile and adult fish passage would be implemented annually based on provisions in NMFS' biological opinions and through coordination with regional work groups. These studies would be intended to provide information related to key passage uncertainties, for improving operational criteria, modifying or improving existing fish passage facilities, and constructing new passage facilities.

Special operations will be necessary for several research studies developed in response to the actions identified in the NMFS biological opinion. Their successful implementation will depend on special project operations. Research-related project operations would be developed with NMFS, coordinated with the regional forums, and identified in the Fish Passage Plan.

3.2.9 Predator Control Program

The Northern Pikeminnow Management Program, designed to substantially reduce predation losses of juvenile outmigrants, would continue. The program includes harvest technology

research, prey protection measures, basic biological research, and a bounty- or sport-reward fishery to encourage the public to harvest northern pikeminnows. Caspian terns have also been identified as a major predator on juvenile salmonids, particularly in the Columbia River estuary near Rice Island. The Action Agencies would continue to conduct studies to determine the significance of predation by fishes and birds throughout the FCRPS and to identify measures to reduce juvenile salmonid losses to these predators. The measures may include expanding activities that are already under way (e.g., avian lines, water cannons), as well as initiating new measures.

3.2.10 Adaptive Management Framework Through Adoption of Performance Measures

The Action Agencies' biological assessment focuses on establishing a course of action for the FCRPS that avoids jeopardy and facilitates the future recovery of listed stocks. Avoidance of jeopardy and facilitation of recovery necessarily requires that the Action Agencies consider actions and improvements in the hydrosystem in connection with actions and improvements expected for habitat, harvest, and hatcheries. Specific actions identified above would provide the base for future operations and actions in the hydrosystem, subject to adjustment over time. The biological assessment also outlines a proposed "Construct for Achieving Survival Improvements" that would establish measurable biological performance standards for the hydrosystem, prioritize actions, and estimate the likely outcome of future actions. The Construct would provide a basis for some experimental management actions to improve understanding of key uncertainties and, thus, the ability to implement future actions to achieve recovery.

Long-term actions identified or evaluated in the biological assessment as potentially of benefit to listed species include ongoing studies evaluating the feasibility of lower Snake River actions, such as dam breaching, and the John Day phase 1 report that addresses juvenile fish passage alternatives (Corps, 2000c). Various actions under consideration to improve TDG and temperature conditions for the benefit of anadromous and resident species are also described, as well as various system modifications, including new turbine designs, surface bypass/collectors, and improved transport facilities. Changes in storage project operations and configurations in the Snake and lower Columbia rivers for the benefit of anadromous and resident fish (e.g., gas abatement and increased flow augmentation) are also described.

The Action Agencies' Construct is based on establishing an overall recovery goal. It would provide a method of defining desired levels of improvement in habitat, harvest, hatcheries, and hydropower, developing performance standards associated with these levels of improvement, evaluating and setting priorities for possible actions in each area, and selecting the most appropriate combination of actions for each category. The Action Agencies propose to use this method to evaluate possible future hydro actions, recognizing that overall recovery goals and associated obligations for survival improvements among all the categories may not be established within the timeframe of the FCRPS consultation. Accordingly, the Action Agencies

recommend that interim performance standards be developed during consultation to enhance decision-making and to provide a model for developing performance standards for all four areas.

3.3 ISSUANCE OF SECTION 10 PERMIT FOR JUVENILE FISH TRANSPORTATION PROGRAM BY NMFS

During 1999, the Corps' Walla Walla District applied to NMFS for a new Section 10 permit for the JFT. As an interim measure, NMFS extended the Corps' existing Permit 895 under authority of Section 10 of the ESA and NMFS regulations governing ESA-listed fish and wildlife permits (50 CFR parts 217 through 227). The extended permit is valid until December 31, 2000, or until replaced by the new permit. The Corps is conducting a feasibility study, in conjunction with this consultation, to evaluate several alternatives to juvenile fish transportation. The extension of Permit 895 allows the duration of the permit to coincide with this reinitiation of ESA Section 7 consultation on the long-term management strategy for the FCRPS. Permit 895 authorizes the Corps' annual direct takes of juvenile endangered SR sockeye salmon, juvenile threatened SR spring/summer chinook salmon (naturally produced and artificially propagated), juvenile threatened SR fall chinook salmon, and juvenile endangered UCR steelhead (naturally produced and artificially propagated). All are associated with the Corps' JFT at four hydroelectric projects on the Snake and Columbia rivers (Lower Granite, Little Goose, Lower Monumental, and McNary). Permit 895 also authorizes the Corps' annual incidental takes of ESA-listed adult fish associated with fallbacks through the juvenile fish bypass systems at the four dams. With regard to the Corps' request to include an annual take of adult and juvenile endangered UCR spring chinook salmon, NMFS determined that any take of this species associated with Corps transportation activities would be incidental under the existing requirement to suspend transportation operations from McNary Dam during the spring migration period.

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4.0 BIOLOGICAL INFORMATION

4.1 LIFE HISTORIES, FACTORS FOR DECLINE, AND CURRENT RANGEWIDE STATUS

NMFS published the information in this section previously as Appendix A to the paper "A Standardized Quantitative Analysis of the Risks Faced by Salmonids in the Columbia River Basin" (McClure et al. 2000a). Additional details regarding the life histories, factors for decline, and current rangewide status of these species are found in Appendix C of this biological opinion.

4.1.1 Snake River Spring/Summer Chinook Salmon

4.1.1.1 Geographic Boundaries and Spatial Distribution

The location, geology, and climate of the Snake River region create a unique aquatic ecosystem for chinook salmon. Spring- and/or summer-run chinook salmon are found in several subbasins of the Snake River (CBFWA 1990). Of these, the Grande Ronde and Salmon rivers are large, complex systems composed of several smaller tributaries that are further composed of many small streams. In contrast, the Tucannon and Imnaha rivers are small systems with most salmon production in the main river. In addition to these major subbasins, three small streams (Asotin, Granite, and Sheep creeks) that enter the Snake River between Lower Granite and Hells Canyon dams provide small spawning and rearing areas (CBFWA 1990). Although there are some indications that multiple ESUs may exist within the Snake River basin, the available data do not clearly demonstrate their existence or define their boundaries. Because of compelling genetic and life-history evidence that fall chinook salmon are distinct from other chinook salmon in the Snake River, however, they are considered a separate ESU.

4.1.1.2 Historical Information

Historically, spring and/or summer chinook salmon spawned in virtually all accessible and suitable habitat in the Snake River system (Evermann 1895; Fulton 1968). During the late 1800s, the Snake River produced a substantial fraction of all Columbia River basin spring and summer chinook salmon, with total production probably exceeding 1.5 million in some years. By the mid-1900s, the abundance of adult spring and summer chinook salmon had greatly declined. Fulton (1968) estimated that an average of 125,000 adults per year entered the Snake River tributaries from 1950 through 1960. As evidenced by adult counts at dams, however, spring and summer chinook salmon have declined considerably since the 1960s (Corps 1989).

4.1.1.3 Life History

In the Snake River, spring and summer chinook share key life history traits. Both are stream-type fish, with juveniles that migrate swiftly to sea as yearling smolts. Depending primarily on location within the basin (and not on run type), adults tend to return after either 2 or 3 years in the ocean. Both spawn and rear in small, high-elevation streams (Chapman et al. 1991), although where the two forms coexist, spring-run chinook spawn earlier and at higher elevations than summer-run chinook.

4.1.1.4 Habitat and Hydrology

Even before mainstem dams were built, habitat was lost or severely damaged in small tributaries by construction and operation of irrigation dams and diversions, inundation of spawning areas by impoundments, and siltation and pollution from sewage, farming, logging, and mining (Fulton 1968). Recently, the construction of hydroelectric and water storage dams without adequate provision for adult and juvenile passage in the upper Snake River has kept fish from all spawning areas upstream of Hells Canyon Dam.

4.1.1.5 Hatchery Influence

There is a long history of human efforts to enhance production of chinook salmon in the Snake River basin through supplementation and stock transfers. The evidence is mixed as to whether these efforts have altered the genetic makeup of indigenous populations. Straying rates appear to be very low.

4.1.1.6 Population Trends and Risks

For the SR spring/summer chinook salmon ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[1] ranges from 0.96 to 0.80, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to the effectiveness of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated median population growth rates and the risk of absolute extinction for the seven spring/summer chinook salmon index stocks,[2] using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years for the wild component ranges from zero for Johnson Creek to 0.78 for the Imnaha River (Table B-5 in McClure et al. 2000b). At the high end, assuming that the hatchery fish spawning

[1] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1999 adult returns. Population trends are projected under the assumption that all conditions will stay the same into the future.

[2] McClure et al. (2000c) have calculated population trend parameters for additional SR spring/summer chinook salmon stocks.

in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years ranges from zero for Johnson Creek to 1.00 for the wild component in the Imnaha River (Table B-6 in McClure et al. 2000b).

4.1.2 Snake River Fall Chinook Salmon

4.1.2.1 Geographic Boundaries and Spatial Distribution

The Snake River basin drains an area of approximately 280,000 km^2 and incorporates a range of vegetative life zones, climatic regions, and geological formations, including the deepest canyon (Hells Canyon) in North America. The ESU includes the mainstem river and all tributaries, from their confluence with the Columbia River to the Hells Canyon complex. Because genetic analyses indicate that fall-run chinook salmon in the Snake River are distinct from the spring/summer-run in the Snake basin (Waples et al. 1991), SR fall chinook salmon are considered separately from the other two forms. They are also considered separately from those assigned to the UCR summer- and fall-run ESU because of considerable differences in habitat characteristics and adult ocean distribution and less definitive, but still significant, genetic differences. There is, however, some concern that recent introgression from Columbia River hatchery strays is causing the Snake River population to lose the qualities that made it distinct for ESA purposes.

4.1.2.2 Historical Information

SR fall chinook salmon remained stable at high levels of abundance through the first part of the twentieth century, but then declined substantially. Although the historical abundance of fall chinook salmon in the Snake River is difficult to estimate, adult returns appear to have declined by three orders of magnitude since the 1940s, and perhaps by another order of magnitude from pristine levels. Irving and Bjornn (1981) estimated that the mean number of fall chinook salmon returning to the Snake River declined from 72,000 during the period 1938 to 1949 to 29,000 during the 1950s. Further declines occurred upon completion of the Hells Canyon complex, which blocked access to primary production areas in the late 1950s (see below).

4.1.2.3 Life History

Fall chinook salmon in this ESU are ocean-type. Adults return to the Snake River at ages 2 through 5, with age 4 most common at spawning (Chapman et al. 1991). Spawning, which takes place in late fall, occurs in the mainstem and in the lower parts of major tributaries (NWPPC 1989; Bugert et al. 1990). Juvenile fall chinook salmon move seaward slowly as subyearlings, typically within several weeks of emergence (Chapman et al. 1991). Based on modeling by the Chinook Technical Committee, the Pacific Salmon Commission estimates that a significant proportion of the SR fall chinook (about 36%) are taken in Alaska and Canada, indicating a far-ranging ocean distribution. In recent years, only 19% were caught off Washington, Oregon, and California, with the balance (45%) taken in the Columbia River (Simmons 2000).

4.1.2.4 Habitat and Hydrology

With hydrosystem development, the most productive areas of the Snake River basin are now inaccessible or inundated. The upper reaches of the mainstem Snake River were the primary areas used by fall chinook salmon, with only limited spawning activity reported downstream from river kilometer (Rkm) 439. The construction of Brownlee Dam (1958; Rkm 459), Oxbow Dam (1961; Rkm 439), and Hells Canyon Dam (1967; Rkm 397) eliminated the primary production areas of SR fall chinook salmon. There are now 12 dams on the mainstem Snake River, and they have substantially reduced the distribution and abundance of fall chinook salmon (Irving and Bjornn 1981).

4.1.2.5 Hatchery Influence

The Snake River has contained hatchery-reared fall chinook salmon since 1981 (Busack 1991). The hatchery contribution to Snake River escapement has been estimated at greater than 47 percent (Myers et al. 1998). Artificial propagation is recent, so cumulative genetic changes associated with it may be limited. Wild fish are incorporated into the brood stock each year, which should reduce divergence from the wild population. Release of subyearling fish may also help minimize the differences in mortality patterns between hatchery and wild populations that can lead to genetic change (Waples 1999). (See NMFS [1999a] for further discussion of the SR fall chinook salmon supplementation program.)

4.1.2.6 Other

Some SR fall chinook historically migrated over 1,500 km from the ocean. Although the Snake River population is now restricted to habitat in the lower river, genes associated with the lengthier migration may still reside in the population. Because longer freshwater migrations in chinook salmon tend to be associated with more-extensive oceanic migrations (Healey 1983), maintaining populations occupying habitat that is well inland may be important in continuing diversity in the marine ecosystem as well.

4.1.2.7 Population Trends and Risks

For the SR fall chinook salmon ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[3] ranges from 0.94 to 0.86, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated the risk of absolute extinction for the aggregate SR fall chinook salmon population, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that

[3] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1996 adult returns. Population trends are projected under the assumption that all conditions will stay the same into the future.

hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years is 0.40 (Table B-5 in McClure et al. 2000b). At the high end, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years is 1.00 (Table B-6 in McClure et al. 2000b).

4.1.3 Upper Columbia River Spring-run Chinook Salmon

4.1.3.1 Geographic Boundaries and Spatial Distribution

This ESU includes spring-run chinook populations found in Columbia River tributaries between the Rock Island and Chief Joseph dams, notably the Wenatchee, Entiat, and Methow River basins. The populations are genetically and ecologically separate from the summer- and fall-run populations in the lower parts of many of the same river systems (Myers et al. 1998). Although fish in this ESU are genetically similar to spring chinook in adjacent ESUs (i.e., mid-Columbia and Snake), they are distinguished by ecological differences in spawning and rearing habitat preferences. For example, spring-run chinook in upper Columbia tributaries spawn at lower elevations (500 to 1,000 m) than in the Snake and John Day River systems.

4.1.3.2 Historical Information

The upper Columbia River populations were intermixed during the Grand Coulee Fish Maintenance Project (1939 through 1943), resulting in loss of genetic diversity between populations in the ESU. Homogenization remains an important feature of the ESU. Fish abundance has trended downward both recently and over the long term. At least six former populations from this ESU are now extinct, and nearly all extant populations have fewer than 100 wild spawners.

4.1.3.3 Life History (Including Ocean)

UCR spring chinook are considered stream-type fish, with smolts migrating as yearlings. Most stream-type fish mature at 4 years of age. Few coded-wire tags are recovered in ocean fisheries, suggesting that the fish move quickly out of the north central Pacific and do not migrate along the coast.

4.1.3.4 Habitat and Hydrology

Spawning and rearing habitat in the Columbia River and its tributaries upstream of the Yakima River includes dry areas where conditions are less conducive to steelhead survival than in many other parts of the Columbia basin (Mullan et al. 1992a). Salmon in this ESU must pass up to nine Federal and private dams, and Chief Joseph Dam prevents access to historical spawning grounds farther upstream. Degradation of remaining spawning and rearing habitat continues to be a major concern associated with urbanization, irrigation projects, and livestock grazing along

riparian corridors. Overall harvest rates are low for this ESU, currently less than 10% (ODFW and WDFW 1995).

4.1.3.5 Hatchery Influence

Spring-run chinook salmon from the Carson National Fish Hatchery (a large composite, non-native stock) were introduced into and have been released from local hatcheries (Leavenworth, Entiat, and Winthrop National Fish Hatcheries [NFH]). Little evidence suggests that these hatchery fish stray into wild areas or hybridize with naturally spawning populations. In addition to these national production hatcheries, two supplementation hatcheries are operated by the WDFW in this ESU. The Methow Fish Hatchery Complex (operations began in 1992) and the Rock Island Fish Hatchery Complex (operations began in 1989) were both designed to implement supplementation programs for naturally spawning populations on the Methow and Wenatchee rivers, respectively (Chapman et al. 1995).

4.1.3.6 Population Trends and Risks

For the UCR spring chinook salmon ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[4] ranges from 0.85 to 0.83, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated median population growth rates and the risk of absolute extinction for the three spawning populations identified by Ford et al. (1999), using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years ranges from 0.97 for the Methow River to 1.00 for the Methow and Entiat rivers (Table B-5 in McClure et al. 2000b). At the high end, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of extinction within 100 years is 1.00 for all three spawning populations (Table B-6 in McClure et al. 2000b).

NMFS has also used population risk assessments for UCR spring chinook salmon and steelhead ESUs from the draft QAR (Cooney 2000). Risk assessments described in that report were based on Monte Carlo simulations with simple spawner/spawner models that incorporate estimated smolt carrying capacity. Population dynamics were simulated for three separate spawning populations in the UCR spring chinook salmon ESU, the Wenatchee, Entiat, and Methow populations. The QAR assessments showed extinction risks for UCR spring chinook salmon of 50% for the Methow, 98% for the Wenatchee, and 99% for the Entiat spawning populations.

[4] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1998 adult returns. Population trends are projected under the assumption that all conditions will stay the same into the future.

These estimates are based on the assumption that the median return rate for the 1980 brood year to the 1994 brood year series will continue into the future.

4.1.4 Upper Willamette River Chinook Salmon

4.1.4.1 Geographic Boundaries and Spatial Distribution

The UWR chinook ESU includes native spring-run populations above Willamette Falls and in the Clackamas River. In the past, it included sizable numbers of spawning salmon in the Santiam River, the middle fork of the Willamette River, and the McKenzie River, as well as smaller numbers in the Molalla River, Calapooia River, and Albiqua Creek. Although the total number of fish returning to the Willamette has been relatively high (24,000), about 4,000 fish now spawn naturally in the ESU, two-thirds of which originate in hatcheries. The McKenzie River supports the only remaining naturally reproducing population in the ESU (ODFW 1998d).

4.1.4.2 Historical Information

There are no direct estimates of the size of the chinook salmon runs in the Willamette River basin before the 1940s. McKernan and Mattson (1950) present anecdotal information that the native American fishery at the Willamette Falls may have yielded 2,000,000 lb (908,000 kg) of salmon (454,000 fish, each weighing 20 lb [9.08 kg]). Based on egg collections at salmon hatcheries, Mattson (1948) estimates that the spring chinook salmon run in the 1920s may have been 5 times the run size of 55,000 fish in 1947, or 275,000 fish. Much of the early information on salmon runs in the upper Willamette River basin comes from operation reports of state and Federal hatcheries.

4.1.4.3 Life History

Fish in this ESU are distinct from those of adjacent ESUs in life history and marine distribution. The life history of chinook salmon in the Upper Willamette River ESU includes traits from both ocean- and stream-type development strategies. Coded-wire-tag (CWT) recoveries indicate that the fish travel to the marine waters off British Columbia and Alaska. More Willamette fish are, however, recovered in Alaskan waters than fish from the Lower Columbia River ESU. UWR chinook mature in their fourth or fifth years. Historically, 5-year-old fish dominated the spawning migration runs; recently, however, most fish have matured at age 4. The timing of the spawning migration is limited by Willamette Falls. High flows in the spring allow access to the upper Willamette basin, whereas low flows in the summer and autumn prevent later-migrating fish from ascending the falls. The low flows may serve as an isolating mechanism, separating this ESU from others nearby.

4.1.4.4 Habitat and Hydrology

Human activities have had enormous effects on the salmonid populations in the Willamette drainage. First, the Willamette River, once a highly braided river system, has been dramatically simplified through channelization, dredging, and other activities that have reduced rearing habitat (i.e., stream shoreline) by as much as 75%. In addition, the construction of 37 dams in the basin has blocked access to over 700 km of stream and river spawning habitat. The dams also alter the temperature regime of the Willamette and its tributaries, affecting the timing of development of naturally spawned eggs and fry. Water quality is also affected by development and other economic activities. Agricultural and urban land uses on the valley floor, as well as timber harvesting in the Cascade and Coast ranges, contribute to increased erosion and sediment load in Willamette basin streams and rivers. Finally, since at least the 1920s, the lower Willamette has suffered municipal and industrial pollution.

4.1.4.5 Hatchery Influence

Hatchery production in the basin began in the late nineteenth century. Eggs were transported throughout the basin, resulting in current populations that are relatively homogeneous genetically (although still distinct from those of surrounding ESUs). Hatchery production continues in the Willamette, with an average of 8.4 million smolts and fingerlings released each year into the main river or its tributaries between 1975 and 1994. Hatcheries are currently responsible for most production (90% of escapement) in the basin.

The Clackamas River currently accounts for about 20% of the production potential in the Willamette River basin, originating from one hatchery plus natural production areas that are primarily located above the North Fork Dam. The interim escapement goal for the area above North Fork Dam is 2,900 fish (ODFW 1998c). However, the system is so heavily influenced by hatchery production that it is difficult to distinguish spawners of natural stock from hatchery origin fish. Approximately 1,000 to 1,500 adults have been counted at the North Fork Dam in recent years.

4.1.4.6 Other

Harvest on this ESU is high, both in the ocean and inriver. The total inriver harvest below the falls from 1991 through 1995 averaged 33% and was much higher before then. Ocean harvest was estimated as 16% for 1982 through 1989. ODFW (1998b) indicates that total (marine and freshwater) harvest rates on UWR spring-run stocks were reduced considerably for the 1991 through 1993 brood years, to an average of 21%.

4.1.4.7 Population Trends and Risks

For the UWR chinook salmon ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[5] ranges from 1.01 to 0.63, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated the risk of absolute extinction for the aggregate UWR chinook salmon population in the McKenzie River, above Leaburg, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years is 0.01 (Table B-5 in McClure et al. 2000b). At the high end, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years is 0.85 (Table B-6 in McClure et al. 2000b).

4.1.5 Lower Columbia River Chinook Salmon

4.1.5.1 Geographic Boundaries and Spatial Distribution

The Lower Columbia River ESU is characterized by numerous short- and medium-length rivers that drain the coast ranges and the west slope of the Cascade Mountains. This ESU includes all native populations from the mouth of the Columbia River to the crest of the Cascade Range, excluding populations above Willamette Falls. The former location of Celilo Falls (drowned by The Dalles reservoir in 1960) is the eastern boundary for this ESU. Stream-type, spring-run chinook salmon found in the Klickitat River or the introduced Carson spring-chinook salmon strain are not included in this ESU. Spring-run chinook salmon in the Sandy River have been influenced by spring-run chinook salmon introduced from the Willamette River ESU. However, analyses suggest that considerable genetic resources still reside in the existing population (Meyers et al. 1998). Recent escapements above Marmot Dam on the Sandy River average 2,800 and have been increasing (ODFWa).

Tule fall chinook from the LCR chinook salmon ESU were observed spawning in the Ives Island area during October 1999. The Hardy/Hamilton creeks/Ives Island complex is located along the Washington shoreline approximately 2 miles below Bonneville Dam.

4.1.5.2 Historical Information

Historical records of chinook salmon abundance are sparse, but cannery records suggest a peak run of 4.6 million fish in 1883. Although fall-run chinook salmon are still present throughout much of their historical range, most of the fish spawning today are first-generation hatchery

[5] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1998 adult returns. Population trends are projected under the assumption that all conditions will stay the same into the future.

strays. Furthermore, spring-run populations have been severely depleted throughout the ESU and extirpated from several rivers.

4.1.5.3 Life History

Most fall-run fish in the LCR chinook salmon ESU emigrate to the marine environment as subyearlings (Reimers and Loeffel 1967, Howell et al. 1985, WDF et al. 1993). Returning adults that emigrated as yearling smolts may have originated from the extensive hatchery programs in the ESU. It is also possible that modifications in the river environment have altered the duration of freshwater residence. CWT recoveries of Lower Columbia River ESU fish suggest a northerly migration route, but (based on CWT recoveries) the fish contribute more to fisheries off British Columbia and Washington than to the Alaskan fishery. Tule fall chinook salmon return at adult ages 3 and 4; "bright" fall chinook return at ages 4 and 5, with significant numbers returning at age 6. Tule and bright chinook salmon are distinct in their spawn timing.

4.1.5.4 Habitat and Hydrology

As in other ESUs, chinook salmon have been affected by the alteration of freshwater habitat (Bottom et al. 1985, WDF et al. 1993, Kostow 1995). Timber harvesting and associated road building peaked in the 1930s, but effects from the timber industry remain (Kostow 1995). Agriculture is widespread in this ESU and has affected riparian vegetation and stream hydrology. The ESU is also highly affected by urbanization, including river diking and channelization, wetland draining and filling, and pollution (Kostow 1995).

4.1.5.5 Hatchery Influence

The Lower Columbia River ESU has been subject to intensive hatchery influence. Hatchery programs to enhance chinook salmon fisheries in the lower Columbia River began in the 1870s, releasing billions of fish over time. That equals the total hatchery releases for all other chinook ESUs combined (Myers et al. 1998). Although most of the stocks have come from inside the ESU, more than 200 million fish from outside the ESU have been released since 1930 (Myers et al. 1998).

4.1.5.6 Population Trends and Risks

For the LCR chinook salmon ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[6] ranges from 0.98 to 0.88, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild

[6] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1997 adult returns for most spawning aggregations. Population trends are projected under the assumption that all conditions will stay the same into the future.

origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS estimated the risk of absolute extinction for nine spawning aggregations,[7] using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years ranges from zero for the Sandy River late run and Big Creek to 1.00 for Mill Creek (Table B-5 in McClure et al. 2000b). At the high end, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years is ≥0.99 for all but one of nine spawning aggregations (zero for the Sandy River late run; Table B-6 in McClure et al. 2000b).

4.1.6 Snake River Steelhead

4.1.6.1 Geographic Boundaries and Spatial Distribution

Steelhead spawning habitat in the Snake River is distinctive in having large areas of open, low-relief streams at high elevations. In many Snake River tributaries, spawning occurs at a higher elevation (up to 2,000 m) than for steelhead in any other geographic region. SR steelhead also migrate farther from the ocean (up to 1,500 km) than most.

4.1.6.2 Historical Information

No estimates of historical (pre-1960s) abundance specific to this ESU are available.

4.1.6.3 Life History (Including Ocean)

Fish in this ESU are summer steelhead. They enter freshwater from June to October and spawn during the following March to May. Two groups are identified, based on migration timing, ocean-age, and adult size. A-run steelhead, thought to be predominately age-1-ocean, enter freshwater during June through August. B-run steelhead, thought to be age-2-ocean, enter freshwater during August through October. B-run steelhead typically are 75 to 100 mm longer at the same age. Both groups usually smolt as 2- or 3-year-olds (Whitt 1954, BPA 1992, Hassemer 1992). All steelhead are iteroparous, capable of spawning more than once before death.

4.1.6.4 Habitat and Hydrology

Hydrosystem projects create substantial habitat blockages in this ESU; the major ones are the Hells Canyon Dam complex (mainstem Snake River) and Dworshak Dam (North Fork Clearwater River). Minor blockages are common throughout the region. Steelhead spawning areas have been degraded by overgrazing, as well as by historical gold dredging and sedimentation due to poor land management. Habitat in the Snake basin is warmer and drier and often more eroded than elsewhere in the Columbia River basin or in coastal areas.

[7] McClure et al. (2000c) have calculated population trend parameters for additional LCR chinook salmon stocks.

4.1.6.5 Hatchery Influence

Hatchery fish are widespread and stray to spawn naturally throughout the region. In the 1990s, an average of 86% of adult steelhead passing Lower Granite Dam were of hatchery origin. Hatchery contribution to naturally spawning populations varies, however, across the region. Hatchery fish dominate some stocks, but do not contribute to others.

4.1.6.6 Population Trends and Risks

For the SR steelhead ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[8] ranges from 0.91 to 0.70, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated the risk of absolute extinction for the A- and B-runs, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years is 0.01 for A-run steelhead and 0.93 for B-run fish (Table B-5 in McClure et al. 2000b). At the high end, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years is 1.00 for both runs (Table B-6 in McClure et al. 2000b).

4.1.7 Upper Columbia River Steelhead

4.1.7.1 Geographic Boundaries and Spatial Distribution

This ESU occupies the Columbia River basin upstream of the Yakima River. Rivers in the area primarily drain the east slope of the northern Cascade Mountains and include the Wenatchee, Entiat, Methow, and Okanogan River basins. The climate of the area reaches temperature and precipitation extremes; most precipitation falls as mountain snow (Mullan et al. 1992b). The river valleys are deeply dissected and maintain low gradients, except for the extreme headwaters (Franklin and Dyrness 1973).

4.1.7.2 Historical Information

Estimates of historical (pre-1960s) abundance specific to this ESU are available from fish counts at dams. Counts at Rock Island Dam from 1933 to 1959 averaged 2,600 to 3,700, suggesting a prefishery run size exceeding 5,000 adults for tributaries above Rock Island Dam (Chapman et al. 1994). Runs may, however, already have been depressed by lower Columbia River fisheries.

[8] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1997 adult returns. Population trends are projected under the assumption that all conditions will stay the same into the future.

4.1.7.3 Life History

As in other inland ESUs (the Snake and mid-Columbia River basins), steelhead in the Upper Columbia River ESU remain in freshwater up to a year before spawning. Smolt age is dominated by 2-year-olds. Based on limited data, steelhead from the Wenatchee and Entiat rivers return to freshwater after 1 year in salt water, whereas Methow River steelhead are primarily age-2-ocean (Howell et al. 1985). Life history characteristics for UCR steelhead are similar to those of other inland steelhead ESUs; however, some of the oldest smolt ages for steelhead, up to 7 years, are reported from this ESU. The relationship between anadromous and nonanadromous forms in the geographic area is unclear.

4.1.7.4 Habitat and Hydrology

The Chief Joseph and Grand Coulee dam construction caused blockages of substantial habitat, as did that of smaller dams on tributary rivers. Habitat issues for this ESU relate mostly to irrigation diversions and hydroelectric dams, as well as to degraded riparian and instream habitat from urbanization and livestock grazing.

4.1.7.5 Hatchery Influence

Hatchery fish are widespread and escape to spawn naturally throughout the region. Spawning escapement is dominated by hatchery-produced fish.

4.1.7.6 Population Trends and Risks

For the UCR steelhead ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[9] ranges from 0.94 to 0.66, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated the risk of absolute extinction for the aggregate UCR steelhead population, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years is 0.25 (Table B-5 in McClure et al. 2000b). Assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years is 1.00 (Table B-6 in McClure et al. 2000b).

Because of data limitations, the QAR steelhead assessments in Cooney (2000) were limited to two aggregate spawning groups—the Wenatchee/Entiat composite and the above-Wells populations. Wild production of steelhead above Wells Dam was assumed to be limited to the

[9] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1996 adult returns. Population trends are projected under the assumption that all conditions will stay the same into the future.

Methow system. Assuming a relative effectiveness of hatchery spawners of 1.0, the risk of absolute extinction within 100 years for UCR steelhead is 100%. The QAR also assumed hatchery effectiveness values of 0.25 and 0.75. A hatchery effectiveness of 0.25 resulted in projected risks of extinction of 35% for the Wenatchee/Entiat and 28% for the Methow populations. At a hatchery effectiveness of 0.75, risks of 100% were projected for both populations.

4.1.8 Middle Columbia River Steelhead

4.1.8.1 Geographic Boundaries and Spatial Distribution

The Middle Columbia River ESU occupies the Columbia River basin from above the Wind River in Washington and the Hood River in Oregon and continues upstream to include the Yakima River, Washington. The region includes some of the driest areas of the Pacific Northwest, generally receiving less than 40 cm of precipitation annually (Jackson 1993). Summer steelhead are widespread throughout the ESU; winter steelhead occur in Mosier, Chenowith, Mill, and Fifteenmile creeks, Oregon, and in the Klickitat and White Salmon rivers, Washington. The John Day River probably represents the largest native, natural spawning stock of steelhead in the region.

4.1.8.2 Historical Information

Estimates of historical (pre-1960s) abundance specific to this ESU are available for the Yakima River, which has an estimated run size of 100,000 (WDF et al. 1993). Assuming comparable run sizes for other drainage areas in this ESU, the total historical run size may have exceeded 300,000 steelhead.

4.1.8.3 Life History

Most fish in this ESU smolt at 2 years and spend 1 to 2 years in salt water before reentering freshwater, where they may remain up to a year before spawning (Howell et al. 1985, BPA 1992). All steelhead upstream of The Dalles Dam are summer-run (Schreck et al. 1986, Reisenbichler et al. 1992, Chapman et al. 1994). The Klickitat River, however, produces both summer and winter steelhead, and age-2-ocean steelhead dominate the summer steelhead, whereas most other rivers in the region produce about equal numbers of both age-1- and 2-ocean fish. A nonanadromous form co-occurs with the anadromous form in this ESU; information suggests that the two forms may not be isolated reproductively, except where barriers are involved.

4.1.8.4 Habitat and Hydrology

The only substantial habitat blockage now present in this ESU is at Pelton Dam on the Deschutes River, but minor blockages occur throughout the region. Water withdrawals and overgrazing

have seriously reduced summer flows in the principal summer steelhead spawning and rearing tributaries of the Deschutes River. This is significant because high summer and low winter temperatures are limiting factors for salmonids in many streams in this region (Bottom et al. 1985).

4.1.8.5 Hatchery Influence

Continued increases in the proportion of stray steelhead in the Deschutes River basin is a major concern. The ODFW and the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO) estimate that 60% to 80% of the naturally spawning population consists of strays, which greatly outnumber naturally produced fish. Although the reproductive success of stray fish has not been evaluated, their numbers are so high that major genetic and ecological effects on natural populations are possible (Busby et al. 1999).

The negative effects of any interbreeding between stray and native steelhead will be exacerbated if the stray steelhead originated in geographically distant river basins, especially if the river basins are in different ESUs. The populations of steelhead in the Deschutes River basin include the following:

- Steelhead native to the Deschutes River
- Hatchery steelhead from the Round Butte Hatchery on the Deschutes River
- Wild steelhead strays from other rivers in the Columbia River basin
- Hatchery steelhead strays from other Columbia River basin streams

Regarding the latter, CTWSRO reports preliminary findings from a tagging study by T. Bjornn and M. Jepson (University of Idaho) and NMFS suggesting that a large fraction of the steelhead passing through Columbia River dams (e.g., John Day and Lower Granite dams) have entered the Deschutes River and then returned to the mainstem Columbia River. A key unresolved question about the large number of strays in the Deschutes basin is how many stray fish remain in the basin and spawn naturally.

4.1.8.6 Population Trends and Risks

For the MCR steelhead ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[10] ranges from 0.88 to 0.75, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated the risk of absolute extinction for four of the spawning aggregations, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild

[10] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period that varies between spawning aggregations. Population trends are projected under the assumption that all conditions will stay the same into the future.

have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years ranges from zero for the Yakima River summer run to 1.00 for the Umatilla River and Deschutes River summer runs (Table B-5 in McClure et al. 2000b). Assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years ranges from zero for the Yakima River summer run to 1.00 for the Deschutes River summer run (Table B-6 in McClure et al. 2000b).

4.1.9 Upper Willamette River Steelhead

4.1.9.1 Geographic Boundaries and Spatial Distribution

The UWR steelhead ESU occupies the Willamette River and tributaries upstream of Willamette Falls, extending to and including the Calapooia River. These major river basins containing spawning and rearing habitat comprise more than 12,000 km^2 in Oregon. Rivers that contain naturally spawning winter-run steelhead include the Tualatin, Molalla, Santiam, Calapooia, Yamhill, Rickreall, Luckiamute, and Mary's, although the origin and distribution of steelhead in a number of these basins is being debated. Early migrating winter and summer steelhead have been introduced into the upper Willamette River basin, but those components are not part of the ESU.

4.1.9.2 Historical Information

Native winter steelhead within this ESU have been declining since 1971 and have exhibited large fluctuations in abundance.

4.1.9.3 Life History

In general, native steelhead of the upper Willamette River basin are late-migrating winter steelhead, entering freshwater primarily in March and April. This atypical run timing appears to be an adaptation for ascending Willamette Falls, which functions as an isolating mechanism for UWR steelhead. Reproductive isolation resulting from the falls may explain the genetic distinction between steelhead from the upper Willamette River basin and those in the lower river. UWR late-migrating steelhead are ocean-maturing fish. Most return at age 4, with a small proportion returning as 5-year-olds (Busby et al. 1996).

4.1.9.4 Habitat and Hydrology

Willamette Falls (Rkm 77) is a known migration barrier. Winter steelhead and spring chinook salmon historically occurred above the falls, whereas summer steelhead, fall chinook, and coho salmon did not. Detroit and Big Cliff dams cut off 540 km of spawning and rearing habitat in the North Santiam River. In general, habitat in this ESU has become substantially simplified since the 1800s by removal of large woody debris to increase the river's navigability.

4.1.9.5 Hatchery Influence

The main hatchery production of native (late-run) winter steelhead occurs in the North Fork Santiam River, where estimates of hatchery proportion in natural spawning areas range from 14% to 54% (Busby et al. 1996). More recent estimates of the percentage of naturally spawning fish attributable to hatcheries in the late 1990s are 24% in the Molalla, 17% in the North Santiam, 5% to 12% in the South Santiam, and less than 5% in the Calapooia (Chilcote 1997, 1998).

4.1.9.6 Population Trends and Risks

For the UWR steelhead ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[11] ranges from 0.94 to 0.87, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated the risk of absolute extinction for four spawning aggregations, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years ranges from zero for the South Santiam River to 0.74 for the Calapooia River (Table B-5 in McClure et al. 2000b). Assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years ranges from 0.74 for the Calapooia River to 1.00 for the Molalla River and South Santiam River spawning aggregations (Table B-6 in McClure et al. 2000b).

4.1.10 Lower Columbia River Steelhead

4.1.10.1 Geographic Boundaries and Spatial Distribution

The Lower Columbia River ESU encompasses all steelhead runs in tributaries between the Cowlitz and Wind rivers on the Washington side of the Columbia, and the Willamette and Hood rivers on the Oregon side. The populations of steelhead that make up the Lower Columbia River ESU are distinguished from adjacent populations by genetic and habitat characteristics. The ESU consists of summer and winter coastal steelhead runs in the tributaries of the Columbia River as it cuts through the Cascades. These populations are genetically distinct from inland populations (east of the Cascades), as well as from steelhead populations in the upper Willamette basin and coastal runs north and south of the Columbia River mouth. Not included in the ESU are runs in the Willamette River above Willamette Falls (Upper Willamette River ESU), runs in the Little and Big White Salmon rivers (Middle Columbia River ESU) and runs based on four imported hatchery stocks: early-spawning winter Chambers Creek/lower Columbia River mix, summer Skamania Hatchery stock, winter Eagle Creek NFH stock, and winter Clackamas River ODFW stock (63 FR 13351 and 13352). This area has at least 36 distinct runs (Busby et al.

[11] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1997 adult returns. Population trends are projected under the assumption that all conditions will stay the same into the future.

1996), 20 of which were identified in the initial listing petition. In addition, numerous small tributaries have historical reports of fish, but no current abundance data. The major runs in the ESU, for which there are estimates of run size, are the Cowlitz River winter runs, Toutle River winter runs, Kalama River winter and summer runs, Lewis River winter and summer runs, Washougal River winter and summer runs, Wind River summer runs, Clackamas River winter and summer runs, Sandy River winter and summer runs, and Hood River winter and summer runs.

4.1.10.2 Historical Information

For the larger runs, current counts have been in the range of one to 2,000 fish (Cowlitz, Kalama, and Sandy rivers); historical counts, however, put these runs at more than 20,000 fish. In general, all runs in the ESU have declined over the past 20 years, with sharp declines in the last 5 years.

4.1.10.3 Habitat and Hydrology

Steelhead in this ESU are thought to use estuarine habitats extensively during outmigration, smoltification, and spawning migrations. The lower reaches of the Columbia River are highly modified by urbanization and dredging for navigation. The upland areas covered by this ESU are extensively logged, affecting water quality in the smaller streams used primarily by summer runs. In addition, all major tributaries used by LCR steelhead have some form of hydraulic barrier that impedes fish passage. Barriers range from impassible structures in the Sandy River basin that block access to extensive, historically occupied, steelhead habitat, to passable but disruptive projects on the Cowlitz and Lewis rivers. The Biological Review Team (BRT 1997) viewed the overall effect of hydrosystem activities on this ESU as an important determinant of extinction risk.

4.1.10.4 Hatchery Influence

Many populations of steelhead in the Lower Columbia River ESU are dominated by hatchery escapement. Roughly 500,000 hatchery-raised steelhead are released into drainages within this ESU each year. As a result, first-generation hatchery fish are thought to make up 50% to 80% of the fish counted on natural spawning grounds. The effect of hatchery fish is not uniform, however. Several runs are mostly hatchery strays (e.g., the winter run in the Cowlitz River [92%] and the Kalama River [77%] and the summer run in the North Fork Washougal River [50%]), whereas others are almost free of hatchery influence (the summer run in the mainstem Washougal River [0%] and the winter runs in the North Fork Toutle and Wind rivers [0% to 1%]).

4.1.10.5 Other

Escapement estimates for the steelhead fishery in the Lower Columbia River ESU are based on inriver and estuary sport-fishing reports; there is a limited ocean fishery on this ESU. Harvest rates range from 20% to 50% on the total run, but for hatchery-wild differentiated stocks, harvest rates on wild fish have dropped to 0% to 4% in recent years (punch card data from WDFW through 1994).

4.1.10.6 Population Trends and Risks

For the LCR steelhead ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[12] ranges from 0.98 to 0.78, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated the risk of absolute extinction for seven of the spawning aggregations, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years ranges from zero for the Kalama River summer run and the Clackamas River and Kalama River winter runs to 1.00 for the Clackamas River summer run and the Toutle River winter run (Table B-5 in McClure et al. 2000b). Assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years rises to 1.00 for all but one population (the risk of extinction is 0.86 for the Green River winter run; Table B-6 in McClure et al. 2000b).

4.1.11 Columbia River Chum Salmon

4.1.11.1 Geographic Boundaries and Spatial Distribution

Chum salmon of the Columbia River ESU spawn in tributaries and in mainstem spawning areas below Bonneville Dam. Most fish spawn on the Washington side of the Columbia River (Johnson et al. 1997).

4.1.11.2 Historical Information

Previously, chum salmon were reported in almost every river in the lower Columbia River basin, but most runs disappeared by the 1950s (Rich 1942, Marr 1943, Fulton 1970). Currently, WDFW regularly monitors only a few natural populations in the basin, one in Grays River, two in small streams near Bonneville Dam, and the mainstem area next to one of the latter two streams.

4.1.11.3 Life History

[12] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period that varies between spawning aggregations. Population trends are projected under the assumption that all conditions will stay the same into the future.

Chum salmon enter the Columbia River from mid-October through early December and spawn from early November to late December. Recent genetic analysis of fish from Hardy and Hamilton creeks and from the Grays River indicate that these fish are genetically distinct from other chum salmon populations in Washington. Genetic variability within and between populations in several geographic areas is similar, and populations in Washington show levels of genetic subdivision typical of those seen between summer- and fall-run populations in other areas and typical of populations within run types (Salo 1991, WDF et al. 1993, Phelps et al. 1994, and Johnson et al. 1997).

4.1.11.4 Other

Historically, the CR chum salmon ESU supported a large commercial fishery, landing more than 500,000 fish per year. Commercial catches declined beginning in the mid-1950s. There are now no recreational or directed commercial fisheries for chum salmon in the Columbia River, although chum salmon are taken incidentally in the gill-net fisheries for coho and chinook salmon, and some tributaries have a minor recreational harvest (WDF et al. 1993).

4.1.11.5 Population Trends and Risks

Hatchery fish have had little influence on the wild component of the CR chum salmon ESU. NMFS estimates an median population growth rate (lambda) over the base period,[13] for the ESU as a whole, of 1.04 (Tables B-2a and B-2b in McClure et al. 2000b). Because census data are peak counts (and because the precision of those counts decreases markedly during the spawning season as water levels and turbidity rise), NMFS is unable to estimate the risk of absolute extinction for this ESU.

4.1.12 Snake River Sockeye Salmon

4.1.12.1 Geographic Boundaries and Spatial Distribution

The only remaining sockeye in the Snake River system are found in Redfish Lake, on the Salmon River. The nonanadromous form (kokanee), found in Redfish Lake and elsewhere in the Snake River basin, is included in the ESU.

[13] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period of 1980 through 1998 adult returns for the Grays River mainstem and the West Fork, Crazy Johnson, and Hamilton creek spawning aggregations, including the 1999 adult returns for Hardy Creek and Hamilton Springs. Population trends are projected under the assumption that all conditions will stay the same into the future.

4.1.12.2 Historical Information

Snake River sockeye were historically abundant in several lake systems of Idaho and Oregon. However, all populations have been extirpated in the past century, except fish returning to Redfish Lake.

4.1.12.3 Life History

In general, juvenile sockeye salmon rear in the lake environment for 1, 2, or 3 years before migrating to sea. Adults typically return to the natal lake system to spawn after spending 1, 2, 3, or 4 years in the ocean (Gustafson et al. 1997).

4.1.12.4 Habitat and Hydrology

In 1910, impassable Sunbeam Dam was constructed 20 miles downstream of Redfish Lake. Although several fish ladders and a diversion tunnel were installed during subsequent decades, it is unclear whether enough fish passed above the dam to sustain the run. The dam was partly removed in 1934, after which Redfish Lake runs partially rebounded. Evidence is mixed as to whether the restored runs constitute anadromous forms that managed to persist during the dam years, nonanadromous forms that became migratory, or fish that strayed in from outside the ESU.

4.1.12.5 Population Trends and Risks

NMFS proposed an interim recovery level of 2,000 adult Snake River sockeye salmon in Redfish Lake and two other lakes in the Snake River basin (Table 1.3-1 in NMFS 1995c). Low numbers of adult SR sockeye salmon preclude a CRI- or QAR-type quantitative analysis of the status of this ESU. Because only 16 wild and 264 hatchery-produced adult sockeye returned to the Stanley basin between 1990 and 2000, however, NMFS considers the status of this ESU to be dire under any criteria. Clearly the risk of extinction is very high.

4.2 SPECIES-LEVEL BIOLOGICAL REQUIREMENTS

The species-level biological requirements of the 12 listed ESUs are described in Section 1.3. NMFS has adopted the species-level biological requirements as its jeopardy standard.

4.3 SPECIES STATUS WITH RESPECT TO SPECIES-LEVEL BIOLOGICAL REQUIREMENTS

The current status of each species, as described in Section 4.1, indicates that the species-level biological requirements described in Section 1.3 are not being met for any of the 12 ESUs considered in this consultation. Improvements in survival rates (assessed over the entire life cycle) are necessary to meet species-level biological requirements in the future.
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5.0 ENVIRONMENTAL BASELINE

The purpose of this section is to identify "the past and present effects of all Federal, State, or private activities in the action area, the anticipated effects of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the effect of State or private actions which are contemporaneous with the consultation in process" (50 CFR § 402.02, definition of "effects of the action"). These factors affect the species' environment or critical habitat in the action area. The factors are described in relation to the action area biological requirements of the species.

5.1 DESCRIPTION OF ACTION AREA

The action area relative to both juvenile and adult Columbia basin salmonids is the part of their habitat that is affected by the FCRPS and other BOR project operations, as described in Section 1. The area is best defined as the farthest upstream point at which smolts enter (or adults exit) the Snake and upper Columbia rivers to the farthest downstream point at which they exit (or adults enter) the migration corridor. In the Snake River, the area translates to immediately below Hells Canyon Dam (or wherever a tributary stream meets the Snake River below Hells Canyon Dam) to the confluence of the Snake and Columbia rivers. In the Columbia River, the action area begins immediately below Chief Joseph Dam (or wherever a tributary stream meets the Columbia River below Chief Joseph Dam). Although the actual upstream extent of the action area varies among ESUs, in all cases the action area extends downstream to the farthest point (the Columbia River estuary and nearshore ocean environment) at which listed salmonids are influenced by FCRPS water management.

5.2 BIOLOGICAL REQUIREMENTS IN ACTION AREA

To some degree, each of the 12 ESUs considered in this opinion reside in, or migrate through, the action area. Biological requirements during these life history stages are obtained through access to essential features of critical habitat. Essential features include adequate 1) substrate (especially spawning gravel), 2) water quality, 3) water quantity, 4) water temperature, 5) water velocity, 6) cover/shelter, 7) food, 8) riparian vegetation, 9) space, and 10) migration conditions (58 FR 68546 for Snake River salmon and 65 FR 773 for all other Columbia River basin salmonids).

5.2.1 Essential Features of Critical Habitat in Action Area

The sections below describe essential features of critical habitat for each of the relevant habitat types: 1) juvenile rearing areas, 2) juvenile migration corridors, 3) areas for growth and development to adulthood, 4) adult migration corridors, and 5) spawning areas in the action area discussed in the following sections.

5.2.1.1 Juvenile Rearing Areas

Essential features of critical habitat for juvenile rearing areas include adequate water quality, water quantity, water velocity, cover/shelter, food, riparian vegetation, space, and safe passage conditions. The requirement for adequate substrate, although relevant to incubation of redds in the mainstem, is discussed under spawning areas, below.

5.2.1.2 Juvenile Migration Corridors

Essential features of critical habitat for juvenile migration corridors include adequate water quality, water quantity, water velocity, cover/shelter, food, riparian vegetation, space, and migration conditions.

5.2.1.3 Areas for Growth and Development to Adulthood

Essential features of critical habitat for areas for growth and development to adulthood include all the essential features of critical habitat for juvenile rearing areas (above).

5.2.1.4 Adult Migration Corridors

Essential features of critical habitat for adult migration corridors include all the essential features of critical habitat for juvenile migration corridors (above), except for adequate food.

5.2.1.5 Spawning Areas

Essential features of critical habitat for spawning areas include all the essential features of critical habitat for juvenile rearing areas (above), with the addition of adequate substrate and the exception of adequate food.

5.2.2 Adequacy of Habitat Conditions in Critical Habitat

Regulations implementing Section 7(a)(2) of the ESA define "destruction or adverse modification" as "a direct or indirect alteration that appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species." Adverse effects on a constituent element of critical habitat generally do not result in a determination of "adverse modification" unless that loss, when added to the environmental baseline, is likely to result in an appreciable decline in the value of the critical habitat for both the survival and the recovery of the listed species (50 CFR Section 402.02).

Quantitatively defining a level of adequacy through specific, measurable standards is difficult for many of these biological requirements. In many cases, the absolute relationship between the critical element and species survival is not clearly understood, thus limiting development of specific, measurable standards. Some parameters are generally well known in the fisheries

literature (e.g., thermal tolerances), allowing NMFS to develop a performance standard in this biological opinion (e.g., a temperature objective at Lower Granite Dam). For other action-area biological requirements, the effects of any adverse impacts on essential features of critical habitat are considered in more qualitative terms.

5.3 FACTORS AFFECTING SPECIES' ENVIRONMENT IN ACTION AREA

5.3.1 Hydrosystem Effects

Columbia River basin anadromous salmonids, especially those above Bonneville Dam, have been dramatically affected by the development and operation of the FCRPS. Storage dams have eliminated spawning and rearing habitat and have altered the natural hydrograph of the Snake and Columbia rivers, decreasing spring and summer flows and increasing fall and winter flows. Power operations cause flow levels and river elevations to fluctuate, affecting fish movement through reservoirs and riparian ecology, and stranding fish in shallow areas. The eight dams in the migration corridor of the Snake and Columbia rivers alter smolt and adult migrations. Smolts experience a high level of mortality passing through the dams. The dams also have converted the once-swift river into a series of slow-moving reservoirs, slowing the smolts' journey to the ocean and creating habitat for predators. Water velocities throughout the migration corridor now depend far more on volume runoff than before development of the mainstem reservoirs.

There have been numerous changes in the operation and configuration of the FCRPS as a result of ESA consultations between the Action Agencies (BPA, the Corps, and BOR) and the services (NMFS and USFWS). The changes have improved survival for the listed fish migrating through the Snake and Columbia rivers. Increased spill at all FCRPS dams allows smolts to avoid both turbine intakes and bypass systems. Increased flow in the mainstem Snake and Columbia rivers provides better inriver conditions for smolts. The transportation of smolts from the Snake River has also been improved by the addition of new barges and modification of existing barges.

In addition to spill, flow, and transportation improvements, the Corps implemented numerous other improvements to project operations and maintenance at all Columbia and Snake river dams. These improvements, such as operating turbines at peak efficiency, new extended-length screens at McNary, Little Goose, and Lower Granite dams, and extended operation of bypass screens, are discussed in greater detail in the 1995 FCRPS Biological Opinion.

It is possible to quantify the survival benefits accruing from these many actions for each of the listed ESUs. For SR spring/summer chinook smolts migrating inriver, the estimated direct survival through the hydrosystem is now between 40% and 60%, compared with an estimated survival rate during the 1970s of 5% to 40%. SR steelhead have probably received a similar benefit because their life history and run timing are similar to those of spring/summer chinook (NMFS 2000h). It is more difficult to obtain direct data and compare survival improvements for fish transported from the Snake River, but there are likely to be improvements for transported fish as well. It is reasonable to expect that the improvements in operation and configuration of

the FCRPS will benefit all listed Columbia basin salmonids and that the benefits will be greater the farther upriver the ESU. However, further improvements are necessary because the Federal hydrosystem continues to cause a significant level of mortality for some ESUs.

Several non-Federal projects licensed by the Federal Energy Regulating Commission (FERC) also affect the 12 ESUs on the mainstem Columbia and Snake rivers. Many of the ESUs are also affected by FERC projects on smaller tributaries or other water development projects.

5.3.2 Habitat Effects

The quality and quantity of freshwater habitat in much of the Columbia River basin have declined dramatically in the last 150 years. Forestry, farming, grazing, road construction, hydrosystem development, mining, and urbanization have radically changed the historical habitat conditions of the basin. With the exception of fall chinook, which generally spawn and rear in the mainstem, salmon and steelhead spawning and rearing habitat is found in tributaries to the Columbia and Snake rivers. Anadromous fish typically spend from a few months to 3 years rearing in freshwater tributaries. Depending on the species, they spend from a few days to 1 or 2 years in the Columbia River estuary before migrating out to the ocean and another 1 to 4 years in the ocean before returning as adults to spawn in their natal streams. Thirty-two subbasins provide spawning and rearing habitat.

Water quality in streams throughout the Columbia River basin has been degraded by human activities such as dams and diversion structures, water withdrawals, farming and grazing, road construction, timber harvest activities, mining activities, and urbanization. Over 2,500 streams and river segments and lakes do not meet Federally approved, state and Tribal water quality standards and are now listed as water-quality-limited under Section 303(d) of the CWA. Tributary water quality problems contribute to poor water quality where sediment and contaminants from the tributaries settle in mainstem reaches and the estuary.

Most of the water bodies in Oregon, Washington, and Idaho that are on the 303(d) list do not meet water quality standards for temperature. Temperature alterations affect salmonid metabolism, growth rate, and disease resistance, as well as the timing of adult migrations, fry emergence, and smoltification. Many factors can cause high stream temperatures, but they are primarily related to land-use practices rather than point-source discharges. Some common actions that result in high stream temperatures are the removal of trees or shrubs that directly shade streams, excessive water withdrawals for irrigation or other purposes, and warm irrigation return flows. Loss of wetlands and increases in groundwater withdrawals have contributed to lower base-stream flows, which in turn contribute to temperature increases. Channel widening and land uses that create shallower streams also cause temperature increases.

Pollutants also degrade water quality. Salmon require clean gravel for successful spawning, egg incubation, and emergence of fry. Fine sediments clog the spaces between gravel and restrict the flow of oxygen-rich water to the incubating eggs. Excess nutrients, low levels of dissolved

oxygen, heavy metals, and changes in pH also directly affect the water quality for salmon and steelhead.

Water quantity problems are also a significant cause of habitat degradation and reduced fish production. Millions of acres of land in the basin are irrigated. Although some of the water withdrawn from streams eventually returns as agricultural runoff or groundwater recharge, crops consume a large proportion. Withdrawals affect seasonal flow patterns by removing water from streams in the summer (mostly May through September) and restoring it to surface streams and groundwater in ways that are difficult to measure. Withdrawing water for irrigation, urban, and other uses can increase temperatures, smolt travel time, and sedimentation. Return water from irrigated fields can introduce nutrients and pesticides into streams and rivers.

On a larger landscape scale, human activities have affected the timing and amount of peak water runoff from rain and snowmelt. Forest and range management practices have changed vegetation types and density, which can affect timing and duration of runoff. Many riparian areas, flood plains, and wetlands that once stored water during periods of high runoff have been developed. Urbanization paves over or compacts soil and increases the amount and pattern of runoff reaching rivers and streams.

Many tributaries have been significantly depleted by water diversions. In 1993, fish and wildlife agency, Tribal, and conservation group experts estimated that 80% of 153 Oregon tributaries had low-flow problems (two-thirds caused at least in part by irrigation withdrawals) (OWRD 1993). The NWPPC showed similar problems in many Idaho, Oregon, and Washington tributaries (NWPPC 1992).

Blockages that stop the downstream and upstream movement of fish exist at many agricultural, hydrosystem, municipal/industrial, and flood control dams and barriers. Highway culverts that are not designed for fish passage also block upstream migration. Migrating fish are diverted into unscreened or inadequately screened water conveyances or turbines, resulting in unnecessary mortality. While many fish-passage improvements have been made in recent years, manmade structures continue to block migrations or kill fish throughout the basin.

Land ownership has played a part in habitat and land-use changes. Federal lands, which compose 50% of the basin, are generally forested and influence upstream portions of the watersheds. While there is substantial habitat degradation across all ownerships, in general, habitat in many headwater stream sections is in better condition than in the largely non-Federal lower portions of tributaries (Doppelt et al. 1993, Frissell 1993, Henjum et al. 1994, Quigley and Arbelbide 1997). In the past, valley bottoms were among the most productive fish habitats in the basin (Stanford and Ward 1992, Spence et al. 1996, ISG 1996). Today, agricultural and urban land development and water withdrawals have significantly altered the habitat for fish and wildlife. Streams in these areas typically have high water temperatures, sedimentation problems, low flows, simplified stream channels, and reduced riparian vegetation.

Mainstem habitats of the Columbia, Snake, and Willamette rivers have been affected by impoundments that have inundated large amounts of spawning and rearing habitat. Historically, fall chinook salmon spawned in the mainstem near The Dalles, Oregon, upstream to the Pend Oreille River in Washington and the Kootenai River in Idaho, in the Snake River downstream of Shoshone Falls, and upstream from the mouth of the Snake River to Grand Coulee Dam. Current mainstem production areas for fall chinook are mostly confined to the Hanford Reach of the mid-Columbia River and to the Hells Canyon Reach of the Snake River, with minor spawning populations elsewhere in the mid-Columbia, below the lower Snake River dams, and below Bonneville Dam. Hanford Reach is the only known mainstem spawning area for steelhead. Chum salmon habitat in the lower Columbia may also have been inundated by Bonneville Reservoir. Mainstem habitat in the Columbia, Snake, and Willamette rivers has been reduced, for the most part, to a single channel, floodplains have been reduced in size, off-channel habitat features have been lost or disconnected from the main channel, and the amount of large woody debris (large snags/log structures) in rivers has been reduced. Most of the remaining habitats are affected by flow fluctuations associated with reservoir management.

The Columbia River estuary has also been changed by human activities. Historically, the downstream half of the estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about 4 miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River kept the environment dynamic. Today, navigation channels have been dredged, deepened and maintained, jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels, marsh and riparian habitats have been filled and diked, and causeways have been constructed across waterways. These actions have decreased the width of the mouth of the Columbia River to 2 miles and increased the depth of the Columbia River channel at the bar from less than 20 to more than 55 feet. Sand deposition at river mouths has extended the Oregon coastline approximately 4 miles seaward and the Washington coastline approximately 2 miles seaward (Thomas 1981).

More than 50% of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. More than 3,000 acres of intertidal marsh and spruce swamps have been converted to other uses since 1948 (Lower Columbia River Estuary Program [LCREP] 1999). Many wetlands along the shore in the upper reaches of the estuary have been converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased.

Studies begun in 1997 by the Oregon Cooperative Fish and Wildlife Research Unit, USGS, and CRITFC have shown that fish-eating birds that nest on islands in the Columbia River estuary (Caspian terns, double-crested cormorants, and glaucous-winged gulls) are significant avian

predators of juvenile salmonids. Researchers estimated that the tern population on Rice Island (16,000 birds in 1997) consumed 6 to 25 million outmigrating smolts during 1997 (Roby et al. 1998) and 7 to 15 million outmigrating smolts during 1998 (Collis et al. 1999). The observed levels of predation prompted the regional fish and wildlife managers to investigate the feasibility of management actions to reduce the impacts. Early management actions appear to have reduced predation rates; researchers estimate that terns consumed 7.3 million smolts during 1999 (Columbia Bird Research 2000). Because Rice Island is a dredged material disposal site in the Columbia River estuary, created by the Corps under its Columbia River Channel Operation and Maintenance Program, the effects of tern predation on the survival and recovery of listed salmonids are considered in a separate consultation on that program. This factor is considered part of the environmental baseline on effects of the FCRPS.

The Basinwide Recovery Strategy outlines a broad range of current habitat programs. Because most of the basin's anadromous fish spawning habitat is in Federal ownership, Federal land management programs are of primary importance. Current management is governed by an ecosystem-based aquatic habitat and riparian-area management strategy known as PACFISH and associated biological opinions. This interim strategy covers the majority of the basin accessible to anadromous fish and includes specific prescriptions designed to halt habitat degradation.

The Basinwide Recovery Strategy also outlines a large number of non-Federal habitat programs. Because non-Federal habitat is managed predominantly for private rather than public purposes, however, expectations for non-Federal habitat are harder to assess. Degradation of habitat for listed fish from activities on non-Federal lands is likely to continue to some degree over the next 10 years, although at a reduced rate due to state, Tribal, and local recovery plans.

5.3.3 Hatchery Effects

For more than 100 years, hatcheries in the Pacific Northwest have been used to replace natural production lost as a result of the FCRPS and other development, not to protect and rebuild natural populations. As a result, most salmon populations in this region are primarily hatchery fish. In 1987, for example, 95% of the coho, 70% of the spring chinook, 80% of the summer chinook, 50% of the fall chinook, and 70% of the steelhead returning to the Columbia basin originated in hatcheries (CBFWA 1990).

While hatcheries certainly have contributed greatly to the overall numbers of salmon, only recently has the effect of hatcheries on native wild populations been demonstrated. In many cases, these effects have been substantial. For example, production of hatchery fish, among other factors, has contributed to the 90% reduction in wild coho salmon runs in the lower Columbia River over the past 30 years (Flagg et al. 1995). Hatcheries have traditionally focused on providing fish for harvest, with less attention given to identifying and resolving factors causing declines of native runs.

NMFS has identified four primary categories of risk that hatcheries can pose on wild-run salmon and steelhead: 1) ecological effects, 2) genetic effects, 3) overharvest effects, and 4) masking effects (NMFS 2000g). Ecologically, hatchery fish can increase predation on, displace, and/or compete with wild fish. These effects are likely to occur when fish are released in poor condition and do not migrate to marine waters, but rather remain in the streams for extended rearing periods during which they may prey on or compete with wild fish. Hatchery fish also may transmit hatchery-borne diseases, and hatcheries themselves may release diseases into streams via water effluents.

Genetically, hatchery fish can affect the genetic variability of native fish via interbreeding, either intentionally or accidentally. Interbreeding can also result from the introduction of native stocks from other areas. Theoretically, interbred fish are less adapted to and productive within the unique local habitats where the original native stock evolved.

In many areas, hatchery fish provide increased fishery opportunities. When wild fish mix with hatchery stock, fishing pressure can lead to overharvest of smaller or weaker wild stocks. Further, when migrating adult hatchery and wild fish mix on the spawning grounds, the health of the wild runs and the condition of the habitat's ability to support runs can be overestimated, because the hatchery fish mask surveyors' ability to discern actual wild run conditions.

The role of hatcheries in the future of Pacific Northwest salmon and steelhead is presently unclear; it will depend on the values people place on fish production and biological diversity. Clearly, conservation of biological diversity is gaining support, and the future role of hatcheries may shift toward judicial use of hatcheries to meet these goals rather than opposing them. One of the prime recommendations in the National Research Council's (NRC's) study of salmon in the Pacific Northwest is that hatchery use "should occur within the context of fully implemented adaptive-management programs that focus on watershed management, not just on the fish themselves" (NRC, 1996). A recent review of this approach for the Columbia basin can be found in ISAB (1998).

5.3.4 Harvest Effects

The history of harvest of Columbia River basin salmon parallels that of the entire region. Commercial fishing developed rapidly with the arrival of European settlers and the advent of canning technologies in the late 1800s. Development of non-Indian fisheries began in about 1830; by 1861, commercial fishing was an important economic activity. The early commercial fishery used gill nets, seines hauled from shore, traps, and fish wheels. Later, purse seines and trolling (using hook and line) fisheries developed. Recreational (sport fishing) began in the late 1800s, occurring primarily in tributary locations (ODFW and WDFW 1998).

Initially, the non-Indian fisheries targeted spring and summer chinook salmon, and these runs dominated the commercial harvest during the 1800s. Eventually the combined ocean and freshwater harvest rates for Columbia River spring and summer chinook exceeded 80% and

sometimes 90% of the run, contributing to the species' decline (Ricker 1959). From 1938 to 1955, the average harvest rate dropped to about 60% of the total spring chinook salmon run and appeared to have a minimal effect on subsequent returns (NMFS 1991b). Until the spring of 2000, when a relatively large run of hatchery spring chinook returned and provided a small commercial Tribal fishery, the last commercial season for spring chinook had occurred in 1977. Present Columbia River harvest rates are very low compared with those from the late 1930s through the 1960s (NMFS 1991b).

The summer chinook salmon run could not sustain the average harvest rate of 88% that was applied between 1938 to 1944 and produced lower returns between 1942 and 1949 (NMFS 1991b). From 1945 through 1949, the Columbia River harvest rate on summer chinook salmon was reduced to about 47%, and subsequently, the run size increased. Construction of Grand Coulee Dam in 1941, with the resulting inundation of summer chinook spawning areas, was a primary factor influencing this species' declining abundance. In the 1950s and 1960s, harvest rates further declined to about 20% (Raymond 1988). This species has not been the target of any commercial harvest since 1963.

Following the sharp declines in spring and summer chinook in the late 1800s, fall chinook salmon became a more important component of the catch. Fall chinook have provided the greatest contribution to Columbia River salmon catches in most years since 1890. Through the first part of this century, the commercial catch was usually canned for marketing. The peak year of commercial sales was 1911, when 49.5 million pounds of fall chinook were landed. Columbia River chinook salmon catches were generally stable from the beginning of commercial exploitation until the late 1940s, when landings declined by about two-thirds to a level that remained stable from the 1950s through the mid-1980s (ODFW and WDFW 1998). Since 1938, total salmonid landings (all species) have ranged from a high of about 2,112,500 fish in 1941 to a low of about 68,000 fish in 1995 (Figure A.1 in ODFW and WDFW 1998).

Whereas freshwater fisheries in the basin were declining during the first half of this century, ocean fisheries were growing, particularly after World War II. This trend occurred up and down the West Coast as fisheries with new gear types leapfrogged over the others to gain first access to the migrating salmon runs. Large, mixed-stock fisheries in the ocean gradually supplanted the freshwater fisheries, which were increasingly restricted or eliminated to protect spawning escapements. By 1949, the only freshwater commercial gear types remaining were gill nets, dip nets, and hoop nets (ODFW and WDFW 1998). This leapfrogging by various fisheries and gear types resulted in conflicts about harvest allocation and the displacement of one fishery by another. Ocean trolling peaked in the 1950s; recreational fishing peaked in the 1970s. The ocean harvest has declined since the early 1980s as a result of declining fish populations and increased harvest restrictions (ODFW and WDFW 1998).

The construction of The Dalles Dam in 1957 had a major effect on Tribal fisheries. The Dalles Reservoir flooded Celilo Falls and inundated the site of a major Indian fishery that had existed for millennia. Commercial Indian landings at Celilo Falls from 1938 through 1956 ranged from

0.8 to 3.5 million pounds annually, based primarily on dip netting (ODFW and WDFW 1998). With the elimination of Celilo Falls, salmon harvest in the area declined dramatically. In 1957, in a joint action, the states of Oregon and Washington closed the Tribal fishery above Bonneville Dam to commercial harvesters. Treaty Indian fisheries that continued during 1957 through 1968 were conducted under Tribal ordinances. In 1968, with the Supreme Court opinion on the appeal of the *Puyallup v. Washington* case, the states reopened the area to commercial fishing by treaty Indians (ODFW and WDFW 1998). For the next 6 years, until 1974, only a limited Tribal harvest occurred above Bonneville Dam. By then, the Tribal fishery had developed an alternative method of setting gill nets that was suitable for catching salmon in the reservoirs (ODFW and WDFW 1998).

The capacity of salmonids to produce more adults than are needed for spawning offers the potential for sustainable harvest of naturally produced (versus hatchery-produced) fish. This potential can be realized only if two basic management requirements are met: 1) enough adults return to spawn and perpetuate the run, and 2) the productive capacity of the habitat is maintained. Catches may fluctuate in response to such variables as ocean productivity cycles, periods of drought, and natural disturbance events. However, as long as the two management requirements are met, fishing can be sustained indefinitely. Unfortunately, both prerequisites for sustainable harvest have been violated routinely in the past. The lack of coordinated management across jurisdictions, combined with competitive economic pressures to increase catches or to sustain them in periods of lower production, resulted in harvests that were too high and escapements that were too low. At the same time, habitat has been increasingly degraded, reducing the capacity of the salmon stocks to produce numbers in excess of their spawning escapement requirements.

For years, the response to declining catches was hatchery construction to produce more fish. Because hatcheries require fewer adults to sustain their production, harvest rates in the fisheries were allowed to remain high, or even increase, further exacerbating the effects of overfishing on the naturally produced (nonhatchery) runs mixed in the same fisheries. More recently, harvest managers have instituted reforms including weak stock, abundance-based, harvest rate, and escapement-goal management.

5.3.5 Natural Conditions

Changes in the abundance of salmonid populations are substantially affected by changes in the freshwater and marine environments. For example, large-scale climatic regimes, such as El Niño, affect changes in ocean productivity. Much of the Pacific Coast was subject to a series of very dry years during the first part of the 1990s. In more recent years, severe flooding has adversely affected some stocks. For example, the low return of Lewis River bright fall chinook salmon in 1999 is attributed to flood events during 1995 and 1996.

Salmon and steelhead are exposed to high rates of natural predation, particularly during freshwater rearing and migration stages. Ocean predation may also contribute to significant

natural mortality, although the levels of predation are largely unknown. In general, salmonids are prey for pelagic fishes, birds, and marine mammals, including harbor seals, sea lions, and killer whales. There have been recent concerns that the rebound of seal and sea lion populations, following their protection under the Marine Mammal Protection Act of 1972, has resulted in substantial mortality for salmonids. In recent years, for example, sea lions have learned to target UWR spring chinook salmon in the fish ladder at Willamette Falls.

A key factor substantially affecting many West Coast stocks has been the general pattern of a 30-year decline in ocean productivity. The mechanism whereby stocks are affected is not well understood. The pattern of response to these changing ocean conditions has differed among stocks, presumably due to differences in their ocean timing and distribution. It is presumed that survival is driven largely by events occurring between ocean entry and recruitment to a subadult life stage. One indicator of early ocean survival can be computed as a ratio of CWT recoveries of subadults relative to the number of CWTs released from that brood year. Time-series of survival rate information for UWR spring chinook, Lewis River fall chinook, and Skagit fall chinook salmon show highly variable or declining trends in early ocean survival, with very low survival rates in recent years (NMFS 1999c).

Recent evidence suggests that marine survival of salmonids fluctuates in response to 20- to 30-year cycles of climatic conditions and ocean productivity (Cramer et al. 1999). This phenomenon has been referred to as the Pacific Decadal Oscillation (PDO). Ocean conditions that affect the productivity of Northwest salmonid populations appear to have been in a low phase of the cycle for some time and to have been an important contributor to the decline of many stocks. The survival and recovery of these species will depend on their ability to persist through periods of low natural survival.

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6.0 EFFECTS OF PROPOSED ACTION

6.1 ANALYTICAL METHODS

The proposed action has been evaluated using the five-part approach for applying the ESA jeopardy standard to Pacific salmon developed in Section 1.3.

6.1.1 Methods for Evaluating Effects on Action-area Biological Requirements

6.1.1.1 Methods for Upriver ESUs

6.1.1.1.1 Adult Fish Survival

The cumulative loss for adults migrating up the Columbia and Snake rivers through the FCRPS projects can be calculated as the difference in adult counts between dams (after adjustments for legal harvest and tributary turnoff). Adult loss, calculated this way, represents both mortality and apparent loss. Mortality can be related to passage through the dams and to other factors as well, such as illegal harvest, predation, gill-net interactions, and disease. Apparent adult loss between dams may be due to factors other than mortality, such as counting errors, double-counting adults that fall back and reascend ladders, and straying and tributary turnoff. A more reliable method to estimate adult passage loss is through the use of data from adult radio-tracking studies. This method rules out the double-counting error associated with the dam count method because it monitors the passage behavior of specific individual adults. Even with this method, however, many adult losses are not accounted for. For instance, there may not be any indication of a tagged adult's final fate, other than that it did not arrive at the next upstream dam. This unaccounted-for loss of the adult may be due either to mortality or to straying and tributary turnoff, but not to the counting errors inherent in the use of dam adult counts. The use of individually coded adult radiotelemetry tags greatly increases the precision associated with studies of adult migration behavior at dams and survival through the mainstem corridor (NMFS 2000e, p. 94).

While uncertainty is associated with the final fate of many radio-tagged adults, NMFS considers the unaccounted-for adult loss estimate calculated from these studies to be more representative of the mortality rate that may be associated with passage through the FCRPS dams than an adult loss estimate based on the comparison of adult counts between dams (NMFS 1995a). Therefore, data from radio-tagging studies, when available, were used to estimate the unaccounted-for adult loss rate and, as a corollary, the minimum survival rates of adults during passage through the hydrosystem. These estimates are considered minimal because some radio-tagged adults may have survived, but were not accounted for. Minimum survival rates were derived by dividing the number of radio-tagged adults detected at an upstream dam by the number of adults tagged minus the number of fish accounted for in the study. Where multiyear study data are available for a particular species, the multiple-year results are averaged. The mean unaccountable loss rate

in the multiyear project and reach studies, the mean minimal survival rates (1-loss), and the per project survival rates are shown in Table 6.1-1.

6.1.1.1.2 Juvenile Fish Survival

The primary method for evaluating the effects of the proposed action on migrating juvenile salmonids in the mainstem Columbia and Snake rivers was through simulation modeling. The Biological Effects Team[1] used NMFS' SIMPAS model to evaluate the biological effects of current FCRPS facilities and operations and the likely benefits of potential measures to improve juvenile salmonid passage survival. This spreadsheet model, developed by NMFS' Northwest Region Hydro Program staff, is a fish passage accounting model that apportions the run to various passage routes (i.e., turbines, fish bypass system, sluiceway/surface bypass, spillway, and/or fish transportation) based on empirical data and assumptions for fish passage route use. The model then accounts for "successful fish passage" (survival) and "losses" (mortalities) through each of the alternative passage routes to estimate total survival past each project. The model also accounts for dam plus pool survival, the proportion of juvenile fish transported, the proportion left to migrate inriver, the system survival of inriver and transported fish combined, and the survival of inriver fish alone.

The Biological Effects Team reviewed and analyzed fish passage assumptions used by NMFS in earlier fish passage modeling exercises, those developed in the PATH process, and the most recent empirical data information to determine the fish passage parameters for input into the SIMPAS model. The team also used the latest compilation of fish passage information in the four white papers recently prepared by the Northwest Fisheries Science Center on 1) "Passage of Juvenile and Adult Salmonids Past Columbia and Snake River Dams," 2) "Predation on Salmonids Relative to the Federal Columbia River Power System," 3) "Salmonid Travel Time and Survival Related to Flow in the Columbia River Basin," and 4) "Summary of Research Related to Transportation of Juvenile Anadromous Salmonids Around Snake and Columbia River Dams" (NMFS 2000e,f,h,i). Detailed descriptions of the SIMPAS model and the results of various simulations are provided in Appendix D.

[1] Since late 1999, NMFS has been engaged in ESA Section 7 consultation with the Federal Action Agencies (the Corps, BOR, and BPA) to develop a biological opinion on the effects of the Action Agencies' proposed action and future operation and configuration of the FCRPS projects. To facilitate completion of the Section 7 consultation process, the Federal agencies formed five action teams during January 2000, including the Biological Effects Team.

Table 6.1-1. Estimates of minimum adult survival and unaccounted loss based on radio-tracking studies through the FCRPS projects.

	Adult Loss					Current Condition			
	Multiyear/Project Radio-tracking Studies		Single-year Reach Studies						
	1995 BiOp	1998 BiOp	RT 96[1]	RT 97[1]	RT 98[1]	Mean Loss[2]	Minimum Mean Survival[3]	Number of Dams	Per-Project Survival[4]
Chinook Salmon									
SR spring/summer chinook	0.209[5]	0.252	0.161	0.158	0.130	0.175	0.825	8	0.976
SR fall chinook	0.393				0.187	0.290	0.710	8	0.958
UCR spring chinook[6]							0.907	4	0.976
LCR spring chinook[6]							0.976		0.976
LCR fall chinook[7]							0.958	1	0.958
Steelhead									
SR steelhead		0.208	0.270	0.204		0.227	0.773	8	0.968
UCR steelhead[8]							0.878	4	0.968
MCR steelhead[8]							0.878	4	0.968
LCR steelhead[8]							0.968	1	0.968
SR sockeye salmon	0.154[9]			0.132[10]		0.143	0.857	8	0.981

[1] T. Bjornn, pers. comm., November 2000 (data from 1996, 1997, and 1998 radio-tracking [RT] studies).
[2] Average of 1995 and 1998 Biological Opinion and radio-tracking studies.
[3] 1 minus mean loss.
[4] Calculated by taking the nth root of the number of dams (n) passed minimum mean survival estimates.
[5] Not included in loss/survival estimates (1998 Biological Opinion estimate is an update of the 1995 Biological Opinion estimate).
[6] Calculated from SR spring/summer chinook salmon per-project survival rates.
[7] Calculated from SR fall chinook salmon per-project survival rates.
[8] Calculated from SR steelhead per-project survival rates.
[9] Based on count analyses (1985 to 1994) (1995 Biological Opinion).
[10] Sockeye passage to Wells Dam.

6.1.1.2 Application to All 12 ESUs

The methods described above are applied to the relatively robust empirical data sets for SR spring/summer chinook salmon (yearlings), SR fall chinook salmon (subyearlings), and SR steelhead migrants. The results are applied to the remaining chinook salmon and steelhead ESUs for which empirical data are lacking. Because juvenile survival studies do not exist for CR chum salmon, mixed-stock LCR fall chinook salmon were used to estimate passage survival through the Bonneville project for this ESU. No adult fish passage studies are available for CR chum salmon. Because juvenile survival studies either do not exist or are inadequate for this purpose, passage survival for sockeye salmon cannot be evaluated for this ESU.

NMFS assesses the effects of the proposed action on action-area biological requirements in a qualitative manner for all 12 ESUs, and the effects of the proposed action on critical habitat types (i.e., juvenile rearing areas, juvenile migrations corridors, areas for growth and development to adulthood, adult migration corridors, and spawning areas) in the action area. The purpose of the evaluation is to determine whether any of the constituent elements of critical habitat are likely to be adversely modified or destroyed under the proposed action.

6.1.2 Methods for Evaluating Effects of Hydrosystem Actions on Species-level Biological Requirements

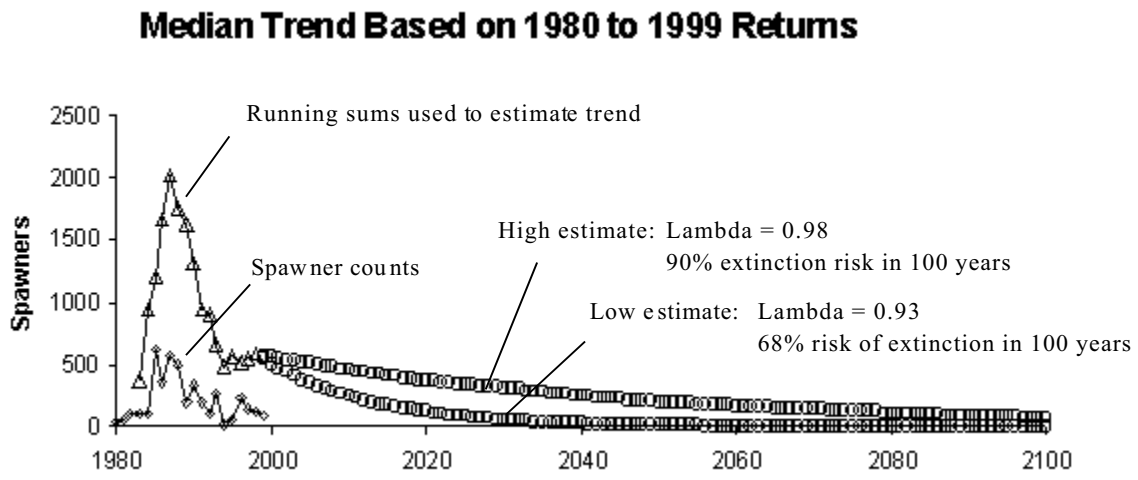
The effects of the proposed action in the action area (Section 6.1.1) must be evaluated in the context of survival throughout the life cycle and compared with the jeopardy standard described in Section 1.3.1.1. NMFS uses the methods presented in this section to perform the analyses called for by Steps 3 and 4 of the Jeopardy Analysis Framework discussed in Section 1.3, above. For all ESUs except SR sockeye salmon, a combination quantitative and qualitative approach was applied. The quantitative analysis attempted to capture most of the effects of the proposed action and of likely actions affecting other life stages, but in all cases complementary qualitative analyses were also necessary. For SR sockeye salmon, only a qualitative approach was possible.

Briefly, the quantitative analysis is described in the first four steps illustrated in Figure 6.1-1. A more detailed description of the quantitative analysis is found in Appendix A. Details specific to each ESU are described in Section 6.3. The qualitative approach is described in the fifth step. Following is a summary of the five-step method of evaluating effects of the proposed action on species-level biological requirements.

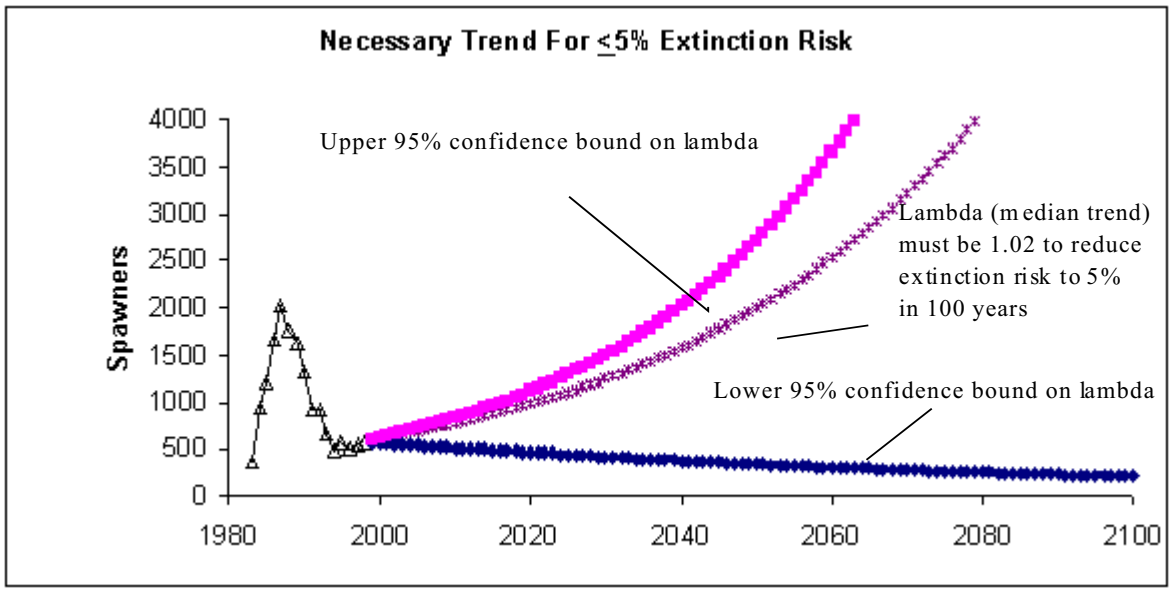
1) Define the recent population trend, based on adult returns from 1980 through the most recent year available. The starting point is the NMFS CRI analysis for 11 ESUs (McClure et al. 2000a,b,c) and the NMFS QAR for the two Upper Columbia River ESUs (Cooney 2000). These reports assess population trends, based on adult returns during recent years. The trend is defined as the median annual population growth rate (lambda). This is estimated in the CRI analysis by methods described in McClure et al. (2000c) and Holmes (in review). Simply put, the analysis fits a stochastic exponential decline curve to running sums of total living current or future

Figure 6.1-1. Primary steps in the analysis of effects of the action on species-level biological requirements for a hypothetical salmon population. Lambda is the median annual population growth rate.

1. Define the recent population trend, based on adult returns from 1980 through the most recent year available.



2. Define the change in trend that is necessary to meet the survival and recovery indicator criteria described in Section 1.3.1.

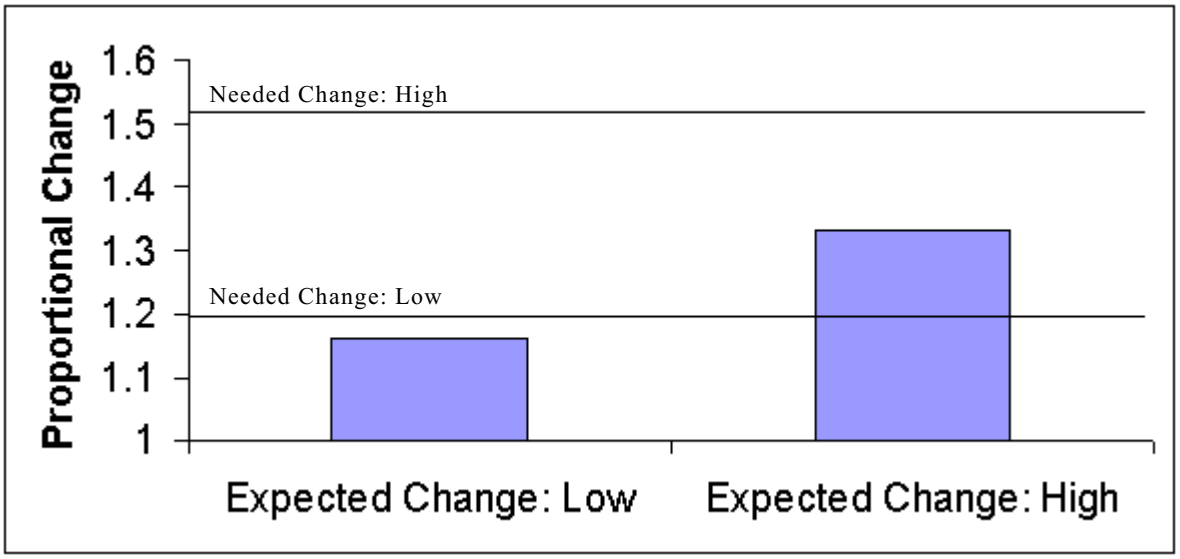


$$\text{Low Needed Survival Change} = \left(\frac{\text{Needed Lambda} = 1.02}{\text{Current Lambda} = 0.98}\right)^{\text{Mean Generation Time [4.5]}} = 1.20$$

$$\text{High Needed Survival Change} = \left(\frac{\text{Needed Lambda} = 1.02}{\text{Current Lambda} = 0.93}\right)^{\text{Mean Generation Time [4.5]}} = 1.52$$

Figure 6.1-1 (Continued). Primary steps in the analysis of effects of the action on species-level biological requirements for a hypothetical salmon population. "Lambda" refers to the median annual population growth rate.

3. Estimate the change in survival rates associated with the proposed action and with expected changes in other life stages and update the estimate of population growth rate.



4. Compare the change in survival resulting from the proposed action with the necessary change defined in step 2.

   - In the example, the highest estimate of the expected survival change achieves the lowest estimate of the goal but the lowest estimate does not. In the worst case, an additional 31% (1.31 times "Low" expected survival rate) survival improvement is still necessary to meet the highest estimate of the goal.

6. Qualitatively evaluate the likelihood that survival through life stages that could not be quantified is likely to sufficiently reduce the additional necessary survival change.

   - Relies on information in Basinwide Recovery Strategy

spawners. Cooney (2000) estimates population growth rate using a stochastic simulation model fit to adult spawner-to-spawner data.

Since the primary purpose of the analysis is to determine the status of stocks and the risks they face under current conditions, NMFS restricted it to the years since 1980. Several agencies and organizations commented on the July 27 draft biological opinion that NMFS should have included earlier starting years in its estimation of population trends. Changes to the hydrosystem were a main component of the choice of 1980 as the starting year, since before then, the hydrosystem on the Columbia River was in a state of flux. The final dam on the mainstem Columbia was completed in 1971, the last of the four lower Snake River dams was completed in 1975, and the full complement of turbines was installed by 1979. The reservoir storage capacity in the Columbia was nearly doubled in 1975, when Libby and Mica dams were completed. Including data from before 1980 would, therefore, confound the evaluation of the current status by implicitly incorporating conditions that no longer exist. The evaluation would also be confounded for other reasons, such as the oceanic regime shift that occurred in the late 1970s (Mantua et al. 1997).

Agencies and organizations commented on the choice of median annual population growth rate as the measure of current trends in the July 27 draft biological opinion (NMFS 2000b) and the anadromous fish appendix. Commenters expressed computational concerns and confusion because NMFS' methods for estimating lambda have changed. Many of the suggestions are reflected in the current analysis. The exact methods are now available in McClure et al. (2000c) and Holmes (in review). Some agencies and organizations suggested alternative indicators of population trend, such as recruits per spawner (R/S) and smolt-to-adult returns (SARs). Use of median annual population growth rate yields results nearly identical to R/S if recruits are defined as adults reaching the spawning grounds. Use of R/S with recruits expressed at other life stages, such as adults to the Columbia River mouth, and use of SARs yields estimates of trend for only part of the life cycle. Unless survival is assumed constant in the other life stages, these measures are not useful for assessing population trends.

NMFS also received comments that the annual population growth rate, as determined in McClure et al. (2000b), is very sensitive to the time period selected for the analysis and to data points considered "outliers." NMFS applies running sums to the abundances, which reduces the influence of individual years. However, NMFS agrees in general with the comment. In response, NMFS developed an alternative method of estimating the mean that is less sensitive to these factors. The difference between the more robust and previous estimates of annual population growth rate vary, but for 80% of all spawning aggregations, the two estimates differ by an absolute value of less than 0.05 (McClure 2000). Whereas this method eliminates the sensitivity to time period (or outliers), the implications for estimates of extinction risk, which are sensitive to the distribution of the data, are not well understood. Additional research is needed to determine whether this method, or an alternative, best addresses the sensitivity of NMFS' analytical method to start and end points and extreme values. Therefore, NMFS has not used this

new method in this biological opinion, but considers this characteristic of the analysis qualitatively when drawing conclusions.

2) Define the change in the trend that is necessary to meet the survival and recovery indicator criteria described in Section 1.3.1. Both McClure et al. (2000b,c) and Cooney (2000) estimated the proportional change in population growth rate necessary to reduce extinction risk to 1% in 24 and 100 years. That change in population growth rate can be translated into a needed change in survival if the mean generation time is known:

$$\Delta S = \Delta\lambda^{\text{mean generation time}}$$

where $\Delta\lambda$ is the multiplicative change in median annual population growth rate (based on 1980 to most recent available year) and ΔS is the multiplicative change in average egg-to-adult survival, or survival during any component life stage, that corresponds to the return years used to estimate $\Delta\lambda$.

McClure et al. (2000b,c) used diffusion approximation methods (Dennis et al. 1991; Holmes in review) to project future population trajectories and estimate extinction risk for the survival indicator criterion. Cooney (2000) used a cohort replacement model (Botsford and Brittinacher 1998) to do the same. Neither approach includes density dependence at the low population levels evaluated in the estimation of extinction risk. A few agencies and organizations that commented on the July 27 draft biological opinion suggested including density dependence at low population levels, and the Idaho Department of Fish and Game suggested including depensation at low population levels. NMFS' assumption of density independence at low population levels is more conservative (i.e., results in higher risk of extinction) than models based on density dependence, such as those based on Ricker functions. A model based on depensation may yield more conservative results, but parameterization of such a model for the populations under consideration must be based almost exclusively on guesswork.

NMFS evaluated the recovery indicator criteria for stocks with interim recovery abundance levels using either simulations with the cohort replacement model for UCR stocks (Cooney 2000) or with an estimate of the minimum change in survival that would be necessary to grow from the current abundance level to the recovery abundance level in either 48 or 100 years (Schiewe 2000a; Appendix A). The first method includes assumptions regarding density dependence as populations approach the recovery abundance level; the second method assumes continued exponential growth near recovery abundance levels. Several agencies and organizations, when commenting on the July 27 draft biological opinion, criticized the absence of density dependance at high abundance levels using this second approach. NMFS agrees that density dependence probably occurs at some high abundance level. The difficulty is in defining the capacity of the system and the rate at which productivity declines as that capacity is approached. NMFS has been unable to detect density dependence in the period since 1980 for Columbia basin stocks (McClure et al. 2000c) and questions the data quality and conclusions from analyses that have been based on longer time-series (Schaller et al. 1999; Zabel and

Williams 2000; Schaller et al. 2000). Therefore, with the exception of the QAR analysis for UCR spring chinook and UCR steelhead, analysis of the survival changes necessary to meet recovery indicator criteria do not include density dependence. However, NMFS qualitatively considers the likelihood that these are minimum estimates in its jeopardy determination.

NMFS applies a simple method of estimating the minimum survival change necessary to meet the recovery indicator criteria for stocks lacking an interim recovery abundance level. As described in Section 1.3.1, the recovery abundance level may be unknown, but it is certainly higher than the current abundance level. Therefore, at a minimum, the median annual population growth rate must be ≥ 1.0. This is determined by simply dividing 1.0 by the estimate of lambda from the first step of the analysis.

3) Estimate the change in survival rates associated with the proposed action and with expected changes in other life stages and update the estimate of population growth rate.

The necessary survival changes identified in the second step of the analysis are based on the assumption that life-stage survival rates influencing adult returns in 1980 through the most recent available year will continue indefinitely. However, the survival rate associated with the proposed action may represent an improvement over the average survival rate influencing 1980-through-most-recent adult returns. Current survival in other life stages may also differ from the 1980-through-most-recent-year average. If these current or expected survival rates are expected to continue, they will change the population growth rate.

NMFS estimates FCRPS juvenile survival and adult survival resulting from the proposed action using the methods defined in Section 6.1.1. The change for each species is addressed separately for each ESU. In some cases, retrospective modeling analyses are available for comparison (e.g., PATH juvenile passage survival estimates for SR spring/summer and fall chinook). In other cases, inferences must be drawn from other species or geographic areas. NMFS also estimates expected survival associated with current and future harvest rates, based on actions defined in the Basinwide Recovery Strategy, and compares that with average historical harvest rates. The combined change in survival is simply the product of the survival change expected from the proposed action and that expected from current harvest rates. For example, if the average smolt survival through the hydrosystem averaged 50% for the migration years corresponding to the risk assessment and it is expected to be 55% as a result of the proposed action, a 10% survival improvement is expected (0.55/0.50 = 1.10). If current and future harvest management results in a 5% survival improvement, the combined change is 15.5% (1.10 x 1.05 = 1.155).

NMFS was not able to quantify expected changes in survival resulting from habitat and hatchery management actions in this analysis. Those effects are evaluated qualitatively in relation to the remaining survival change needed after implementing the proposed action (see below).

The analysis of survival changes used in this biological opinion is identical to that used for SR steelhead in the July 27 draft biological opinion and for the evaluation of alternative harvest

strategies in McClure et al. (2000c), but is simpler than the Leslie matrix approach that was applied to other ESUs (Leslie 1945, 1948). The primary reason for the change is that applying the Leslie matrix requires an estimate of survival through all life stages, while the method used here requires only estimates of survival changes for life stages that are affected by the proposed action, or that have been affected by changes in other management actions. The matrix approach in the July 27 draft biological opinion is useful (Kareiva et al. 2000; Cooney 2000), but it is unnecessarily complex for the analysis required in this biological opinion. Technical discussions on the July 27 draft sometimes focused on estimating survival rates that were not critical to the results and generated debates regarding differences between estimates of population growth rate from the deterministic Leslie matrix and the stochastic modified Dennis model approach. The current method simply updates the original estimate of median annual population growth rate (λ) according to a generalized form of Equation 11 in McClure et al. (2000c):

$$\lambda_{NEW} = \lambda_{OLD}(\text{new life-stage survival rate/old life-stage survival rate})^{1/\text{mean generation time}}$$

4) Compare the change in survival resulting from the proposed action with the necessary change defined in step 2. NMFS constructed ratios that indicate the degree to which the proposed action meets the survival and recovery indicator criteria. Ratios less than, or equal to, 1.0 indicate that the jeopardy standard indicator metrics are met, given the effects of the proposed action and other expected activities. Values over 1.0 indicate that additional improvements in survival are necessary to meet the criterion. Those values represent the multiplier by which survival, after the proposed action and other expected actions are implemented, must be additionally increased.

5) Qualitatively evaluate the likelihood that survival through life stages that could not be quantified is likely to reduce the additional necessary survival change. The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. NMFS must use a combination of qualitative methods and professional judgment to determine the extent to which changes in other life stages might account for the necessary survival improvements. Survival changes can be expressed as changes from the average 1980-to-1999 egg-to-smolt survival, estuary survival, and/or prespawning adult (above the uppermost dam) survival rates. Because the quantitative analysis does not include the effects of FCRPS operations on some life stages in some ESUs (e.g., spawning and rearing requirements of LCR chinook salmon and CR chum salmon), the effects must also be evaluated qualitatively. For SR sockeye salmon, this is the only type of analysis NMFS can perform, because the information available is not suitable for calculating an estimate of current demographic risks, let alone expected survival improvements under the proposed action.

The qualitative evaluation is, therefore, a key factor in the jeopardy determination for each ESU. Among the factors that NMFS will consider at this step are the effects of the proposed action on critical habitat in the action area (see above) in the overall context of all the effects on biological requirements throughout the life cycle. The evaluation draws on a review of the existing literature, including the information summarized in Section 4.1 and Appendix C. Adverse effects

on individuals of a species or constituent elements or segments of critical habitat generally do not result in jeopardy or determination of adverse modifications unless that loss, when added to the environmental baseline, is likely to result in significant adverse affects throughout the species range, or to appreciably diminish the value of the critical habitat for both the survival and the recovery of the listed species (50 CFR Section 402.02). Therefore, NMFS considers the range of critical habitat types affected by the proposed action, the geographic scope of the effects, and the degree to which the effects are likely to limit the productivity of each ESU.

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6.2 EFFECTS OF FCRPS OPERATIONS—ACTION AREA BIOLOGICAL REQUIREMENTS

Development of the Pacific Northwest regional hydroelectric power system, dating to the early twentieth century, has had profound effects on the ecosystems of the Columbia River basin (ISG 1996). These effects have been especially adverse to the survival of anadromous salmonids. The direct effects of the construction of the FCRPS on salmon and steelhead in the Columbia basin can be divided into four categories: blockage of habitat; alteration of habitat; barrier to, or modification of, juvenile migration; and barrier to, or modification of, adult migration. Where no fish passage facilities have been provided, hydroelectric dams completely block anadromous fish runs on the river. In addition, dams inundate historical spawning and rearing habitat. For salmon and steelhead, much of this effect occurred with the construction of the Grand Coulee (1941) and Chief Joseph (1961) dams on the Columbia River and the Hells Canyon Hydroelectric Complex (1959) on the Snake River. More than 55% of the Columbia River basin accessible to salmon and steelhead before about 1939 has been blocked by large dams (NWPPC 1986).

Dams present barriers to the upstream and downstream migrations of anadromous fish. A significant rate of juvenile injury and mortality occurs during downstream passage. Physical injury and direct mortality result from passage through turbines, juvenile fish bypasses, and to a lesser degree, spill. Indirect effects of passage through all routes may include disorientation, stress, delay in passage, exposure to high concentrations of dissolved gases, exposure to warm water, and cumulative effects of the above. Although the direct mortality of adults is probably minimal during passage at individual dams, each dam presents the potential for delays at fishway facilities, energy expenditure in passage through multiple fishways, involuntary fallback, and, during periods of involuntary spill, increased exposure to high concentrations of dissolved gases.

The impoundments created by the FCRPS dams greatly increased the cross-sectional area in much of the Columbia and lower Snake rivers, reducing water velocity and water particle travel times in the impounded river reaches. Regulating water in upriver storage reservoirs modifies the natural hydrograph and affects the listed species throughout the action area, from the upriver storage reservoirs to the Columbia River plume. Water regulation reduces flow (volume per unit time) to less than what would naturally occur during spring and early summer.

Water regulation and impoundment also change water quality factors such as temperature and turbidity, as well as the production of salmonid prey. Reservoirs provide habitat for salmonid predators. Channel complexity is reduced, affecting fluid dynamics (e.g., ISG 1996) and substrate types. Load-following operations at hydrosystem projects (hourly and daily load-following and reduced weekend flows) can affect access to suitable spawning habitat and can trap and strand both adults and juveniles.

6.2.1 Effects on Habitat in Columbia River Mainstem, Estuary, and Plume

The lower Columbia River and estuary habitats have been affected over the past 60 years by the series of mainstem hydrosystem reservoirs and by the operation of upstream multipurpose storage projects. The impoundments have also inundated extensive salmon spawning and rearing habitat. Historically, fall chinook salmon spawned in mainstem reaches from near The Dalles, Oregon, upstream to the Pend Oreille and Kootenai rivers in Idaho and to the Snake River downstream of Shoshone Falls. Presently, mainstem production areas for fall chinook are confined to the Hanford Reach of the Columbia River, the Hells Canyon Reach of the Snake River, the mid-Columbia River, and below the lower Snake River projects and Bonneville Dam. The Hanford Reach is the only known mainstem spawning area for steelhead. Spawning habitat used historically by LCR chinook and CR chum salmon and by LCR steelhead was probably inundated by the Bonneville pool as well.

The mainstem habitats of the lower Columbia and Willamette rivers have been reduced primarily to a single channel: floodplains have been reduced, off-channel habitat features have been eliminated or disconnected from the main channel, and the amount of large woody debris in the mainstem has been greatly reduced. Finally, most of the remaining habitats are affected by flow fluctuations associated with reservoir water management for power peaking, flood control, irrigation, and other operations.

Large multipurpose storage projects, developed in both Canada and the United States, have altered the seasonal runoff pattern and volume of flow into the estuary. Recent model studies by Bottom et al. (2000) indicate that the volume and timing of water and sediment delivery have changed since the late 1880s due to hydrosystem operation, even after the effects of climate change and irrigation withdrawals are taken into account. Compared with the 1880s, current operations do the following:

1. Deliver more water to the estuary during winter (October through April) and less water during spring and summer.

2. Reduce the peak spring freshet by more than 40% and reduce total freshet-season flow volume by about 30%.

3. Lengthen the period of the freshet and move the peak flow earlier (by prereleasing stored water for flood control, which interacts with recent climate change).

4. Greatly increase fall-winter minimum flows.

In addition, the model studies indicate that the hydrosystem and climate change together have decreased suspended particulate matter to the lower river and estuary by about 40% (as measured at Vancouver, Washington) and have reduced fine sediment transport by 50% or more. Overbank flow events, important to habitat diversity, have become rare – in part because flow

management and irrigation withdrawals prevent high flows and in part because diking and revetments have increased the "bankfull" flow level (from about 18,000 to 24,000 m^3/s). The dynamics of estuarine habitat have changed in other ways relative to flow. The availability of shallow (between 10 cm and 2 m depth), low-velocity (less than 30 cm/s) habitat now appears to decrease at a steeper rate with increasing flow than during the 1880s, and the resilience of the estuary to increasing water depth with increasing flow (absorption capacity) appears to have declined.

The significance of these changes to salmonids is unclear. Estuarine habitat is likely to provide services (food and refuge from predators) to subyearling migrants that reside in estuaries for up to 2 months or more (Casillas 1999). Historical data from Rich (1920) indicate that small juvenile salmon (< 50 mm), which entered the Columbia River estuary during May, grew 50 to 100 mm during June, July, and August. Data from a more contemporary period (Dawley et al. 1986; CREDDP 1980) show neither small juveniles entering the estuary in May nor growth over the summer season.

The Columbia River plume also appears to be an important habitat for juvenile salmonids, particularly during the first month or two of ocean residence. The plume may simply represent an extension of the estuarine habitat. More likely, it represents a unique habitat created by interaction of the Columbia River freshwater flow with the California Current and local oceanographic conditions. Ongoing studies show that nutrient concentrations in the plume are similar to nutrient concentrations associated with upwelled waters. Upwelling is a well-recognized oceanographic process that produces highly productive areas for fish; primary productivity, and more importantly, the abundance of zooplankton prey, is higher in the plume compared with adjacent nonplume waters. Further, salmon appear to prefer low surface-salinity waters, as the abundance and distribution of juvenile salmon are higher and more concentrated in the Columbia River plume compared with adjacent, more saline waters. These findings support the notion that the plume is an important habitat for juvenile salmonids. What is not known is how Columbia River flows affect the structure of the plume during outmigration periods, and whether critical threshold flows are needed. Ongoing research will document important relationships between juvenile salmon growth and survival during this stage of their life history.

6.2.2 Effects of Project Operations on Juvenile Salmonid Passage—General Considerations

The presence of dams in the migratory corridor results in some migrational delay (Raymond 1969, 1979), thereby influencing migration speed and timing of juveniles. Dams also impede the safe passage of juveniles. Some juvenile mortality is associated with all routes of passage at dams, with the highest mortality occurring through turbines (Whitney et al. 1997) and lowest direct mortality through spillways (NMFS 2000e). Some passage routes have additional effects, such as the increase in TDG (water quality) caused by spill.

For SR and UCR chinook salmon and steelhead, an analysis of effects on survival is the primary method used in this biological opinion for evaluating the effects of the proposed action on the biological requirements of listed species in the action area. An important objective of project operations is to increase survival by routing a high proportion of juveniles past the projects in a manner that avoids passing them through turbines. The proportion of smolts that pass a project through bypass systems or over spillways—project fish passage efficiency (FPE)—varies by species composition and may vary within a season and between years for a single species with changes in smolt condition, environmental conditions, and project operations.

6.2.2.1 Juvenile Salmonid Passage Through Turbines—General Considerations

Turbine survival studies for juvenile passage published through 1990 at the Snake and lower Columbia River dams have been reviewed by Iwamoto and Williams (1993). The Independent Scientific Group (ISG 1996) and Whitney et al. (1997) reviewed studies published through 1995. Turbine mortality has been estimated primarily for juvenile salmon, although at least two studies have estimated steelhead mortality (Weitkamp et al. 1986; Olson and Kaczynski 1980). Whitney et al. (1997) pointed out that in studies where marked fish were immediately recovered in the tailrace, mortality estimates were less than 7% (average 5.5%). In studies with longer times between turbine passage and recovery, mortality levels averaged 10.9% (Whitney et al. 1997). Whitney et al. (1997) also suggested that the lower survival estimates probably included some level of mortality associated with predation on disoriented smolts after turbine passage. That is, turbine passage not only causes direct mortality but may also cause indirect mortality by increasing a fish's susceptibility to predation.

6.2.2.2 Juvenile Salmonid Passage Through Bypass Systems—General Considerations

Estimates of the direct survival rate of juvenile salmon and steelhead through bypass systems include mortality rates associated with turbine intake screens, gatewells, orifices, bypass flumes, dewatering screens, sampling facilities (including holding tanks), and bypass outfall conduits. Although direct survival through mechanical screen bypass systems is higher than through turbines, fish transiting bypass systems often exhibit increased signs of stress (compared to control groups) as measured by blood chemistry, increased descaling, and possibly delayed mortality (NMFS 2000e). Estimates of direct bypass mortality found at sampling facilities for the bypass systems at the Federal hydroelectric projects on the Snake and lower Columbia rivers suggest that the direct mortality of wild yearling steelhead and chinook salmon is generally less than 1% (Martinson et al. 1997; Spurgeon et al. 1997; summarized in the 1998 FCRPS Supplemental Biological Opinion), although some level of stress or injury may result in mortality later in the life cycle. Bypass survival may be indirectly affected by predation at poorly located outfall sites or by delayed mortality associated with injury or stress caused by passing through one or more bypass systems.

6.2.2.3 Juvenile Salmonid Passage Through Spill—General Considerations

Whitney et al. (1997) reviewed 13 estimates of spill mortality published through 1995 (three for steelhead and 10 for salmon) and concluded that the most likely range in mortality for standard spill bays is 0% to 2%. However, the authors also pointed out that the presence of local conditions such as back-eddies or other features that provide refuge for predators may lead to higher spillway passage mortality. In general, relative to other passage routes currently available, direct juvenile survival is highest through spillbays (NMFS 2000e). Although the FCRPS is currently managed to meet TDG standards, concentrations may rise to levels that induce gas bubble trauma (GBT) in salmonids under high levels of involuntary spill, reducing the survival of both the juvenile and adult life stages. This concern emphasizes the importance of the physical and biological TDG monitoring programs at the Federal dams.

6.2.2.4 Juvenile Inriver Reach Survival—General Considerations

Williams et al. (in review) expanded the 1960s and 1970s estimates of direct survival of yearling salmonid migrants from the head of the upstream reservoir (Ice Harbor Dam through 1968, Lower Monumental Dam in 1969, Little Goose Dam from 1970 to 1974, and Lower Granite Dam since 1975) to the tailrace of Bonneville Dam, and compared these with expanded 1993-through-1999 estimates. During the 1960s, with four dams in place, direct survival of yearling migrant fish through the hydrosystem was 32% to 56%. Four more dams were constructed between 1968 and 1975. Estimates of system survival during the 1970s typically ranged from 10% to 30%, but were less than 3% for the drought years 1973 and 1977. During the most recent period, 1995 to 1999, system survival of SR spring/summer chinook salmon has ranged from 42% to 59%, substantially higher than during the 1970s and similar to 1960s levels. The recent increase is probably the result of good flow conditions combined with implementation of the project operations and fish passage improvements prescribed in the 1995 FCRPS Biological Opinion.

The rate of survival of subyearling fall chinook salmon through the hydrosystem is lower than that of yearling chinook salmon. During the 1995-through-1999 outmigrations, NMFS PIT-tagged Lyons Ferry Hatchery subyearling fall chinook salmon with passive integrated transponders (PITs) and released them above Lower Granite Dam. Survival from the point-of-release in a free-flowing reach of the Snake River to the tailrace of Lower Granite Dam averaged from about 55% for the earliest releases to about 13% for groups released in early July, coinciding with substantial increases in water temperature and decreases in flow and turbidity. These survival estimates incorporate the effects of mortality during rearing (i.e., from parr to active migrant stage) migration through free-flowing reaches, and migration through Lower Granite Reservoir and Dam. In the reach between the tailrace of Lower Granite Dam and that of Lower Monumental Dam (i.e., encompassing two dams and reservoirs), the survival of summer migrants was estimated within a season and for a given season, among years. Weekly estimates of survival averaged from about 11% to 68%, the lowest pertaining to releases later in the season, when environmental conditions were relatively poor (e.g., high water temperature, low flow, and

low turbidity). Survival of run-of-the-river subyearling chinook salmon from the tailrace of McNary Dam to the tailrace of John Day Dam was approximately 41.0% and 77.5% in 1998 and 1999, respectively. Estimates of subyearling chinook salmon survival through this reach before the development of the hydrosystem are lacking and thus cannot be compared with recent estimates. However, recent estimates suggest that passage through the hydrosystem results in high mortality rates for Snake River subyearling chinook salmon during the summer, when environmental conditions deteriorate. One caveat to this conclusion is that, based on preliminary data, juvenile subyearlings detected in the Snake River for the first time during September and October have adult return rates that are approximately five times higher than those of subyearlings detected during summer.

6.2.3 Specific Effects of FCRPS Operations on Juvenile Salmonid Passage and Survival

6.2.3.1 Juvenile Salmonid Passage Through Turbine Units at FCRPS Projects

In recent years, evaluations of turbine mortality have been conducted under the turbine operations presumed to provide the best conditions for fish (i.e., operations within 1% of peak efficiency). NMFS' studies of turbine survival for yearling chinook in the Snake River produced estimates of 92.0%, 86.5%, and 92.7% at Little Goose, Lower Monumental, and Lower Granite dams in 1993, 1994, and 1995, respectively. Steelhead survival from turbine passage at Little Goose Dam in 1997 was 93.4% (Muir et al. in review).

The Biological Effects Team and NMFS[2] used the SIMPAS model to calculate juvenile passage survival rates through the dams under the proposed action (current conditions). Inputs included turbine survival rates that ranged from 90% to 93% for yearling chinook and steelhead migrants and rates that ranged from 90% to 94% for subyearling migrants (the particular rate used for each dam is listed on Tables D-1 through D-3 in Appendix D). These turbine survival estimates are based on information presented in NMFS (2000e), Marmorek et al. (1998), and Ledgerwood et al. (1990).

6.2.3.2 Juvenile Salmonid Passage Through Bypass Systems at FCRPS Projects

The FCRPS dams use two submersible fish screen designs to guide fish away from turbine intakes and into juvenile bypass systems: a standard-length submersible traveling screen (STS) and an extended-length submersible bar screen (ESBS). STSs are currently installed at Lower

[2] To facilitate completion of the ESA Section 7 consultation process, the Federal agencies formed five action teams during January 2000. The Biological Effects Team was charged with estimating the effects of current operations and potential future configurations and operations on the survival of listed juvenile outmigrants. This information was used by NMFS to analyze the listed species' biological requirements in the action area, as well as at the species level. The team included Federal biologists and engineers representing NMFS, the Corps, and BPA. NMFS' Hydro Program staff picked up where the Biological Effects Team analysis left off to complete the biological effects analysis described in this section and in Appendix D.

Monumental, Ice Harbor, John Day, and Bonneville dams. ESBSs are currently installed at Lower Granite, Little Goose, and McNary dams. The Dalles Dam does not have a mechanical screen juvenile bypass system.

Intake screens guide migrating juveniles from turbine intakes into gatewells. FGE is a measure of how efficiently intake screens guide juveniles out of turbine intakes. Higher FGE equates with higher diversion of the migrants away from turbine passage and into the bypass system. To calculate juvenile passage survival rates through the dams under the proposed action (current conditions) with the SIMPAS model, the Biological Effects Team and NMFS used FGE rates that ranged from 39% to 83% for yearling chinook, 9% to 62% for subyearling chinook migrants, and 41% to 93% for steelhead migrants. The particular fish guidance rate selected for each dam is listed in Tables D-1 through D-3 in Appendix D. These FGE rates are based on information from the 1998 FCRPS Supplemental Biological Opinion and on NMFS (2000c,e) and Marmorek et al. (1998).

Once guided into gatewells by intake screens, fish exit through orifices to a collection channel traveling the length of the powerhouse. The channel conveys fish and the orifice flow directly to the tailrace or to a dewatering facility. The dewatering facility reduces bypass system flow to approximately 30 to 40 cfs and then the fish, with the remaining water, are sent via flume to a tailrace outfall or to a holding facility for transportation. Smolt-monitoring facilities installed at projects with key bypass systems collect data for estimating species composition, fish condition, run timing, and other passage indices. PIT-tagged fish can be detected at these facilities, the time and date of passage noted, and fish diverted for further evaluation, if needed.

Design criteria for mechanical screen bypass systems are described in NMFS (1995b,c), Corps' bypass system design memoranda (Corps 1995, 1996, 1999a), the Corps' annual Fish Passage Plan (Corps 1999e), and the American Society of Civil Engineers' manual of intake design guidelines (ASCE 1995). NMFS' guidelines for locating and designing bypass outfalls are presented in NMFS (1995b).

Bypass system survival has been evaluated using recoveries of marked fish. These estimates include both direct and at least a portion of any indirect effects of bypass systems, depending on where the tagged fish are recaptured and whether (and where) any indirect losses occur. Muir et al. (1995, 1996, 1998) reported that survival through bypass systems at Snake River dams, based on PIT-tagged fish released into the collection channel, ranged from 95.4% to 99.4% for yearling chinook and from 92.9% to 98.3% for steelhead. Estimated survival was 95.3% for steelhead that passed through the entire bypass system at Little Goose Dam in 1997 (Muir et al. 1998). Ledgerwood et al. (1994) evaluated survival through the Bonneville First Powerhouse juvenile bypass system. They found that recoveries of marked (CWT) subyearling chinook in the Columbia River estuary were significantly lower for fish that passed through the bypass and tailrace than for fish released 2.5 km downstream.

To calculate juvenile passage survival rates through the dams under the proposed action (current conditions) with the SIMPAS model, the Biological Effects Team and NMFS used bypass survival rates that ranged from 90% to nearly 99% for yearling chinook, 88% to 98% for subyearling chinook, and 90% to 98% for steelhead migrants. The particular bypass survival rate used for each dam is listed on Tables D-1 through D-3 in Appendix D. These bypass survival rates are based on information presented in the NMFS (2000e), Marmorek et al. (1998), Ledgerwood et al. (1990), and Smith et al. (2000).

6.2.3.2.1 Juvenile Salmonid Passage Through Spillways and Sluiceways at FCRPS Projects. The spillway of any FCRPS dam consists of a forebay, multiple spill gates, an ogee, a stilling basin, and a tailrace. Most spillway gates are built from a radial design with a 60-foot radius and 50-foot width. The spillways at Bonneville and McNary dams have vertically operated lift gates of similar width. The number of gates per spillway varies from 8 to 10 at lower Snake River dams to 18 to 23 at lower Columbia River dams. The ogee maintains the shape of the spillway flow between the gates and the stilling basin. Most FCRPS dams are equipped with flow deflectors that help reduce the amount of dissolved gas produced at a given level of flow; these are located on the ogee sections at elevations specific to each project.

The level of spill and daily and seasonal timing currently provided for fish passage at FCRPS dams is specified in the 1998 Supplemental FCRPS Biological Opinion (see Table III-2) and in Appendix A to NMFS (2000e). Current estimates of spill effectiveness (the proportion of fish approaching a project that pass via the spillway) for FCRPS dams are listed in Tables D-1 through D-3 in Appendix D. Spill efficiency is calculated as spill effectiveness divided by the proportion of total river flow passing over the spillway during the evaluation period. Spill efficiency and effectiveness have been reviewed recently by Steig (1994), Giorgi (1996), Whitney et al. (1997), and Marmorek and Peters (1998). Estimates of spill efficiency vary by project and the values used by the Biological Effects Team and NMFS as inputs to the SIMPAS model are listed in Tables D-1 through D-3 in Appendix D. The rates are based on information in Marmorek et al. (1998), Ploskey et al. 1999, Eppard et al. 2000, Adams and Rondorf 1999, Hansel et al. (1999), and, where empirical data were not available, on NMFS' best professional judgment.

Data on juvenile spillway passage survival for FCRPS dams are summarized in NMFS (2000e, p. 64 and Table 9). To calculate juvenile passage survival rates through the dams under the proposed action (current conditions) with the SIMPAS model, the Biological Effects Team and NMFS used spillway survival rates that ranged from 90% to 100% for yearling chinook salmon and steelhead migrants and from 88% to 98% for subyearling chinook (see Tables D-1 through D-3 in Appendix D). These rates are based on information presented in NMFS (2000e), Marmorek et al. (1998), Dawley et al. (1999), Holmes (1952), and Ledgerwood et al. (1990).

In its white paper on predation, NMFS (2000f) identifies a key issue that connects these fish passage spill programs with predation at the FCRPS dams. Predator concentrations are typically highest in the immediate forebays and tailraces of dams, areas where smolts are delayed and

where structures and back-eddies (refuge for predators) and disorientation make smolts particularly vulnerable. Because the effects of spill volume, spill patterns, and spill duration (e.g., 12- versus 24-hour) on forebay and tailrace survival are unknown (NMFS 2000f, p. 35), NMFS considers the effect of dam operations on smolt predation a critical uncertainty.

The NMFS' SIMPAS spreadsheet model combines turbine, bypass, and spillway survival rates with FGE, spill efficiency, and diel passage rates to estimate the survival of juvenile migrants at each FCRPS dam. Diel passage rates are the proportion of juvenile migrants passing during the day and during nighttime hours. The nighttime rates that the Biological Effects Team and NMFS used as inputs to the SIMPAS model are listed in Tables D-1 through D-3 in Appendix D. For yearling and subyearling chinook and steelhead migrants, these range from 50% to 83%, varying by dam and season (NMFS 2000f, Marmorek et al. 1998, Kuehl 1986, Biosonics 1998, Steig and Johnson 1986, Sullivan et al. 1986, and, where empirical data were not available, NMFS' best professional judgment).

6.2.3.3 Estimates of Post-Bonneville Juvenile Mortality Related to Passage Through FCRPS Under Proposed Action

Any mortality of juvenile salmonids that occurs after fish have passed Bonneville Dam can be caused by natural processes such as predation, competition, effects of ocean productivity on growth and health, and climate-induced effects on habitat quality. However, mortality can also be related to a variety of anthropogenic factors such as poor fitness of introduced hatchery stocks, effects such as degradation of rearing habitat (including the estuary and nearshore ocean) on wild stocks, harvest, and delayed effects of passage through the hydrosystem. The latter, a subject of this biological opinion, is discussed in two forms: the differential delayed mortality (D) of transported fish (compared with inriver migrants), and the delayed mortality of inriver migrants.

6.2.3.3.1 Delayed Mortality of Transported Smolts. The differential delayed mortality of transported fish is expressed as the ratio of the post-Bonneville survival of transported fish to that of nontransported fish (differential post-Bonneville survival, D). If the ratio is 1.0 or greater, then transported fish have an equal or greater post-Bonneville survival rate than nontransported fish. If the ratio is less than 1.0, the post-Bonneville survival of transported fish is lower. In the latter case, the difference is generally attributed to delayed effects of the collection and transportation processes. NMFS estimated a mean value of D for the combined 1994 through 1997 outmigrations for SR spring/summer chinook salmon and SR steelhead (NMFS 2000i) using two methods for expanding empirical estimates of inriver survival (a step necessary to estimating D; see NMFS 2000i).

The two methods were used to produce the following range of mean D-values for each species:

	Mean 1994-97 D Estimate
SR spring/summer chinook salmon	0.63 - 0.73
SR steelhead	0.52 - 0.58

Although these estimates represent the best scientific information available at this time, NMFS notes that they are based on relatively small numbers of returning adults and that large confidence intervals surround each estimate (NMFS 2000i).

Even more uncertainty exists regarding the differential post-Bonneville mortality of transported SR fall chinook salmon. Because this species has not been the subject of formal transportation studies, the scientific justification for any given estimate of D is weaker than for SR spring/summer chinook salmon or steelhead. NMFS (2000i) reviewed the range of alternative assumptions used by Peters et al. (1999) to estimate D for this species: application of returns of transported and nontransported fish PIT-tagged during the 1995 outmigration; application of transport studies from McNary Dam (i.e., based on Hanford Reach fall chinook) to SR fall chinook; and comparisons of different assumptions about D and other values in relation to the best fit of a life-cycle model to the observed recruit-per-spawner data. The estimates of D derived using these alternative methods ranged from approximately 0.05 to over 1.0. NMFS (2000i) reviewed the methods and noted that each had inherent strengths and weaknesses. For purposes of this biological opinion, NMFS considers the PIT-tag method used by PATH more consistent with methods used by NMFS to estimate spring/summer chinook and steelhead Ds than either of the other PATH approaches. Using this method, PATH estimated D = 0.24, with very wide statistical confidence limits. NMFS finds that this represents the best fall chinook D-estimate currently available and applies it as a point estimate in the analyses discussed in Section 6.3, below. Because the estimate should be viewed with caution, NMFS presents a sensitivity analysis to a range of possible D-values in Appendix A.

For purposes of the analyses described in this biological opinion, the estimated D-values described above are assumed to have occurred under the conditions of the proposed action. Empirical evidence to the contrary is lacking. The D-value for UCR spring chinook salmon transported from McNary Dam is assumed equal to that estimated for SR spring/summer chinook salmon transported from all collector projects (between 0.63 and 0.73). The D-value for UCR steelhead transported from McNary Dam is assumed equal to that estimated for SR steelhead transported from all collector projects (0.52 to 0.58). Few individuals from these ESUs would be transported under the proposed action (current operations).

6.2.3.3.2 Delayed Mortality of Nontransported Smolts. Time-series of adult returns for salmon and steelhead indicate that stocks declined throughout the Pacific Northwest starting in the late 1970s (NRC 1996). However, stocks from the Snake River appeared to decline more than lower Columbia River stocks. PATH modeling on the effects of the hydrosystem on salmonid

populations indicated that direct losses through the hydrosystem alone could not account for the changes in spawner/recruit ratios observed between the 1960s and 1980s. The magnitude of this unexplained extra mortality depends on the analytical framework from which it is derived, since it is the leftover mortality or loss of productivity that is not accounted for by other predictor variables in a salmon life-cycle model. In the biological opinion modeling framework, which uses a different life-cycle model than that employed by PATH, the extra mortality is based on PATH models and is mortality that is not accounted for (or that may be incorrectly accounted for) by the following:

1. Spawner-recruitment productivity parameters

2. Estimates of direct mortality from inriver juvenile passage models

3. Estimates of additional delayed mortality of transported fish relative to inriver fish (D value)

4. A year-effect term that accounts for year-to-year changes in productivity that are common across a large group of stocks and that is intended to capture common environmental effects

PATH developed three hypotheses to explain the potential sources of the unexplained mortality: hydrosystem, ocean regime shift, and stock viability degradation (Marmorek and Peters 1998). Mechanisms by which the hydrosystem could produce extra mortality (i.e., in the form of delayed mortality of nontransported fish) include the effects of hydrosystem regulation on flow and the timing of ocean entry, the cumulative effects of stress/injury associated with bypass system or hydrosystem passage, and the effects of disease transmission and delay as fish transit bypass systems or fish ladders. Schaller at el. (1999) analyzed spawner/recruit data and contrasted productivity patterns for yearling chinook salmon stocks from the upper Columbia and Snake rivers with those from the lower Columbia River, concluding that differences in productivity between the upper and lower river stocks are primarily due to the number of dams each must pass (eight or nine versus three or fewer dams). The other two hypotheses proposed by PATH contend that the unexplained mortality is not caused by the hydrosystem and, therefore, is not delayed mortality. The ocean-regime-shift hypothesis attributes the recent low survival of salmonids to cyclical changes in ocean productivity. The stock-viability-degradation hypothesis represents the potential negative effects of hatcheries on wild stocks, including effects of diseases, inbreeding depression, etc.

Uncertainty continues over the importance of the hydrosystem as the source of extra (delayed) mortality, or whether the effect should be attributed to other factors. The rate at which mainstem projects were added to the hydrosystem is autocorrelated with changes in ocean productivity, changes in Columbia River hydrology affected by increased storage capacity in the upper Columbia and Snake river basins, reliance on hatcheries to meet production goals, habitat degradation, and other factors that came into play during the same period. Because these trends

coincide but were not planned as a statistical experiment, statistical methods cannot be used to define the cause of delayed mortality.

Recent PIT-tag studies also bear on the question of extra mortality as the delayed mortality of nontransported fish. The SARs of smolts that were PIT-tagged during the 1995 migration differed according to the number of projects at which they were detected (i.e., in the bypass system). The more frequently a fish was detected, the lower the SAR. These differences cannot be explained by differences in direct passage survival rates. Although there were insufficient returns from the 1996 migration to make similar estimates, and returns from the 1997 migration did not indicate a multiple bypass effect, the pooled 1995-through-1998 data indicate that adult return rates for fish that passed one or more times through the bypass systems are lower than for fish that were never detected (NMFS 2000e). The differences are not statistically significant.

NMFS (2000e) reviewed several hypotheses to explain the results. Consistent with the delayed mortality of nontransported fish, the reduced return rate may be a result of cumulative stress or injury associated with the bypass experience. Alternatively, NMFS (2000e) pointed out that the observations may be related to 1) problems with the PIT tags used in 1995; 2) problems associated with the PIT-tag diversion systems rather than the bypasses (which would not have affected the run at large); or 3) a higher incidence of bacterial kidney disease (BKD) infection in fish moving at greater depths (i.e., fish likely to be guided into bypasses). The second of these hypotheses was tested at Lower Monumental Dam during 1999. The results indicated no difference between fish bypassed directly to the river and those passing through the juvenile fish monitoring facility (NMFS 2000e). The third alternative was tested by exposing juvenile chinook salmon infected with the bacteria that cause BKD to stressors and hypoxia, simulating potential deleterious conditions during bypass passage (Mesa et al. 2000). Infection levels and mortality were unchanged.

NMFS (2000e) reviewed the evidence for or against each hypothesis regarding delayed mortality of nontransported fish. No conclusions were drawn, and NMFS noted the need for additional research. However, to conduct the analysis described in this biological opinion, it is necessary for NMFS to assume either that no delayed mortality exists, or that some level of delayed mortality occurs, based on the best available scientific information. The choice can have a significant effect on analytical results, as demonstrated by Marmorek and Peters (1998) and Peters and Marmorek (2000).

In light of this review, and on the basis of its best professional judgment, NMFS applied a range of delayed mortality assumptions to the analyses of Snake River ESUs in this biological opinion. At the low end of the range, NMFS assumed no delayed mortality of nontransported fish and, at the high end, assumed that all extra mortality estimated by PATH was delayed mortality, caused by passage through the four Snake River dams. It is doubtful that either of these extreme estimates is correct, but they were chosen to capture the range of possible values. Several agencies and organizations that reviewed the July 27 draft biological opinion commented that NMFS should abandon the 0% delayed mortality assumption. NMFS agrees that there may be

some nonzero minimum level of delayed mortality of nontransported fish. However, NMFS has no basis for defining that level. It is noteworthy that two of the three main PATH assumptions assume that this value is zero, as described above. For upper- and mid-Columbia ESUs, NMFS assumed that delayed mortality of nontransported fish might be as low as zero but would be no higher than the PATH estimates for the same species in the Snake River. For lower Columbia River ESUs, which pass no more than one FCRPS dam, NMFS assumed no delayed mortality.

6.2.4 Effects of Project Operation on Adult Salmonid Passage—General Considerations

Three specific components of adult migration through the FCRPS corridor may affect listed species: 1) delay at project fishways; 2) passage success at project structures; and 3) injuries and mortalities resulting from upstream and downstream passage through project facilities. Each component could increase prespawning mortality. For fish that reach spawning areas, indirect effects associated with passage through multiple dams can reduce fecundity and reproductive success. Unfortunately, the relationship between passage components and reproductive success is not clearly understood. In addition, a percentage of adults fail to enter project fishways and pass upstream. This could be due to a fish's inability to detect fishway entrances, or to the lack of distinguishable environmental cues inducing fish to continue upstream past the project. As a result of these indirect effects, a component of adult populations may not successfully spawn.

The hydrosystem may also have a positive effect on some aspects of the upstream migration. For example, travel time and energy expenditures of upstream migrants are lower in reservoirs than in free-flowing rivers. However, NMFS (2000e) estimates that the net effect of delay at dams, combined with faster passage through reservoirs, is a median travel time through the lower Snake River that is the same or faster with dams in place than with no dams.

Adult salmon and steelhead pass upstream through FCRPS dams by means of fishways that were installed as part of the original project construction. The fishways typically consist of an entrance gallery and ladder, a diffuser system that provides additional water at the ladder entrances (to attract fish from the tailrace), and a flow-control section at the ladder exit that maintains ladder flow over various forebay elevations. Observation areas are established in each ladder to monitor upstream progress (i.e., fish-counting stations). The ladders at Bonneville and Lower Granite dams have traps used for broodstock collection and monitoring. Migrational delays are most likely to occur at fish ladder entrances, in the collection galleries (at junctions between galleries and ladders), and when the traps are operated. Injury related to adult fish passage facilities is usually minimal. However, system failures (e.g., displacement of diffuser gratings in the entrance pools) can result in significant injury and mortality.

Adult passage information (e.g., time spent immediately downstream of the dam, success of entry into the collection channel and fishway entrances, time taken to traverse the ladder) is typically evaluated using radiotelemetry. Therefore, project passage data assess how well radio-tagged fish pass from the tailrace of a dam into and through its fish passage facilities. The

behavior of radio-tagged fish is assumed to be similar to that of untagged fish, and laboratory assessments of tagged and untagged fish and several years of field evaluations support this assumption (although little information is available regarding tagging effects on subsequent reproductive success). The data do not establish a direct relationship between project passage times and reproductive success, although hypothetically, any reduction in passage time would reduce an individual's energy expenditure and improve the likelihood that it would survive to spawn. Although specific criteria are not available, obvious delays in passage may indicate a need for operational or structural modifications.

Adult radio-tagged fish are monitored with aerial and underwater antennas as they move through the tailrace and into and through the fish passage facilities. Additional information can be collected by manually tracking radio-tagged fish from a boat or plane. Project passage times are only developed for radio-tagged fish that successfully pass the dam. Although data for fish that do not pass the dam are of equal or greater value, it is very difficult to determine a causative factor for this behavior. Failure to pass a dam may be the result of a poorly designed passage facility, inadequate attraction flows, or complicated flow patterns, exacerbated by project operations. Fish that fail to pass a dam may also be destined for a downstream spawning location or may have been injured before reaching the dam (due to natural or other effects). Tagging effects or regurgitated tags, none of which are related to operation of the facilities, can also be manifested in the data set and affect the conclusions. As a result, the detection rate of radio-tagged fish as they advance upstream indicates a rate of adult loss that cannot be entirely attributed to a particular experience, such as dam passage, but must be attributed to a combination of factors. This adult loss rate, termed "unaccountable adult loss," cannot be used to isolate specific cause-and-effect relationships between passage and reproductive success. It can be used, however, to assess the general, overall success of adult salmonids migrating upstream through the Snake and Columbia river corridors and to develop an index for assessing annual improvements in passage conditions. Nevertheless, factors contributing to unaccounted losses must be partitioned so that appropriate improvements can be determined.

6.2.4.1 Effect of FCRPS Project Operation on Adult Salmonid Passage

The survival of radio-tagged spring/summer chinook salmon from Ice Harbor Dam to Lower Granite Dam was high in the 1990s, ranging from 86% (1993) to 98% (1998) for adult fish tagged in the lower Columbia River. Migration rates vary with species, year, season, and environmental conditions. In general, fish appear to move through the projects at rates similar to unimpounded reaches. Bjornn and Peery (1992) concluded that, in the Snake River before impoundment, spring/summer chinook salmon migrated from 18 to 24 km/day. In recent radio-tracking studies (1996 to 1998), spring/summer chinook salmon traveled the reach between Ice Harbor and Lower Granite dams at a median rate of 14 to 20 km/day (Bjornn et al. 1998). Further, a 1993 comparison of travel times through impounded and unimpounded Snake River reaches showed little difference in median travel time for this species (Bjornn et al. 1999a). In 1998, the median migration rates for PIT-tagged adults between Bonneville and Lower Granite dams were 38 km/day for fall chinook salmon, 27 km/day for spring/summer chinook salmon,

and 14 km/day for steelhead of known Snake River origin. Steelhead migration rates vary with season and temperature (NMFS 2000e).

Adults can be delayed at dams during periods of high daytime spill (Turner et al. 1983, 1984) by increased difficulty in finding ladder attraction flows as well as fallback. Adult migration times increase as fish (re)locate the ladder and reascend the dam. Fallback rates as high as 20% have been documented for total dam fallback; a 28% fallback rate has been documented for fish exiting the Bradford Island ladder at Bonneville Dam (Bjornn et al. 1998). Mortality rates of 8% have been observed for adults falling back through spillways (Bjornn et al. 1998) and 14% to 26% for fallback through turbines (Mendel and Milks 1995).

The Biological Effects Team and NMFS used results from radiotelemetry studies to estimate minimal adult survival and unaccountable adult loss under the proposed action (current operations) for steelhead and spring/summer and fall chinook salmon passing through the FCRPS projects. Lacking telemetry study information for Snake River sockeye, the Biological Effects Team and NMFS used the survival estimate reported in the 1995 FCRPS Biological Opinion (based on 1985 to 1994 dam count analyses) and telemetry information collected in 1997 with sockeye tagged at Bonneville and monitored to Wells Dam on the upper Columbia. The current minimal survival for those Snake River species migrating through eight FCRPS dams is estimated to range from 71% for fall chinook salmon to 86% for sockeye (Table 6.1-1). The current minimal survival rates for steelhead and spring chinook salmon fall between these values. The Biological Effects Team and NMFS used these estimates of current minimal survival through eight dams to calculate the approximate per-project survival rate, assuming that the survival through each dam is similar. Current per-project minimal survival ranges from 96% for fall chinook to 98% for sockeye. These per-project minimal survival rates were then used to calculate minimal survival rates for species for which specific radiotelemetry FCRPS passage results were unavailable, such as UCR steelhead and spring chinook (Table 6.1-1). Unaccountable loss through eight dams, which range from 14% for sockeye to 29% for fall chinook, are attributable to unaccounted tributary turnoff, unreported catch, indirect effects of harvest, regurgitated tags, and dam passage (i.e., mortality during fallback through turbines).

6.2.4.1.1 Downstream Migrating Adults (Kelts). Unlike chinook salmon, steelhead may survive to spawn more than once. Before construction of most of the lower Columbia and lower Snake River dams, the proportion of repeat spawning summer steelhead was small, e.g., 3.4% (Long and Griffin 1937). A study of repeat spawners to the Clearwater River showed a 1.6% return (Whitt 1954). More recently, summer steelhead populations that do not pass through any dam or pass through only one (i.e., spawners from lower Columbia River tributaries) have approximately 7% and 3% proportions of repeat spawners, respectively (Howell et al. 1985, cited in Busby et al. 1996).

Data acquired through sampling in the Lower Granite and Little Goose dam bypass systems during the peak fallback season of April through June 2000 were used to arrive at a preliminary

estimate of 16,745 steelhead kelts present in the Lower Snake River at Lower Granite Dam during the study period (Evans and Beaty abstract in Corps 2000 Annual Research Review).

The mortality of kelts passing FCRPS projects has not been estimated. For those that pass through turbines, mortality is probably similar to that estimated for upstream migrating adults that fall back through turbines. It is unlikely that many kelts survive multiple dam passage to spawn a second time.

6.2.5 Effects of Water Regulation and Impoundments on Salmonid Migration and Survival—General Considerations

One indication of historical trends in salmonid habitat alteration by hydroelectric (and multipurpose) dams is the total amount of water stored by these projects (total storage capacities). The Corps (1984) defines major hydroelectric projects as those having an active storage capacity in excess of 100,000 acre-feet (kaf), or with an installed generating capacity greater than 40 megawatts (MW). According to the Corps, there are 89 such projects in the Columbia River basin. Their combined active storage capacity is over 57.3 million acre-feet (Maf), and their combined hydrosystem generating capability is over 35.7 gigawatts. This total storage capacity represents over 40% of the Columbia River's average annual runoff volume. Many of the largest storage projects have been developed in the area of the Columbia River above Chief Joseph Dam, the current upstream limit of the range of anadromous salmonids in the Columbia River.

Because the reservoirs have greater surface areas and volumes and lower water velocities than the undammed river, changes in water temperature, dissolved oxygen levels, turbidity, water chemistry, and aquatic habitat may result. In deep reservoirs, thermal and chemical stratification is likely to occur, with potentially significant effects on the aquatic life in the reservoir and farther downstream. The downstream effects can be either beneficial or adverse, depending on the site, water quality, and size of the impoundment. Fish that reside in reservoirs are often better adapted to the characteristics of slow-moving water than salmonids, which evolved in free-flowing systems.

In addition, because all but the most buoyant types of suspended materials settle out in reservoirs, these impoundments alter suspended loads and patterns of sediment deposition downstream. Altered particulate loads may affect aquatic assemblages in the water column and patterns of deposition in downstream river reaches, the estuary, and nearshore ocean environments.

6.2.5.1 General Effects of FCRPS Hydrosystem Operations on Salmon and Steelhead

Development of multipurpose storage dams and hydroelectric projects on the mainstem Columbia and Snake rivers has greatly altered the natural runoff pattern in the basin by increasing fall and winter flows and decreasing spring and summer flows. Spring runoff is now

stored in large headwater reservoirs so that it can be used to produce electricity on demand, as well as to provide benefits for flood control, irrigation, navigation, and recreation. Fourteen of the 89 basin reservoirs, both inside and outside the FCRPS, are routinely drafted in the winter and early spring to control mainstem floods and meet winter electrical loads. Changes in the pattern of runoff affect flow and temperature in the river channel as well as the character of the estuary and size of the freshwater plume in the nearshore ocean.

Dam development and reservoir storage on the mainstem Columbia and Snake rivers have reduced spring flows and increased the cross-sectional area of the river, resulting in reduced water velocities and downstream migration delays. Migrating salmon must pass up to nine dams and reservoirs on their migrations to and from the ocean. Longer travel time affects the migratory behavior of juvenile fish and increases their exposure to predatory fish and birds.

Adult salmon migrating to natal spawning grounds also are delayed at dams during high flow years, due to their difficulty in locating fish ladder attraction flows. For example, high flow and involuntary spill conditions, which can assist downstream migrants at mainstem dams, may hinder upstream fish migration by masking attraction flows to the fishway or inducing fallback. Adult fallback can cause mortality to fish passing through the turbines or can cause delay by requiring fish to find and reascend the ladder. High spills can also increase exposure to nitrogen supersaturation, which in extreme cases can result in direct or indirect (delayed) mortality. Increased migration time at several dams may have a cumulative effect, resulting in prespawning mortality of adult fish or reduced success of late spawners.

Operation of FCRPS projects has a systemwide effect on anadromous fish because of the integrated operation of the various Federal projects for power generation and flood control objectives (see below). Operational effects of FCRPS dams on salmonids include the following:

- Turbine mortality
- Migration delay, which may increase exposure to factors (such as disease) that reduce viability
- GBT and mortality
- Increased susceptibility to predation
- Bypass system and spillway mortality
- Combined effects resulting from regulated flows and temperature regimes
- Power-peaking operations resulting in stranding and dessication or exposure to bird predators

6.2.5.2 Streamflow Effects of FCRPS and Other BOR Project Operations

The FCRPS affects streamflow primarily through operations designed to produce power, control floods, and supply water for irrigation. The following sections describe the nature of power production, flood control, and water supply operations and estimates the effects of these operations on flow conditions in the mainstem Columbia and Snake rivers.

6.2.5.2.1 Electrical Generation. Each of the FCRPS projects in the lower Snake and Columbia rivers contains one or more powerhouses. The eight projects are operated in a coordinated fashion to meet current and anticipated electrical loads, both within the region and in other areas. Surplus generation is marketed by BPA. Electrical loads are typically highest from 6:00 a.m. to 10:00 p.m., are higher during weekdays than on weekends, and peak with seasonal heating and cooling demands. Operations for power production mimic demand.

The FCRPS and other power generating utilities in the Pacific Northwest are operated under the Pacific Northwest Coordination Agreement (PNCA) to meet anticipated electrical loads. The PNCA calls for annual planning, which must accommodate all the authorized purposes of the Columbia River hydro projects. It establishes processes that coordinate the use of planned U.S. - Canada Salmon Treaty storage operations with Federal and non-Federal project operations in the Northwest, and it enables the region's power producers to optimize system reliability and power production after giving priority to nonpower objectives. It recognizes project and system requirements that frequently change to serve multiple river uses. Individual project owners set the requirements for using their own reservoirs.

All PNCA parties coordinate to meet multiple-use system requirements. Power generation, which is planned under terms of the agreement, complies with these requirements. The PNCA planning process establishes day-to-day rights and obligations to exchange power, draft reservoirs, and associated transactions. The PNCA parties conduct annual planning. Each party to the agreement identifies its anticipated electrical loads, the output of its nonhydro resources, planned maintenance outages, and any existing contracts for firm energy purchases or exchanges. Each reservoir owner submits multiple-use operating requirements and constraints (flood control, irrigation, fish, wildlife protection, municipal use, and navigation) that must be incorporated into the annual plan. These requirements and constraints are analyzed to determine the firm energy load carrying capacity (FELCC) for the system as a whole and for each PNCA party individually.

The FELCC is the amount of energy each individual utility system, or the coordinated system as a whole, can produce on a firm basis during actual operations. Firm energy is produced over the region's worst water condition, called the critical period, defined as that portion of the 60-year streamflow record that would produce the least amount of power with all reservoirs drafted from full to empty. Reservoir draft limits (critical rule curve and refill curves) are established to facilitate meeting the FELCC while maintaining a high probability of refill. Reservoir operators are obligated to operate within the constraints imposed by these curves or else they incur power exchange obligations.

The effects of load-following are well outside the range of conditions that aquatic organisms might experience in a natural river. Little natural (free-flowing) habitat remains in the Columbia River downstream of Chief Joseph Dam. The reach between the head of McNary pool and Priest Rapids Dam (known as the Hanford Reach) is a notable exception. On the Columbia, the tailrace of one project flows almost immediately into the forebay of the next. Similarly, the natural river

has been replaced by reservoirs in the Snake River from the head of Lower Granite Reservoir to the Snake's confluence with the Columbia.

Through careful coordination, daily peaking operations result in modest changes in reservoir water levels. However, flow velocities within the reservoirs change diurnally in a pattern similar to the daily flow fluctuations, including a lag associated with reservoir hydrodynamics. In riverine sections like the Hanford reach (with shallow margins and gravel bars), flow fluctuations can lead to entrapment and stranding of spawning adults and juveniles in rearing habitat.

6.2.5.2.2 Flood Control. Flood control is an authorized purpose at six FCRPS storage reservoirs (Albeni Falls, Dworshak, Grand Coulee, Hungry Horse, John Day, and Libby). Both Federal and non-Federal storage reservoirs in the basin, including several U.S.–Canada Salmon Treaty reservoirs, are operated in a coordinated fashion to reduce the risk of floods, both in local areas downstream of several projects (local flood control) and in the Portland, Oregon–Vancouver, Washington, urban area (system flood control). The latter function—systemwide flood control—is accomplished by drafting the major storage reservoirs during fall, winter, and early spring, providing space to protect against unusual rainfall events and to capture the spring freshet. The Corps' objective is to "operate reservoirs to reduce to non-damaging levels at all potential flood damage areas in Canada and the United States insofar as possible, and to regulate larger floods that cannot be controlled to non-damaging levels to the lowest possible level with the available storage space" (Corps 1999b).

Runoff is forecast from monthly snowpack surveys from January to May, weather forecasts, soil moisture content, and anticipated future precipitation. The estimates are used to identify flood storage requirements at each project, using predetermined storage reservation diagrams. Also termed rule curves, the diagrams anticipate the minimum amount of storage that will be required at the end of each month to reduce flood risk to an acceptable level. As such, the rule curves also define the maximum reservoir water surface elevation allowed under existing conditions and criteria.

Flood control operations can be considered in two steps: reservoir evacuation (drafting) in advance of the spring freshet (most likely flood season in the Columbia basin) and reservoir refill during the freshet and temporarily during intervening runoff events. Drafting is conducted in two periods. During September through December, several projects are drafted to meet predetermined targets (runoff forecasts are not yet available, and early drafting facilitates the deep drafts required in the wettest years before the flood/refill season). Early drafts also provide protection from fall floods and increase system generation. During January through March, drafting varies with predicted runoff and available storage space, in accordance with established storage reservation diagrams. During April through July, reservoirs are gradually refilled to provide flood protection (by reducing river flows that would otherwise occur) while reducing potential spill, generating electric power, and providing the flows that outmigrating salmon need.

6.2.5.2.3 Effects of BOR Project Operations. The proposed action includes continued operation of BOR's 19 projects in the Columbia River basin (Table 1-1), excluding those in the Snake River basin, as they are currently operated.[3] Operation and configuration of BOR's projects have both direct and indirect effects on salmon survival. Direct effects include entrainment at project diversions, attraction to unsafe habitats such as wasteways, and discharge of warm and/or contaminated water from wasteways. Indirect effects are primarily associated with changes in flow timing due to reservoir storage management activities and streamflow depletion from water withdrawals. Of these, NMFS considers streamflow changes the most pervasive, affecting flow-dependent habitat in tributaries, throughout the migration corridor, and into the estuary.

By storing and releasing water at project reservoirs and by diverting water to serve project lands, BOR project operations affect streamflow conditions downstream of each project. Except for the Hungry Horse Project, all BOR projects deplete streamflows by making water available for irrigation, providing most of the Federally authorized irrigation water in the basin. About 33 Maf are diverted from the Columbia River and its tributaries annually for private and Federal irrigation, and about 14 Maf of this total are consumed (BOR 1999a). Of the 4.1 Maf diverted at BOR projects upstream of the Columbia River's confluence with the Snake River, 2.3 Maf are consumed (BOR 2000a) (Table 6.2-1).[4] All but about 311 kaf of this 2.3 Maf depletion occurs when available storage is being managed to achieve NMFS' flow objectives (April through August).

As indicated in Section 1, this analysis focuses on BOR irrigation project effects on streamflow in the mainstem Columbia River during the juvenile salmon migration season (April through August). Where they exist, other salmon survival effects of BOR's projects (except the Columbia Basin Project and projects upstream of Chief Joseph Dam) will be further evaluated in consultations designed to supplement this biological opinion. All known effects of the Columbia Basin Project are described here and in Section 6.2.5.2.5. These effects could occur in the tributaries, the mainstem Columbia River, and the Columbia estuary. The only known effects of

[3]Because of ongoing negotiations in a general adjudication of water rights under way in Idaho, BOR could not adequately define its proposed action to facilitate consultation for its 11 irrigation projects in the Snake River basin. Since discussions are continuing, BOR has indicated that the proposed action may be different from those measures set forth in its December 21, 1999, biological assessment. Accordingly, BOR has asked to extend the consultation on these 11 projects pending a revised proposed action and analysis of effects. NMFS has agreed to extend the current consultation with regards to BOR's projects in the Snake River basin and to exclude those projects from this biological opinion. BOR anticipates providing the necessary additional information, and NMFS anticipates issuing a supplemental biological opinion on these projects before water from these projects is needed for irrigation use in the 2001 growing season.

[4]These water consumption estimates are based on crop consumption data. Actual streamflow depletions may be larger due to evaporation in project reservoirs, conveyance losses, and in the case of the Columbia Basin Project, losses from an extensive network of secondary reservoirs and wetlands. The estimates also assume that diverted water that is not consumed by crops returns to the river during the months in which the diversions occur. This is not always true. Actual streamflow depletion effects of BOR-supplied irrigation during the juvenile salmon outmigration range between the total amount of diversions and storage change (11.4 Maf) and total crop consumption (5.6 Maf).

the projects above Chief Joseph Dam on listed salmon and steelhead result from the cumulative hydrologic effects of their operations on streamflows in the Columbia River downstream of Chief Joseph Dam.

Estimating the hydrologic effects requires defining the flow conditions that would occur if BOR's projects did not exist or were operated with constant storage volumes and without diversion. For purposes of this biological opinion, NMFS defines the "constant storage" environmental baseline as the estimated flows under current operations at a given point plus the current levels of BOR-caused flow changes upstream of that point, less any return flows. Flow change includes reservoir operations and can result in increased streamflows when reservoir drafting exceeds crop consumption rates. The principal sources for these data are estimated mean monthly water use for recent years, provided by BOR (2000a,b), and the estimated hydrologic effects of operating all projects in the basin as proposed over a 50-year record (1929 through 1978), provided by BPA (2000a).

Table 6.2-1. Estimated monthly average crop water consumption (acre-feet of water consumed) at BOR's irrigation projects in the Columbia River basin.

Project	March	April	May	June	July	August	September	October	Project Totals
Columbia Basin Project	53,708	237,659	247,423	228,452	266,389	213,787	141,075	76,479	1,464,972
Yakima Project		13,608	119,524	190,512	217,955	119,524	27,216	7,031	695,370
Green Spots [1]		2,457	17,139	34,400	50,781	29,834	5,529	635	140,775
Upper Basin Totals	53,708	253,724	384,086	453,364	535,125	363,145	173,820	84,145	2,301,117
Umatilla Project			11,456	16,468	21,480	16,468	5,728		71,600
Deschutes River			40,715	69,797	93,062	78,521	11,633		293,728
The Dalles		504	1,890	2,520	3,276	2,646	1,512	252	12,600
Willamette River		297	1,782	9,207	13,662	3,861	891	297	29,997
Basin Totals	53,708	254,525	439,929	551,356	666,605	464,641	193,584	84,694	2,709,042

Source: BOR 2000(a,b).
[1] Several small projects in the upper Columbia River basin (Bitteroot, Missoula Valley, Frenchtown, Dalton Gardens, Avondale, Rathdrum Prairie, Spokane Valley, Chief Joseph, and Okanogan).

Hydrologic effects are not biological effects. Streamflow conditions in the migration corridor have been found to affect juvenile salmon survival (NMFS 2000h), however, and NMFS has established flow rates at several sites that serve as water management objectives to protect outmigrating juvenile salmon (NMFS 1995a, NMFS 1998). This assessment focuses on how BOR-based flow depletions affect the probability that the flow objectives can be achieved.

Several commenters noted that even if BOR discontinued delivering water for irrigation, it is unlikely that all the released water would remain instream. Private diversions would capture some fraction of the water, perhaps most. Therefore, although the following analysis attributes

substantial streamflow depletion effects to BOR project operations, it is not clear that BOR could, with any reasonable certainty, avoid these effects.

Based on recent water use information (BOR 2000a,b), the combined effects on Columbia River flows at Priest Rapids and McNary dams of all the BOR projects considered in this opinion are shown in Table 6.2-2.

Table 6.2-2. Estimated monthly streamflow depletions (cfs) at Priest Rapids and McNary dams caused by BOR's 19 irrigation projects in the Columbia River basin.

	April	May	June	July	August
Priest Rapids	4,042	4,310	4,425	5,167	3,969
McNary	6,654	8,604	7,647	6,056	1,681

Source: BOR 2000a,b.

In the following analysis (Tables 6.2-3 and 6.2-4), the frequency with which mean monthly streamflows for each month during the juvenile migration season (April through August) over the 50-year simulation (BPA 2000a) would meet the applicable objective under the proposed action (BPA 2000a) is compared with objective attainment without BOR-based irrigation. NMFS assumes that the estimated monthly streamflow depletions attributable to BOR in recent years (BOR 2000a,b) approximates the quantity of BOR depletions for all years. This assumption is required because whereas total streamflow depletions have been estimated on a monthly basis for the entire period of record (BPA 1993, BOR 1999b), no previous study has isolated the effects of BOR-based irrigation depletions from total irrigation depletions.

Table 6.2-3. Percent of years that simulated mean monthly flows at Priest Rapids Dam from 1929 through 1978 (50-year record) would meet NMFS' flow objectives without BOR-caused flow changes and under current operations (proposed action). [1]

Month (objective)	Without BOR-caused Flow Changes	Current Operations	BOR-caused Nonattainment
April (135 kcfs)	62 %	56 %	6 %
May (135 kcfs)	90 %	86 %	4 %
June (135 kcfs)	86 %	78 %	8 %

Source: NMFS analyses, based on BOR (2000a,b) and BPA base case HYDROSIM run 00FSH30 (BPA 2000a).
[1] The seasonal flow objective is considered met if monthly average flows are within 1,000 cfs of the objective.

Table 6.2-4. Percent of years that simulated mean monthly flows at McNary Dam from 1929 through 1978 (50-year record) would meet NMFS' flow objectives [1] without BOR-caused flow changes and under current operations (proposed action).[1]

Month (objective)	Without BOR-caused Flow Changes	Current Operations	BOR-caused Nonattainment
April (220-260 kcfs)	60 %	48 %	12 %
May (220-260 kcfs)	74 %	64 %	10 %
June (220-260 kcfs)	58 %	50 %	8 %
July (200 kcfs)	52 %	48 %	4 %
August (200 kcfs)	10 %	8 %	2 %

Source: NMFS analyses, based on BOR (2000a,b) and BPA base case HYDROSIM run 00FSH30 (BPA 2000a).
[1] The seasonal flow objective is considered met if monthly average flows are within 1,000 cfs of the objective.

As illustrated above, operation of BOR's reservoirs and consumption of delivered water on project lands reduces the frequency with which the flow objectives can be achieved, particularly during the spring. The spring effects include those of reservoir refill, as well as crop consumption. Reservoir refill effects are at least partially attributable to flood control operations that cannot easily be isolated from storage needed because of previous water deliveries. Irrigation-caused streamflow depletions during the summer are moderated by reservoir releases. It is, therefore, apparent that BOR's 19 projects adversely affect flow and flow-dependent salmon survival in the Columbia River primarily in April, May, and June.

Beyond these flow-depletion effects, there are other operational effects on the ability meet the flow objectives. For example, BOR operates Lake Roosevelt (Grand Coulee) to be at or above elevation 1,240 by May 1 to supply irrigation water to clients in the Columbia Basin Project. Under this operation, Grand Coulee can store water while downstream flow objectives are not being met.

These projects also have hydrologic effects outside the juvenile salmon migration/irrigation season (September through March). Depending on storage conditions and water supply forecasts, BOR may evacuate project reservoirs to provide flood storage or store incoming water to improve the likelihood of meeting subsequent irrigation demands. Those activities affect fish in the river at the time (e.g., lower Columbia River chum) and influence the reservoir storage that would have to be refilled during the spring freshet, thereby affecting subsequent juvenile migrants. The effects of storage operations during the juvenile migration season are reasonably captured in the water-use analysis presented above. The effects of BOR reservoir operations from September through March are considered in the broader systemwide context of reservoir operations, discussed in Section 6.2.5.2.4 below.

6.2.5.2.4 Cumulative Hydrologic Effects. By providing a storage capacity of almost 40% of the average annual runoff of the Columbia River above Bonneville Dam and operating to meet

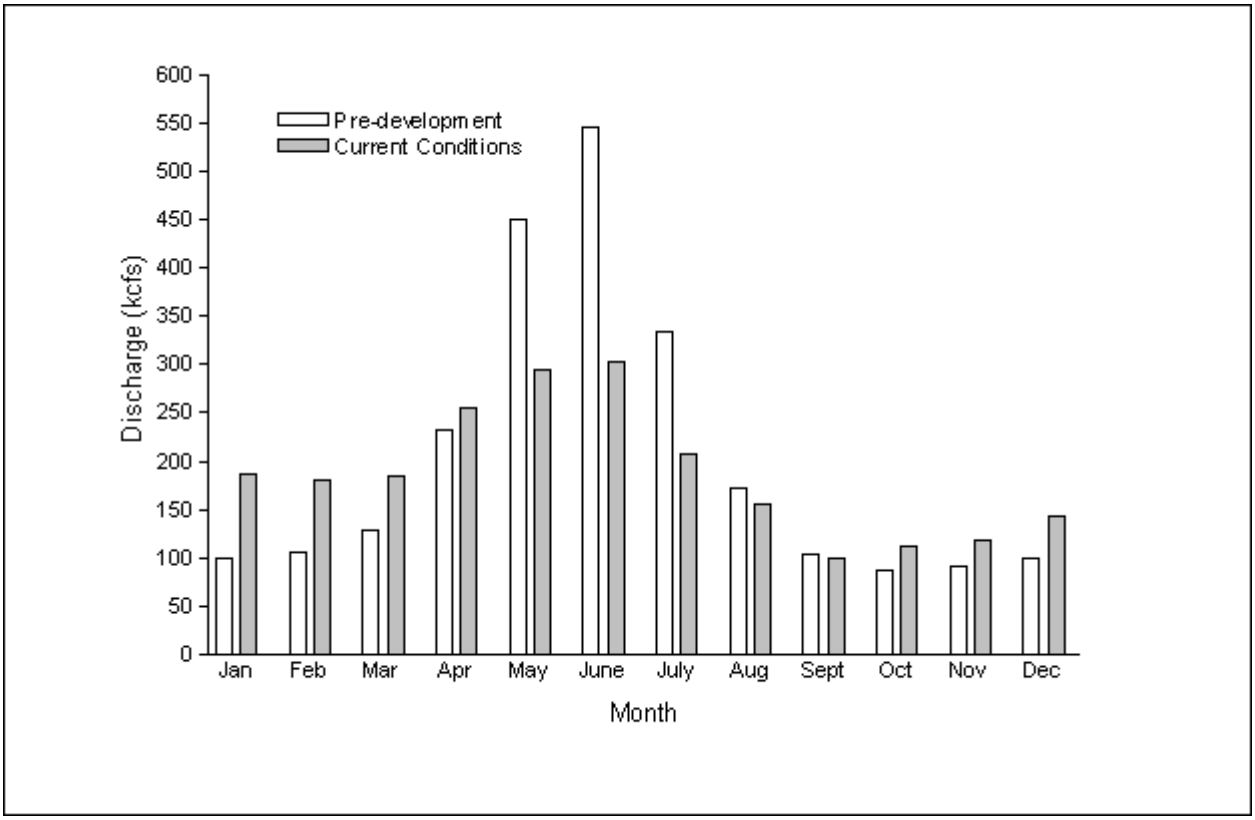
electrical generation, flood control, and irrigation demands, reservoir operations affect streamflow conditions in the river (Figure 6.2-1). The spring freshet (May through July) has been greatly reduced, affecting turbidity and sediment transport, estuary conditions, and the extent and characteristics of the Columbia River plume in the Pacific Ocean. Under the proposed action (current operations), mean monthly flows at Bonneville Dam in August and September mimic natural conditions. During October through March, current operations generally augment natural flows, potentially benefitting fall spawners in the Ives Island area below Bonneville Dam. Current mean monthly flows during April again mimic natural conditions. Even in months when current mean flows are similar to natural conditions, the range of weekly, daily, and hourly fluctuations due to reservoir operations for electrical load following greatly exceed what would be expected under natural conditions. Further, near-natural streamflows do not overcome the effects on salmon survival presented by the conversion of much of the river from free-flowing to a series of impoundments.

Nearly 71% of the 47 Maf of active storage capacity in the Columbia River basin is above Chief Joseph Dam (Corps 1991, NWPPC 1987), about 20.4 Maf of which is located in Canada. Therefore, most of the change in the natural shape of the hydrograph in the lower Columbia River is due to streamflow regulation in the upper basin, a substantial portion of which occurs in Canada and is outside the scope of this consultation. Also, non-Federal water developments (principally irrigation) deplete Columbia River flows by about 7 Maf annually. While Federal reservoir operations appear to be responsible for about half the total change in streamflows at Bonneville Dam depicted in Figure 6.2-1, these hydrologic effects have implications for salmon survival through the FCRPS and downstream of it.

6.2.5.2.5 Additional Effects of Columbia Basin Project. The Columbia Basin Project is BOR's largest irrigation project in the upper Columbia River basin (above McNary Dam), diverting 2.7 Maf of water to irrigate 672,000 acres of land (BOR 2000a). Project lands extend from Billy Clapp Lake, about 40 miles south of Grand Coulee Dam, to the edges of the Pasco and Richland, Washington, metropolitan area. The continued operation of the Columbia Basin Project may affect listed salmon and steelhead in ways other than those defined by the flow-depletion analysis above.

Water Quality. Columbia Basin Project wasteways deliver irrigation waste water to several locations in the Columbia River downstream from Rock Island Dam. The BOR estimates that the total combined capacity of these wasteways to be less than 700 cfs (BOR 2000b). Temperatures of return flows occasionally range up to 90°F (32°C) (BOR 2000c). Irrigation return flows may also contain high concentrations of plant nutrients (nitrogen and phosphorus) and pesticide and herbicide residues. The effects of such pollution in the Columbia River is probably small, given the river's dilution capacity (wasteway capacity is about 0.4% of average river flows). Further, water use in the Columbia Basin Project is increasingly efficient (Montgomery Water Group 1997). That is, deliveries to farmland are approaching the amount of water required by crops. Therefore, less water is wasted, and less wastewater and pollutants return to the river in project wasteways. NMFS is concerned, however, that even small

Figure 6.2-1. Simulated mean monthly discharge at Bonneville Dam before development and under current project configuration and operations. Source: BOR (1999b).



Note: Data were developed by simulating streamflows under the alternative conditions over the 50-year period from September 1929 through October 1978. Current conditions include about 7 Maf of private-irrigation-caused streamflow depletions and Canadian reservoir operations not associated with the proposed action.

concentrations of some agricultural chemicals can adversely affect the aquatic community in general and salmon in particular (Scholz et al. 2000, Waring and Moore 1997).

Adult Attraction to Project Wasteways. Spawning adult chinook salmon have been observed in the lower portions of some of the Columbia Basin Project wasteways. Given the poor water quality in these wasteways, it is likely that spawning success is low to nonexistent. Spawning fish in this area are primarily unlisted upriver bright Columbia River fall chinook salmon. NMFS is not aware of any information on whether these wasteways attract listed fish.

Entrainment at Unscreened Diversion Pumps. The Columbia Basin Project owns and operates two pump plants (Burbank No. 2 and Burbank No. 3) in Lake Wallula (McNary pool) that are not currently screened. The intakes may attract and entrain rearing juvenile salmonids.

6.2.5.3 Effects of Water Regulation and Impoundments on Salmonid Migration and Survival

Most of the information in this section is taken from the NMFS white paper on flow, travel time, and survival (NMFS 2000h).

Hydroelectric system storage and regulation reduce river flows significantly during the spring and early summer months, when juvenile salmon and steelhead migrate downstream to the ocean (Figure 6.2-1). Reservoirs created by dams have increased the total cross-sectional area of the river, decreasing water velocity and turbidity. These conditions have led to increased travel time for migrating smolts and subjected them to greater exposure to predators and other factors of mortality (Raymond 1979, 1988; Williams et al. (in review). Moreover, the change from free-flowing river to a series of reservoirs has substantially modified the river's thermal regime. The large mass of stored water (approximately 48 Maf) has created thermal inertia, making the river slower to cool in the fall and slower to warm in the spring, thus moderating temperature extremes. Through a variety of mechanisms, these flow-related environmental changes have affected the timing of saltwater entry for juvenile migrants. Fall chinook salmon from the Snake River basin are particularly susceptible to changes in the thermal regime as they spawn and rear in the mainstem river. Further, delays in their migration due to slack water impoundments place these juvenile migrants in reservoirs during periods when water temperatures approach chinook salmon's thermal tolerance.

Flow can also affect levels of spill at dams which affects smolt travel time and survival. Spill can be forced (flow exceeds hydraulic capacity of the project) or voluntary. Voluntary spill has been used extensively since 1995 to reduce the proportion of smolts passing through turbines as prescribed in the 1995 FCRPS Biological Opinion (NMFS 1995a). Use of spill increases survival by passing greater numbers of smolts over the spillway, the route of passage with the highest survival. Spill can also reduce smolt travel time by reducing delay in forebays.

Spring migrants (spring/summer chinook salmon and steelhead) and summer migrants (fall chinook salmon) have distinct life histories and migrate downstream during separate periods. Thus, flow augmentation will have different effects on those classes of salmonids.

Spring migrants actively move through the hydrosystem as yearlings (or older). NMFS has not detected a relationship between flow and survival in the Lower Granite to McNary reach (NMFS 2000h). However, due to data limitations, these analyses did not examine the relationship through the reservoirs below McNary Dam and thus do not fully address potential flow effects. For example, predation by the northern pikeminnow is considerably higher in lower Columbia River reservoirs and the free-flowing river below Bonneville Dam than in the Snake River (Ward et al. 1995). NMFS (2000h) demonstrated, through its own analyses and a review of other studies, a strong and consistent inverse relationship between travel time and flow for spring migrants. Thus, by decreasing the residence time of smolts in the lower river, higher spring flows may reduce exposure to predators. This hypothesis has yet to be tested, but the existence

of survival benefits from increased flow expressed outside the lower Snake River study reaches is supported by relationships between SARs or recruits-per-spawner and seasonal flow (NMFS 2000h).

A significant negative relationship between smolt travel time through the Snake River and subsequent return of adults (expressed as SARs) has been described for wild spring/summer chinook salmon from Marsh Creek, Idaho, for the years 1960 to 1987 (Petrosky 1992). That is, fewer adults return from years when the juvenile migration takes longer because of low stream flows than during high-flow years when the juveniles move faster. A significant relationship was observed between estimates of 1964 to 1984 SARs of all wild SR spring/summer chinook stocks (Raymond 1988) and estimates of water particle travel time during outmigrations. Smolt travel time is fairly well predicted by water particle travel time. Last, an analysis of an adult spring/summer chinook wild stock returning to the Imnaha River (tributary of Snake River) indicates that SARs are correlated with smolt travel time (Petrosky and Schaller 1992). To summarize, several studies indicate a relationship between river conditions when juveniles outmigrated and the rate at which adults returned from those juvenile year classes. Years of higher river flow produced higher rates of adult returns than low-water years.

A limitation of survival estimates made by using PIT-tags is that they measure only direct survival through part of the hydrosystem. Conditions smolts experience during migration are reflected in the estimates of smolt survival, but the indirect effects, or delayed mortality (mortality caused by passage experience that occurs downstream from PIT-tag detection sites), are not. Slower travel times could result in greater depletion of energetic reserves, reversal of smoltification characteristics, and greater exposure to disease. These factors could lead to delayed mortality not captured in the existing juvenile smolt survival studies.

SR fall chinook salmon begin downstream migration in the late spring or early summer as subyearlings. Downstream migration is protracted over several months and is accompanied by rearing. This complex life history makes interpreting data more difficult compared with spring migrants. NMFS (2000h) concluded that highly significant relationships existed between survival from release points in the Snake River to Lower Granite Dam and the factors of flow, river temperature, and turbidity for SR fall chinook salmon. Also, survival decreased markedly from early to late release dates. Because environmental variables were highly correlated, determining the most important factor for subyearling fall chinook salmon survival is not possible. The inconsistent relationships between survival from Lower Granite Dam to Lower Monumental Dam and flow, river temperature, and turbidity from year to year (NMFS 2000h), create uncertainty in the fall chinook analysis. However, releases of cold water in the summer from Dworshak Dam on the North Fork of the Clearwater River not only can help reduce elevated water temperatures, but at the same time can augment flow during the summer when juvenile SR fall chinook migrate.

River flow, water temperature, and turbidity can affect subyearling fall chinook survival in a number of ways. Fish that migrate under lower flows later in the season may be more

susceptible to disorientation, reversal of smoltification, disease (Park 1969, Raymond 1988, Berggren and Filardo 1993), and a decreased tendency to migrate under conditions of low turbidity (Steel 1999). Thus, they may experience passage delays. Although the evidence for these effects is inconclusive, it indicates a potential adverse effect of the proposed action in the form of migration delays. In addition, operations at dams change under lower flows (e.g., less spill, greater diel-flow fluctuations) in ways that can decrease fish survival. Warmer water for late-season migrants leads to increased metabolic demands of predators (Curet 1993, Vigg and Burley 1991, Vigg et al. 1991) and thus to increased predation rates. The FGE of turbine intake screens is also reduced in warmer water, resulting in more fish passing through turbines (Krcma et al. 1985), which may cause decreased survival. Vulnerability to sight-feeding predators also increases as turbidity decreases (Zaret 1979) by increasing predator reactive distance and encounter rates (Vinyard and O'Brien 1976, Shively et al. 1991). Higher turbidity reduces predation rates on juvenile salmonids by providing protective cover during rearing (Simenstad et al. 1982, Gregory 1993, Gregory and Levings 1998).

Research since 1995 suggests that the spring flow objectives in the Action Agencies' proposed action for the Snake and Columbia rivers are reasonable. These flows do not mimic historical (predevelopment) streamflows, nor do they entirely overcome the migration delay imposed by the hydrosystem's dams and impoundments. However, the juvenile spring/summer chinook salmon that migrate downstream through the system have had, in recent years, direct survival rates that approach levels measured in the 1960s. This does not imply that smolt survival levels are high enough to ensure recovery for the species, nor does it suggest that flow management is the primary cause of this improvement. Rather, it suggests that flow management, in conjunction with all other fish protection measures, has had a beneficial effect on smolt survival.

Evidence for a survival benefit to fall chinook salmon from flow management is supported by research results. Data sets consistently demonstrate strong relationships between flow and survival and between temperature and survival (NMFS 2000h). Providing suitable environmental conditions would probably yield substantial survival benefits. The data indicate that the benefits of additional flow in the Snake River continue at flows well above those recently observed during a wetter-than-average hydrologic condition that included the use of stored water to augment flows (but below that observed in 1997, when survival was lower).

The likelihood of meeting the flow objectives through the Action Agencies' proposed action is summarized in Table 6.2-5.

6.2.5.3.1 Water Regulation Affects Spawning and Rearing Areas. Fall chinook salmon are known to spawn in the tailraces of Lower Granite, Little Goose, and Ice Harbor dams. Dauble et al. (1999), conducting spawner surveys using underwater video techniques, found a few redds (<20) per year of study (1993 through 1997). Although within-site fidelity appeared high, the frequency of use of known tailrace spawning areas varied. In addition, the importance of these areas to the viability of the ESU and the effects of FCRPS flow management on habitat use are unknown.

Table 6.2-5. Percent of year flows at Lower Granite, Priest Rapids, McNary, and Bonneville dams are expected to meet or exceed specified flow objectives under base case, based on 50-year simulation (1929 through 1978).

Period	Project			
	Lower Granite	Priest Rapids	McNary	Bonneville
January	N/A	N/A	N/A	88
February	N/A	N/A	N/A	78
March	N/A	N/A	N/A	78
April	38	56	48	N/A
May	60	86	64	N/A
June	68	78	50	N/A
July	40	N/A	48	N/A
August	0	N/A	8	N/A
September	N/A	N/A	N/A	8
October	N/A	N/A	N/A	20
November	N/A	N/A	N/A	74
December	N/A	N/A	N/A	90

Source: BPA 2000a. Flow objectives are Lower Granite Dam – 85 to 100 kcfs (spring) and 50 to 55 kcfs (summer); Priest Rapids – 135 kcfs (spring); McNary Dam – 220 to 260 kcfs (spring), 200 kcfs (summer); Bonneville Dam – 125 kcfs (November through March). Probability of flows exceeding 125 kcfs at Bonneville Dam during September or October are also shown, although there is no flow objective during those months under the proposed action. N/A = not applicable.

Most subyearling SR fall chinook salmon rear in the free-flowing Snake River above Lower Granite Reservoir. Connor et al. (1999) reported that these fish become pelagic-oriented once they enter the reservoir. As described above (Section 6.2.5.3), flow management operations that affect travel time, water temperature, and turbidity may affect the growth and survival of these subyearlings in a number of ways, including relative vulnerability to predation. However, there is no evidence that food resources in the pelagic zone would be adversely affected under the proposed action.

A relatively small proportion the subyearling population in the lower Snake River rear in the lower Snake River reservoirs—fry that are swept downstream from spawning areas in the lower Grande Ronde and Clearwater rivers and the mainstem Snake River below Hells Canyon Dam, and individuals spawned in the tailraces of Lower Granite and Little Goose dams. Curet (1993) reported that subyearlings were distributed primarily over sand substrate along the shoreline of Lower Granite and Little Goose reservoirs during their early rearing period, becoming pelagic-oriented when shoreline temperatures exceeded 64° to 68°F (18° to 20°C). Littoral zone food

resources could be adversely affected if load-following operations periodically dewatered the substrate. However, the 1995 RPA required the Corps to operate the lower Snake pools within 1 foot of minimum operating pool, minimizing the disruption of nearshore habitat.

Hydrosystem operations also influence ecological conditions (flow, water depth) of habitat necessary for spawning, incubation, and rearing in the mainstem area (Ives Island) below Bonneville Dam. Flow management helps maintain immigration corridors between the mainstem and tributaries used for spawning by chum salmon, as well as emigration corridors for smolts. Average daily flows and flow fluctuations can affect the areal extent of available spawning habitat, cover or dewater redds, and strand juveniles and adult salmon.

Both LCR chinook salmon and CR chum salmon have been observed spawning in the Ives Island area below Bonneville Dam. LCR chinook salmon, tule-type fish that are distinguished from upriver or lower river brights by their body color (brownish tinge) and shape as well as early run timing, were observed there for the first time during October 1999 (Hymer 1999b). Field biologists reported a peak count of 45 redds on October 19th (ODFW and WDFW 1999). CR chum salmon were first observed in the Ives Island area during 1967 (ODFW, WDFW, and USFWS 1999). Targeted censuses began in 1998, when the species was proposed for listing. Both the hydraulic connection between the backwater area that separates Ives and Pierce islands (and the mainstem Columbia River) from the Washington shoreline and the areal extent of submerged spawning habitat are strongly affected by FCRPS flow management and tides. According to USFWS, ODFW, and WDFW field biologists, a Bonneville outflow of at least 125 kcfs is needed to create and sustain the hydraulic connection, with a higher flow needed to counteract any temporary drop in river elevation (e.g., during the lower low of a spring-tide cycle) (FPAC 1999). However, before construction of the Bonneville Second Powerhouse, flows as low as 90 kcfs may have been sufficient to maintain the connection (Corps 2000a). The slough that separated Hamilton Island from the Washington shoreline was bisected by a dike and backfilled with materials excavated from the construction site for Powerhouse II beginning in the mid-1970s (Harza 2000).

Although chum salmon redds can be superimposed in pristine systems, this condition may indicate that the carrying capacity of spawning habitat is exceeded (Burner 1951). Keeley et al. (1996) found that the number of migrating fry per m^2 in side channels to tributary streams reached a maximum when female density reached 1 per m^2. The Ives Island spawning area is essentially a side channel to the Columbia River. Preliminary results from a piezometer study show that it may share an important habitat characteristic with smaller side channels used by this species, upwelling through at least a portion of the available gravel (Geist 2000). Thus, flow management operations that restrict the areal extent of habitat in the Ives Island area, either by limiting access to potential habitat or by degrading habitat quality through fluctuating flows, are also likely to affect carrying capacity. The specifics of these functional relationships (i.e., effects of flow levels on the carrying capacity of spawning habitat in the Ives Island area) are the subject of ongoing research.

Chum salmon spawn in the lower Columbia River during late October through December, typically after local precipitation begins and baseflows increase in the mainstem. At present, access to chum salmon spawning habitat in Hamilton Creek and its tributary, Spring Channel, (and possibly to Hardy Creek, Hymer 1999a) is also maintained by FCRPS flows greater than 125 kcfs. Flows at this level are more likely to occur during November and December than before mid-October. However, as stated above, access may now depend on higher mainstem flows than before the Corps bisected and backfilled Hamilton Slough.

Flow through the Ives Island area is important not just during the fall spawning period but also through incubation, rearing, and emergence. Salmon sac-fry larvae are particularly vulnerable to GBT.[5] Operations such as spill for debris removal, gas generation/abatement testing, or spill for juvenile fish passage (e.g., the March release of hatchery smolts from Spring Creek fish hatchery) can create TDG concentrations high enough to kill yolk sac fry. However, mortality can be prevented by providing flows that create a compensation depth over the redds, reducing the effective TDG concentration to 105% of saturation or less.[6]

Seining data collected by the Oregon and Washington departments of fish and wildlife show that the body size (fork length) of subyearling chinook salmon captured in the Ives Island area during winter/spring 1999 and 2000 increased progressively during the period January through July (USFWS 2000b). Because tule fall chinook salmon spawned in this area only during fall 1999, most of these observations pertain to Ives Island brights (UCR summer/fall-run chinook salmon). However, it is likely that tule fall chinook also rear in the Ives Island area before emigration. Emigrating smolts and any juvenile chinook that rear in the area are subject to stranding and death due to dessication or bird predation under some Bonneville operations. In contrast, the seining data show that CR chum salmon leave the area soon after emergence (USFWS 2000).

Juvenile fall chinook salmon emerging from the Ives Island area are likely to rear in the mainstem lower Columbia River. Juvenile chinook salmon collected by beach seine at eight sites between the mouth of the Willamette River and the estuary appeared to grow in total length between April and July 1993 (Hinton and Emmett 1994). This statement is based on the shift in the mode of the length frequency distribution for fish captured each month.

6.2.5.3.2 Food Resources and Physiological Status. The hydrosystem has changed the juvenile salmonid migration corridor from a free-flowing river to a series of run-of-the-river impoundments. There are few empirical data on the relationship between FCRPS operations, food supply, diet, growth, and the physiological processes that control growth. NMFS is uncertain whether yearling chinook migrants have a biological requirement for food in the juvenile migration corridor or, if food is needed, whether the abundance or composition of the

[5] Once the yolk is fully absorbed and the body cavity has "buttoned up," fry are relatively tolerant to high TDG concentrations.

[6] Depth compensation is equal to a 10% reduction in TDG for each meter of water depth (Weitkamp and Katz 1980). For example, if TDG measured in the water over the shallowest redd is 115%, there must be at least 1 m of water covering the redds to give an effective TDG of 105% at the redd level.

prey assemblage is adversely modified by FCRPS operations. However, subyearling SR fall chinook grow and thus have a biological requirement for food in the juvenile migration corridor. As described in the preceding section, subyearling chinook salmon are primarily pelagic-oriented once they reach the head of Lower Granite Reservoir, but a small proportion of the run occupies shallow, sandy areas. Food resources in the pelagic zone of mainstem reservoirs are different from those in free-flowing reaches (e.g., terrestrial insects and zooplankton predominate in reservoirs versus aquatic insects in the free-flowing river). NMFS is uncertain, however, whether this change in prey assemblage adversely affects biological requirements for food during the juvenile migration. Similarly, water-level fluctuations associated with reservoir operations may affect the life cycles of invertebrate prey, but the existence of this effect in the Snake and Columbia river reservoirs downstream, and the potential implications for SR fall chinook subyearling migrants, are hypothetical at this time.

Although physiological processes in Pacific salmon have received a great deal of attention (Groot et al. 1995), studies have focused primarily on fish reared in production or experimental hatcheries. Smolting is a critical process for cultured fish; fish released from hatcheries as smolts are more likely to show directed migration to the ocean (Zaugg 1981, 1989; Muir et al. 1994). McKenzie et al. (1983, 1984) demonstrated that higher downstream survival of yearling hatchery fish was associated with higher percent body lipid at release. However, little is known of the endocrine and physiological status of naturally reared salmon. In a recent study in the Yakima River using wild yearling chinook salmon, Beckman et al. (2000) observed low lipid and glycogen levels in fish that were only one-third through their migration. This suggests that additional energy to support migration may come from food captured during the migration or from stored protein. If so, the causal mechanisms that lead to a high metabolic rate and catabolic status of smolts are unclear. Moreover, NMFS cannot assign effects on the physiological status of active migrants to specific operations, such as alteration of the hydrograph or flow fluctuations.

6.2.6 Effects of Project Operations on Water Quality

The operation and configuration of the FCRPS, as well as other non-Federal projects on the Columbia River, have two primary effects on water-quality-related salmon survival: dissolved gas supersaturation, and temperature.

6.2.6.1 Total Dissolved Gas

TDG is generated when water is spilled at dams. Falling water entrains volumes of air and carries the air into the depths of the stilling basin. Stilling basins are designed to dissipate energy and are often 50 to 60 feet deep. Hydrostatic pressure at depth in the basin forces the entrained gases into solution, causing supersaturation. Supersaturated gases in river water can off-gas at any air/water interface, e.g., the river surface, wave action on the surface, or air bubbles from rapids and riffles. TDG conditions often persist for many miles below spilling dams, however.

Water highly supersaturated with TDG (greater than 110% saturation) can produce a hazardous condition for aquatic organisms. Fish relying on dissolved oxygen for their life processes become equilibrated with the gaseous state of the river. Gas is absorbed into the bloodstream of fish during respiration. Supersaturated gases in fish tissues tend to pass from the dissolved state to the gaseous phase as internal bubbles or blisters. This condition is called GBT and can be debilitating and fatal to the afflicted organism, including upstream and downstream migrating salmonids (Ebel and Raymond 1976). Susceptibility to GBT is highest near the water surface, because the reduced hydrostatic pressure allows the gas to come out of solution.

Columbia River fisheries managers and the owner-operators of the hydroelectric projects recognized the TDG effects of spill and its adverse effects on salmon survival in the early 1960s. They began seeking ways to prevent gas from being driven into solution or to augment ways of getting gas out of solution once it had been generated.

The spillway deflector, or "flip-lip," was one of the early structural mechanisms developed for this purpose. The intent of the deflector is to control the plunging water and prevent it from carrying entrained air deep into the stilling basin. When properly built, installed, and operated, the flip-lip causes the spilled water to be deflected from its downward path and be jetted out in a horizontal, or "skimming" flow. Thus deflectors reduce the amount of TDG in the tailrace within a given range of spill volumes. In years with large spring runoff volumes, the hydraulic capacity of the FCRPS projects and the design range of the spill deflectors may be exceeded. When that occurs, forced involuntary spill results, and deflector gas abatement performance can diminish. The TDG levels generated frequently exceed the biological opinion gas cap of 120% TDG, and the incidence and severity of GBT may increase.

Deflectors have been constructed and operated on the mainstem projects since the early 1970s. Recent deflectors have incorporated improved engineering factors based on lessons learned from earlier deflector design and operation, near-field testing of TDG levels, and consideration of performance-enhancing requirements. Nearly all Columbia/Snake River projects now have deflectors (Table 6.2-6). Gas-abatement measures installed at a facility upstream can have a beneficial incremental effect on TDG levels beyond the next project downstream. Moreover, cumulative benefits can result from implementing multiple gas-abatement actions at multiple dams.

A number of other gas-abatement alternatives were identified in the dissolved gas abatement study (DGAS), mandated by the 1995 FCRPS Biological Opinion and conducted by the Corps. This comprehensive, multiyear study included investigations of raised stilling basins (to prevent aeration plunging to supersaturation depths), raised tailraces (to reduce channel depths downstream of stilling basins), side-channel spillways, submerged discharge tunnels (to reduce air entrainment at the intake), and other concepts. They were found to have potential for injuring fish at an excessive rate, or creating structural problems. DGAS has not recommended further investigation of these alternatives.

Table 6.2-6. FCRPS projects with installed flip-lips, number of spillway bays, and bays with flip-lips.

Project	Total Number of Spillway Bays	Number of Spillway Bays with Deflectors
Lower Granite	8	8
Little Goose	8	6 (Bays 2-7)
Lower Monumental	8	6 (Bays 2-7)
Ice Harbor	10	10
McNary	22	18 (Bays 3-20)
John Day	20	18 (Bays 2-19)
The Dalles	23	None
Bonneville	18	13 (Bays 4-15, 18)

6.2.6.1.1 Risk Assessment of Allowing TDG to 120% of Saturation. Spilling waters at the projects is the most benign way to move nontransported juvenile downstream migrants past the dams. Spilling large volumes of water sweeps the fish in those waters over the dam and avoids passage through the turbines. The TDG generated by this strategy can exceed current water quality standards (110% TDG standard set by EPA, the affected states, and the Colville Confederated Tribes). As a result, the Federal government has to seek temporary variances of those standards before spilling water to benefit juvenile salmon.

In 1995, the region's fishery agencies and the Indian Tribes published the "Spill and 1995 Risk Management" report (WDFW, ODFW, IDFG, and CRITFC 1995). The assessment considered the benefits of spill to increase juvenile fish passage, the risks associated with spill-generated gas, and the survival of juveniles through other routes of passage. The conclusion of that report was that juvenile mortality associated with turbine passage exceeded that due to TDG from spill until the TDG exceeded 120 to 125%. Recognizing the inherent risk in the application of this conclusion to river operations, the agencies and Tribes urged implementation of an extensive physical and biological monitoring program to track the effects of the spill program. Appendix E contains an updated risk assessment for the spill program described in the 2000 FCRPS Biological Opinion and reviews the results of 5 years of the recommended monitoring program. The update provides a basis for evaluating the options considered in developing the 2000 FCRPS Biological Opinion.

The biological monitoring program has recorded the effects of the biological opinion spill program. The overall number of fish affected with GBT signs observed over the years has proven to be lower than originally assumed when the 1995 FCRPS Biological Opinion was developed. The biological monitoring program has shown that the average incidence of signs increases above 1% when TDG exceeds 115%. When fish are exposed to gas levels greater than 120%, there is an increasing trend in incidence and severity of these signs. The most severe

signs display a similar trend above 125%. For example, 2 of the last 5 years, 1996 and 1997, were characterized by high volumes of involuntary spill with TDG levels ranging from 130% to 140% for days. In these 2 years, the incidence of GBT signs was 3.2% to 3.3% of the fish observed. In 1995, 1998, and 1999, the signs ranged from 0.04% to 0.7% of all fish sampled, demonstrating the effect of biological opinion spill levels with TDG levels managed to 115% and 120% in the project forebays and tailraces, respectively.

The biological monitoring program has established action criteria to reduce the level of TDG based on the incidence of GBT signs. Actions should be taken if 15% of the fish examined exhibit any bubbles on unpaired fins, or if 5% of the fish examined exhibit bubbles covering 25% or more of the surface of any unpaired fin. The action levels are a conservative interpretation of previous biological research results. These action levels have been reached only during high water, e.g., involuntary spill, conditions.

Appendix E reviews the early studies of TDG biological effects, including mortality, GBT signs, and depth compensation as reported in the 1995 risk assessment. More recent research in these areas is also reported. Work on GBT signs has demonstrated the incidence, severity, progression, and relevance of signs in fish. It has been shown that GBT signs correlate with exposure, are progressive, and are useful in understanding the biological implications of TDG exposure.

A critical point assumed in the early risk assessment was that fish migrate at a protective or compensatory depth. Studies since 1995 have shown that juveniles travel at depths sufficient to negate predicted mortalities from the earlier 1970s laboratory studies conducted in shallow conditions. Furthermore, studies of adult swimming depths, currently under way, reveal similar findings. Adults have been tagged with radio transmitters capable of detecting and recording travel depths. The findings thus far indicate that the fish move at depths that would compensate for TDG of 115% to 140%.

The 5 years of physical monitoring have demonstrated a sensitive and accurate monitoring system. During water years characterized by runoff volumes where the spill is due primarily to the biological opinion voluntary spill program, the TDG produced is accurately detected, and spill adjustments can be made to restrict gas below the 120% level. TDG monitoring also detects excursions above 120% TDG caused by involuntary spill during high water years with large freshet volumes. Physical monitoring has also recorded the beneficial effects of the various gas abatement efforts implemented over the last 5 years in the hydrosystem.

6.2.6.2 Water Temperature

Hydroelectric dams have modified natural temperature regimes in the mainstream Columbia River. Snake River basin storage reservoirs are known to affect water temperatures (Yearsley 1999), by extending water residence times and by changing the heat exchange characteristics of affected river reaches. In particular, seasonal temperature fluctuations generally decrease below

larger storage reservoirs that thermally stratify and that have hypolimnetic discharges. Downstream temperatures are cooler in the summer as cold hypolimnetic waters are discharged, but warmer in the fall as energy stored in the epilimnion during the summer is released (Spence et al. 1996). Because of the thermal storage provided by these large reservoirs, seasonal variations in downstream temperatures are reduced in much the same way as seasonal variations in streamflow.

Lower Columbia and Snake River FCRPS reservoirs are considered run-of-river reservoirs with reduced water residence time compared with large storage projects. Mainstem run-of-river reservoirs generally have relatively weak thermal stratification. Thus, in those reservoirs, water temperature will be relatively uniform from top to bottom. The FCRPS reservoirs can also affect water temperatures, however, by extending water residence times and changing the heat exchange characteristics in the lower Snake and Columbia rivers, compared with an unimpounded river (Yearsley 1999). The Independent Scientific Group (ISG 1996) concluded that "mainstem reservoirs in the Snake and Columbia rivers have created shallow, slow-moving reaches of shorelines where solar heating has raised temperatures of salmon rearing habitat above tolerable levels," and that the operation of "storage impoundments in the Columbia River basin [has] shifted annual peak temperatures of the mainstem . . . to later in the season, when late summer and fall migrating salmonids encounter them."

Water temperature conditions have a complex array of effects on salmonids. Intergravel water temperatures affect the rate of embryonic development, with about 1,000 degree-days needed for incubation and emergence (Weatherley and Gill 1995). Post-emergence growth rates are directly related to water temperature. Water temperatures experienced by migrating juvenile salmon have been shown to affect survival (Connor et al. 1998, Smith et al. 1998, Muir et al. 1999).

An emerging issue is potential water temperature effects on juvenile migration timing. It is known that juvenile fall chinook now migrate up to 4 weeks later than they did before development of the Hells Canyon Complex and the Corps' four lower Snake River projects. The working hypothesis is that juvenile migration timing during incubation and early rearing life stages is delayed by cooler than historical water temperatures, which occur primarily above the Lower Snake projects but directly below the Hells Canyon Complex. This effect may be exacerbated by delayed spawning due to excessively warm fall temperatures. Because water temperatures and juvenile salmon mortality rates increase from mid-July through mid-September, delayed outmigration timing reduces juvenile fall chinook survival through Lower Granite Reservoir.

During July and August of some years, warm water from the lower Snake River enters the Columbia River in the McNary pool. This warm water plume tends to stay along the south bank as it approaches McNary Dam.

Turbine unit operations at McNary Dam during the summer low flow and warm temperature condition can influence the temperature of water drawn into the juvenile fish collection gallery.

Thermal profile data collected at McNary Dam have been used to develop special powerhouse operations (i.e., north powerhouse loading) to partially alleviate the potential for thermal stress on juvenile summer migrants that are collected for transportation. Even when south powerhouse units are not operated, however, warm water from along the south shoreline can still be drawn toward the northern operating turbine units.

Immigrating adults can be delayed by excessively warm water temperatures (Karr et al. 1998). In addition, fall chinook spawning is inhibited by temperatures above 61°F (16°C) (McCullough 1999). Delay can reduce the ability of adult fish to survive to spawning and vigor and fecundity during spawning. Water temperature also indirectly affects salmon survival. Foraging rates of piscivorous fish are directly related to temperature (Vigg and Burley 1991), and the rates of infectivity and mortality of several diseases are known to be directly related to temperature.

Thus, operation of storage reservoirs affects both the thermal characteristics of the river and the thermally regulated aspects of salmon survival. For this reason, the thermal effects of reservoir operation are an important consideration in developing system operations aimed at protecting and restoring listed salmonids.

Water temperature also affects the rate of physiological development in smolts. Zaugg and Wagner (1973) and Zaugg (1981) found that exposure of steelhead smolts to water temperatures greater than 12°C resulted in reduced ATPase activity and migratory behavior. Because dams cause migrational delay, smolts are exposed to seasonal increases in water temperature that can result in increased rates of residualism. The effects of increased water temperatures on other salmonids is less clear and warrants further investigation.

6.2.6.2.1 Operation of Dworshak Reservoir to Control Snake River Water Temperatures. Lower Granite Reservoir occupies the Snake River from river mile (RM) 108 to RM 148 and backs water into the Snake and Clearwater rivers a few miles upstream of their confluence near Lewiston, Idaho. It is the first major reservoir encountered by emigrating Snake River juvenile salmon and the last major reservoir negotiated by immigrating adults. A substantial portion of juvenile fall chinook salmon mortality occurs in Lower Granite Reservoir (Smith et al. 1998, Connor et al. 1998, Muir et al. 1999).

During the summer, all emigrating juveniles collected at Lower Granite Dam are transported to release points downstream of Bonneville Dam, the lowermost dam on the Columbia River. In recent years, up to 50% of the outmigrating Snake River fall chinook juveniles passing Lower Granite Dam have been collected and transported (Peters et al. 1999). For these transported fish, Lower Granite Reservoir is the last reservoir transited during their seaward migrations.

Survival of PIT-tagged juvenile fall chinook salmon from release points in the Snake and Clearwater rivers to Lower Granite Dam is strongly correlated with water temperature, as well as flow and turbidity, in Lower Granite Reservoir (NMFS 2000h). To minimize water temperature-related effects on juvenile fall chinook, Dworshak Dam on the North Fork Clearwater, about

2 river miles upstream of the Clearwater River and 60 miles from Lower Granite Reservoir, is routinely operated to release large amounts of cool water during the months of July and August to reduce water temperatures in Lower Granite Reservoir and downstream reaches. Dworshak Reservoir is a deep impoundment (over 600 feet at full pool) that stratifies in the summer, and Dworshak Dam is equipped with a variable-intake depth-release structure that facilitates selecting a specific discharge water temperature. During July and August reservoir managers typically release water at 48° to 50°F (9° to 10°C) at the request of regional salmon managers. Cooler releases are possible but may result in adverse juvenile salmon growth conditions at a downstream hatchery and the Clearwater River. This operation reduces ambient water temperature by approximately 4° to 6°F (-2° to -3°C) at Lower Granite Dam when elevated temperatures are a concern in the Snake River (July and August).

6.2.7 Effects of Predator Control Programs on Salmonid Migration and Survival—General Considerations

Dams and reservoirs are generally believed to have increased the incidence of predation over historical levels (Poe et al. 1994). Impoundments in the Columbia River basin increase the availability of microhabitats in the range preferred by northern pikeminnow and other predators (Faler et al. 1988, Beamesderfer 1992, Mesa and Olson 1993, Poe et al. 1994). They also can increase local water temperatures, which increases digestion and consumption rates by northern pikeminnow (Falter 1969, Steigenberger and Larkin 1974, Beyer et al. 1988, Vigg and Burley 1991, Vigg et al. 1991); decrease turbidity, which may increase capture efficiency of predators (Gray and Rondorf 1986); favor introduced competitors, which could cause some predators to shift to a diet composed largely of juvenile salmonids (Poe et al. 1994); and increase stress and subclinical disease of juvenile salmonids, which could increase susceptibility to predation (Rieman et al. 1991, Gadomski et al. 1994, Mesa 1994). In addition, dam-related passage problems and reduced river discharge can affect the availability, distribution, timing, and aggregation of migrating salmonids, thereby increasing exposure time to predation (Raymond 1968, 1969, 1979, 1988; Park 1969, Van Hyning 1973, Bentley and Raymond 1976). In particular, they can increase exposure time later in the season, when predator consumption rates are high (Beamesderfer et al. 1990, Rieman et al. 1991).

6.2.7.1 Effects of FCRPS Predator Control Measures on Salmonid Migration and Survival

Northern pikeminnow predation throughout the Columbia and Snake rivers was indexed in 1990-1993 based on electrofishing catch rates of predators and the occurrence of salmonids in predator stomachs relative to estimates in John Day Reservoir (Ward et al. 1995). Northern pikeminnow abundance was estimated to total 1.8 million, and daily consumption rates averaged 0.06 salmonids per predator (Beamesderfer et al. 1996). Average index values for predation losses relative to the estimate for John Day Reservoir are reported on Table 9 in NMFS (2000f). These index values would translate into 16.4 million juvenile salmon and steelhead consumed annually by northern pikeminnow, based on numbers observed in John Day Reservoir. This is 8% of the

approximately 200 million hatchery and wild juvenile salmonid migrants in the system. Other work corroborates findings for the Snake River (Chandler 1993, Curet 1993) and the mid-Columbia between Priest Rapids and Chief Joseph dams (Burley and Poe 1994).

Predator control fisheries have been implemented in the Columbia basin since 1990 to harvest Northern pikeminnow with a goal of 10% to 20% exploitation, annually. From 1991 to 1996, three fisheries (sport-reward, dam angling, and gill net) harvested approximately 1.1 million northern pikeminnow greater than or equal to 250 mm fork length. Total exploitation averaged 12.0% (range, 8.1% to 15.5%) for 1991 to 1996.

Modeling results indicate that potential predation on juvenile salmonids by northern pikeminnow has decreased 25% since fishery implementation. Friesen and Ward (1999) estimated a long-term reduction in potential predation of 3.8 million juvenile salmonids per year if northern pikeminnow exploitation rates are maintained at mean levels. Projected estimations of systemwide percent reduction in juvenile salmonid mortality from predation by northern pikeminnow (relative to pre-1990 levels) due to the predator control program is 13.0% for 1992 to 1999 and 14.9% for 2000 to 2006 (Table 10, D. Ward and H. Schaller, pers. comm. to PATH Hydro Work Group, March 16, 1999). The mortality reduction estimates are derived from a spreadsheet model based on predator population size structure and the mean total pikeminnow exploitation rate estimates (D. Ward, ODFW, pers. comm., July 29, 1999).

The annual systemwide reduction in pikeminnow predation is projected to level off at about 15% during 2000 to 2006 (Figure 1 in NMFS 2000f, page 17). The mortality reduction below Bonneville Dam shows a similar trend and magnitude. The mortality reduction in the lower Columbia River reservoirs also shows a similar trend, but a higher magnitude (i.e., a future projection of about 18%). The highest estimated predation mortality reductions are in The Dalles Reservoir, over 30% annual reductions during 1996 through 2006. Pikeminnow populations and predation on salmonids are relatively low in McNary Reservoir, with low potential from predation reductions. The three lower Snake River reservoirs were intermediate (5% to 11%) during 1993 through 1998, and are projected to level off at about 3% to 4% reductions for 1999 through 2006. Lower Granite has 0% reductions due to negligible populations of northern pikeminnow.

6.2.8 Effects of FCRPS Juvenile Fish Transportation Program on Salmonid Migration and Survival

Transportation increases the survival of listed species from Lower Granite, Little Goose, Lower Monumental, or McNary Dam, to the river below Bonneville Dam, compared with survival of fish left to migrate inriver. Research has shown that the return of adults, collected and transported as juveniles, is higher than that of juvenile fish that are left to migrate inriver (NMFS 2000i).

The juvenile fish transportation program reduces adverse effects in downstream migrating juvenile salmon and steelhead from adverse environmental conditions created by Corps dams and reservoirs on the lower Snake and lower Columbia rivers. Juvenile salmon and steelhead are collected and transported from Lower Granite Dam, located at RM 107.5 on the Snake River, Washington, to the Columbia River below Bonneville Dam, located at RM 146.1, about 40 miles upstream of Portland, Oregon. Endangered SR sockeye, threatened SR chinook, and threatened SR steelhead are collected along with unlisted hatchery and wild salmon and unlisted hatchery steelhead at Lower Granite, Little Goose, and Lower Monumental dams on the Snake River. At McNary Dam, on the Columbia River, transportation of spring migrants continues to be suspended, so primarily summer migrants are transported from that location, although limited numbers of listed endangered hatchery and wild UCR steelhead and spring chinook and threatened MCR steelhead are incidentally collected and transported from McNary Dam. Listed and unlisted hatchery and wild salmon and steelhead are transported by truck and barge past three to seven downstream reservoirs and dams. Survival of endangered and threatened species is enhanced because they are transported around reservoirs and dams, where higher mortality would occur than in the transportation process. From 1995 through 1999, the juvenile fish transportation program has been carried out in accordance with the 1995 RPA, the 1998 Supplemental FCRPS Biological Opinion, ESA Section 10 Permit 895, and operating criteria in the Corps' annual Fish Passage Plan.

From the time juveniles enter the fish collection systems until they are loaded on barges, juvenile fish mortality is documented. Since 1994 at Lower Granite Dam, total collection mortality has been 0.2% or less. Yearling chinook mortality has ranged from 0.3% to 0.9%, wild steelhead mortality has been less than 0.1%, and wild subyearling chinook mortality has ranged from 0.4 to 3.6%. Sockeye salmon mortality has ranged from 0.3% to 5.1%, with 0.3% in 1998. At Little Goose Dam, overall mortality has ranged from 0.3% to 0.8% since 1994. Yearling wild chinook mortality ranged from 0.6% to 2.1%, wild steelhead from 0.1% to 0.3%, and wild subyearling chinook from 1.4% to 7.7%. Sockeye salmon mortality ranged from 2.3% to 8.9% over the same period. Overall mortality at Lower Monumental Dam since 1994 has ranged from 0.1% to 0.4%. Yearling wild chinook mortality ranged from 0.1% to 0.5%, wild steelhead from 0.1% to 0.3%, and wild subyearling chinook from 0.4% to 2.1%. Sockeye salmon mortality ranged from 0.0% to 4.0% over the same period. At McNary Dam facility mortalities have ranged from 0.4% to 1.5%. Yearling chinook morality has ranged from 0.1% to 1.1%, subyearling chinook from 0.5% to 2.1%, and sockeye salmon from 0.1 to 1.9. With the exception of McNary Dam, seasonal mortality since 1994 has been less than 1% at the collector dams. In the trucks and barges, observed seasonal mortality typically is less than 1% (Corps' application for Section 10 permit, November 18, 1999).

Under the 1994-to-1999 existing condition, the average proportion of the Snake River mixed stock yearling chinook population collected and transported from the three Snake River collector dams is estimated at 72% (ranging from 64% to 89%, depending on river conditions). For summer-migrating SR fall chinook, the overall proportion of the population collected and transported is small, because significant mortality occurs before the fish reach Lower Granite.

Similarly, the proportion of fall chinook potentially collected and transported averages about 48% and ranges from 27% to 62%, depending on river conditions (see Table 6.2-7). For SR steelhead, under the 1994-to-1999 existing condition, the average proportion transported is estimated at 77%, with a range of 71% to 89%. Post-season estimates of the proportion of wild Snake River yearling chinook transported from 1995 to 1998 range from 55% to 85% (1998 Supplemental FCRPS Biological Opinion, and Graves 1998).

Without transportation, survival of combined mixed-stock Snake River yearling chinook salmon from Lower Granite Dam to below Bonneville Dam for the 1994-to-1999 existing condition is estimated at 41%, ranging from 27% to 52%, depending on river conditions. With transportation, combined transport and inriver survival to below Bonneville Dam is estimated at 80%, ranging from 74% to 88%, also depending on river conditions. For summer-migrating Snake River fall chinook, the proportion of the population surviving to below Bonneville Dam without transportation is estimated at 10% for the 1995-to-1999 existing condition, ranging from about 1% to 16%. With transportation, estimates of the proportion of the population surviving to below Bonneville range from 26% to 61% (Table 6.2-7). For Snake River steelhead, the proportion of the population surviving to below Bonneville Dam without transportation is estimated at 41% for the 1994-to-1999 condition, ranging from about 32% to 47%. With transportation, combined transport and inriver survival to below Bonneville Dam is estimated at 82%, ranging from 79% to 87% (Table 6.2-7).

6.2.9 Summary of Effects of Proposed Action in Action Area

The following sections describe the effects of the proposed action in the action area for each of the 12 listed Columbia River basin ESUs. The action area is defined by NMFS regulations (50 CFR Section 402) as "all areas to be affected directly or indirectly by the Federal action and not merely the area involved in the action." The action area includes designated critical habitats within the Columbia River basin and estuary (58 FR 68546 for Snake River salmon and 65 FR 7765 for all other Columbia River basin salmonids), an area that serves as a migratory corridor for adult and juvenile life stages of listed anadromous fish and as a rearing area for juveniles.[7]

The following discussion is organized by the primary constituent elements of those critical habitat types that are relevant to salmonids: 1) juvenile rearing areas; 2) juvenile migration corridors; 3) areas for growth and development to adulthood; 4) adult migration corridors; and 5) spawning areas (Section 5.2.1). Essential features of each type of critical habitat, specified in Sections 5.2.1.1 through 5.2.1.5, include adequate water quality (TDG and temperature), water

[7] Marine habitats (i.e., including the Columbia River plume) are also vital to salmon and steelhead, and ocean conditions are believed to have a major influence on the species' survival. Although NMFS has not included the Pacific Ocean as critical habitat in its final rules on critical habitat (65 FR 7746), the agency will reevaluate this issue and may propose including specific marine zones for salmon and steelhead ESUs in a separate notice. However, regardless of the specific areas designated, Federal agencies are required to ensure that their actions, regardless of whether they occur in freshwater, estuarine, or marine habitats, do not jeopardize the continued existence of a listed species.

Table 6.2-7. Project and system survival and the proportion of juvenile Snake River spring/summer and fall chinook salmon and steelhead outmigrants transported under a range (1994 to 1999) of flow conditions as estimated using NMFS' spreadsheet model (SIMPAS).[1]

	Project Survival (% Dam + Pool Survival)													
YEAR	LGR	LGS	LMN	IHR	MCN	JDA	TDA	BON	% Inriver Survival (LGR to BON)	% Inriver Survival (MCN to BON)	Prop. ESU Transported	% Total System Survival	% Total System Survival with D	
SR spring/summer chinook salmon													D=0.63	D=0.73
1994	93.6	83.0	84.7	89.0	85.8	77.3	84.5	82.9	27.2	46.4	89.2	88.1	55.8	64.5
1995	90.6	88.2	92.5	93.6	93.6	85.2	87.2	86.9	41.8	60.4	64.0	73.5	50.3	56.6
1996	97.9	92.6	92.9	87.0	87.0	84.4	86.9	87.0	40.6	55.5	70.9	79.9	54.2	61.1
1997	91.3	94.2	89.4	89.3	89.3	83.3	86.5	86.9	38.4	56.0	65.5	74.3	50.6	57.1
1998	92.4	98.5	85.3	95.7	95.7	82.2	87.7	88.0	45.1	60.8	72.0	80.4	54.3	61.4
1999	94.1	95.0	92.5	95.1	95.1	85.3	89.3	91.1	51.9	66.0	72.2	82.4	56.1	63.2
6-yr avg	93.3	91.9	89.5	91.6	91.1	82.9	87.0	87.2	40.8	57.5	72.3	79.8	53.6	60.6
SR fall chinook salmon													D=0.24	
1994	No data collected in 1994													
1995	66.8	89.0	79.5	87.8	82.0	73.8	81.5	80.4	16.4	39.6	59.6	59.1	14.7	
1996	47.9	89.8	78.2	87.3	82.8	72.7	81.1	79.1	11.3	38.6	42.4	42.2	10.6	
1997	35.3	56.6	64.4	63.5	54.6	34.0	63.9	50.4	0.5	6.0	26.5	26.0	6.2	
1998	55.8	77.1	92.1	87.8	83.0	73.7	81.5	80.2	13.9	39.9	48.1	47.7	11.9	
1999	76.6	66.5	89.0	80.4	74.3	59.5	76.2	70.3	8.6	23.7	61.8	61.1	15.0	
5-yr avg	56.5	75.8	80.6	81.4	75.3	62.7	76.8	72.1	10.2	29.6	47.7	47.2	11.7	

Table 6.2-7 (continued). Project and system survival and the proportion of juvenile Snake River spring/summer and fall chinook salmon and steelhead outmigrants transported under a range (1994 to 1999) of flow conditions.

	Project Survival (% Dam + Pool Survival)													
YEAR	LGR	LGS	LMN	IHR	MCN	JDA	TDA	BON	% Inriver Survival (LGR to BON)	% Inriver Survival (MCN to BON)	Prop. ESU Transported	% Total System Survival	% Total System Survival with D	
SR steelhead													D=0.52	D=0.56
1994	90.0	84.4	89.2	90.8	88.2	81.3	85.8	85.0	32.2	52.3	89.0	87.4	45.5	49.0
1995	94.4	88.9	95.0	92.7	92.6	88.4	88.1	88.7	47.8	64.0	71.4	80.7	47.1	49.9
1996	93.4	93.8	93.7	88.9	88.9	86.0	87.3	87.8	42.8	58.6	74.8	81.6	46.4	49.3
1997	96.3	96.6	90.2	91.3	91.4	85.1	87.0	88.0	45.5	59.5	78.5	85.4	48.5	51.6
1998	92.5	93.0	88.9	89.3	89.3	83.1	89.7	91.8	41.8	61.1	75.0	80.8	45.6	48.6
1999	90.8	92.6	91.5	91.3	91.3	92.0	84.0	81.2	40.2	57.3	73.1	79.0	44.6	47.5
6-yr avg	92.9	91.7	91.4	90.7	90.3	85.8	87.0	86.9	41.5	58.6	77.0	82.4	46.3	49.3

[1] Values shown are estimates, based on juvenile survival studies rather than adult returns, and representing the expected performance of mixed (wild + hatchery) runs. Spring/summer chinook salmon and steelhead are yearling migrants; fall chinook salmon are subyearling migrants.

quantity, and water velocity; cover or shelter; food, air, light, minerals, or other nutritional or physiological requirements; riparian vegetation; substrate, space for population growth and normal behavior, and safe passage conditions.

The following sections summarize the effects of the proposed action on these essential features of critical habitat within the action area for the 12 ESUs of salmon and steelhead evaluated in this biological opinion. The discussion begins with summary tables (Tables 6.2-8 and 6.2-9) that indicate whether each species' biological requirements are likely to be affected by the proposed action. In some cases, NMFS is uncertain whether or not there will be an effect, as described in the accompanying text.

6.2.9.1 Snake River Spring/Summer Chinook Salmon

6.2.9.1.1 Juvenile Rearing Areas. SR spring/summer chinook salmon rear in tributary systems to the mainstem Snake River and do not have biological requirements for rearing habitat within the action area.

6.2.9.1.2 Juvenile Migration Corridors

Juvenile SR spring/summer chinook salmon are yearling migrants, with downstream movement during April through June.

Water Quality. Biological monitoring during the previous 5 years shows that the incidence of GBT in migrating smolts remains below 1% when dissolved-gas concentrations in the upper water column do not exceed 115%. During the spring and early summer in high-volume water years (e.g.,1996 and 1997), involuntary spill has caused TDG to exceed the state water quality standard (110%) and waiver levels of 120% in tailraces and 115% in forebays, with a corresponding increase in the incidence of signs of GBT. Studies since 1995, however, indicate that juveniles avoid exposure by traveling at dissolved gas "compensation" depths (Section 6.2.6.1).

Juvenile spring migrants through FCRPS reservoirs are not subject to thermal effects under the proposed action (Section 6.2.5.2).

Water Quantity/Water Velocity/Cover/Shelter. Although yearling chinook salmon move relatively quickly through the FCRPS, they have biological requirements for cover and shelter in the sense of refuge from predators. NMFS has not detected a relationship between flow and survival for yearling chinook salmon in the Lower Granite-to-McNary reach. NMFS has demonstrated a strong and consistent relationship between travel time and flow for spring migrants below McNary Dam, where northern pikeminnow predation rates are particularly high. By decreasing the residence time of yearling smolts in the lower river, higher spring flows may reduce exposure time to predators. This hypothesis is supported by relationships between SARs or R/S and seasonal flows. Under the proposed action, the likelihood of meeting or exceeding

Table 6.2-8. Summary of the effects of the proposed action on essential features of critical habitat within the action area for five ESUs of chinook salmon and for chum salmon in the Columbia River basin.

Essential Habitat	Chinook Salmon					Chum Salmon
	SR Spring/ Summer	SR Fall	UCR Spring	UWR	LCR[1]	
Juvenile Rearing Areas						
— Water quality	NR	E	NR	NR	E	E
— Water quantity/velocity	NR	E	NR	NR	E	E
— Food	NR	U	NR	NR	E	E
— Cover/shelter	NR	N	NR	NR	E	E
— Riparian vegetation	NR	N	NR	NR	E	E
— Space	NR	N	NR	NR	E	E
— Migration conditions	NR	E	NR	NR	E	E
Juvenile Migration Corridors						
— Water quality	E	E	E	N	E	E
— Water quantity/velocity	E	E	E	N	N	E
— Cover/shelter	E	U	E	N	N	E
— Food	U	N	U	U	U	U
— Riparian vegetation	NR	N	NR	U	U	NR
— Space	N	N	N	N	U	N
— Migration conditions	E	E	E	N	E	U
Areas for Growth and Development to Adulthood	U	U	U	U	U	U
Adult Migration Corridor						
— Water quality	E	E	E	E	E	N
— Water quantity/velocity	E	E	E	N	E	N
— Food	NR	NR	NR	NR	NR	NR
— Cover/shelter	N	N	N	N	N	N
— Riparian vegetation	NR	NR	NR	NR	NR	NR
— Space	N	N	N	N	N	N
— Migration conditions	E	E	E	N	E	E
Spawning Areas						
— Water quality	NR	U	NR	NR	U	N
— Water quantity/velocity	NR	U	NR	NR	E	E
— Food	NR	NR	NR	NR	NR	NR
— Cover/shelter	NR	NR	NR	NR	NR	NR
— Riparian vegetation	NR	NR	NR	NR	NR	NR
— Space	NR	U	NR	NR	E	E
— Migration conditions	NR	U	NR	NR	E	E
— Substrate	NR	U	NR	NR	E	E

Note: NR = no biological requirement, E = effect (magnitude may be unknown), U = uncertain, N = no effect.
[1] Effects on spawning and rearing areas for LCR chinook salmon apply only to the Ives Island area below Bonneville Dam where this species spawned in October 1999.

Table 6.2-9. Summary of the effects of the proposed action on essential features of critical habitat within the action area for five ESUs of steelhead and for sockeye salmon in the Columbia River basin.

Essential Habitat	Steelhead					Sockeye Salmon
	SR	UCR	MCR	UWR	LCR	
Juvenile Rearing Areas	NR	NR	NR	NR	NR	NR
Juvenile Migration Corridors						
— Water quality	E	E	E	E	E	E
— Water quantity/velocity	E	E	E	N	N	E
— Cover/shelter	E	E	E	N	N	E
— Food	U	U	U	U	U	U
— Riparian vegetation	NR	NR	NR	NR	NR	NR
— Space	N	N	N	N	N	N
— Migration conditions	E	E	E	N	E	E
Areas for Growth and Development to Adulthood	U	U	U	U	U	U
Adult Migration Corridor						
— Water quality	E	E	E	E	E	E
— Water quantity/velocity	E	E	E	E	E	E
— Food	NR	NR	NR	NR	NR	NR
— Cover/shelter	N	N	N	N	N	N
— Riparian vegetation	NR	NR	NR	NR	NR	NR
— Space	N	N	N	N	N	N
— Migration conditions	E	E	E	N	E	E
Spawning Areas	NR	NR	NR	NR	NR	NR

Note: NR = no biological requirement, E = effect (magnitude may be unknown), U = uncertain, N = no effect.
[1] Effects on spawning and rearing areas for LCR chinook salmon apply only to the Ives Island area below Bonneville Dam where this species spawned in October 1999.

flow objectives at Lower Granite and McNary dams during the spring migration season (late April, May, and June) is 68% or less (Table 6.2-5).

Riparian Vegetation/Space. Because yearling chinook salmon migrate midchannel through FCRPS reservoirs (Battelle and USGS 2000), they do not have biological requirements for riparian vegetation in the juvenile migration corridor. Further, there is no evidence that the reservoir environment has resulted in loss of the amount of physical habitat required by yearling migrants in the migration corridor (Battelle and USGS 2000).

Food. NMFS is uncertain whether yearling migrants have a biological requirement for food in the juvenile migration corridor or, if food is required, whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Migration Conditions. Using SIMPAS, the Biological Effects Team and NMFS estimated that an average of 72% of the run was transported from the Snake River collector projects during 1994 through 1999 (Table 6.2-7). The rest of the run migrated inriver past eight FCRPS projects. The direct survival of transported juveniles over the same period was at least 98%, and NMFS estimates that the average system survival rate of inriver migrants was approximately 41%. The total (transported plus inriver) system survival rate for SR spring/summer chinook salmon ranged on average from 54% to 61% (depending on the level of differential mortality of transported fish assumed in the SIMPAS analysis).

6.2.9.1.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River plume that in turn affect the growth and survival of yearling SR spring/summer chinook salmon. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.1.4 Adult Migration Corridors

Water Quality. Biological monitoring over the previous 5 years has shown that the incidence of signs of GBT in migrating adults remains below 1% when TDG concentrations in the upper water column do not exceed 115%. During spring and early summer in high-volume water years (e.g., 1996 and 1997), involuntary spill has caused TDG to exceed state water quality standard waiver levels of 120% in tailraces and 115% in forebays, with a corresponding increase in the incidence of signs of GBT. However, studies since 1995 indicate that adults avoid exposure by traveling at dissolved gas “compensation” depths (Section 6.2.6.1).

High water temperatures (i.e., generally considered to be greater than 68°F (20°C) for salmonids) are observed systemwide during late summer and early fall, due in part to thermal storage in FCRPS reservoirs (Section 6.2.6.2). However, because SR spring/summer chinook salmon migrate through FCRPS reservoirs before July, adults from this ESU are not subject to these thermal effects.

Water Quantity/Velocity. Travel time and energy expenditures of upstream migrants are lower in reservoirs than in free-flowing rivers. Adults may be delayed in the tailrace or adult collection channel, but once they begin to ascend the ladder, delays are minimal. Under the proposed action, delay will be minimized by operating to meet water velocity and flow criteria at fishway entrances and channels. The net effect of delay at lower Snake River dams, combined with faster passage through reservoirs, is a median travel time at least as fast with dams in place as with no dams.

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. SR spring/summer chinook salmon do not have biological requirements for riparian vegetation or food in the adult migration corridor.

Migration Conditions. Based on recent radio-tracking studies, the mean survival rate of adult migrants between Bonneville and Lower Granite dams is 82%, equivalent to a per-project survival rate of 98% (Table 6.1-1).

6.2.9.1.5 Spawning Areas. SR spring/summer chinook salmon do not have biological requirements for spawning habitat within the action area.

6.2.9.2 Snake River Fall Chinook Salmon

6.2.9.2.1 Juvenile Rearing Areas and Migration Corridors

Juvenile SR fall chinook salmon are subyearling migrants, moving downstream during June through September and rearing during at least part of this period.

Water Quality. The potential for adverse affects on dissolved gas conditions under the proposed action is lower than described above for SR spring/summer chinook salmon, because involuntary spill is extremely unlikely during the summer migration season.

Conversely, high water temperatures are observed systemwide during summer and early fall. As described in Section 6.2.6.2, the survival of juvenile fall chinook through Lower Granite Reservoir may be reduced by an interaction between the thermal effects of FCRPS operations and Idaho Power Company's operations at its Hells Canyon Complex. Under the proposed action, cooler water will be released from Dworshak Reservoir during the late summer to reduce water temperatures in the reach between Lower Granite Reservoir and Ice Harbor Dam.

Water Quantity/Velocity. NMFS' research has identified strong, positive relationships between the survival of subyearling migrants and flow, temperature, and turbidity. Operations at dams change under lower flows (e.g., less spill, greater diel-flow fluctuations) in ways that can decrease fish survival. FGEs of subyearling chinook decrease at higher temperatures, so more

fish are likely to pass through turbines. Further, vulnerability to sight-feeding predators increases as flows and turbidity decrease. The likelihood of meeting mainstem flow objectives at Lower Granite and McNary dams during the summer migration season varies from 40% to 68% (Lower Granite Dam during July and June) to no more than 8% (both locations during August) (Table 6.2-5).

Cover/Shelter/Riparian Vegetation. Subyearling fall chinook salmon in the lower Snake River reservoirs are either pelagic-oriented or found over sandy, mostly unvegetated substrate (Section 6.2.5.3.2). Although it is uncertain whether subyearlings have biological requirements for cover, shelter, and vegetation (beyond the effect of mainstem flow as a potential refuge from predation; see above), there is no indication that the proposed action will have adverse effects on these elements of rearing habitat in the action area.

Space. There is no evidence that the reservoir environment has resulted in loss of the amount of physical habitat required by subyearling migrants in the migration corridor (Battelle and USGS 2000).

Food. Subyearling SR fall chinook have a biological requirement for food in the juvenile migration corridor/rearing area. Prey resources in mainstem reservoirs are different than those in free-flowing reaches (e.g., terrestrial insects and zooplankton predominate in reservoirs versus aquatic insects in the free-flowing river). NMFS is uncertain, however, whether this change in prey assemblage adversely affects biological requirements for food during this life stage. Similarly, although water level fluctuations associated with reservoir operations could affect the life cycles of invertebrate prey in the littoral zone, the 1995 RPA required the Corps to operate the lower Snake River pools within 1 foot of minimum operating pool, minimizing the disruption of shallow water habitat.

Migration Conditions. Juveniles are summer migrants with peak movement past Lower Granite Dam during July. Using SIMPAS, NMFS estimated that an average of 48% of the run was transported from the Snake River collector projects during 1995 through 1999 (Table 6.2-7). The rest of the run migrated inriver past eight FCRPS projects. The direct survival of transported juveniles was at least 98%, and NMFS estimates that the average system survival rate of inriver migrants over the same period was approximately 10%. The total (transported plus inriver) system survival rate for SR fall chinook salmon was, on average, approximately 12%.

6.2.9.2.2 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River estuary and plume that in turn affect the growth and survival of subyearling SR fall chinook salmon. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.2.3 Adult Migration Corridors

Water Quality. FCRPS operations interact with effects of operations at the Hells Canyon Complex to increase water temperatures in the lower Snake River from mid-July through mid-September. Adults entering the Snake River during this period can be delayed by elevated water temperatures, potentially reducing fish condition and fecundity during spawning.

Water Quality/Velocity. Effects of the proposed action on biological requirements for water quantity and velocity in adult migration corridors are the same as those discussed for SR spring/summer chinook salmon (above).

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. SR fall chinook salmon do not have biological requirements for riparian vegetation or food in the adult migration corridor.

Migration Conditions. Based on recent radio-tracking studies, the mean survival rate of adult migrants between Bonneville and Lower Granite dams is 71%, equivalent to a per-project survival rate of 96% (Table 6.1-1).

6.2.9.2.4 Spawning Areas. Fall chinook salmon are known to spawn in the tailraces of Lower Granite, Little Goose, and Ice Harbor dams. The effects of FCRPS flow management on use of this spawning habitat (water quantity and velocity, space, access to habitat, and availability of suitable substrate) is unknown. Spawning may be inhibited at temperatures above 61°F (16°C). SR fall chinook salmon do not have biological requirements for food, cover, shelter, or riparian vegetation in spawning areas.

6.2.9.3 Upper Columbia River Spring Chinook Salmon

6.2.9.3.1 Juvenile Rearing Areas. Juvenile UCR spring chinook salmon rear in tributaries and migrate through the FCRPS as yearlings and do not have biological requirements for rearing habitat in the action area.

6.2.9.3.2 Juvenile Migration Corridors

Juvenile UCR spring chinook salmon are spring migrants with peak movement past Rock Island Dam in the mid-Columbia reach during late April and May.

Water Quality/Water Quantity/Water Velocity/Cover/Shelter/Food/Riparian Vegetation/Space. Effects of the proposed action on these constituent elements of critical habitat in juvenile migration corridors are similar to those discussed for SR spring/summer chinook salmon (above). The likelihood of meeting or exceeding spring flow objectives at Priest Rapids and McNary

dams under the proposed action is less than 80%, except at Priest Rapids during May (86%; Table 6.2-5).

Migration Conditions. Depending on their natal tributary, juveniles pass through five (Methow River), four (Entiat River), or three (Wenatchee River) PUD projects before reaching McNary Dam. Transportation from McNary Dam has not been used as a protection measure for this ESU under existing operations. However, a portion of the run (typically less than 5%; Figure VI-5 in NMFS 2000d) may have been collected and transported in the past. Although there are no ESU-specific survival rates for UCR spring chinook salmon through FCRPS hydroprojects, NMFS assumes that they are adequately represented by data for SR spring/summer chinook salmon (total system survival rate averaged 58% during 1994 through 1999; Table 6.2-7).

6.2.9.3.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River plume that in turn affect the growth and survival of yearling UCR spring chinook salmon. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.3.4 Adult Migration Corridors

Water Quality/Water Quantity/Velocity. Effects of the proposed action on biological requirements for these constituent elements of critical habitat in the adult migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. SR spring/summer chinook salmon do not have biological requirements for riparian vegetation or food in the adult migration corridor.

Migration Conditions. Based on recent radio-tracking studies with SR spring/summer chinook salmon, NMFS estimates that the mean survival rate of adult UCR spring chinook salmon from below Bonneville Dam to the head of McNary pool is 91%, equivalent to a per-project survival rate of 98% (Table 6.1-1).

6.2.9.3.5 Spawning Areas. UCR spring chinook salmon do not have biological requirements for spawning habitat in the action area.

6.2.9.4 Upper Willamette River Chinook Salmon

6.2.9.4.1 Juvenile Rearing Areas. Juvenile UWR chinook salmon rear in tributaries and migrate through the FCRPS as yearlings and do not have biological requirements for rearing habitat in the action area.

6.2.9.4.2 Juvenile Migration Corridors

Juvenile UWR chinook salmon migrate through the mainstem lower Columbia River both as yearlings and as subyearlings.

Water Quality. Most of the migration moves through the lower Columbia River during February through May, before peak spring runoff and periods of involuntary spill. Thus, biological requirements for water quality in the juvenile migration corridor will not be affected by the proposed action.

Water Quantity/Water Velocity/Cover/Shelter. Biological requirements for water quantity and velocity, cover, or shelter in the mainstem Columbia River juvenile migration corridor are not likely to be adversely affected by the proposed action. Flow objectives have not been developed to benefit UWR chinook salmon.

Food. Subyearling UWR chinook salmon migrants are likely to have a biological requirement for food in the mainstem Columbia River juvenile migration corridor. However, NMFS is uncertain whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Riparian Vegetation. NMFS is uncertain whether subyearling UWR chinook salmon have biological requirements for riparian vegetation in the mainstem Columbia River juvenile migration corridor or if such requirements will be affected by the proposed action.

Space. Biological requirements for space in the mainstem Columbia River juvenile migration corridor are not likely to be adversely affected by the proposed action.

Migration Conditions. Juvenile UWR chinook salmon do not pass any FCRPS dams and therefore are not subject to mortality during project passage.

6.2.9.4.3 Areas for Growth and Development to Adulthood. UWR chinook salmon emigrate from the Willamette River basin as a mixture of yearling and subyearling fish. Current FCRPS operations may have effects on rearing habitat in the Columbia River estuary and plume that in turn affect the growth and survival of one or both types of juvenile UWR chinook salmon. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.4.4 Adult Migration Corridors

Water Quality. Adult UWR chinook salmon migrate through the FCRPS during March through June. The latter portion of the run may be exposed to high TDG concentrations during periods of involuntary spill.

Water Quantity/Velocity/Cover/Shelter/Space. Biological requirements of adult UWR chinook salmon for water quantity and velocity and for cover, shelter, and space in the mainstem Columbia River adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. UWR chinook salmon do not have biological requirements for riparian vegetation or food in the mainstem Columbia River adult migration corridor.

Migration Conditions. Adults leave the mainstem Columbia River to enter the Willamette system below Bonneville Dam and thus are not subject to project passage mortality.

6.2.9.4.5 Spawning Areas. UWR chinook salmon do not have biological requirements for spawning habitat in the action area.

6.2.9.5 Lower Columbia River Chinook Salmon

6.2.9.5.1 Juvenile Rearing Areas

The proposed action will affect biological requirements for rearing habitat of LCR chinook salmon in the Ives Island area below Bonneville Dam, where individuals from this ESU were observed spawning once, during October 1999.

Water Quality/Quantity/Velocity. Spill operations at Bonneville Dam, such as spill for debris removal, gas generation/abatement testing, or juvenile fish passage, can create TDG concentrations high enough to kill yolk sac fry in redds in the Ives Island area. This effect can be prevented by providing flows that create a compensation depth over the redds, reducing the effective TDG concentration to 105% of saturation or less. During spring 2000, a Bonneville outflow of at least 200 kcfs was needed to create the compensation depth for Ives Island redds (i.e., redds dug at spawning flows of 125 to 165 kcfs). Under the proposed action, the likelihood of providing Bonneville outflows greater than or equal to 125 kcfs is 88% during January and 78% during February and March (Table 6.2-5).

Cover/Shelter/Food/Riparian Vegetation/Space. Data derived primarily from Ives Island brights (UCR summer/fall-run chinook salmon ESU) indicate that LCR chinook salmon are likely to have biological requirements for these elements of rearing habitat in the Ives Island area after emergence (January through July).

Migration Conditions. FCRPS flow operations affect migration conditions in the form of access to juvenile rearing habitat in the Ives Island area. Flow fluctuations can strand subyearlings, making them vulnerable to death through desiccation or avian predation.

6.2.9.5.2 Juvenile Migration Corridors

Juvenile LCR chinook salmon are primarily subyearling migrants, moving through the mainstem lower Columbia River during spring and early summer.

Water Quality. Effects of the proposed action on biological requirements for water quality in the mainstem Columbia River migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Water Quantity/Water Velocity/Cover/Shelter. Biological requirements for water quantity and velocity, cover, or shelter in the juvenile migration corridor are not likely to be adversely affected by the proposed action. Mainstem Columbia River flow objectives have not been developed to benefit LCR chinook salmon.

Riparian Vegetation. NMFS is uncertain whether subyearling LCR chinook salmon have biological requirements for riparian vegetation in the mainstem Columbia River migration corridor or if such requirements will be adversely affected by FCRPS operations.

Food. Subyearling LCR chinook salmon migrants are likely to have biological requirements for food in the mainstem Columbia River migration corridor. NMFS is uncertain, however, whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Space. Biological requirements for space in the mainstem Columbia River migration corridor are not likely to be adversely affected by FCRPS operations.

Migration Conditions. Only juveniles that emerge from the Wind, Little White Salmon, and [Big] White Salmon rivers in Washington and the Hood River in Oregon encounter Bonneville Dam after entering the Columbia River. Although there are no ESU-specific survival rates of LCR chinook salmon past Bonneville Dam, NMFS assumes that these are adequately represented by data for yearling and subyearling chinook salmon migrants in the run at large. Using SIMPAS, NMFS estimated an average system survival rate of 87% for yearling migrants and 72% for subyearling migrants through Bonneville pool and dam during 1994 through 1999 (Table 6.2-7). It should be noted, however, that the potential for these effects applies to a limited number of the subbasin populations.

6.2.9.5.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River estuary and plume that in turn affect the growth and survival of subyearling LCR chinook salmon. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.5.4 Adult Migration Corridors

Water Quality/Water Quantity/Water Velocity. Effects of the proposed action on biological requirements for water quality, quantity, and velocity in the mainstem Columbia River migration corridor are different for the spring- and fall-run components of the ESU. For spring-run chinook salmon, effects are similar to those described above for SR spring/summer chinook salmon. For fall-run fish, low flows during late summer and early fall, related to high temperatures, may delay migration through the Bonneville pool and potentially lead to disease transmission between adults delayed in fish ladders. The potential for these effects, however, applies to a limited number of the subbasin populations.

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. LCR chinook salmon do not have biological requirements for riparian vegetation or food in the adult migration corridor.

Migration Conditions. Based on recent radio-tracking studies with SR spring/summer and fall chinook salmon, NMFS estimates that the average survival rate of adult migrants from below Bonneville to tributaries to the Bonneville pool is 98% for spring-run fish and 96% for fall-run fish (Table 6.1-1). It should be noted that this type of mortality is limited to passage at one project for part of the subbasin populations.

6.2.9.5.5 Spawning Areas

The proposed action will affect biological requirements for spawning habitat of LCR chinook salmon in the Ives Island area below Bonneville Dam, where individuals from this ESU were observed spawning once, during October 1999.

Water Quality/Water Quantity/Velocity/Space/Migration Conditions/Substrate. The Action Agencies can use reservoir storage from the upper Columbia and Snake river basins to augment mainstem flows below Bonneville Dam, creating access to, and increasing the areal extent of, shallow-water spawning habitat in the Ives Island area. Under the proposed action, the likelihood of meeting a minimum spawning flow (125 kcfs at Bonneville Dam) during September and October is 20% or less (Table 6.2-5). Short-term fluctuations in flow in the Ives Island area, especially below 125 kcfs, can strand adult fall chinook and interrupt spawning. Adult LCR chinook salmon do not have biological requirements for food, cover, shelter, or riparian vegetation associated with spawning habitat. NMFS is uncertain whether FCRPS reservoir storage affects temperature in the Ives Island area during late September and early October, when tule fall chinook spawn.

Cover/Shelter/Food/Riparian Vegetation. LCR chinook salmon do not have biological requirements for cover, shelter, food, or riparian vegetation in spawning habitat.

6.2.9.6 Snake River Steelhead

6.2.9.6.1 Juvenile Rearing Areas. Juvenile SR steelhead rear in tributary systems to the mainstem Snake River and do not have biological requirements for rearing habitat in the action area.

6.2.9.6.2 Juvenile Migration Corridors

Juvenile SR steelhead migrate as yearlings, with peak movement past Lower Granite Dam during April and May.

Water Quality/Quantity/Velocity/Cover/Shelter. Effects of the proposed action on biological requirements for water quality, quantity, velocity, cover, and shelter in juvenile migration corridors are the same as those discussed for SR spring/summer chinook salmon (above).

Riparian Vegetation. Yearling steelhead migrants do not have biological requirements for riparian vegetation in the juvenile migration corridor.

Food. NMFS is uncertain whether yearling steelhead migrants have a biological requirement for food in the juvenile migration corridor or, if food is required, whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Space. Biological requirements for space in the mainstem juvenile migration corridor are not likely to be adversely affected by the proposed action.

Migration Conditions. Using SIMPAS, NMFS estimated that an average of 77% of the run was transported from the Snake River collector projects during 1994 through 1999 (Table 6.2-7). The rest of the run migrated inriver past eight FCRPS projects. The direct survival of transported juveniles over the same period was at least 98%, and NMFS estimates that the average system survival rate of inriver migrants was approximately 42%. The total (transported plus inriver) system survival rate for SR steelhead ranged from 46% to 49%, on average (depending on the level of differential mortality of transported fish assumed in the analysis).

6.2.9.6.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River plume that in turn affect the growth and survival of yearling SR steelhead. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.6.4 Adult Migration Corridors

Water Quality/Water Quantity/Velocity. The run timing of SR steelhead overlaps with that of both SR summer and SR fall chinook. Effects of the proposed action on biological requirements for water quality, quantity, and velocity in the adult mainstem Columbia and Snake river

migration corridors are, therefore, the same as those discussed for both SR spring/summer chinook salmon and SR fall chinook salmon (above).

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. SR steelhead do not have biological requirements for riparian vegetation or food in the adult migration corridor.

Migration Conditions. Based on recent radio-tracking studies, the mean survival rate of adult migrants between Bonneville and Lower Granite dams is 77%, equivalent to a per-project survival rate of 97% (Table 6.1-1). Few downstream-migrating adult steelhead (kelts) survive to spawn a second time without passing through dams (7% to lower Columbia River tributaries). The mortality of kelts passing through FCRPS projects has not been investigated. Assuming that turbine survival is similar to that of upstream migrating adults (22% to 57%, page VI-15 in NMFS 1998), the survival of kelts past multiple dams to spawn a second time is unlikely.

6.2.9.6.5 Spawning Areas. SR steelhead spawn in tributary systems to the mainstem Snake River and do not have biological requirements for spawning habitat in the action area.

6.2.9.7 Upper Columbia River Steelhead

6.2.9.7.1 Juvenile Rearing Areas. Juvenile UCR steelhead rear in tributary systems to the mainstem Columbia River and do not have biological requirements for rearing habitat in the action area.

6.2.9.7.2 Juvenile Migration Corridors

Juvenile UCR steelhead are yearling migrants, moving through the mainstem Columbia River during spring.

Water Quality. Effects of the proposed action on biological requirements for water quality in juvenile migration corridors are the same as those discussed for SR spring/summer chinook salmon in the juvenile migration corridor (above).

Water Quantity/Velocity/Cover/Shelter. Under the proposed action, the likelihood of meeting or exceeding flow objectives at Priest Rapids and McNary dams during the spring migration season (April, May, and June) is 78% or less under the base case, except during May at Priest Rapids (86%; Table 6.2-5).

Riparian Vegetation. Yearling steelhead migrants do not have biological requirements for riparian vegetation in the mainstem Snake and Columbia river migration corridors.

Food. NMFS is uncertain whether yearling steelhead migrants have biological requirements for food in the mainstem migration corridor or, if food is required, whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Space. Biological requirements for space in the mainstem migration corridor are not likely to be adversely affected by the proposed action.

Migration Conditions. Juveniles are spring migrants with peak movement past Rock Island Dam in the mid-Columbia reach during May. Depending on their natal tributary, juveniles pass through five (Methow River), four (Entiat River), or three (Wenatchee River) mid-Columbia PUD projects before reaching McNary Dam. Under existing operations, transportation from McNary Dam has not been used as a protection measure for UCR steelhead. However, a portion of the run (typically less than 5%; Figure VI-5 in NMFS 2000d) has been collected and transported in the past. Although there are no ESU-specific survival rates of UCR steelhead through FCRPS hydroprojects, NMFS assumes that these are adequately represented by data for SR steelhead. Using SIMPAS, NMFS estimated that the total system survival rate of juvenile steelhead from the head of McNary pool to below Bonneville Dam averaged 59% during 1994 through 1999 (Table 6.2-7).

6.2.9.7.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River plume that in turn affect the growth and survival of yearling UCR steelhead. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.7.4 Adult Migration Corridors

Water Quality/Water Quantity/Velocity. Effects of the proposed action on biological requirements for water quality, quantity, and velocity in adult migration corridors are the same as those discussed for SR spring/summer chinook salmon (above).

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. UCR steelhead do not have biological requirements for riparian vegetation or food in the adult migration corridor.

Migration Conditions. Based on recent radio-tracking with SR steelhead, NMFS estimates that the mean survival rate of adult migrants from below Bonneville Dam to the head of McNary pool is 88%, equivalent to a per-project survival rate of 97% (Table 6.1-1).

6.2.9.7.5 Spawning Areas. UCR steelhead spawn in tributary systems to the mainstem Columbia River and do not have biological requirements for spawning habitat in the action area.

6.2.9.8 Middle Columbia River Steelhead

6.2.9.8.1 Juvenile Rearing Areas. Juvenile MCR steelhead rear in tributary systems to the mainstem Columbia River and do not have biological requirements for rearing habitat in the action area.

6.2.9.8.2 Juvenile Migration Corridors

Juvenile MCR steelhead are yearling migrants, moving through the mainstem lower Columbia River during spring.

Water Quality. Effects of the proposed action on biological requirements for water quality in the mainstem Columbia River migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Water Quantity/Velocity/Cover/Shelter. Flow objectives have not been developed to benefit MCR steelhead. However, yearling migrants from this ESU will probably benefit from flow objectives at Priest Rapids and McNary dams, developed to protect yearling migrants from the upper Columbia River basin. Under the proposed action, the likelihood of meeting or exceeding flow objectives at Priest Rapids and McNary dams during the spring migration season (April, May, and June) is 78% or less under the base case, except during May at Priest Rapids (86%; Table 6.2-5).

Riparian Vegetation. Yearling steelhead migrants do not have biological requirements for riparian vegetation in the mainstem migration corridor.

Food. NMFS is uncertain whether yearling steelhead migrants have a biological requirement for food in the juvenile migration corridor or, if food is required, whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Space. Biological requirements for space in the juvenile migration corridor are not likely to be adversely affected by the proposed action.

Migration Conditions. Juveniles are spring migrants. These fish do not pass Rock Island Dam, so there is no ESU-specific information on historical passage patterns. Only those that emigrate from the Yakima and Walla Walla subbasins encounter McNary Dam after entering the Columbia River. Under existing operations, transportation from McNary Dam has not been used as a protection measure for MCR steelhead. However, a portion of the run from the Yakima and Walla Walla subbasins has probably been collected and transported in the past. Although there are no ESU-specific survival rates of MCR steelhead through FCRPS projects, NMFS assumes that these are adequately represented by data for SR steelhead. Using SIMPAS, NMFS estimated that the average FCRPS system survival rate of juvenile steelhead from the Yakima and Walla Walla subbasins, from the head of McNary pool to below Bonneville Dam, during 1994 through

1999 was 59% (Table 6.2-7). Based on the project-specific survival rates shown in Table 6.2-7, the average system survival rates of MCR steelhead emigrating from tributaries to the John Day and The Dalles pools are, on average, approximately 65% and 76%, respectively.

6.2.9.8.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River plume that in turn affect the growth and survival of yearling MCR steelhead. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.8.4 Adult Migration Corridors

Water Quality/Water Quantity/Velocity. Effects of the proposed action on biological requirements for water quality, quantity, and velocity in the adult mainstem Columbia River migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the adult mainstem migration corridor are not likely to be adversely affected by the proposed action.

Food/Riparian Vegetation. Adult MCR steelhead do not have biological requirements for food and riparian vegetation in the mainstem Columbia River migration corridor.

Migration Conditions. Based on recent radio-tracking studies with SR steelhead, NMFS estimates that the mean survival rates of adult MCR steelhead migrants in the reach from below Bonneville Dam to the heads of The Dalles, John Day, and McNary pools are 94%, 91%, and 88%, respectively, equivalent to a per-project survival of 97% (Table 6.1-1).

6.2.9.8.5 Spawning Areas. MCR steelhead spawn in tributary systems to the mainstem Columbia River and do not have biological requirements for spawning habitat in the action area.

6.2.9.9 Upper Willamette River Steelhead

6.2.9.9.1 Juvenile Rearing Areas. Juvenile UWR steelhead rear in tributary systems to the mainstem Columbia River and do not have biological requirements for rearing habitat in the action area.

6.2.9.9.2 Juvenile Migration Corridors

Juvenile UWR steelhead are yearling migrants, moving through the mainstem lower Columbia River during spring.

Water Quality. Effects of the proposed action on biological requirements for water quality in the mainstem Columbia River migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Water Quantity/Velocity/Cover/Shelter/Space. Biological requirements for water quantity and velocity, cover, shelter, or space in the juvenile migration corridor are not likely to be adversely affected by the proposed action. Mainstem Columbia River flow objectives have not been developed to benefit juvenile UWR steelhead.

Riparian Vegetation. Yearling steelhead migrants do not have biological requirements for riparian vegetation in the mainstem Columbia River migration corridor.

Food. NMFS is uncertain whether yearling steelhead migrants have a biological requirement for food in the mainstem Columbia River migration corridor or, if food is required, whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Migration Conditions. Juvenile UWR steelhead enter the Columbia River below Bonneville Dam and thus are not subject to passage mortality.

6.2.9.9.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River plume that in turn affect the growth and survival of yearling UWR steelhead. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.9.4 Adult Migration Corridors

Water Quality/Water Quantity/Velocity. Effects of the proposed action on biological requirements for water quality, quantity, and velocity in the adult mainstem Columbia River migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the mainstem Columbia River migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. UWR steelhead do not have biological requirements for riparian vegetation or food in the mainstem Columbia River migration corridor.

Migration Conditions. Adults leave the Columbia River to enter the Willamette system below Bonneville Dam and thus are not subject to project passage mortality.

6.2.9.9.5 Spawning Areas. UWR steelhead spawn in tributary systems to the mainstem Columbia River and do not have biological requirements for spawning habitat in the action area.

6.2.9.10 Lower Columbia River Steelhead

6.2.9.10.1 Juvenile Rearing Areas. Juvenile LCR steelhead rear in tributary systems to the mainstem Columbia River and do not have biological requirements for rearing habitat in the action area.

6.2.9.10.2 Juvenile Migration Corridors

Juvenile LCR steelhead migrate as yearlings, moving through the mainstem lower Columbia River during spring.

Water Quality. Effects of the proposed action on biological requirements for water quality in the mainstem Columbia River juvenile migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Water Quantity/Velocity/Cover/Shelter/Space. Biological requirements for water quantity and velocity, cover, shelter and space in the mainstem Columbia River juvenile migration corridor are not likely to be adversely affected by the proposed action. Flow objectives have not been developed to benefit LCR steelhead.

Riparian Vegetation. Yearling steelhead migrants do not have biological requirements for riparian vegetation in the mainstem Columbia River migration corridor.

Food. NMFS is uncertain whether yearling steelhead migrants have a biological requirement for food in the juvenile migration corridor or, if food is required, whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Migration Conditions. There is no ESU-specific information on historical passage patterns or survival rates, but only migrants from the Wind River, Washington, and the Hood River, Oregon, encounter Bonneville Dam after entering the Columbia River. NMFS assumes that their survival rates are adequately represented by data for SR steelhead. Using SIMPAS, NMFS estimated an average survival rate of 87% through Bonneville pool and dam during 1994 through 1999 (Table 6.2-7). It should be noted, however, that the potential for these effects is limited to passage at one (i.e., Bonneville) project for part of the subbasin populations.

6.2.9.10.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River plume that in turn affect the growth and survival of yearling LCR steelhead. The evidence for these relationships is largely inferential, however, and is the subject of ongoing research.

6.2.9.10.4 Adult Migration Corridors

Water Quality/Water Quantity/Velocity. Effects of the proposed action on biological requirements for water quantity and velocity in the adult mainstem Columbia River migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the mainstem Columbia River migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. LCR steelhead do not have biological requirements for riparian vegetation or food in the adult mainstem Columbia River migration corridor.

Migration Conditions. Based on recent radio-tracking studies with SR steelhead, NMFS estimates that the mean survival rate of adult migrants from below Bonneville Dam to tributaries in Bonneville pool is approximately 97% (Table 6.1-1). It should be noted, however, that the potential for these effects is limited to passage at one (i.e., Bonneville) project for part of the subbasin populations.

6.2.9.10.5 Spawning Areas. LCR steelhead spawn in tributary systems to the mainstem Columbia River and do not have biological requirements for spawning habitat in the action area.

6.2.9.11 Columbia River Chum Salmon

6.2.9.11.1 Juvenile Rearing Areas. Effects of the proposed action on biological requirements for juvenile rearing habitat are the same as those discussed for LCR chinook salmon in juvenile rearing areas (above).

6.2.9.11.2 Juvenile Migration Corridors

Juvenile CR chum salmon are subyearling migrants, moving through the mainstem lower Columbia River during late winter and early spring.

Water Quality. Effects of the proposed action on the biological requirements of juvenile CR chum salmon for water quality in the mainstem Columbia River juvenile migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Water Quantity/Velocity/Cover Shelter. Under the proposed action, the likelihood of meeting or exceeding flow objectives at Bonneville Dam during the late winter/early spring migration season is 78% (i.e., during February and March, Table 6.2-5).

Riparian Vegetation. Subyearling chum salmon migrants do not have biological requirements for riparian vegetation in the mainstem Columbia River migration corridor.

Food. NMFS is uncertain whether subyearling CR chum salmon migrants are likely to have biological requirements for food in the mainstem Columbia River migration corridor, or whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Space. Biological requirements for space in the juvenile migration corridor are not likely to be adversely affected by the proposed action.

Migration Conditions. Although chum salmon spawned historically in the lower reaches of several tributaries to the Bonneville pool and along the Washington shoreline, this habitat was inundated by the Bonneville pool in 1938 (Fulton 1970). Although some adult chum salmon still pass Bonneville Dam (see below), the smolt monitoring program has no record of juvenile chum salmon passage at Bonneville Dam between 1985 and the present (Wood 2000). Thus, although the facts are uncertain, it is unlikely that more than a very small proportion of any year class is affected by project passage.

6.2.9.11.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River estuary and plume that in turn affect the growth and survival of subyearling CR chum salmon. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.11.4 Adult Migration Corridors

Water Quality/Water Quantity/Velocity/Cover/Shelter/Space. Adult CR chum salmon are late fall/early winter migrants. Biological requirements for water quality, quantity, velocity, cover, shelter, or space in the mainstem Columbia River adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. CR chum salmon do not have biological requirements for riparian vegetation or food in the adult migration corridor.

Migration Conditions. Adult chum salmon are known to show little persistence in surmounting river blockages and falls (63 FR 11775). The extent to which Bonneville Dam has acted as a barrier to upstream migration is unknown. The latest available full counts of chum salmon over Bonneville Dam are 195 and 135 adults during 1998 and 1999, respectively (Table C-12). There are no estimates of adult passage survival of CR chum salmon at Bonneville or any other FCRPS dam.

6.2.9.11.5 Spawning Areas. The Action Agencies can use reservoir storage from the upper Columbia and Snake river basins to augment mainstem flows below Bonneville Dam, creating access to and increasing the areal extent of spawning habitat in the Ives Island area. Under the proposed action, the likelihood of meeting a minimum spawning flow (125 kcfs at Bonneville Dam) during November and December is 90% or less (Table 6.2-5). Adult CR chum salmon do not have biological requirements for food, cover, shelter, or riparian vegetation associated with spawning habitat. FCRPS reservoir storage does not affect temperatures in the Ives Island area during November and December, when chum salmon spawn.

6.2.9.12 Snake River Sockeye Salmon

6.2.9.12.1 Juvenile Rearing Areas. Juvenile SR sockeye salmon rear in rear in lakes in tributary systems to the Snake River and, therefore, do not have biological requirements for rearing habitat in the action area.

6.2.9.12.2 Juvenile Migration Corridors

Juvenile SR sockeye salmon are yearling migrants, with peak movement past Lower Granite Dam during May.

Water Quality. Effects of the proposed action on biological requirements for water quality in juvenile migration corridors are the same as those discussed for SR spring/summer chinook salmon in the mainstem Snake and Columbia river juvenile migration corridor (above).

Water Quantity/Velocity/Cover/Shelter. Under the proposed action, the likelihood of meeting or exceeding flow objectives at Lower Granite and McNary dams during the spring migration season (April, May, and June) is 68% or less (Table 6.2-5).

Riparian Vegetation. Yearling sockeye salmon migrants do not have biological requirements for riparian vegetation in the mainstem Snake and Columbia river migration corridor.

Food. NMFS is uncertain whether yearling sockeye salmon migrants have a biological requirement for food in the mainstem Snake and Columbia river migration corridor or, if food is required, whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Space. Biological requirements for space in the mainstem Snake and Columbia river migration corridor are not likely to be adversely affected by the proposed action.

Migration Conditions. An unknown proportion of the juvenile migration is transported from the Snake River collector projects. Studies at John Day and Wanapum dams with run-of-the-river unlisted UCR sockeye salmon found that the FGE of juvenile sockeye salmon was lower than that of spring chinook salmon or steelhead. If this finding also applies to the Snake River ESU, it is likely that a smaller proportion of the sockeye salmon outmigration is transported compared with that of spring/summer chinook salmon or steelhead. If transport rates are lower, it is likely that the total direct survival of this species is also less than that of other yearling migrants.

6.2.9.12.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River plume that in turn affect the growth and survival of yearling SR sockeye salmon. The evidence for these relationships is largely inferential, however, and is the subject of ongoing research.

6.2.9.12.4 Adult Migration Corridors

Water Quality/Quantity/Velocity. Effects of the proposed action on biological requirements for water quality, quantity, and velocity in the mainstem Columbia and Snake river adult migration corridor are the same as those for SR spring/summer chinook salmon (above).

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. Adult SR sockeye salmon do not have biological requirements for riparian vegetation or food in the mainstem Columbia and Snake river migration corridor.

Migration Conditions. Because few adult sockeye salmon have returned to the Snake River basin in recent years, little information has been collected on their survival through mainstem FCRPS projects. Tagging studies using adult sockeye salmon from the unlisted Upper Columbia River ESU measured an average per-project survival of 98% through the lower Columbia River. Expanding the per-project rate over the 8-project (Bonneville to Lower Granite) reach, NMFS estimates an adult survival rate of 86% for this ESU (Table 6.1-1).

6.2.9.12.5 Spawning Areas. SR sockeye salmon spawn in tributary systems to the mainstem Columbia River and do not have biological requirements for spawning habitat in the action area.

6.3 ANALYSIS OF EFFECTS OF PROPOSED ACTION ON BIOLOGICAL REQUIREMENTS OVER FULL LIFE CYCLE

Appendix C describes the median annual population growth rate (lambda) and the risk of absolute extinction at the ESU and, in some cases, the population level. In this section, NMFS examines the likely effects of the proposed action on the risk of extinction and the likelihood of recovery (Section 1.3.1.1 and 6.1.2). Although the jeopardy standard is ultimately a qualitative assessment of whether there is a high likelihood of survival with an adequate potential for recovery, NMFS considers the specific level of improvement needed to achieve particular risk levels as one indication of population status relative to that jeopardy standard (Sections 1.3.1.1 and 6.1.2). These risk levels (≤5% risk of extinction in 24 and 100 years; ≥50% likelihood of meeting interim recovery abundance levels in 48 and 100 years; ≥50% likelihood that population growth rate will be stable or increasing) are referred to subsequently as "survival indicator criteria" or "recovery indicator criteria." This standardized analysis is used to evaluate the importance of the effects described in the preceding section as likely to occur in the action area in the context of the full life cycle. The data for some of the ESUs considered in this biological opinion are too scarce or of inadequate quality to permit a quantitative life-cycle analysis of this type. For some of those ESUs, inferences can be drawn from the quantitative results described for the other ESUs.

Details of the quantitative analyses used to evaluate the effects of the proposed action on biological requirements over the full life cycle are described in Section 6.1.2 and Appendix A. Quantitative and qualitative estimates are summarized for several ESUs in the following sections.

6.3.1 Snake River Spring/Summer Chinook Salmon

Evaluation of species-level effects of the proposed action requires placing the action-area effects in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of SR spring/summer chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range, including habitat degradation in many areas due to timber harvest, grazing, and mining practices (loss of pools, high temperatures, low flows, poor overwintering conditions, and high sediment loads).

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

6.3.1.1 Populations Evaluated

NMFS evaluated 43 spawning aggregations of SR spring/summer chinook salmon. Seven of these are the index stocks described in the June 27, 2000, draft biological opinion, previous NMFS analyses (McClure et al. 2000b), and PATH reports (Marmorek et al. 1998). The remaining spawning aggregations were the subject of new analyses in McClure et al. (2000c). NMFS has not yet determined which, if any, of the index stocks and additional spawning aggregations represent "populations," as defined by McElhany et al. (2000), but all are treated as independent populations because of the statistical assumptions inherent in the analysis.

6.3.1.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. NMFS also estimated the change from the base period lambda necessary to achieve ≥50% likelihood of meeting interim recovery abundance levels (NMFS 1995c) in 48 and 100 years using the most current estimates of lambda and methods described in Appendix A. Interim recovery abundance levels have been defined only for three ESUs and, in the SR spring/summer chinook ESU, only for the seven index stocks. Therefore, NMFS estimated the change in lambda necessary to meet an alternative recovery indicator criterion of lambda ≥1.0 (Appendix A) for all other spawning aggregations. Details of each of these estimates are included in Appendix A.

NMFS also investigated the effects of adding preliminary returns in 2000 and an estimate of expected returns in 2001 (based on jack abundance) to the time-series used to estimate lambda in each of the calculations described above. Estimates are included in McClure (2000b). These preliminary returns were included in the lowest estimates of necessary survival changes.

6.3.1.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from 1980 to 1999 will continue indefinitely into the future. However, the juvenile SR spring/summer chinook salmon survival rate associated with the proposed action represents an improvement from the average survival rate influencing base period adult returns. That is because many structural and operational modifications to the hydrosystem have been implemented since 1980. Juvenile bypass systems were installed at McNary Dam in the early 1980s, at both Bonneville Dam powerhouses and at John Day Dam in the mid-1980s, and at Lower Monumental and Ice Harbor dams in the early 1990s. Juvenile bypass systems were also upgraded at Little Goose and McNary dams in the early 1990s, extended-length intake screens that increase guidance away from turbines were installed in bypasses at three projects in the late 1990s, and the Bonneville Second Powerhouse bypass was upgraded at the end of the 1990s. Bypass systems at Lower Granite, Little Goose, Lower Monumental, and McNary (through 1994) dams have allowed

juvenile transportation from those projects, increasing the proportion of smolts transported over the base period and increasing the corresponding direct juvenile survival rate.

Spill rates also increased during the period, improving the survival of inriver migrants. The 1989 spill agreement provided spill to ensure that 70% of spring migrants and 50% of summer migrants passed each project without going through turbines. The 1995 FCRPS Biological Opinion established spill levels equivalent to 80% of both spring and summer migrants passing a project without going through turbines, unless dissolved gas caps prevented it. Flow deflectors were installed at Ice Harbor and John Day dams in the mid-1990s, reducing TDG levels and permitting additional spill. Since the mid-1990s, NMFS has required that turbines be operated within 1% of peak efficiency to improve the survival of fish passing through turbines.

During the same period, flow augmentation also increased to improve survival of inriver migrants. The NWPPC water budget was established during the 1983 migration season. It consisted of a program for spring flow augmentation using a volume approach. No summer flow augmentation was established. In 1992 and 1993, the volumes available for flow augmentation were increased and summer flow augmentation was established. The 1995 FCRPS Biological Opinion established spring and summer target flows and identified additional storage volumes to increase the likelihood of meeting the targets. Although these changes to the hydropower corridor have been made since 1980, the period chosen for the analysis of extinction risk does not include the extremely large and one-time impacts of dam construction.

NMFS used two methods to estimate the proportional change in juvenile survival from that experienced on average by adults returning from 1980 to 1999 to that associated with the proposed action. The first method compared PATH estimates of juvenile survival during 1980 to 1992 (retrospective scenario of Marmorek et al. 1998) to PATH estimates of 1995 FCRPS Biological Opinion operations applied to the same water conditions (scenario A2 of Marmorek et al. 1998). The purpose was to evaluate historical survival versus an approximation of current juvenile survival under a 13-year range of water conditions. NMFS applied the approach in response to comments by agencies and organizations that the method used in the July 27 draft biological opinion evaluated the change from historical to current operations under too narrow a range of water years for current operations, which led to overly optimistic results.

The 1980 juvenile passage survival corresponds to the first migration year that fully contributes to adult returns in the first pair of 5-year running sums used to calculate lambda (McClure et al. 2000c, Holmes [in review]). The 1992 migration year was the last available from the PATH analysis. The survival rate used in the NMFS' comparison included estimates of direct survival to below Bonneville Dam from both of PATH's alternative passage models and differential post-Bonneville survival of transported fish, as described in Section 6.2.3.3.1 (D = 0.63 to 0.73). NMFS included differential post-Bonneville survival (D) in the survival estimates because, even though NMFS finds no evidence that D changed between the two periods, different proportions of fish were transported over time. Because the proportion of transported fish surviving to Bonneville is multiplied by D, this leads to a significant impact of the D term. On the other

hand, delayed mortality of nontransported fish had no effect on the proportional change in survival, so was not relevant to this analysis. The expected survival change ranged from 27% to 38%, depending on passage model and D assumption, and averaged 32% (1.32 times the average historical survival rate) across all assumptions.

The second method represented a modification of the approach used in the July 27 draft biological opinion. In this case, the historical period was defined using PATH passage model estimates for 1980 to 1992 and SIMPAS model estimates for 1994 to 1997. The 1980 juvenile passage survival was defined for the earliest year, for reasons described above. The 1997 smolt migration was the last migration year contributing to the 1999 adult returns in NMFS' 1980-to-1999 risk assessment. An estimate for 1993 is not available from either passage modeling system. The average of all 17 years was the estimate corresponding to NMFS' 1980-to-1999 risk assessment. NMFS defined current operations, corresponding to effects of the proposed action, as the 1994-to-1999 average SIMPAS estimates. Section 6.2 describes the rationale for equally weighting each year when calculating the average. This second method resulted in expected survival improvements ranging from 12% to 35%, depending upon passage model and D assumption, and averaged 24% (1.24 times the average historical survival rate) across all assumptions.

The July 27, 2000, draft biological opinion included a method similar to this second approach, since it also combined SIMPAS and PATH estimates of juvenile survival to evaluate the change in juvenile survival. Several agencies and organizations criticized that approach, claiming that some intrinsic difference between PATH and SIMPAS passage models overestimates the survival improvement associated with the proposed action. The difference cited most frequently was the treatment of reservoir survival in each passage model. However, both of PATH's passage models provide fairly close fits to NMFS' 1994-to-1996 PIT-tag reach survival estimates (Marmorek and Peters 1998), and the SIMPAS model is calibrated directly to those and to the 1997-to-1999 reach survival estimates (Appendix D). Additionally, both the structure and parameterization of the dam passage components of the SIMPAS model are very similar to those used in PATH (Appendix D). The main difference is that some of the parameter estimates used in SIMPAS reflect new information obtained since the PATH models were completed (Appendix D). Ideally, NMFS would compare PATH and SIMPAS estimates for the same years and actions to test the assumption that SIMPAS provides higher estimates of survival than PATH models. While this was possible for SR fall chinook results (see Section 6.3.3), there are no years for which both PATH and SIMPAS SR spring/summer chinook estimates exist. However, it is unlikely that significant discrepancies between PATH and SIMPAS exist because of the similar structure and similar fit to PIT-tag reach survival estimates, and because both the PATH-only and PATH/SIMPAS methods included in this analysis yield similar results. Also, because the method using both PATH and SIMPAS yields a lower estimate of the survival change than does the exclusive use of PATH estimates, this approach does not produce optimistic results compared with PATH.

No other quantifiable survival rates changed significantly between the average 1980-to-1999 and the current condition. For example, there is no evidence to suggest that adult survival through the hydrosystem has changed significantly under current operations, compared with average adult survival between 1980 and 1999. Current and future spring and summer chinook harvest rates are very similar to average harvest rates throughout the 1980-to-1999 period, so NMFS did not attempt to identify a change in survival associated with current harvest rates. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival, estuary survival, and adult survival above Lower Granite Dam that may have resulted from habitat and hatchery management actions, so no change in those survival rates is included in this quantitative analysis. In Section 6.3.1.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the proposed action.

6.3.1.4 Additional Necessary Survival Changes

Table 6.3-1 shows the effect of the 24% to 32% survival rate increase expected from the proposed action on the future median annual population growth rates for 43 SR spring/summer chinook spawning aggregations. In some cases (e.g., Marsh Creek), the resulting population growth rate is expected to change from a declining trend (lambda <1.0) to a stable or increasing trend. In spite of the expected improvement in population growth rate, at least 22, and possibly as many as 27, of the 43 spawning aggregations require additional survival improvements to meet the survival and recovery indicator criteria. Table 6.3-1 displays the additional improvements in survival that would be necessary, beyond the 24% to 32% improvement associated with the proposed action, to reduce the 100-year extinction risk to 5% and either increase the likelihood of recovery in 48 years to 50% or increase the likelihood of achieving a stable or increasing population growth rate to 50%. These indicator criteria are presented because, if they are achieved, all the survival and recovery indicator criteria will be achieved.

Values in Table 6.3-1 less than or equal to 1.0 indicate that no further survival improvements are necessary to meet the survival and recovery indicator criteria. Values greater than 1.0 represent the multiplier by which survival would have to improve to achieve these criteria. For example, the survival change necessary to reduce the risk of extinction in 100 years to 5% (columns 8 and 9 of Table 6.3-1) is 0.89 to 1.10 for the Sulphur Creek index stock. This means that the proposed action, combined with expected survival in other life stages (see Section 6.3.1.6, below), is sufficient to reduce the 100-year extinction risk to 5% or less under the highest estimate of the expected survival change and the lowest estimate of the needed improvement. On the other hand, under the lowest estimate of the expected survival change and the highest estimate of the necessary survival change, an additional 10% survival improvement (1.10 times expected survival rate) is needed. This means that an additional 10% increase in egg-to-adult survival, or any component life-stage-specific survival rate, would be necessary to achieve no more than a 5% risk of extinction in 100 years for this index stock under the most pessimistic assumptions NMFS evaluated.

Table 6.3-1. Snake River spring/summer chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	0.82	0.91	1.24	1.32	0.86	0.97	1.53	1.63	1.17	1.98
Index Stocks:										
Bear Valley/Elk creeks	1.02	1.03	1.24	1.32	1.06	1.09	0.75	0.81	0.83	0.93
Imnaha River	0.88	0.92	1.24	1.32	0.92	0.98	0.88	1.21	1.32	1.74
Johnson Creek	1.01	1.03	1.24	1.32	1.06	1.10	0.76	0.81	0.73	0.87
Marsh Creek	0.99	1.00	1.24	1.32	1.03	1.06	0.77	0.93	1.02	1.17
Minam River	0.93	1.02	1.24	1.32	0.98	1.09	0.76	1.18	0.88	1.33
Poverty Flats	0.99	1.02	1.24	1.32	1.04	1.09	0.76	0.81	0.77	0.94
Sulphur Creek	1.04	1.05	1.24	1.32	1.09	1.12	0.89	1.10	0.81	0.91
Additional Aggregations:										
Alturas Lake Creek	0.75	0.75	1.24	1.32	0.78	0.79	N/A	N/A	2.81	3.00
American River	0.91	0.91	1.24	1.32	0.95	0.97	N/A	N/A	1.16	1.24
Big Sheep Creek	0.85	0.88	1.24	1.32	0.89	0.91	N/A	N/A	1.35	1.65
Beaver Creek	0.95	0.95	1.24	1.32	1.00	1.01	N/A	N/A	0.94	1.00
Bushy Fork	0.98	0.98	1.24	1.32	1.03	1.04	N/A	N/A	0.83	0.88
Camas Creek	0.92	0.92	1.24	1.32	0.97	0.98	N/A	N/A	1.09	1.16
Cape Horn Creek	1.05	1.05	1.24	1.32	1.10	1.12	N/A	N/A	0.60	0.64
Catherine Creek	0.78	0.85	1.24	1.32	0.82	0.83	N/A	N/A	1.57	2.41
Catherine Creek N. Fork	0.92	0.92	1.24	1.32	0.97	0.98	N/A	N/A	1.09	1.17
Catherine Creek S. Fork	0.80	0.80	1.24	1.32	0.83	0.85	N/A	N/A	2.10	2.24
Crooked Fork	1.00	1.00	1.24	1.32	1.05	1.06	N/A	N/A	0.76	0.81
Grande Ronde River	0.77	0.84	1.24	1.32	0.81	0.82	N/A	N/A	1.66	2.54
Knapp Creek	0.89	0.89	1.24	1.32	0.93	0.95	N/A	N/A	1.27	1.36
Lake Creek	1.06	1.06	1.24	1.32	1.11	1.13	N/A	N/A	0.59	0.63
Lemhi River	0.98	0.98	1.24	1.32	1.02	1.04	N/A	N/A	0.84	0.90
Lookingglass Creek	0.72	0.79	1.24	1.32	0.76	0.77	N/A	N/A	2.11	3.40
Loon Creek	1.00	1.00	1.24	1.32	1.05	1.07	N/A	N/A	0.74	0.79
Lostine Creek	0.87	0.90	1.24	1.32	0.91	0.93	N/A	N/A	1.20	1.50
Lower Salmon River	0.92	0.92	1.24	1.32	0.96	0.98	N/A	N/A	1.11	1.19
Lower Valley Creek	0.92	0.92	1.24	1.32	0.97	0.98	N/A	N/A	1.08	1.15
Moose Creek	0.94	0.94	1.24	1.32	0.99	1.00	N/A	N/A	0.98	1.04
Newsome Creek	1.03	1.03	1.24	1.32	1.08	1.09	N/A	N/A	0.67	0.72
Red River	0.91	0.91	1.24	1.32	0.95	0.97	N/A	N/A	1.16	1.23
Salmon River E. Fork	0.94	0.94	1.24	1.32	0.99	1.00	N/A	N/A	1.00	1.07
Salmon River S. Fork	1.06	1.06	1.24	1.32	1.11	1.13	N/A	N/A	0.58	0.62
Secesh River	0.98	0.98	1.24	1.32	1.02	1.04	N/A	N/A	0.84	0.90
Selway River	0.91	0.91	1.24	1.32	0.96	0.97	N/A	N/A	1.13	1.21
Sheep Creek	0.80	0.80	1.24	1.32	0.84	0.85	N/A	N/A	2.06	2.20
Upper Big Creek	0.97	0.97	1.24	1.32	1.02	1.03	N/A	N/A	0.88	0.93
Upper Salmon River	0.90	0.90	1.24	1.32	0.95	0.96	N/A	N/A	1.18	1.26
Upper Valley Creek	1.03	1.03	1.24	1.32	1.08	1.10	N/A	N/A	0.66	0.70
Wallowa Creek	0.86	0.86	1.24	1.32	0.90	0.92	N/A	N/A	1.48	1.58
Wenaha River	0.84	0.90	1.24	1.32	0.88	0.90	N/A	N/A	1.19	1.74
Whitecap Creek	0.90	0.90	1.24	1.32	0.95	0.96	N/A	N/A	1.19	1.27
Yankee Fork, Salmon R	0.88	0.88	1.24	1.32	0.93	0.94	N/A	N/A	1.32	1.41
W. Fork, Yankee Fork	0.99	0.99	1.24	1.32	1.04	1.05	N/A	N/A	0.79	0.85

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically, except for the Imnaha (50% as effective). For index stocks, it also includes preliminary 2000 and projected 2001 returns in time series used to estimate lambda.
[3] Low represents estimation of juvenile survival improvement based on a comparison of PATH retrospective and prospective (A2) results.
[4] High represents estimation of juvenile survival improvement based on a combination of PATH and SIMPAS results.
[5] Low represents the low 1980-to-1999 lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-1999 lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A, including preliminary 2000 and projected 2001 returns for index stocks) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A, including only final returns through 1999) divided by the low estimate of the expected survival improvement.

Three of the seven index stocks require no additional survival changes beyond those expected under the proposed action to meet the survival and recovery indicator criteria. The other four index stocks require additional survival improvements ranging from 12% to 74%. For the additional spawning aggregations, data were insufficient for estimating extinction risk, and no interim recovery levels have yet been determined. For the spawning aggregations, the necessary survival change is that which will result in lambda of 1.0. Under all assumptions, 21 of the 36 spawning aggregations require additional survival changes, ranging from 9% to 240%. An additional two spawning aggregations need no additional survival change under the best-case assumptions that NMFS evaluated, but they need survival changes ranging between 4% and 7% under the worst-case assumptions. The remaining 13 spawning aggregations require no additional survival improvements under any of the assumptions evaluated.

These results are similar to those of PATH, with respect to the need for additional survival improvements after the proposed action is implemented, in order to meet approximations of the survival and recovery indicator metrics. The magnitude of the additional changes differs, however, between the two approaches and among different PATH reports. The PATH decision analysis (Marmorek et al. 1998) presents a more optimistic view than the NMFS analysis, while a PATH preliminary analysis of experimental management options (Peters and Marmorek 2000) estimates the need for larger survival increases than estimated in NMFS' analysis.

PATH evaluated two actions similar to the proposed action (A1 and A2) for the seven SR spring/summer chinook salmon index stocks (Marmorek et al. 1998). The mean likelihood of reaching recovery goals in 48 years was approximately 50% for A1 and slightly less than 50% for A2 for the sixth-worst of the seven index stocks. Using this PATH analysis, survival changes necessary to meet this goal appear to be relatively small compared with NMFS' estimates. In contrast, NMFS' analysis finds that a 0% to 33% survival increase is necessary for the sixth-worst stock[8] to achieve recovery within 48 years (Table 6.3-1). This more optimistic PATH analysis used a larger set of historical brood years (1950s through 1990s) and a broader set of assumptions for future conditions than the NMFS analysis.

A PATH analysis of experimental management options evaluated the risk of continuing the survival rates associated with only the 1978-to-1994 brood years into the future (Peters and Marmorek 2000). Under this set of assumptions, the PATH analysis was more pessimistic than NMFS' analysis. A 170% survival improvement would be necessary for the sixth-worst stock to achieve a 50% probability of recovery in 48 years. This PATH analysis did not consider the 24%-to-32% survival increase from average 1980 to the present survival (described in Section 6.3.1.3). Even if this survival improvement had been included in the PATH analysis, however, the estimated survival shortfall would still be greater than the shortfall estimated by the analysis in this biological opinion (Table 6.3.1.3). Both of these PATH analyses differ from NMFS' analysis in the time periods they considered. PATH models also included density dependence, which continually reduced productivity as stocks approach abundance levels near the recovery goal. In the case of Sulphur Creek, the sixth-worst stock in PATH's analysis, the maximum

[8] The sixth-worst stock is Marsh Creek under some assumptions, Minam River under others.

sustainable production was estimated at approximately 280 spawners (calculated from the slope of beta in Table 2 in Schaller et al. 1999), which is nearly identical to NMFS' interim recovery level (283 spawners).

PATH also estimated the probability of quasi-extinction (five fish per generation) in 100 years if 1978 to 1994 brood year survival continued (Peters and Marmorek 2000). The extinction risk ranged from 5.8% for the Imnaha index stock to 87.4% for the Marsh Creek stock. These estimates are comparable to NMFS' estimates of absolute extinction risk (0% to 100%, depending on index stock and hatchery-origin spawner effectiveness (McClure et al. 2000c). The improvements from the 1980-to-recent period described above should reduce extinction risk similarly for each model; however, the PATH model appears insensitive to changes in extinction risk with alternative management actions (Peters and Marmorek 2000).

PATH also evaluated the performance of these stocks relative to the 1995 FCRPS Biological Opinion's 24-year and 100-year survival metric (replaced with the extinction indicator criterion in the current analysis). The mean PATH results for the probability of being above the survival threshold were 65% over 24 years and 75% over 100 years (Marmorek et al. 1998). These estimates can be compared to 70%, which is a numerical approximation of the acceptable risk considered by NMFS in the 1995 FCRPS Biological Opinion. Thus, PATH determined that the A1 and A2 actions met an approximation of the acceptable level of risk over 100 years, but fell somewhat short of meeting that criterion over a 24-year period. The more pessimistic PATH experimental management report, which projected 1978-through-1994 brood year survivals into the future (Peters and Marmorek 2000), estimates that an additional 640% survival increase is needed for the worst index stock to meet the 24-year survival criterion and an additional 170% increase is necessary to meet the 100-year survival criterion. Estimates for the sixth-worst stock were more optimistic. As described above, this analysis did not apply the 24%-to-33% improvements from the survival of the 1980 through 1999 brood years. It does not appear, however, that inclusion of these improvements would significantly reduce the necessary additional survival improvement estimated by PATH.

6.3.1.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. The substantial comments primarily questioned the estimates of hydrosystem survival associated with the proposed action (addressed in Section 6.2), the method of estimating the expected proportional change in the juvenile survival rate from the average associated with base period returns (addressed above in one new and one modified method of estimating the expected change), the analytical assumption that all survival changes are achieved instantaneously, and the assumption that the effectiveness of hatchery-origin spawners may have been as low as 20% of that of wild-origin spawners.

Concerns about the implementation schedule were primarily directed at the RPA described in the July 27 draft biological opinion, which included actions not yet implemented. The analysis of the proposed action, however, as described above, is based on actions currently being implemented. Specifically, the juvenile survival rates through the hydrosystem are estimated from survival studies conducted between 1994 and 1999, and are not based on an expectation of future improvements. This criticism is, therefore, not relevant to the analysis of the proposed action.

In the July 27 draft biological opinion, NMFS evaluated actions under a 20%-to-80% range of assumptions regarding historical effectiveness of hatchery-origin natural spawners. NMFS concluded that the 80% assumption produced unrealistic results, so did not consider it when defining necessary survival improvements for the July 27 draft biological opinion's RPA. Many commenters disagreed with this conclusion. NMFS later determined that a computational error in the original CRI risk assessment was responsible for the unrealistic results, not the assumption of historical 80% hatchery-origin spawner effectiveness. NMFS therefore agrees with comments on this point and is considering results from the full 20%-to-80% range of assumptions in all analyses, unless specific information for a particular stock indicates that other assumptions are more appropriate.

Several agencies and organizations commented further that NMFS' 20%-to-80% range of historical effectiveness of hatchery-origin spawners was incorrect, and recommended that only the high end of this range should be applied to SR spring/summer chinook index stocks. Only ODFW included information to support this opinion. The information provided for the Imnaha River stock included a review of the wild fish supplementation effort on that tributary that was convincing to NMFS. Waples (2000a) suggested that it would be reasonable to use a range of 20%-to-80% relative reproductive success for hatchery fish in the biological opinion analysis for most stocks. It also suggested that, absent information to the contrary, it is reasonable to assume that values for local, nondomesticated supplementation stocks would fall in the upper half of the range. NMFS concludes that the Imnaha program falls into this category. From the start, it has been oriented toward helping (rather than replacing) natural production, and its monitoring program has been one of the best in the region. However, even the best-run hatchery program cannot avoid all genetic effects of fish culture, which are not zero even for a single generation. Furthermore, reproductive success in the first generation of naturally spawning hatchery fish can also be influenced by nongenetic fish culture effects. Even the most natural hatchery environment differs in many ways from the natural environment experienced by wild fish. All studies that have directly evaluated reproductive success of hatchery fish in the wild have found a significant reduction, even for programs with histories similar to that of the Imnaha. NMFS concludes, therefore, that a range of 50% to 80% is more reasonable for the Imnaha River index stock than 20% to 80%, a change the analysis described above reflects.

Oregon provided information on the effect of hatchery spawners on the Minam River index stock. NMFS did not find the arguments convincing. The Minam is (or was) a wild population not intended to be supplemented with hatchery fish, but that happened inadvertently through

straying of the non-native Rapid River stock. Waples (2000a) suggested that, without information to the contrary, it might be reasonable to assume that the reproductive success of hatchery fish in this situation would be in the lower half of the 20%-to-80% range. Oregon argued that the Minam River stock could not have been adversely affected by hatchery straying because its spawner-to-Columbia-River-recruit survival index has shown a similar trend to that of the Marsh Creek index stock, which is not influenced by hatchery spawners. That analysis provides indirect evidence that the effectiveness of hatchery spawners may be relatively high. However, another indirect line of evidence is available from genetic data collected from parr. In the Minam, as well as in the Grande Ronde River, the Wenaha River, and Catherine Creek, NMFS found that samples from some years were genetically very similar to the Lookingglass Hatchery stock, while samples from other years were quite distinctive (Waples 2000b). These results have been presented in regional meetings, as well as to the Grande Ronde science panel convened in 1996 to evaluate using Lookinglass Hatchery fish in the basin.

There is no strong correlation between estimated stray rate and degree of genetic similarity in the yearly samples. A possible explanation is that reproductive success of the stray hatchery fish was quite variable, being high in some years and low in others. Other possible explanations are high sampling variance in the genetic data or estimates of stray rate. Population allele frequencies vary considerably year to year as a result of drift in these small populations, but this random process should not produce a series of years in which the similarity to Lookingglass Hatchery stock is high. In summary, available information is equivocal regarding the reproductive success of stray hatchery fish in the Minam River. The data are consistent with the hypothesis that success is relatively high in at least some years, but it would not be prudent to assume that is the case in general. Therefore, NMFS continued to evaluate a 20%-to-80% range of hatchery effectiveness for the Minam River index stock in the analysis described above.

Most of the other SR spring/summer chinook index stocks are not affected by this assumption because hatchery-origin spawners are either absent or represent a small fraction of natural spawners. Substantive arguments or additional information were not received for these other stocks.

This analysis also contains assumptions that may make the results overly pessimistic. Three are the analytical assumptions that all spawning aggregates behave as independent populations; that all supplementation programs cease immediately; and that background survival will continue as it has from 1980 to the present.

NMFS assumed for its analysis that all spawning aggregates behave as independent populations. This assumption is unlikely, however, given the geographic proximity and demographic and genetic similarity of many of the spawning aggregates. Nevertheless, it is a conservative assumption in the absence of information about this ESU to the contrary. If a review by a technical recovery team defines the SR spring/summer chinook populations (as used by McElhany et al. 2000) as groups of two to several spawning aggregates, which would have higher combined abundance than the component spawning aggregates, the extinction risk

analysis will indicate that smaller changes in survival are necessary to avoid extinction. The recovery analysis may or may not be more optimistic than the analysis described above, depending on the final recovery abundance levels and other recovery criteria. Until a thorough review of the population structure of this ESU is complete, NMFS has few options for addressing problems with this assumption. NMFS' primary response is to evaluate the jeopardy standard with an expectation that only 80% of available spawning aggregates must meet expected criteria.

A second assumption that leads to pessimistic results is the analytical focus on risk to wild fish. This approach is consistent with ESA precepts, which call for the evaluation of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. However, it discounts the short-term benefits (and for some ESUs, such as SR sockeye, the necessity) of hatchery programs. The analysis described above assumes that any ongoing supplementation programs stop immediately; the risk to the wild component of ESUs is based on this assumption. To the extent that current supplementation programs are reducing the extinction risk for wild fish, this effect is not included in the results of this analysis. Again, few options are available to NMFS to address the shortcomings of this assumption. A more complex modeling approach could be pursued, but it would be limited by uncertainty about how to quantify the benefits and negative impacts of ongoing supplementation programs. It would also require a variety of assumptions regarding the likely scope and duration of future hatchery programs. In short, there is little that NMFS can do to improve on this assumption in the quantitative analysis. However, the factor is considered qualitatively in reaching a jeopardy conclusion.

A third assumption that may lead to pessimistic results is the implicit assumption that climatic conditions and other background factors influencing survival will continue as they have, on average, between 1980 and the present. Coronado and Hilborn (1998a,b) and Deriso et al. (1996) compared trends in survival among salmonid stocks from a range of locations in the Pacific Northwest that experience varying degrees of anthropogenic effects. Both analyses indicated that most stocks experienced above-average survival for the early 1980s brood years, but that survival has generally been below average since about the 1983 brood year. The common survival trends among stocks are probably a result of large-scale stressors, such as ocean conditions (Francis and Hare 1994, Mantua et al. 1997, Hare et al. 1999). The analysis described above assumes that the generally poor conditions influencing 1980-to-1999 returns will continue indefinitely. However, preliminary estimates of return rates in 2000 are well above average, and some have hypothesized that ocean conditions may be shifting to a more favorable regime. NMFS investigated the effects of adding preliminary returns in 2000 and an estimate of expected returns in 2001 (based on 2000 jack abundance) to the time-series used to estimate lambda. This information was used to define the most optimistic results for this ESU. If recent high returns indicate a favorable shift in climatic conditions that will continue over several years, that additional reason for optimism is not captured in the analysis. However, NMFS does consider the possibility of an ongoing effect of favorable climate qualitatively in reaching a jeopardy conclusion.

6.3.1.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-1 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above the uppermost dam). The sufficiency of Federal survival and recovery measures to augment survival improvements resulting from the FCRPS proposed action is highly uncertain unless there can also be reliable progress on non-Federal survival and recovery measures in other life stages. The proposed action includes language that may be interpreted as a commitment by the Action Agencies to undertake or fund some of these non-Federal measures. The biological assessment is not explicit enough, however, to reach that conclusion with certainty. NMFS concludes that some proportion of the additional survival improvements identified in Table 6.3-1 may be achieved through ongoing Federal activities and through the proposed action. However, it is unlikely that the necessary improvements can be fully achieved because of the limited commitment to fund non-Federal habitat and hatchery improvements to offset hydrosystem impacts in the Action Agencies' biological assessment.

6.3.2 Snake River Fall Chinook Salmon

Evaluation of species-level effects of the proposed action requires placing the action-area effects in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of SR spring/summer chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. Specifically, almost all the historical spawning habitat in the Snake River basin is blocked by the Hells Canyon Complex. Other irrigation and hydroelectric projects block access to habitat in tributaries to the Columbia River below Hells Canyon. Habitat quality is degraded by agricultural water withdrawals, grazing, vegetation management, and forestry and mining practices (lack of pools, high temperatures, low flows, poor overwintering conditions, and high sediment loads).

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other

likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

6.3.2.1 Populations Evaluated

NMFS analyzed the single aggregate Snake River fall chinook population. The analysis was based on Lower Granite Dam counts, so it does not include spawning areas in the Tucannon River and in the mainstem below some Corps dams.

6.3.2.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. NMFS also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the aggregate population interim recovery abundance level (based on NMFS 1995c; specifics in Appendix A) in 48 and 100 years using the most current estimates of lambda and methods described in Appendix A.

6.3.2.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from the base period will continue indefinitely. However, the juvenile SR fall chinook salmon survival rate associated with the proposed action is an improvement over the average survival rate influencing base period adult returns. That is because of the many structural and operational modifications to the hydrosystem since 1980 (Section 6.3.1.3).

NMFS used two methods to estimate the proportional change in juvenile survival from that experienced on average by adults returning from 1980 to 1999 to that associated with the proposed action. The first method compared PATH estimates of juvenile survival for the 1976-to-1992 migration years (retrospective scenario of Marmorek et al. 1998) with PATH estimates of 1995 FCRPS Biological Opinion operations applied to the same water conditions (scenario A2 of Marmorek et al. 1998). The rationale and general method were identical to those defining the first method for SR spring/summer chinook salmon (Section 6.3.1.3). However, NMFS included an estimate of differential delayed mortality specific to SR fall chinook salmon (D = 0.24, Section 6.2.3.3) and used all available PATH retrospective juvenile survival estimates corresponding to base period adult returns. The expected survival change using this method ranged from -2% to +31%, depending on the PATH passage model, and averaged 15% (1.15 times the average historical survival rate).

The second method defined the historical period using PATH passage models, as described above. NMFS did not supplement the historical PATH estimates with SIMPAS passage survival estimates, as in the second method used for SR spring/summer chinook salmon (Section 6.3.1.3)

because the first available SIMPAS estimate for fall chinook was the 1995 migration year, and those fish would not return as adults until at least 1997. NMFS defined current operations, corresponding to effects of the proposed action, as the 1995-to-1999 average SIMPAS estimates. Section 6.2 describes the rationale for equally weighting each year when calculating the average. The second method resulted in expected survival improvements ranging from -7% to +40%, depending on the PATH passage model, and averaged 16% (1.16 times the average historical survival rate) across all assumptions.

The second approach was similar to that included in the July 27, 2000, draft biological opinion, which also compared estimates of current operations, based on SIMPAS, to PATH estimates of historical juvenile survival. Several agencies and organizations criticized that approach, as described for SR spring/summer chinook salmon in Section 6.3.1.3. Reservoir survival in PATH's Columbia River Salmon Passage (CRiSP) passage model is directly calibrated to NMFS' 1995-to-1998 PIT-tag reach survival estimates (Peters et al. 1999), as is SIMPAS (Appendix D). PATH's Fish Leaving Under Several Hypotheses (FLUSH) model is not directly calibrated to this data (Peters et al. 1999). However, Figures 4.3.2-4 and 4.3.3-6 of Peters et al. (1999) suggest that the FLUSH model corresponds to the PIT-tag survival estimates, which are highly variable, about as well as the CRiSP model does.

In addition, both the structure and parameterization of the dam passage components of the SIMPAS model are very similar to those used in PATH (Appendix D). The main difference is that some of the parameter estimates used in SIMPAS reflect new information obtained since the PATH models were completed (Appendix D). NMFS compared total juvenile survival (including D = 0.24) estimates generated by the PATH FLUSH model and by SIMPAS for the 1995-through-1998 migration years. In each case, the estimates varied by no more than 3% and averaged 0.5% (Appendix A). CRiSP estimates developed for PATH ended in 1992, so it was not possible to conduct a similar comparison. However, significant discrepancies between PATH and SIMPAS are unlikely, because of the similar structure and similar fit to PIT-tag reach survival estimates, and because both the PATH-only and PATH/SIMPAS methods in this analysis yield similar results.

In addition to the change in juvenile passage survival, harvest rates changed significantly during this period. NMFS used two methods to evaluate the reduction in harvest from the 1980-to-1996 return year average. The first method is similar to that used in the July 27, 2000, draft biological opinion, which relies on PATH estimates of age-specific ocean exploitation rates and inriver exploitation rates (Peters et al. 1999). However, three changes were made in response to comments. First, the Pacific Salmon Commission (PSC) age-specific ocean natural survival rates were used in place of the constant natural survival rate assumed in the July 27 analysis. Second, the PSC maturation rates were used in preference to the CRI "propensity to reproduce" (bx) estimates in the earlier analysis, because of their greater consistency with the methods used by PATH. The modifications produced minor changes in the analysis. The third change (defining the current and future harvest rates as 70% of the 1988-to-1993 ocean and inriver harvest rates), however, reduced the expected survival improvement from that estimated

previously. The modified definition of current and future harvest rates is more consistent with the Basinwide Recovery Strategy and with recent NMFS biological opinions on fall chinook harvest than is the previous definition (average 1993-to-1996 harvest rates). Using this approach, NMFS estimates that the reduction in ocean harvest rates has resulted in a 6% survival improvement, that the reduction in inriver harvest has resulted in a 9% survival improvement, and that the combination has resulted in a 16% survival improvement.

NMFS used a second method to estimate the reduction in harvest, to address comments by CRITFC and others that the PATH-derived harvest estimates in the July 27 draft did not match the estimates used by harvest management entities and by NMFS in its harvest biological opinions. Commenters did not question the validity of the PATH estimates, which are based on CWT cohort survival estimates, but suggested that the estimates be reconciled with the PSC and *U.S. v. Oregon* Technical Advisory Committee harvest rate estimates. NMFS was unable to reconcile the estimates, but concluded that there are advantages and disadvantages of both the PATH approach and the harvest modeling approach used by PSC and the Technical Advisory Committee. Therefore, NMFS includes estimates derived from both approaches in this analysis.

The second method relies on results of a PSC model run (Simmons 2000) that expresses combined ocean and inriver harvest as losses of age-3 to -5 adult equivalents to the mouth of the Columbia River. NMFS compared average 1980-to-1996 adult equivalent exploitation rates to 70% of average 1988-to-1993 adult equivalent exploitation rates. The estimated survival change using this second method was 40%.

The four combinations of the two alternative harvest change methods and the two alternative juvenile survival change methods result in estimates of total survival change ranging from 31% to 63% (1.31 to 1.63 times the average historical survival rate).

No other quantifiable survival rates changed significantly between the average 1980-to-1999 and the current condition. For example, there is no evidence to suggest that adult passage survival through the hydrosystem has changed significantly under current operations, compared with average adult survival between 1980 and 1999. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival, estuary survival, and adult survival above Lower Granite Dam that may have resulted from habitat and hatchery management actions. Therefore, no change in those survival rates is included in this quantitative analysis. In Section 6.3.2.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the proposed action.

6.3.2.4 Additional Necessary Survival Changes

Table 6.3-2 shows the effect of the 31%-to-63% increase in survival rate expected from the proposed action on the future median annual population growth rates for the aggregate SR fall chinook population. The resulting population growth rate is expected to change from a declining

trend (lambda <1.0) to a stable or increasing trend (lambda = 1.03) under the highest estimate of survival change. Under the lowest estimate of improved survival, however, the population growth rate is still expected to decline. In both cases, an additional improvement of from 6% to 64% is needed to meet the recovery indicator criteria.

The results of the NMFS SR fall chinook analysis for the proposed action are generally consistent with the PATH assessments of a similar action. Both assessments indicate that no additional survival changes are needed to meet alternative survival indicator criteria, given similar assumptions regarding annual climate/environmental variability, harvest rates, and differential mortality for transported smolts. However, both assessments indicate that additional survival improvements would be required to meet the 48-year recovery indicator criterion.

PATH evaluated an action (A2) that incorporated most of the elements of the proposed action with respect to SR fall chinook (Peters et al. 1999). The action A2 incorporated the changes in hydropower operations called for in the 1995 FCRPS Biological Opinion. PATH evaluated actions under a range of assumptions regarding post-Bonneville Dam differential delayed mortality of transported fish relative to nontransported fish (expressed as a differential survival factor D). The ability of action A2 to meet PATH survival and recovery criteria depended on the assumption regarding D. If D is relatively high or if it had improved substantially over base values, PATH projected that A2 would readily exceed survival and recovery criteria used in the assessments. Under the assumption that D has remained at approximately 20%, approximating the level used in the current NMFS analysis (see Section 6.2.3.3), action A2 was projected to meet survival criteria but to fall short of recovery targets. Specifically, the PATH analysis projected the mean likelihood of reaching recovery goals in 48 years as 34%, 16 percentage points below the 50% likelihood associated with the recovery indicator criterion.

Table 6.3-2. Snake River fall chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
SR fall chinook aggregate	0.87	0.92	1.31	1.63	0.93	1.03	0.75	1.07	1.06	1.64

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low represents estimation of juvenile survival improvement based on PATH retrospective and prospective (A2) results and change in harvest rate based on PATH.
[4] High represents estimation of juvenile survival improvement based on a combination of PATH and SIMPAS and harvest rate change based on PSC modeling.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

6.3.2.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. Most comments were not specific to SR fall chinook salmon, but many of the points raised for SR spring/summer chinook salmon may also apply to SR fall chinook salmon. Substantial comments primarily questioned the estimates of hydrosystem survival associated with the proposed action (addressed in Section 6.2); the method of estimating the expected proportional change in the juvenile survival rate from the average associated with base period returns (addressed above in one new and one modified method of estimating the expected change); the method of estimating the change in harvest rate (addressed above in one new and one modified method); the analytical assumption that all survival changes are achieved instantaneously; and the assumption that the effectiveness of hatchery-origin spawners may have been as low as 20% that of wild-origin spawners.

Concerns about the implementation schedule were directed primarily at the RPA in the July 27 draft biological opinion, which included actions not yet implemented. However, the analysis of the proposed action, as described above, is based on actions (including reduced harvest) currently being implemented. Therefore, this criticism is not relevant to the analysis of the proposed action.

As described in Section 6.3.1.5 for SR spring/summer chinook, NMFS agrees that the full 20%-to-80% range of assumptions regarding historical effectiveness of hatchery-origin natural spawners should be included in the analysis and in NMFS' conclusions. No comments were received suggesting that any range other than 20% to 80% should be applied to SR fall chinook salmon.

This analysis also contains assumptions that may make the results overly pessimistic. Two such assumptions are that all supplementation programs cease immediately and that background survival will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for and the effects of the assumption that supplementation will cease immediately. That assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. To the extent that current supplementation programs reduce the short-term extinction risk for wild fish, however, that effect is not included in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climatic conditions and other background factors influencing survival have been below average for most of the period included in this analysis. Assuming that climatic conditions and other background factors influencing survival will continue as they have, on

average, during the years influencing 1980-through-1996 adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. Some preliminary information suggests that this may be the case for SR fall chinook. Table C-5 of Appendix C indicates that wild adult returns to lower Granite Dam in 1997 and 1999 were higher than estimates of escapement in any year between 1980 and 1996, while 1998 was one of the lowest wild escapements of that period. While these estimates were not calculated in the same manner as the estimates of escapements used in the analysis described above, they roughly indicate improving survival in recent years. NMFS does not rely on the expectation of improving ocean and other climatic conditions, but that factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.2.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-2 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above the uppermost dam). The sufficiency of Federal survival and recovery measures to augment survival improvements resulting from the FCRPS proposed action is highly uncertain unless there can also be reliable progress on non-Federal survival and recovery measures in other life stages. The proposed action includes language that may be interpreted as a commitment by the Action Agencies to undertake or fund some of these non-Federal measures. The biological assessment is not explicit enough, however, to reach that conclusion with certainty. NMFS concludes that some proportion of the additional survival improvements identified in Table 6.3-2 may be achieved through ongoing Federal activities and through the proposed action. However, it is unlikely that the necessary improvements can be fully achieved because of the limited commitment to fund non-Federal habitat and hatchery improvements to offset hydrosystem impacts in the Action Agencies' biological assessment.

6.3.3 Upper Columbia River Spring Chinook Salmon

Evaluation of species-level effects of the proposed action requires placing the action-area effects in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of UCR spring chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and

Appendix C) limits this ESU over its full range. Chief Joseph and Grand Coulee dams prevent access to historical spawning grounds farther upstream. Local problems relate to irrigation diversions and hydroelectric development, as well as riparian and instream habitat degraded from urbanization and livestock grazing along riparian corridors.

In this section, NMFS quantitatively evaluates action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

6.3.3.1 Populations Evaluated

NMFS analyzed the three populations identified by Ford et al. (1999) as components of this ESU: the Wenatchee River population, the Methow River population, and the Entiat River population. Ford et al. (1999) identified interim recovery goals for each population and included the criterion that all three must meet these goals for delisting.

6.3.3.2 Necessary Survival Change

McClure et al. (2000b,c) and Cooney (2000) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. Cooney (2000) and NMFS (Appendix A) also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the three population interim recovery abundance levels (Ford et al. 1999) in 48 and 100 years using the most current estimates of lambda and methods described in Appendix A. The CRI analytical approach (McClure et al. 2000b) and the QAR analytical approach (Cooney 2000) produce different estimates of necessary survival changes for these populations. NMFS considers both approaches to have advantages and disadvantages and uses results from both to define a range of necessary survival change.

NMFS also investigated the effects of adding 1999-to-2000 preliminary and 2001 projected returns to the time-series used to estimate lambda in each of the calculations described above. The 2001 projections are based on recent jack counts. Estimates are included in McClure et al. (2000b) and Cooney (2000). The preliminary estimates are included in the lowest estimates of necessary survival changes.

6.3.3.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from 1980 to 1998 will continue indefinitely. However, the Basinwide Recovery Strategy identifies implementation of the Mid-Columbia Habitat Conservation Plan (HCP) at five PUD projects as a probable element of recovery planning that is, therefore, included in the analysis, consistent with step 4 of the jeopardy analysis framework described in Section 1.3. The Basinwide Recovery Strategy

estimates that this action will be implemented within 2 to 5 years. Cooney (2000, Table 20) estimates that implementing the HCP will improve survival by 28% for the Wenatchee population, 40% for the Entiat population, and 49% for the Methow population.

NMFS estimates that juvenile survival from McNary Dam to Bonneville Dam has changed from the average survival rate affecting adult returns in 1980 through 1998 because transportation from McNary Dam has discontinued, and because structural and operational modifications to the four lower Columbia River dams have been implemented since 1980 (Section 6.3.1.3). The project modifications have improved survival for inriver migrants, but the system survival from McNary Dam to Bonneville has declined from the average rate during the base period, when a significant proportion of the smolts were transported (Cooney 2000; Appendix A). The proposed action specifies that nearly all fish must remain in the river because of very low returns of transported smolts in 1994, after the new McNary bypass system was constructed (Appendix B to 1998 FCRPS Biological Opinion).

The size of the estimated decline in McNary-Bonneville juvenile survival depends on the estimate of historical differential post-Bonneville survival (D; see Section 6.2.3.3) during the years when smolts were transported from McNary Dam. NMFS evaluated D estimates ranging from 0.8 to 1.0, based on results of historical McNary transportation studies (Cooney et al. 2000; reviewed in NMFS 2000i). Only a fraction of the run is transported for the proposed action, so estimating D under the proposed action is not necessary for this ESU. Cooney (2000, Table 23) estimated 1980-to-1994 juvenile survival from McNary to Bonneville at 60.7% and 69.0% for historical D estimates of 0.8 and 1.0, respectively. These historical survival estimates are higher than the SIMPAS McNary-to-Bonneville survival estimates from 1994 to 1999, which averaged 57.5%. The resulting change in lower river survival associated with the proposed action was -5% (D = 0.8) to -17% (D = 1.0).

Combining changes in survival resulting from implementation of the Mid-Columbia HCP and modifications to the four lower Columbia River FCRPS projects results in a 7% to 41% increase in survival, depending on the population under consideration and the historical D estimate (Table 6.3-3; Appendix A).

No other quantifiable survival rates changed significantly between that affecting base period adult returns and the current and expected future condition. For example, there is no evidence to suggest that adult passage survival through the hydrosystem has changed significantly under current operations, compared with average adult survival between 1980 and 1998. Harvest rates also did not change significantly during that period. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival (other than those expected from the HCP), estuary survival, and adult survival above the upper dam that may have resulted from habitat and hatchery management actions, so no change in those survival rates is included in this quantitative analysis. In Section 6.3.3.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the proposed action.

6.3.3.4 Additional Necessary Survival Changes

Table 6.3-3 shows the effect of the 7%-to-41% survival rate increase expected from the proposed action on the future median annual population growth rates for the three UCR spring chinook populations. These effects vary according to whether the QAR analytical approach (Cooney 2000) or the CRI analytical approach (McClure et al. 2000c) is used to estimate the current population growth rate and the necessary change. Both the CRI and the QAR approaches indicate that the population growth rate will continue to be negative for all three populations after HCP implementation and continuation of the proposed action. On the basis of CRI estimates of the current population growth rate, additional survival improvements ranging from 55% to 226% (1.55 to 3.26 times the average base period survival rate) will be necessary to meet the recovery indicator criteria. On the basis of QAR estimates, additional survival improvements ranging from 45% to 153% (1.45 to 2.53 times the average base period survival rate) will be necessary to meet the recovery indicator criteria.

Table 6.3-3. Upper Columbia River spring chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

							Additional Change In Survival Needed to Achieve:			
Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU aggregate - CRI	0.84	0.85	1.16	1.32	0.86	0.90	1.40	1.65	1.55	1.86
Methow River - QAR	0.92	0.90	1.24	1.41	0.94	0.97	0.94	1.06	1.45	1.65
Entiat River - QAR	0.89	0.89	1.17	1.33	0.92	0.95	1.18	1.35	1.60	1.82
Wenatchee R. - QAR	0.88	0.92	1.07	1.21	0.89	0.96	1.16	1.64	1.77	2.53
Methow River - CRI	0.85	0.90	1.24	1.41	0.89	0.97	1.51	1.94	1.55	2.23
Entiat River - CRI	0.81	0.89	1.17	1.33	0.84	0.95	1.15	1.95	1.54	2.56
Wenatchee R. - CRI	0.80	0.85	1.07	1.21	0.81	0.89	1.43	2.14	2.15	3.26

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically and inclusion of preliminary and projected returns through 2001 for CRI estimates.
[3] Low represents an estimate of juvenile survival improvement based on assumption of historical D=0.8 from McNary Dam.
[4] High represents an estimate of juvenile survival improvement based on assumption of historical D=1.0 from McNary Dam.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A, including preliminary 2000 and projected 2001 returns for all except Methow QAR and Entiat QAR) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A, including only final returns through 1999) divided by the low estimate of the expected survival improvement.

6.3.3.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. Most comments were not specific to, or in some cases relevant to, UCR spring chinook salmon. Three comments of particular relevance, however, were that NMFS should not assume that the Mid-Columbia HCP will be implemented and achieve its survival goals within the time described in the Basinwide Recovery Strategy; that the analysis is overly optimistic because it assumes that all survival changes are achieved instantaneously; and that the analysis is overly optimistic because NMFS rejected the assumption of 80% effectiveness of hatchery-origin natural spawners.

The first two comments apply to implementation of the HCP because it is the only future survival improvement anticipated in the analysis. CRITFC believes that anticipated HCP survival rates will not be achieved at all five PUD dams for at least 10 years because long-term gas-abatement projects are needed to achieve the necessary spill levels. NMFS agrees that there is some uncertainty about the exact schedule for achieving all survival improvements anticipated in the HCP, but the proposed HCP for the Chelan and Douglas PUDs and the draft EIS anticipate that the survival improvements will be achieved by the end of Phase I (2003). If this does not occur, it is reasonable to anticipate additional changes under the terms of the proposed HCP. Regardless of the exact implementation schedule, the analysis described above does assume that HCP survival improvements are achieved immediately, which is not the case. NMFS conducted a sensitivity analysis on the effect of a 10-year delay in implementing *any* survival improvements over the 1980-to-1998 average survival rate (Appendix C). Under this worst-case scenario, the CRI estimate of necessary survival change for the Wenatchee population increases from the estimate in Table 6.3-3 (additional 116% to 226% change) to a 265% to 368% change (Appendix A). This extreme scenario is unlikely, since some improvements associated with the HCP have already been achieved, but NMFS considers the implications of delayed implementation qualitatively in reaching jeopardy conclusions for this ESU.

As described in Section 6.3.1.5 for SR spring/summer chinook, NMFS agrees that the full 20%-to-80% range of assumptions regarding the historical effectiveness of hatchery-origin natural spawners should be included in the analysis and in NMFS' conclusions. The results described above reflect that range. No comments were received to suggest that any range other than 20% to 80% should be applied to UCR spring chinook salmon.

This analysis also contains assumptions that may make the results overly pessimistic. Two such assumptions are that all supplementation programs cease immediately, and that background survival will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for and the effects of the assumption that supplementation will cease immediately. That assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative effects of

hatchery programs. To the extent that current supplementation programs reduce the short-term extinction risk for wild fish, however, that effect is not included in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climatic conditions and other background factors influencing survival have been below average for most of the period included in this analysis. The assumption that climatic conditions and other background factors influencing survival will continue as they have, on average, during the years influencing 1980-through-1998 adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. Preliminary estimates of return rates in 2000 are well above average, and some hypothesize that ocean conditions may be shifting to a more favorable regime. NMFS investigated the effects of adding preliminary returns in 2000 and an estimate of expected returns in 2001 (based on 2000 jack abundance) to the time-series used to estimate lambda. This information was used to define the most optimistic results for this ESU. If recent high returns indicate a favorable shift in climatic conditions that will continue over several years, that additional reason for optimism is not captured in the quantitative analysis. However, NMFS does consider the possibility of an ongoing effect of favorable climate qualitatively in reaching a jeopardy conclusion.

6.3.3.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management, other than effects anticipated in the HCP. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-3 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above the uppermost dam). The sufficiency of Federal survival and recovery measures to augment survival improvements resulting from the FCRPS proposed action is highly uncertain unless there can also be reliable progress on non-Federal survival and recovery measures in other life stages. The proposed action includes language that may be interpreted as a commitment by the Action Agencies to undertake or fund some of these non-Federal measures. The biological assessment is not explicit enough, however, to reach that conclusion with certainty. NMFS concludes that some proportion of the additional survival improvements identified in Table 6.3-3 may be achieved through ongoing Federal activities and through the proposed action. However, it is unlikely that the necessary improvements can be fully achieved because of the limited commitment to fund non-

Federal habitat and hatchery improvements to offset hydrosystem impacts in the Action Agencies' biological assessment.

6.3.4 Upper Willamette River Chinook Salmon

Evaluation of the species-level effects of the proposed action requires placing the action-area effects of the proposed action in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of UWR chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include the loss of habitat due inundation or blockages resulting from the construction of numerous tributary hydroelectric and irrigation facilities, and habitat degradation due to timber harvest, development (agricultural, municipal, and industrial), dam development, and river channelization and dredging. Many of these activities result in poor water quality, high sediment loads, altered thermal regimes, and a large reduction in available spawning and rearing habitat.

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions could increase annual population growth rates such that survival and recovery are likely. Because UWR chinook salmon do not migrate past any mainstem dams on the lower Columbia River, NMFS has not estimated total system survival under the proposed action for this ESU.

6.3.4.1 Populations Evaluated

NMFS quantitatively evaluated one spawning aggregation, the McKenzie River above Leaburg Dam. Adequate information was not available for similar analyses for additional spawning aggregations. NMFS has not yet determined which, if any, of the UWR chinook spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the McKenzie River aggregation as an independent population satisfies the statistical assumptions inherent in the analysis.

6.3.4.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria for the McKenzie River spawning aggregation. NMFS also estimated the change from base period lambda necessary to achieve $\geq$50% likelihood of meeting the recovery indicator criterion of lambda $\geq$1.0 for this spawning aggregation. Details of these estimates are provided in Appendix A.

6.3.4.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for UWR chinook salmon, referenced above, assumes that the life-stage survival rates that influenced the base period adult returns will continue indefinitely. For this ESU, NMFS cannot identify any significant changes in survival rates under current or expected future conditions compared with those that influenced the base period adult returns. Survival changes due to implementing the proposed action can be quantified only for species that migrate past mainstem dams, which excludes UWR chinook salmon. NMFS was unable to quantify potential changes in egg-to-smolt survival, estuary survival, or adult survival that may have resulted from recent or ongoing habitat and hatchery management actions. In Section 6.3.4.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the proposed action.

6.3.4.4 Additional Necessary Survival Changes

Table 6.3-4 shows that the proposed action is not expected to increase the population survival rate; a negative median annual population growth rate is expected to continue for the UWR chinook spawning aggregation in the McKenzie River above Leaburg Dam. An additional survival improvement of from 9% to 65% (1.09 to 1.65 times the average base period survival rate) is needed to meet the extinction indicator criteria.

Table 6.3-4. Upper Willamette River chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

							Additional Change In Survival Needed to Achieve:			
	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
Spawning Aggregation	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
McKenzie River above Leaburg Dam	0.90	0.99	1.00	1.00	0.90	0.99	1.09	1.65	1.05	1.59

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

6.3.4.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations noted that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the proposed action would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, UWR chinook salmon. In fact, this analysis contains assumptions that may make the results overly pessimistic. For example, NMFS assumes that all supplementation programs cease immediately, and that the background survival rate will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for and the effects of the assumption that supplementation will cease immediately. That assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. To the extent that current supplementation programs reduce the short-term extinction risk for wild fish, however, that effect is not included in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climate and other background factors influencing survival have been below average for most of the period included in this analysis. Assuming that these factors will continue as they have, on average, during the years influencing 1980-through-1998 adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. NMFS does not rely on the expectation of improving ocean and other climatic conditions, but that factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.4.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the proposed action on survival below Bonneville Dam, or changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-4 are likely to be achieved through recent or anticipated future actions that affect other life stages.

Current FCRPS operations do not affect mainstem spawning or rearing habitat for UWR chinook salmon, although flow regulation may affect critical habitat for rearing in the estuary and plume. Available evidence is inferential, however, and thus insufficient for concluding that the proposed action will appreciably diminish the capacity of estuary or plume habitat to meet the biological requirements of listed fish. Thus, it is unlikely that the FCRPS is currently limiting the survival of this ESU below Bonneville Dam or that the proposed action will change the population survival rate.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal and non-Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above Willamette Falls). The proposed action, along with the future recovery efforts in the habitat and hatchery sectors anticipated in the Basinwide Recovery Strategy, is expected to be sufficient to meet survival and recovery indicator criteria.

6.3.5 Lower Columbia River Chinook Salmon

Evaluation of the species-level effects of the proposed action requires placing the action-area effects of the proposed action in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of LCR chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include the impacts of timber harvest (altered riparian vegetation, unstable streambanks, and decreased habitat complexity), agricultural practices (channelization and loss of riparian vegetation), road construction, and urban and industrial development; dams on the Cowlitz, Lewis, (Big) White Salmon, Clackamas, Sandy, and Hood rivers, which block fish passage to historical spawning areas; residual effects of mudflows from the Mt. St. Helens eruption (1980), which significantly disrupted and degraded habitat in the South Fork Toutle and Green rivers – as did post-eruption dredging, diking, and bank protection works in the Cowlitz River (below its confluence with the Toutle River); hatchery programs, beginning in the 1870s, which released billions of fish, homogenizing stocks between subbasins and introducing others from outside the ESU such that most of the fall-run chinook salmon spawning today in the Lower Columbia River ESU are first-generation hatchery strays; and an average total exploitation rate on fall-run stocks from this ESU of 65% for the base period brood years (approximately 45% in the ocean and 20% in freshwater).

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions could increase annual population growth rates such that survival and recovery are likely.

6.3.5.1 Populations Evaluated

NMFS quantitatively evaluated 20 spawning aggregations below Bonneville Dam. Adequate information was not available for similar analyses for spawning aggregations above Bonneville Dam. NMFS has not yet determined which, if any, of the LCR chinook salmon spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the 20

aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

6.3.5.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria for the 20 spawning aggregations of LCR chinook salmon. NMFS also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the recovery indicator criterion of lambda ≥1.0 for each aggregation. Details of these estimates are provided in Appendix A.

6.3.5.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for the 20 spawning aggregations of LCR chinook salmon referenced above assumes that the life-stage survival rates that influenced the base period adult returns will continue indefinitely. Although structural and operational modifications have been made to Bonneville Dam since 1980, none of the spawning aggregations for which NMFS could perform quantitative analyses pass this project. Further, NMFS was unable to quantify potential changes in egg-to-smolt or estuary survival that may have resulted from recent or ongoing habitat and hatchery management actions. Instead, in Section 6.5.3.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

6.3.5.4 Additional Necessary Survival Changes

Table 6.3-5 shows that the proposed action is not expected to increase the survival rate of these 20 LCR chinook salmon spawning aggregations, all located below Bonneville Dam; negative median annual population growth rates are expected to continue. Survival improvements needed to meet the survival and recovery indicator criteria range from 3% to 732% (1.03 to 8.32 times the average base period survival rates). For the Lewis and Clark spawning aggregation, improvements of 934% to 1,493% (10.34 to 15.93 times the average base period survival rates) are needed.

Table 6.3-5. Lower Columbia River chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
Aggregations Above Bonneville Dam (insufficient information for analysis)										
Aggregations Below Bonneville Dam										
Bear Creek	0.73	0.82	1.00	1.00	0.73	0.82	2.14	3.13	1.89	2.83
Big Creek	0.84	0.93	1.00	1.00	0.84	0.93	1.10	1.62	1.31	1.97
Clatskanie River	0.80	0.89	1.00	1.00	0.80	0.89	2.93	4.12	1.55	2.32
Cowlitz River tule	0.82	0.92	1.00	1.00	0.82	0.92			1.33	1.99
Elochoman River	0.88	0.99	1.00	1.00	0.88	0.99			1.04	1.56
Germany Creek	0.83	0.93	1.00	1.00	0.83	0.93			1.30	1.95
Gnat Creek	0.84	0.94	1.00	1.00	0.84	0.94	2.07	2.95	1.27	1.91
Grays River tule	0.76	0.85	1.00	1.00	0.76	0.85			1.76	2.64
Kalama River spring	0.76	0.85	1.00	1.00	0.76	0.85			1.87	2.80
Kalama River	0.89	0.99	1.00	1.00	0.89	0.99			1.06	1.58
Klaskanine River	0.80	0.89	1.00	1.00	0.80	0.89	2.30	3.27	1.54	2.30
Lewis River bright	0.97	0.99	1.00	1.00	0.97	0.99			1.05	1.11
Lewis River spring	0.81	0.91	1.00	1.00	0.81	0.91			1.46	2.20
Lewis R., E. Fork tule	0.99	0.99	1.00	1.00	0.99	0.99			1.03	1.03
Lewis & Clark River	0.49	0.54	1.00	1.00	0.49	0.54			10.34	15.93
Mill Creek fall	0.72	0.81	1.00	1.00	0.72	0.81	2.44	3.58	2.19	3.29
Plympton Creek	0.86	0.95	1.00	1.00	0.86	0.95	1.18	1.74	1.21	1.82
Sandy River late	0.98	0.98	1.00	1.00	0.98	0.98	1.00	1.00	1.07	1.09
Skamokawa Creek	0.74	0.82	1.00	1.00	0.74	0.82			2.05	3.08
Youngs River	0.84	0.94	1.00	1.00	0.84	0.94	6.73	8.32	1.25	1.88

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

6.3.5.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the proposed action would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, LCR chinook salmon. In fact, this analysis contains assumptions that may make the results overly pessimistic. For example, NMFS assumes that all supplementation programs cease immediately, and that the background survival rate will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for and the effects of the assumption that supplementation will cease immediately. That assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. However, if current supplementation programs reduce the short-term extinction risk for wild fish, that effect is not reflected in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climatic conditions and other background factors influencing survival have been below average for most of the period included in this analysis. Assuming that these factors will continue as they have, on average, during the years influencing 1980-through-1998 adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. NMFS does not rely on the expectation of improving ocean and other climatic conditions, but that factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.5.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the proposed action on survival below Bonneville Dam or changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-5 are likely to be achieved through recent or anticipated future actions that affect other life stages.

Current FCRPS operations affect mainstem spawning and rearing habitat for the spawning aggregation of LCR chinook salmon observed in the Ives Island area during October 1999. Flow regulation may affect critical habitat for rearing in the estuary and plume. Available evidence is inferential, however, and thus insufficient for concluding that the proposed action will appreciably diminish the capacity of estuary or plume habitat to meet the biological requirements of listed fish. Because LCR chinook salmon were observed spawning in the Ives Island area only once, it is unlikely that the FCRPS is currently limiting the survival of this ESU below

Bonneville Dam or that the proposed action will change the survival rate of any of the subbasin populations considered in the quantitative analysis.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal and non-Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival and estuary survival. The proposed action, along with the future recovery efforts in the habitat and hatchery sectors anticipated in the Basinwide Recovery Strategy, is expected to be sufficient to meet survival and recovery indicator criteria.

6.3.6 Snake River Steelhead

Evaluation of species-level effects of the proposed action requires placing the action-area effects in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of SR steelhead in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. Hydrosystem projects create substantial habitat blockages for this ESU. The major ones are the Hells Canyon Complex on the mainstem Snake River and Dworshak Dam on the North Fork of the Clearwater River. Minor blockages are common throughout the region. Steelhead spawning areas have been degraded by overgrazing, as well as by historical gold dredging and sedimentation due to poor land management. Hatchery fish are widespread and stray to spawn naturally throughout the region. In the 1990s, an average of 86% of adult steelhead passing Lower Granite Dam were of hatchery origin. Hatchery contribution to naturally spawning populations varies across the region, however, some stocks are dominated by hatchery fish, whereas others are composed of all wild fish.

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

6.3.6.1 Populations Evaluated

NMFS evaluated A-run and B-run aggregate groups of SR steelhead (McClure et al. 2000b,c). These analyses are based on Lower Granite Dam counts, with the two groups distinguished by date and/or size. Once past Lower Granite Dam, SR steelhead spawn in tributaries throughout the lower Snake River basin, and it is likely that there are multiple populations within these aggregates. However, populations have not yet been defined according to criteria in McElhany et al. (2000) and spawner data from tributaries are not available. The Idaho Department of Fish and Game, in comments on the July 27 draft biological opinion, suggested that NMFS should

assign lower abundance levels to each aggregate group, to simulate the greater risk of extinction faced by smaller populations that probably exist in the basin. In response, NMFS evaluated the sensitivity of necessary survival changes to steelhead pseudopopulations, defined as 10% of the abundance of the A-run aggregate and 33% of the B-run aggregate abundance (McClure et al. 2000b; Appendix A). These approximations were based on information on spawning distribution contained in Busby et al. (1996) and the 1990 NWPPC subbasin plans (Tucannon River, Salmon River, Grande Ronde River, and Clearwater River plans). Those documents identify the major summer steelhead spawning areas with respect to each ESU. B-run steelhead are believed to return mainly to three general areas (Middle Fork Salmon River, Upper Salmon River, and the South Fork Salmon River). Summer steelhead returns classified as A-run appear to be distributed among a wider array of spawning areas throughout the Snake River region.

6.3.6.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. NMFS also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the lambda ≥1.0 (Appendix A) recovery indicator criterion. Details of these estimates are included in Appendix A.

6.3.6.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from the base period will continue indefinitely. However, the juvenile SR steelhead survival rate associated with the proposed action represents an improvement from the average survival rate influencing base period adult returns. That is because many structural and operational modifications to the hydrosystem have been implemented since 1980, as described in Section 6.3.1.3.

Section 6.2.8 contains juvenile survival estimates for the proposed action, but no estimates of average juvenile survival during the base period are available. Neither PATH nor NMFS has attempted to estimate the SR steelhead survival rates, including transported fish and possible indirect effects. Because direct estimates of historical steelhead juvenile passage survival are not available, NMFS assumes that the proportional change in juvenile SR steelhead survival from the base to current (proposed action) condition equals the proportional change estimated for SR spring/summer chinook salmon in Section 6.3.1.3 (24% to 32%, depending on method). Improvements to the system over that period (e.g., new bypasses, increased spill levels, increased flow rates, and new transportation facilities) probably have affected spring-migrating yearling steelhead and yearling chinook similarly. The 1998 FCRPS Biological Opinion contains details regarding similar effects of the hydrosystem on the two ESUs. The 1998 FCRPS Biological Opinion relied on a comparison of SR spring/summer chinook and SR steelhead to draw conclusions for steelhead. Additional information about effects of the hydrosystem on each ESU is available in NMFS (2000e,h,i).

In addition to the change in juvenile passage survival, harvest rates changed significantly during this period. The average 1984-through-1997 harvest rates for A-run and B-run steelhead were obtained from ODFW and WDFW (2000). Estimates for 1980-through-1983 returns were not available, except for the run at large. NMFS compared this historical average with the Basinwide Recovery Strategy's 17% B-run harvest cap, which represents the most likely current and future B-run harvest rate. The Basinwide Recovery Strategy does not describe a similar harvest rate for A-run steelhead, so an approximation was obtained by multiplying the B-run harvest cap by the recent ratio of A:B harvest rates (Appendix A). The result was a 10% A-run current and future harvest rate. The reduced harvest rate represents a 7.2% A-run survival increase from the average survival during the 1980-to-1997 period and a 16.3% B-run survival increase.

The reduced harvest rates and the two alternative methods for estimating juvenile survival change result in estimates of total survival change ranging from 33% to 42% (1.33 to 1.42 times the average historical survival rate) for A-run steelhead and 44% to 54% (1.44 to 1.54 times the average historical survival rate) for B-run steelhead.

No other quantifiable survival rates changed significantly between the average base period condition and the current condition. For example, there is no evidence to suggest that adult survival through the hydrosystem has changed significantly under current operations, compared with average adult survival between 1980 and 1999. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival, estuary survival, and adult survival above Lower Granite Dam that may have resulted from habitat and hatchery management actions, so no change in those survival rates was included in this quantitative analysis. In Section 6.3.6.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the proposed action.

6.3.6.4 Additional Necessary Survival Changes

Table 6.3-6 shows the effect of the 33% to 42% A-run survival rate increase and the 44% to 54% B-run survival increase expected from the proposed action on the future median annual population growth rates. The survival improvement is not sufficient to reduce the declining population trend for SR steelhead. Additional survival improvement greater than 56% to 370%, depending on assumptions and aggregate run, would be necessary to achieve the recovery indicator criterion of lambda greater than 1.0.

The effect of the proposed action on the ability to meet the recovery indicator criterion was not affected by the pseudopopulation sensitivity analysis because the pseudopopulations were assumed to have the same abundance trends as the A-run and B-run aggregates. The use of pseudopopulations did increase the risk of extinction, compared with that of the aggregates, but not significantly. For example, the highest estimate of the survival improvement necessary to meet the survival indicator criteria was 173% for the B-run aggregate and 188% for the B-run

pseudopopulation (Table 6.3-6). In all cases, it was more difficult to meet the recovery indicator criteria than the survival indicator criteria, so the overall needed survival change was not affected by the use of pseudopopulations.

Table 6.3-6. Snake River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

							Additional Change In Survival Needed to Achieve:			
	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
Spawning Aggregation	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU aggregate	0.72	0.83	1.38	1.48	0.77	0.90	1.01	2.11	1.72	3.91
A-run aggregate	0.74	0.85	1.33	1.42	0.78	0.92	0.92	1.89	1.56	3.41
A-run pseudo-population[9]	0.74	0.85	1.33	1.42	0.78	0.92	1.04	2.10	1.56	3.41
B-run aggregate	0.74	0.84	1.44	1.54	0.79	0.89	1.28	2.73	2.09	4.70
B-run pseudo-population[10]	0.74	0.84	1.44	1.54	0.79	0.89	1.35	2.88	2.09	4.70

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low represents SR spring/summer chinook low estimate.
[4] High represents SR spring/summer chinook high estimate.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.
[9] Pseudopopulation is 10% of A-run aggregate abundance.
[10] Pseudopopulation is 33% of B-run aggregate abundance.

6.3.6.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. Substantial comments primarily questioned the estimates of hydrosystem survival associated with the proposed action (addressed in Section 6.2); the method of estimating the expected proportional change in the juvenile survival rate from the average associated with base period returns (addressed with one new and one modified method of estimating the expected change for SR spring/summer chinook; the application of that survival change to steelhead was not questioned); the analytical assumption that all survival changes are achieved instantaneously; and the

assumption that the effectiveness of hatchery-origin spawners may have been as low as 20% that of wild-origin spawners.

Concerns about the implementation schedule were primarily directed at the RPA in the July 27 draft biological opinion, which included actions not yet implemented. However, the analysis of the proposed action, as described above, is based on actions that are currently being implemented.

As described in Section 6.3.1.5 for SR spring/summer chinook, NMFS agrees that the full 20%-to-80% range of assumptions regarding the historical effectiveness of hatchery-origin natural spawners should be included in the analysis and in NMFS' conclusions. No comments were received to suggest that any range other than 20% to 80% should be applied to SR steelhead.

This analysis also contains assumptions that may make the results overly pessimistic. The main ones that may apply to SR steelhead are that all supplementation programs cease immediately, and that background survival will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for and the effects of the assumption that supplementation will cease immediately. This assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. To the extent that current supplementation programs reduce the short-term extinction risk for wild fish, however, that effect is not included in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climatic conditions and other background factors influencing survival have been below average for most of the period included in this analysis. The assumption that climatic conditions and other background factors influencing survival will continue as they have, on average, during the years influencing 1980 through 1997 adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. NMFS does not rely on the expectation of improving ocean and other climatic conditions, but that factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.6.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-6 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above the uppermost dam). The sufficiency of Federal survival and recovery measures to augment survival improvements resulting from the FCRPS proposed action is highly uncertain unless there can also be reliable progress on non-Federal survival and recovery measures in other life stages. The proposed action includes language that may be interpreted as a commitment by the Action Agencies to undertake or fund some of these non-Federal measures. The biological assessment is not explicit enough, however, to reach that conclusion with certainty. NMFS concludes that some proportion of the additional survival improvements identified in Table 6.3-6 may be achieved through ongoing Federal activities and through the proposed action. However, it is unlikely that the necessary improvements can be fully achieved because of the limited commitment to fund non-Federal habitat and hatchery improvements to offset hydrosystem impacts in the Action Agencies' biological assessment.

6.3.7 Upper Columbia River Steelhead

Evaluation of species-level effects of the proposed action requires placing the action-area effects in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of UCR spring chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. Specifically, Chief Joseph and Grand Coulee dams block substantial portions of the historical spawning range. Habitat problems are largely related to irrigation diversions and hydroelectric dams, as well as degraded riparian and instream habitat from urbanization and livestock grazing. Hatchery fish are widespread and escape to spawn naturally throughout the region. The relative contribution of these hatchery spawners to natural production rates is unknown.

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

6.3.7.1 Populations Evaluated

Ford et al. (1999) identified at least three populations comprising this ESU: the Wenatchee River population, the Methow River population, and the Entiat River population. Ford et al. (1999) identified interim recovery goals for each population and included the criterion that all three must meet these goals for delisting. Steelhead spawner estimates are available only from

dam counts, so Cooney (2000) evaluated the Methow River population based on Wells Dam counts and evaluated the combined Wenatchee River and Entiat River populations based on differences between Rock Island and Wells Dam counts. McClure et al. (2000b,c) analyzed the aggregate ESU based on Rock Island Dam counts.

6.3.7.2 Necessary Survival Change

McClure et al. (2000b,c) and Cooney (2000) described changes from the base period (1980 to 1996 for CRI aggregates; 1980 to 1999 for QAR populations) median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. Cooney (2000) also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the Methow and combined Wenatchee/Entiat population interim recovery abundance levels (Ford et al. 1999) in 48 and 100 years. NMFS (Appendix A) estimated the survival change necessary to meet the alternative recovery indicator criterion of lambda ≥ 1.0 for the aggregate run, using lambda estimates from McClure et al. (2000b) and methods described in Appendix A. The CRI analytical approach (McClure et al. 2000c) and the QAR analytical approach (Cooney 2000) produce different estimates of necessary survival changes for these populations. NMFS considers both approaches to have advantages and disadvantages and uses results from both to define a range of necessary survival change.

6.3.7.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from the base period will continue indefinitely. The Basinwide Recovery Strategy, however, identifies implementation of the Mid-Columbia HCP at five PUD projects as a probable element of recovery planning that is, therefore, included in the analysis, consistent with step 4 of the jeopardy analysis framework described in Section 1.3. The Basinwide Recovery Strategy estimates that this action will be implemented within 2 to 5 years. Cooney (2000, Table 20) estimates that implementation of the HCP will improve survival by 23% for the Wenatchee population, 33% for the Entiat population, and 38% for the Methow population.

NMFS estimates that juvenile survival from McNary Dam to Bonneville Dam has changed from the average survival rate affecting adult returns in 1980 through 1998 because transportation from McNary Dam has discontinued, and because structural and operational modifications to the four lower Columbia River dams have been implemented since 1980 (Section 6.3.1.3). The project modifications have improved survival for inriver migrants, but the system survival from McNary Dam to Bonneville has declined from the average rate during the base period, when a significant proportion of the smolts were transported (Cooney 2000; Appendix A). The proposed action specifies that nearly all fish shall remain in the river because of very low returns of transported smolts in 1994, after the new McNary bypass system was constructed (Appendix B to 1998 FCRPS Biological Opinion).

The size of the estimated decline in McNary-Bonneville juvenile survival depends on the estimate of historical differential post-Bonneville survival (D; see Section 6.2.3.3) during the years when smolts were transported from McNary Dam. NMFS evaluated D estimates ranging from 0.8 to 1.0, based on results of historical McNary transportation studies (Cooney 2000; reviewed in NMFS 2000i). Only a fraction of the run is transported for the proposed action, so estimating D under the proposed action is not necessary for this ESU. Cooney (2000, Table 23) estimated 1980-to-1994 juvenile survival from McNary to Bonneville at 60.7% and 69.0% for historical D estimates of 0.8 and 1.0, respectively. These historical survival estimates are higher than the SIMPAS McNary-to-Bonneville survival estimates from 1994 to 1999, which averaged 58.8%. The resulting change in lower river survival associated with the proposed action was -3% (D = 0.8) to -15% (D = 1.0).

Harvest rates have also declined over this period. The change in harvest rate estimated for SR A-run steelhead also applies to this ESU. This reduced harvest rate results in a 7.2% survival improvement.

Combining changes in survival resulting from implementation of the Mid-Columbia HCP, reduced harvest rates, and modifications to the four lower Columbia River FCRPS projects results in a 12% to 43% increase in survival, depending on the population under consideration and the historical D estimate (Table 6.3-3; Appendix A).

No other quantifiable survival rates changed significantly between that affecting base period adult returns and the current and expected future condition. For example, there is no evidence to suggest that adult passage survival through the hydrosystem has changed significantly under current operations, compared with average adult survival between 1980 and 1996/1998. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival (other than those expected from the HCP), estuary survival, and adult survival above the upper dam that may have resulted from habitat and hatchery management actions, so no change in those survival rates is included in this quantitative analysis. In Section 6.3.7.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the proposed action.

6.3.7.4 Additional Necessary Survival Changes

Table 6.3-7 shows the effect of the 12%-to-43% survival rate increase expected from the proposed action on the future median annual population growth rates for the Methow and Wenatchee/Entiat populations and the aggregate ESU. Because different methods were used to estimate the population requirements and the aggregate ESU requirements, differences may be a result of either the analytical method or the scale of the analysis. Low estimates of the expected population growth indicate that it will continue to be negative after HCP implementation and continuation of the proposed action. Higher estimates indicate that it will be stable or increasing, based on QAR population-specific results, or will continue to decrease, based on the CRI aggregate estimate. Additional survival improvements ranging from 8% to 243% (1.08 to 3.43

times the average base period survival rate) will be necessary to meet the recovery indicator criteria. The QAR population-level approach provides slightly more optimistic results than the CRI aggregate ESU approach, suggesting that a maximum 146% increase in survival is necessary.

Table 6.3-7. Upper Columbia River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
UCR steelhead aggregate - CRI	0.69	0.83	1.19	1.36	0.72	0.90	1.19	2.76	1.47	3.43
Methow - QAR	0.81	0.97	1.26	1.43	0.86	1.06	0.80	1.71	1.08	2.46
Wenatchee/Entiat - QAR[9]	0.85	0.94	1.12	1.28	0.87	1.00	0.88	1.49	1.17	1.96

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low represents an estimate of juvenile survival improvement based on assumption of historical D=0.8 from McNary Dam.
[4] High represents an estimate of juvenile survival improvement based on assumption of historical D=1.0 from McNary Dam.
[5] Low represents the low 1980-to-1999 lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-1999 lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.
[9] Expected survival change is based on the Wenatchee estimate of HCP survival increase (Cooney 2000, Table 20). Entiat estimate from same source
is higher.

6.3.7.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. Most comments were not specific to, or in some cases relevant to, UCR steelhead. However, three comments of particular relevance were that NMFS should not assume that the Mid-Columbia HCP will be implemented and achieve its survival goals within the time described in the Basinwide Recovery Strategy; that the analysis is overly optimistic because it assumes that all survival changes are achieved instantaneously; and that the analysis is overly optimistic because NMFS rejected the assumption of 80% effectiveness of hatchery-origin natural spawners.

The first two comments apply to implementation of the HCP because it is the only future survival improvement anticipated in the analysis. The implementation schedule for the HCP is discussed in Section 6.3.3.5. Regardless of the exact implementation schedule, the analysis described above does assume that HCP survival improvements are achieved immediately. NMFS conducted a sensitivity analysis on the effect of a 10-year delay in implementing *any* survival improvements over the base period (1980-to-1996/1998) average survival rate for UCR spring chinook (Section 6.3.3.5; Appendix C). Under this worst-case scenario, the CRI estimate of necessary survival change for the Wenatchee population increased significantly from the estimate that assumed immediate implementation. This extreme scenario is unlikely, since some improvements associated with the HCP have already been achieved, but NMFS considers the implications of delayed implementation qualitatively in reaching jeopardy conclusions for this ESU.

As described in Section 6.3.1.5 for SR spring/summer chinook, NMFS agrees that the full 20%-to-80% range of assumptions regarding the historical effectiveness of hatchery-origin natural spawners should be included in the analysis and in NMFS' conclusions. The results described above reflect that range. No comments were received to suggest that any range other than 20% to 80% should be applied to UCR steelhead.

This analysis contains assumptions that may make the results overly pessimistic. Two such assumptions are that all supplementation programs cease immediately, and that background survival will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for and the effects of the assumption that supplementation will cease immediately. That assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. To the extent that current supplementation programs reduce the short-term extinction risk for wild fish, however, that effect is not included in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climatic conditions and other background factors influencing survival have been below average for most of the period included in this analysis. The assumption that climatic conditions and other background factors influencing survival will continue as they have, on average, during the years influencing base period adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. The sensitivity of the results to projected 2000-to-2001 returns for UCR spring chinook indicates that necessary survival rates could decrease significantly if returns are as predicted (Section 6.3.3.5). NMFS does not rely on the expectation of improving ocean conditions, but that factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.7.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management, other than effects anticipated in the HCP. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-7 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above the uppermost dam). The sufficiency of Federal survival and recovery measures to augment survival improvements resulting from the FCRPS proposed action is highly uncertain unless there can also be reliable progress on non-Federal survival and recovery measures in other life stages. The proposed action includes language that may be interpreted as a commitment by the Action Agencies to undertake or fund some of these non-Federal measures. The biological assessment is not explicit enough, however, to reach that conclusion with certainty. NMFS concludes that some proportion of the additional survival improvements identified in Table 6.3-7 may be achieved through ongoing Federal activities and through the proposed action. However, it is unlikely that the necessary improvements can be fully achieved because of the limited commitment to fund non-Federal habitat and hatchery improvements to offset hydrosystem impacts in the Action Agencies' biological assessment.

6.3.8 Middle Columbia River Steelhead

Evaluation of species-level effects of the proposed action requires placing the action-area effects in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of SR spring/summer chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. They include timber harvest (altered riparian vegetation, unstable streambanks, and decreased habitat complexity), agricultural practices (channelization and loss of riparian vegetation), road construction, and urban and industrial development. Pelton Dam on the Deschutes River blocks access to historical spawning areas, and there are numerous minor blockages from smaller dams and impassable culverts throughout the region. In addition, the genetic integrity of the ESU is threatened by past and present hatchery practices. Hatchery fish are widespread and escaping to spawn naturally throughout the region, so that adults of hatchery origin make up a substantial portion of the spawning population in several basins (e.g., the Umatilla and Deschutes rivers).

In this section, NMFS evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

6.3.8.1 Populations Evaluated

NMFS evaluated four spawning aggregations of MCR steelhead. The Yakima River aggregation passes through four FCRPS projects, the Umatilla River aggregation passes through three FCRPS projects, and the Deschutes River and Warm Springs aggregations pass through two FCRPS projects. NMFS has not yet determined which, if any, of these spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the four aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

6.3.8.2 Necessary Survival Change

McClure et al. (2000b) described changes from the 1980-to-1994 (Yakima and Warm Springs) or 1980-to-1996 (Deschutes and Umatilla) median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. NMFS also estimated the change from base period (1980 to 1994/1996) lambda necessary to meet the recovery indicator criterion of lambda $\geq$1.0 (Appendix A). Details of these estimates are found in Appendix A.

6.3.8.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from the base period will continue indefinitely. The juvenile SR spring/summer chinook salmon survival rate through the lower Columbia River associated with the proposed action, however, represents a change from the average survival rate influencing base period adult returns. That is because many structural and operational modifications to the Federal hydrosystem have been implemented since 1980 (Section 6.3.1.3) and, for the Yakima spawning aggregation, transportation from McNary Dam has been curtailed since 1994.

The Yakima spawning aggregation passes through the same four FCRPS projects as the UCR steelhead ESU and is, therefore, likely to experience the same survival change estimated for that ESU. The FCRPS project modifications have improved survival for inriver migrants, but the system survival from McNary Dam to Bonneville has declined from the average rate during the base period, when a significant proportion of the smolts were transported (Cooney 2000; Appendix A). The proposed action specifies that nearly all fish will remain in the river because of very low returns of transported smolts in 1994, after the new McNary bypass system was constructed (Appendix B to 1998 FCRPS Biological Opinion). The size of the estimated decline in McNary-Bonneville juvenile survival for the Yakima aggregation depends on the estimate of historical differential post-Bonneville survival (D; see Section 6.2.3.3) during the years when

smolts were transported from McNary Dam. NMFS evaluated D estimates ranging from 0.8 to 1.0, based on results of historical McNary transportation studies (Cooney 2000; reviewed in NMFS 2000i). Only a fraction of the run is transported for the proposed action, so estimating D under the proposed action is not necessary for this ESU. Cooney (2000, Table 23) estimated 1980-to-1994 juvenile survival from McNary to Bonneville at 60.7% and 69.0% for historical D estimates of 0.8 and 1.0, respectively. These historical survival estimates are higher than the SIMPAS McNary-to-Bonneville survival estimates from 1994 to 1999, which averaged 58.8%. The resulting change in lower river survival associated with the proposed action was -3% (D = 0.8) to -15% (D = 1.0) for the Yakima River spawning aggregation.

The Umatilla River spawning aggregation passes through three FCRPS projects below the last transportation site. NMFS compared the estimate in Cooney (2000, Table 22) of average 1980-to-1994 inriver survival through these projects (61.3%) with the average SIMPAS 1994-to-1999 estimate through the same projects (65.1%). The resulting survival change for the Umatilla spawning aggregate is 6%.

The Deschutes River and Warm Springs spawning aggregations pass through two FCRPS projects below the last transportation site. NMFS compared the estimate in Cooney (2000, Table 22) of average 1980-to-1994 inriver survival through these projects (75.7%) with the average SIMPAS 1994-to-1999 estimate through the same projects (75.7%). No change in juvenile survival, therefore, is anticipated for the Deschutes and Warm Springs spawning aggregations.

In addition to changes in juvenile passage survival, adult harvest rates have changed from the average during the period. NMFS assumes that these spawning aggregations have experienced a change similar to that estimated for other summer-run steelhead in the Columbia basin. The A-run harvest rate reduction resulted in a survival increase of 7.2% for SR steelhead (Section 6.3.6.3). NMFS estimates that the same survival change affects all four MCR steelhead spawning aggregations in this analysis.

Combining changes in survival resulting from modifications to the four lower Columbia River FCRPS projects and reductions in harvest rates results in a -9% to +4% change in survival for the Yakima spawning aggregation, a 14% increase for the Umatilla spawning aggregation, and a 7% increase for the Deschutes and Warm Springs spawning aggregations (Table 6.3-8; Appendix A).

No other quantifiable survival rates changed significantly between the average base period condition and the current condition. For example, there is no evidence to suggest that adult survival through the hydrosystem has changed significantly under current operations, compared with average adult survival between 1980 and 1994/1996. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival, estuary survival, and adult survival above the upper dam that may have resulted from habitat and hatchery management actions, so no change in those survival rates was included in this quantitative analysis. In Section 6.3.8.6, NMFS

makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the proposed action.

6.3.8.4 Additional Necessary Survival Changes

Table 6.3-8 shows the effect of the -9% to +14% survival rate change expected from the proposed action on the future median annual population growth rates for the four MCR steelhead spawning aggregations in this analysis. Population growth rates are expected to be negative for all aggregations, except for an upward trend under the highest estimate of lambda for the Yakima River aggregation. Additional survival changes of 53% to 270% (1.53 to 3.70 times the base period average survival rates) are necessary to meet recovery indicator criteria for the Deschutes, Warm Springs, and Umatilla spawning aggregations. A 0%-to-10% improvement (0.96 to 1.10 times the average base period survival rate) is needed for the Yakima River aggregation to meet the survival indicator criterion, which is the more difficult criterion to meet for this aggregation.

Table 6.3-8. Mid-Columbia River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

							Additional Change In Survival Needed to Achieve:			
	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
Spawning Aggregation	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU aggregate	0.77	0.84	1.05	1.08	0.78	0.86	N/A	N/A	2.22	3.68
Deschutes R. summer	0.77	0.84	1.07	1.07	0.78	0.85	1.45	2.34	2.30	3.70
Warm Springs hatchery summer	0.91	0.91	1.07	1.07	0.92	0.92	1.32	1.35	1.54	1.54
Umatilla R. summer	0.90	0.90	1.14	1.14	0.93	0.92	1.02	1.00	1.53	1.48
Yakima R. summer	1.01	1.04	0.91	1.04	1.00	1.04	0.96	1.10	0.80	1.01

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low for Yakima R. represents an estimate of juvenile survival improvement based on assumption of historical D=0.8 from McNary Dam.
[4] High for Yakima R. represents an estimate of juvenile survival improvement based on assumption of historical D=1.0 from McNary Dam.
[5] Low represents the low 1980-to-1999 lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-1999 lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

6.3.8.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. Most comments were not specific to, or in some cases relevant to, MCR steelhead. However, two comments of particular relevance were that the analysis is overly optimistic because it assumes that all survival changes are achieved instantaneously, and that the analysis is overly optimistic because NMFS rejected the assumption of 80% effectiveness of hatchery-origin natural spawners.

Concerns about the implementation schedule were primarily directed at the RPA in the July 27 draft biological opinion, which included actions not yet implemented. However, the analysis of the proposed action, as described above, is based on actions that are currently being implemented.

As described in Section 6.3.1.5 for SR spring/summer chinook, NMFS agrees that the full 20%-to-80% range of assumptions regarding historical effectiveness of hatchery-origin natural spawners should be included in the analysis and in NMFS' conclusions. The results described above reflect that range. No comments were received to suggest that any range other than 20%-to-80% should be applied to MCR steelhead.

This analysis contains assumptions that may make the results overly pessimistic. Two such assumptions are that all supplementation programs cease immediately, and that background survival will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for and the effects of the assumption that supplementation will cease immediately. This assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. However, to the extent that current supplementation programs reduce the short-term extinction risk for wild fish, that effect is not included in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climatic conditions and other background factors influencing survival have been below average for most of the time period included in this analysis. The assumption that climatic conditions and other background factors influencing survival will continue as they have, on average, during the years influencing base period adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. The sensitivity of the results to projected 2000-to-2001 returns for UCR spring chinook indicated that necessary survival rates could decrease significantly if returns are as predicted (Section 6.3.3.5). NMFS does not rely on the expectation of improving ocean conditions, but this factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.8.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-8 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional needed survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above the uppermost dam). The sufficiency of Federal survival and recovery measures to augment survival improvements resulting from the FCRPS proposed action is highly uncertain unless there can also be reliable progress on non-Federal survival and recovery measures in other life stages. The proposed action includes language that may be interpreted as a commitment by the Action Agencies to undertake or fund some of these non-Federal measures. The biological assessment is not explicit enough, however, to reach that conclusion with certainty. NMFS concludes that some proportion of the additional survival improvements identified in Table 6.3-8 may be achieved through ongoing Federal activities and through the proposed action. However, it is unlikely that the necessary improvements can be fully achieved because of the limited commitment to fund non-Federal habitat and hatchery improvements to offset hydrosystem impacts in the Action Agencies' biological assessment.

6.3.9 Upper Willamette River Steelhead

Evaluation of the species-level effects of the proposed action requires placing the action-area effects of the proposed action in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of UWR steelhead in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. They include the loss of habitat due to inundation or blockages resulting from the construction of numerous tributary hydroelectric and irrigation facilities; and habitat degradation due to timber harvest, development (agricultural, municipal, and industrial), dam development, and river channelization and dredging. Many of these activities result in poor water quality, high sediment loads, altered thermal regimes, and a large reduction in available spawning and rearing habitat. Overharvest and hatchery production have also contributed to the decline of this ESU.

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life

cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions could increase annual population growth rates such that survival and recovery are likely.

6.3.9.1 Populations Evaluated

NMFS quantitatively evaluated four spawning aggregations: the Molalla, North Santiam, South Santiam, and Calapooia river populations. NMFS has not yet determined which, if any, of the UWR steelhead spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the four aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

6.3.9.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria for the four spawning aggregations. NMFS also estimated the change from base period lambda necessary to achieve $\geq$50% likelihood of meeting the recovery indicator criterion of lambda $\geq$1.0 for each aggregation. Details of these estimates are provided in Appendix A.

6.3.9.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for UWR steelhead, referenced above, assumes that the life-stage survival rates that influenced the base period adult returns will continue indefinitely. For this winter-run steelhead ESU, NMFS cannot identify any significant changes in survival rates under current or expected future conditions compared to those that influenced the base period adult returns. Survival changes due to implementing the proposed action can be quantified only for species that migrate past mainstem dams, which excludes UWR steelhead. NMFS was unable to quantify potential changes in egg-to-smolt survival, estuary survival, or adult survival that may have resulted from recent or ongoing habitat and hatchery management actions. In Section 6.3.9.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the proposed action.

6.3.9.4 Additional Necessary Survival Changes

Table 6.3-9 shows that the proposed action is not expected to increase the population survival rate; negative median annual population growth rates are expected to continue for each of the four UWR steelhead spawning aggregations. Survival improvements needed to meet the recovery indicator criteria range from 30% to 108% (1.30 to 2.08 times the average base period survival rates).

6.3.9.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the proposed action would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, UWR steelhead. In fact, this analysis contains assumptions that may make the results overly pessimistic. For example, NMFS assumes that all supplementation programs cease immediately and that the background survival rate will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for, and the effects of, the assumption that supplementation will cease immediately. That assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. To the extent that current supplementation programs reduce the short-term extinction risk for wild fish, however, that effect is not included in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Table 6.3-9. Upper Willamette River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU aggregate	0.88	0.92	1.00	1.00	0.88	0.92	1.13	1.39	1.37	1.69
Molalla River	0.84	0.91	1.00	1.00	0.84	0.91	1.34	1.96	1.45	2.08
N. Santiam River	0.89	0.92	1.00	1.00	0.89	0.92	1.20	1.34	1.42	1.58
S. Santiam River	0.87	0.94	1.00	1.00	0.87	0.94	1.06	1.50	1.30	1.78
Calapooia River	0.93	0.93	1.00	1.00	0.93	0.93	1.53	1.53	1.36	1.36

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climate and other background factors influencing survival have been below average for most of the period included in this analysis. Assuming that these factors will continue as they did, on average, during the years influencing 1980-through-1997 adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. NMFS does not rely on the expectation of improving ocean and other climatic conditions, but that factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.9.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the proposed action on survival below Bonneville Dam, or changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-9 are likely to be achieved through recent or anticipated future actions that affect other life stages.

Current FCRPS operations do not affect mainstem spawning or rearing habitat for UWR steelhead, although flow regulation may affect critical habitat for rearing in the estuary and plume. Available evidence is inferential, however, and thus insufficient for concluding that the proposed action will appreciably diminish the capacity of estuary or plume habitat to meet the biological requirements of listed fish. Thus, it is unlikely that the FCRPS is currently limiting the survival of this ESU below Bonneville Dam or that the proposed action will change the population survival rate.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional needed survival improvement may result from ongoing Federal and non-Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above Willamette Falls). The proposed action, along with the future recovery efforts in the habitat and hatchery sectors anticipated in the Basinwide Recovery Strategy, is expected to be sufficient to meet survival and recovery indicator criteria.

6.3.10 Lower Columbia River Steelhead

Evaluation of the species-level effects of the proposed action requires placing the action-area effects of the proposed action in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of LCR steelhead in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include timber harvest (altered

riparian vegetation, unstable streambanks, and decreased habitat complexity), agricultural practices (channelization and loss of riparian vegetation), road construction, and urban and industrial development. Upstream passage is blocked by dams on the Lewis, Clackamas, Sandy, and Hood rivers, and there are minor blockages (such as impassable culverts) throughout the region. Mudflows from the eruption of Mt. St. Helens (1980) significantly disrupted and degraded habitat in the South Fork Toutle and Green rivers, as did post-eruption dredging, diking, and bank protection works in the Cowlitz River below its confluence with the Toutle River. In addition, the genetic integrity of the ESU is threatened by past and present hatchery practices. Each year, hatcheries release approximately 3 million steelhead smolts in basins occupied by the ESU (Busby et al. 1996). In many basins, hatchery strays compose most of the spawning population.

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions could increase annual population growth rates such that survival and recovery are likely.

6.3.10.1 Populations Evaluated

NMFS quantitatively evaluated seven spawning aggregations below Bonneville Dam. Adequate information was not available for similar analyses for spawning aggregations above Bonneville Dam. NMFS has not yet determined which, if any, of the LCR steelhead spawning aggregations represent "populations," as defined by McElhany et al. (2000), but treating the seven aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

6.3.10.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rates (lambda) that are necessary to meet the survival indicator criteria for the seven subbasin spawning aggregations. NMFS also estimated the change from the base period lambda necessary to achieve $\geq$50% likelihood of meeting the recovery indicator criterion of lambda $\geq$1.0 for each aggregation. Details of these estimates are provided in Appendix A.

6.3.10.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for LCR steelhead, referenced above, assumes that the life-stage survival rates that influenced the base period adult returns for winter steelhead in the Clackamas, Green, Kalama, Sandy, and Toutle rivers will continue indefinitely. Adult harvest rates for summer steelhead in the Clackamas and Kalama subbasins have changed, however. NMFS assumes that the size of the change from the average rate over the base period is similar to that estimated for other summer-

run steelhead in the Columbia basin. The A-run harvest rate reduction resulted in a survival increase of 7.2% for SR steelhead (Section 6.3.6.3).

NMFS was unable to quantify potential changes in egg-to-smolt or estuary survival that may have resulted from recent or ongoing habitat and hatchery management actions. Instead, in Section 6.3.10.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA. Although structural and operational modifications have been made to Bonneville Dam since 1980, none of the spawning aggregations for which NMFS could perform quantitative analyses passes this project.

6.3.10.4 Additional Necessary Survival Changes

Table 6.3-10 shows that the proposed action is expected to increase the survival rate of two of the LCR steelhead spawning aggregations because of harvest rate reductions. Negative median

Table 6.3-10. Lower Columbia River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU aggregate	0.80	0.91	1.00	1.00	0.80	0.91	N/A	N/A	1.53	2.71
Aggregations Above Bonneville Dam (insufficient information for analysis)										
Aggregations Below Bonneville Dam										
Clackamas R. summer	0.73	0.83	1.07	1.07	0.74	0.84	1.75	3.34	2.44	4.76
Clackamas R. winter	0.76	0.88	1.00	1.00	0.76	0.88	1.35	2.57	1.75	3.43
Green R. winter	0.90	0.90	1.00	1.00	0.90	0.90	1.80	1.80	1.58	1.58
Kalama R. summer	0.77	0.91	1.07	1.07	0.78	0.92	1.09	2.50	1.51	3.67
Kalama R. winter	0.90	0.97	1.00	1.00	0.90	0.97	1.00	1.14	1.13	1.58
Sandy R. winter	0.85	0.91	1.00	1.00	0.85	0.91	1.19	1.63	1.49	2.08
Toutle R. winter	0.88	0.88	1.00	1.00	0.88	0.88	1.30	1.30	1.81	1.81

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

annual population growth rates are expected to continue for all seven aggregations, however. Survival improvements needed to meet the survival and recovery indicator criteria range from 13% to 376% (1.13 to 4.76 times the average base period survival rates).

6.3.10.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the proposed action would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, LCR steelhead. In fact, this analysis contains assumptions that may make the results overly pessimistic. For example, NMFS assumes that all supplementation programs cease immediately, and that the background survival rate will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for and the effects of the assumption that supplementation will cease immediately. That assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. However, if current supplementation programs reduce the short-term extinction risk for wild fish, that effect is not included in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climate and other background factors influencing survival have been below average for most of the period included in this analysis. Assuming that these factors will continue as they have, on average, during the years influencing 1980-through-1998 adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. NMFS does not rely on the expectation of improving ocean and other climatic conditions, but that factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.10.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the proposed action on survival below Bonneville Dam or changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-10 are likely to be achieved through recent or anticipated future actions that affect other life stages.

Current FCRPS operations do not affect mainstem spawning or rearing habitat for LCR steelhead, although flow regulation may affect critical habitat for rearing in the estuary and plume. Available evidence is inferential, however, and thus insufficient for concluding that the proposed action will appreciably diminish the capacity of estuary or plume habitat to meet the

biological requirements of listed fish. Thus, it is unlikely that the FCRPS is currently limiting the survival of this ESU below Bonneville Dam or that the proposed action will change the population survival rate.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal and non-Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival and estuary survival. The proposed action, along with the future recovery efforts in the habitat and hatchery sectors anticipated in the Basinwide Recovery Strategy, is expected to be sufficient to meet interim survival and recovery criteria.

6.3.11 Columbia River Chum Salmon

Evaluation of the species-level effects of the proposed action requires placing the action-area effects of the proposed action in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of CR chum salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include water withdrawals, conveyance, storage, and flood control, resulting in insufficient flows, stranding, juvenile entrainment, and instream temperature increases; logging and agriculture (loss of large woody debris, sedimentation, loss of riparian vegetation, and habitat simplification); mining (especially gravel removal, dredging, and pollution); urbanization (stream channelization, increased runoff, pollution, and habitat simplification); development of many small hydropower facilities in lower river areas; passage mortality at Bonneville Dam; and substantial habitat loss in the Columbia River estuary and associated areas.

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions could increase annual population growth rates such that survival and recovery are likely.

6.3.11.1 Populations Evaluated

NMFS quantitatively evaluated six spawning aggregations below Bonneville Dam. NMFS has not yet determined which, if any, of the CR chum salmon spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the six aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

6.3.11.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria for the six spawning aggregations. NMFS also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the recovery indicator criterion of lambda ≥1.0 for each aggregation. Details of these estimates are provided in Appendix A.

6.3.11.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for CR chum salmon, referenced above, assumes that the life-stage survival rates that influenced the base period adult returns will continue indefinitely. Although structural and operational modifications have been made to Bonneville Dam since 1980, none of the spawning aggregations for which NMFS could perform quantitative analyses passes this project. Further, NMFS was unable to quantify potential changes in egg-to-smolt or estuary survival that may have resulted from recent or ongoing habitat and hatchery management actions. Instead, in Section 6.3.11.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy.

6.3.11.4 Additional Necessary Survival Changes

Table 6.3-11 shows that the proposed action is not expected to increase spawning aggregation survival rates. Negative median annual population growth rates are expected to continue for two of the CR chum salmon spawning aggregations (mainstem Grays River and Hamilton Creek). An additional survival improvement of from 18% to 36% (1.18 to 1.36 times the average base period survival rates) is needed to meet the recovery indicator criteria for these two spawning aggregations.

6.3.11.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations comments that NMFS' analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the proposed action would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, CR chum salmon. In fact, this analysis contains an assumption that may make the results overly pessimistic. Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climate and other background factors influencing survival have been below average for most of the period included in this analysis. Assuming that these factors will continue as they have, on average, during the years influencing base period (1980-through-1998/1999) adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. NMFS does not rely on the expectation of improving ocean or other climatic conditions, but that factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.11.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the RPA on survival below Bonneville Dam or changes in survival in other life stages that result from habitat management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-11 are likely to be achieved through recent or anticipated future actions that affect other life stages. NMFS was also unable to quantify potential changes in egg-to-smolt or estuary survival that may have resulted from recent or ongoing habitat management actions. Instead, in Section 9.7.2.11.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

Table 6.3-11. Columbia River chum salmon estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU aggregate	1.04	1.04	1.00	1.00	1.04	1.04	N/A	N/A	0.88	0.88
Aggregations Above Bonneville Dam (insufficient information for analysis)										
Aggregations Below Bonneville Dam										
Grays R. west fork	1.23	1.23	1.00	1.00	1.23	1.23	N/A	N/A	0.47	0.47
Grays R. mouth to head	0.96	0.96	1.00	1.00	0.96	0.96	N/A	N/A	1.18	1.18
Hardy Creek	1.05	1.05	1.00	1.00	1.05	1.05	N/A	N/A	0.85	0.85
Crazy Johnson	1.16	1.16	1.00	1.00	1.16	1.16	N/A	N/A	0.59	0.59
Hamilton Creek	0.92	0.92	1.00	1.00	0.92	0.92	N/A	N/A	1.36	1.36
Hamilton Springs	1.11	1.11	1.00	1.00	1.11	1.11	N/A	N/A	0.68	0.68

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

Although some adult CR chum salmon are known to pass Bonneville Dam each year, spawning is essentially restricted to two areas below Bonneville: the Grays River basin in the Columbia River estuary, and the Hardy and Hamilton creek/Ives Island complex. According to BPA's 50-year simulation of base case operations, the proposed action would adversely affect use of much of the latter spawning habitat in a high proportion of water years. Load-following operations further reduce habitat quality by alternately watering and dewatering redds and stranding juveniles and adults. As described in Section 6.3.11, the productivity of CR chum salmon appears limited by the availability of spawning habitat. Although much of the historical range has been lost due to detrimental land use practices in lower river tributaries, the proposed action is likely to limit spawning habitat quantity and quality in a large part of the species' current range. Thus, FCRPS operations, coupled with survival in other life stages, affect the likelihood of meeting the survival and recovery indicator criteria.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal and non-Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, and estuary survival. The proposed action, however, along with the future recovery efforts in the habitat and hatchery sectors anticipated in the Basinwide Recovery Strategy, is not expected to be sufficient to meet survival and recovery indicator criteria.

6.3.12 Snake River Sockeye Salmon

Evaluation of the species-level effects of the proposed action requires placing the action-area effects of the proposed action in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of SR sockeye salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include tributary hydropower and irrigation storage projects that block or restrict fish passage, water withdrawals that dewater streams, and unscreened diversions.

Because the abundance of SR sockeye salmon is extremely low, the risk of extinction cannot be calculated using the methods that NMFS employs in this biological opinion. The risk is undoubtedly very high, however, due to the extreme low abundance of SR sockeye salmon in recent years, this ESU has not been used in passage survival studies. NMFS has not, therefore, estimated total system survival under the proposed action for this ESU. Assuming that juvenile mortality in the action area is similar to that of other yearling migrants, the proposed action is likely to contribute to the ongoing high risk of extinction. The survival rate in the action area is not known with certainty, but survival resulting from the proposed action is clearly lower than that needed to meet the survival and recovery standards. Other factors also affect elements of critical habitat and thus contribute to this ESU's high risk of extinction (summarized in Section

4.1 and Appendix C), but the FCRPS is a significant factor. The high risk of extinction is partially mitigated by a captive breeding program, funded by the Action Agencies, which provides some assurance that SR sockeye salmon will not go extinct in the immediate future. However, long-term survival and recovery in the wild require a substantial increase in survival through the FCRPS and in other life stages. The proposed action, along with the future recovery efforts in the habitat and hatchery sectors anticipated in the Basinwide Recovery Strategy, is not expected to be sufficient to meet survival and recovery indicator criteria.

6.3.13 Summary—Effects of Proposed Action on Biological Requirements Over Full Life Cycle

The ESU-specific analyses in Sections 6.3.1 through 6.3.11 include both quantitative and qualitative assessments.[9] The quantitative analyses show that recent survival changes, if continued into the future, will increase the likelihood of meeting survival and recovery indicator criteria for stocks that pass through one or more FCRPS projects. Summer steelhead stocks throughout the basin, including two of the spawning aggregations in the LCR steelhead ESU, will also benefit from recent harvest reductions. For all ESUs, however, many stocks will need additional survival improvements beyond those expected from the proposed action and all other reasonably foreseeable recovery activities, ranging in size from a few percentage points to several orders of magnitude (Table 6.3-12).[10]

NMFS' qualitative assessment considers the extent to which the proposed action (and other reasonably foreseeable recovery activities) affects the capacity of critical habitat to provide biological requirements for listed fish. In addition to the likely effects of the proposed action, a large number of factors (e.g., tributary land use practices, interactions with hatchery fish, and ocean conditions) affect the current population trends of Columbia basin salmonids. These effects are organized by critical habitat type (juvenile rearing areas, juvenile migration corridors, areas for growth and development, adult migration corridors, and spawning habitat) in Table 6.3-13. As shown in that table, the FCRPS has the potential to diminish the value of critical habitat for survival and recovery across much of the life cycle for some species. SR fall chinook salmon, for example, spawn in the tailraces of several lower Snake River projects and rear in the FCRPS during their juvenile migration, as well as experiencing the effects of project passage.

In contrast, based on the best scientific information now available, the effects of current FCRPS operations appear to be relatively minor for UWR and LCR chinook salmon and for UWR and LCR steelhead; the Upper Willamette River ESUs do not pass any FCRPS projects, and only part of the spawning aggregations comprising each of the Lower Columbia River ESUs pass even one project. Current FCRPS operations do not affect mainstem spawning or rearing habitat for those species, although flow regulation may affect critical habitat for rearing in the estuary and plume.

[9] Quantitative analyses are not possible for SR sockeye salmon.

[10] Critical assumptions that influence results for each ESU are discussed in the preceding sections.

Evidence of effects in the estuary and plume is inferential, however, and insufficient for concluding that the proposed action will appreciably diminish the capacity of those areas to meet the biological requirements of listed fish. This issue requires further study.

Table 6.3-12. Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action. "Low" and "High" estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change			
Spawning Aggregation	**Low**	**High**		
Snake River Spring/Summer Chinook				
ESU aggregate	53	98		
Bear Valley/Elk creeks	0	0		
Imnaha River	32	74		
Johnson Creek	0	0		
Marsh Creek	2	17		
Minam River	0	33		
Poverty Flats	0	0		
Sulphur Creek	0	10		
Alturas Lake Creek	181	200	*	Based only on lambda ≥ 1.0
American River	16	24	*	Based only on lambda ≥ 1.0
Big Sheep Creek	35	65	*	Based only on lambda ≥ 1.0
Beaver Creek	0	0	*	Based only on lambda ≥ 1.0
Bushy Fork	0	0	*	Based only on lambda ≥ 1.0
Camas Creek	9	16	*	Based only on lambda ≥ 1.0
Cape Horn Creek	0	0	*	Based only on lambda ≥ 1.0
Catherine Creek	57	142	*	Based only on lambda ≥ 1.0
Catherine Creek North Fork	9	17	*	Based only on lambda ≥ 1.1
Catherine Creek South Fork	110	124	*	Based only on lambda ≥ 1.2
Crooked Fork Creek	0	0	*	Based only on lambda ≥ 1.0
Grande Ronde River	66	154	*	Based only on lambda ≥ 1.0
Knapp Creek	27	36	*	Based only on lambda ≥ 1.0
Lake Creek	0	0	*	Based only on lambda ≥ 1.0
Lemhi River	0	0	*	Based only on lambda ≥ 1.0
Lookingglass Creek	111	240	*	Based only on lambda ≥ 1.1
Loon Creek	0	0	*	Based only on lambda ≥ 1.0
Lostine Creek	20	50	*	Based only on lambda ≥ 1.0
Lower Salmon River	11	19	*	Based only on lambda ≥ 1.0
Lower Valley Creek	8	15	*	Based only on lambda ≥ 1.0
Moose Creek	0	4	*	Based only on lambda ≥ 1.0
Newsome Creek	0	0	*	Based only on lambda ≥ 1.0

Table 6.3-12 (continued). Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action. "Low" and "High" estimates are based on a range of assumptions, as described in the text. A value of, for example, "8" indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change			
Spawning Aggregation	**Low**	**High**		
Red River	16	23	*	Based only on lambda ≥ 1.0
Salmon River East Fork	0	7	*	Based only on lambda ≥ 1.0
Salmon River South Fork	0	0	*	Based only on lambda ≥ 1.0
Secesh River	0	0	*	Based only on lambda ≥ 1.0
Selway River	13	21	*	Based only on lambda ≥ 1.0
Sheep Creek	106	120	*	Based only on lambda ≥ 1.0
Upper Big Creek	0	0	*	Based only on lambda ≥ 1.0
Upper Salmon River	18	26	*	Based only on lambda ≥ 1.0
Upper Valley Creek	0	0	*	Based only on lambda ≥ 1.0
Wallowa Creek	48	58	*	Based only on lambda ≥ 1.0
Wenaha River	19	74	*	Based only on lambda ≥ 1.0
Whitecap Creek	19	27	*	Based only on lambda ≥ 1.0
Yankee Fork of Salmon River	32	41	*	Based only on lambda ≥ 1.0
West Fork of Yankee Fork, Salmon River	0	0	*	Based only on lambda ≥ 1.0
Snake River Fall Chinook				
Aggregate	6	64		
Upper Columbia River Spring Chinook				
ESU aggregate - CRI	55	86		
Methow River-QAR	45	65		
Entiat River-QAR	60	82		
Wenatchee River-QAR	77	153		
Methow River-CRI	55	123		
Entiat River-CRI	54	156		
Wenatchee River-CRI	116	226		
Upper Willamette River Chinook				
McKenzie River above Leaburg Dam	9	65		

Table 6.3-12 (continued). Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action. "Low" and "High" estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change		
Spawning Aggregation	**Low**	**High**	
Lower Columbia River Chinook			
Aggregations Above Bonneville Dam			
(insufficient information for analysis)			
Aggregations Below Bonneville Dam			
Bear Creek	114	213	
Big Creek	31	97	
Clatskanie River	193	312	
Cowlitz River tule	33	99	* Based only on recovery metric.
Elochoman River	4	56	* Based only on recovery metric.
Germany Creek	30	95	* Based only on recovery metric.
Gnat Creek	107	195	
Grays River tule	76	164	* Based only on recovery metric.
Kalama River spring	87	180	* Based only on recovery metric.
Kalama River	6	58	* Based only on recovery metric.
Klaskanine River	130	227	
Lewis River bright	5	11	* Based only on recovery metric.
Lewis River spring	46	120	* Based only on recovery metric.
Lewis, East Fork tule	3	3	* Based only on recovery metric.
Lewis and Clark River	934	1,493	
Mill Creek fall	144	258	
Plympton Creek	21	82	
Sandy River late	7	9	
Skamokawa Creek	105	208	* Based only on recovery metric.
Youngs River	573	732	
Snake River Steelhead			
ESU aggregate	72	291	
A-run aggregate	56	241	
A-run pseudopopulation	56	241	
B-run aggregate	109	370	
B-run pseudopopulation	109	370	

Table 6.3-12 (continued). Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action. "Low" and "High" estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change		
Spawning Aggregation	**Low**	**High**	
Upper Columbia River Steelhead			
ESU aggregate - CRI	47	243	
Methow - QAR	8	146	
Wenatchee/Entiat - QAR	17	96	
Mid-Columbia River Steelhead			
ESU aggregate	122	268	* Based only on recovery metric.
Deschutes River summer	130	270	
Warm Springs hatchery summer	54	54	
Umatilla River summer	53	48	
Yakima River summer	0	10	
Upper Willamette River Steelhead			
ESU aggregate	37	69	
Molalla River	45	108	
N. Santiam River	42	58	
S. Santiam River	30	78	
Calapooia River	53	53	
Lower Columbia River Steelhead			
ESU aggregate	53	171	* Based only on recovery metric.
Aggregations Above Bonneville Dam			
(insufficient information for analysis)			
Aggregations Below Bonneville Dam			
Clackamas River summer	144	376	
Clackamas River winter	75	243	
Green River winter	80	80	
Kalama River summer	51	267	
Kalama River winter	13	58	

Table 6.3-12 (continued). Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action. "Low" and "High" estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change		
Spawning Aggregation	**Low**	**High**	
Sandy River winter	49	108	
Toutle River winter	81	81	
Columbia River Chum Salmon			
ESU aggregate	0	0	* Based only on recovery metric
Aggregations Above Bonneville Dam			
(insufficient information for analysis)			
Aggregations Below Bonneville Dam			
Grays River west fork	0	0	
Grays River mouth to head	18	18	
Hardy Creek	0	0	
Crazy Johnson	0	0	
Hamilton Creek	36	36	
Hamilton Springs	0	0	

Table 6.3-13. Effects of proposed action, current FCRPS operations (shown in **bold**), and other ongoing actions on critical habitat at species-level.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas—Growth/Develop	Adult Migration Corridor	Spawning Habitat
SR spring/summer chinook	- Some habitat (incl. water) quality is degraded by tributary land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish - Some habitat access is depleted by water diversions	**For inriver migrants:** **- Water quality (dissolved gas) declines during involuntary spill** **- Mortality due to passage past 8 FCRPS projects** **- Potential exposure to predators in LCR reservoirs** **- Potential delayed mortality due to FCRPS passage** **For transported fish:** **- Potential delayed mortality** - Hatchery practices potentially lead to adverse interactions with wild fish	**- Potential habitat degradation in plume** - Incidental ocean harvest - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	**- Mortality due to passage past 8 FCRPS projects** **- Water quality (dissolved gas) is degraded during involuntary spill** - Incidental mainstem harvest	- Some habitat quality is degraded by tributary land-use practices and water diversions - Some habitat access is impeded by water diversions
SR fall chinook	**For inriver migrants:** **- Decline in water quality (temperature) during summer and early fall (by heat capacity of mainstem reservoirs) in the Snake River is partially mitigated by cold water releases from Dworshak Reservoir** **- Mortality due to passage past 8 FCRPS projects** **- Mortality in reservoirs due to low summer flows** **- Potential delayed mortality due to FCRPS passage** **- Exposure to predators in reservoirs** **For transported fish – potential delayed mortality** - Hatchery practices potentially lead to adverse interactions with wild fish		**- Potential habitat degradation in estuary and plume** - Incidental ocean harvest - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	**- Mortality due to passage past 8 FCRPS projects** **- Decline in water quality (temperature) during summer and early fall (by heat capacity of mainstem reservoirs) in the Snake River is partially mitigated by cold water releases from Dworshak Reservoir** - Incidental mainstem harvest	**- Unknown effects of flow management on use of spawning habitat below Lower Granite, Little Goose, and Ice Harbor dams** - Irrigation and hydroelectric projects block access to habitat in some tributaries below Hells Canyon Complex - Water quality in lower ends of some tributaries is degraded by land use practices - Hatchery practices potentially lead to adverse interactions with wild fish

Table 6.3-13 (continued). Effects of proposed action, current FCRPS operations (shown in **bold**), and other ongoing actions on critical habitat at species-level.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas—Growth/Develop	Adult Migration Corridor	Spawning Habitat
UCR spring chinook	- Some habitat (incl. water) quantity and quality is degraded by irrigation diversions and tributary land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish	**- Water quality (dissolved gas) declines during involuntary spill** **- Mortality due to passage past 4 FCRPS projects** **- Potential delayed mortality due to FCRPS passage** **- Potential exposure to predators in LCR reservoirs** - Mortality due to passage past up to 5 PUD projects - Hatchery practices potentially lead to adverse interactions with wild fish	**- Potential habitat degradation in the plume** - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	**- Mortality due to passage past 4 FCRPS projects** **- Water quality (dissolved gas) is degraded during involuntary spill** - Mortality due to passage past up to 5 PUD projects - Incidental mainstem harvest	- Some habitat quantity and quality degraded by tributary hydropower development, irrigation withdrawals and land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish
UWR chinook	- Some access is reduced and quality is degraded by tributary hydropower and irrigation development and land-use practices	- Water quality degraded by tributary land-use practices	**- Potential habitat degradation in estuary and plume** - Incidental ocean harvest - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	- Water quality and quantity degraded by tributary land-use practices	- Some habitat quantity and quality degraded by tributary hydropower development and land-use practices

Table 6.3-13 (continued). Effects of proposed action, current FCRPS operations (shown in **bold**), and other ongoing actions on critical habitat at species-level.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas—Growth/Develop	Adult Migration Corridor	Spawning Habitat
LCR chinook	- Some access is reduced and quality is degraded by tributary hydropower development and land-use practices **-Access to and quantity and quality of habitat at Ives Island affected by FCRPS flows**	- Water quality degraded by tributary land-use practices **- Mortality due to passage past 1 FCRPS project for a limited number of spawning aggregations**	**- Potential habitat degradation in estuary and plume** - Incidental ocean harvest - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	- Water quality and quantity degraded by tributary land-use practices **- Mortality due to passage past 1 FCRPS project for a limited number of spawning aggregations**	- Some habitat quantity and quality degraded by tributary hydropower development and land-use practices **- Access to and quantity and quality of habitat at Ives Island affected by FCRPS flows**
SR steelhead	- Blockages to tributary habitat are common - Some habitat (incl. water) quality is degraded by tributary land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish	**For inriver migrants:** **- Water quality (dissolved gas) declines during involuntary spill** **- Mortality due to passage past 8 FCRPS projects** **- Potential delayed mortality due to FCRPS passage** **- Potential exposure to predators in LCR reservoirs** **For transported fish:** **– Potential delayed mortality** - Hatchery practices potentially lead to adverse interactions with wild fish	**- Potential habitat degradation in plume** - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	**- Mortality due to passage past 8 FCRPS projects** **- Water quality (dissolved gas) is degraded during involuntary spill** - Incidental mainstem and tributary harvest	- Blockages to tributary habitat are common - Some habitat (incl. water) quality is degraded by tributary land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish

Table 6.3-13 (continued). Effects of proposed action, current FCRPS operations (shown in **bold**), and other ongoing actions on critical habitat at species-level.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas—Growth/Develop	Adult Migration Corridor	Spawning Habitat
UCR steelhead	- Some habitat (incl. water quality) is degraded by irrigation diversions and tributary land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish	**- Water quality (dissolved gas) declines during involuntary spill** **- Mortality due to passage past 4 FCRPS projects** **- Potential delayed mortality due to FCRPS passage** **- Potential exposure to predators in LCR reservoirs** - Mortality due to passage past up to 5 PUD projects - Hatchery practices potentially lead to adverse interactions with wild fish	**- Potential habitat degradation in plume** - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	**- Mortality due to passage past 4 FCRPS projects** **- Water quality (dissolved gas) is degraded during involuntary spill** - Mortality due to passage past up to 5 PUD projects - Incidental mainstem harvest	- Some quantity and quality degraded by tributary hydropower development, irrigation withdrawals, and land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish
MCR steelhead	- Some access is reduced and quality is degraded by tributary hydropower and irrigation development and land-use practices	- Some water quality degraded by tributary land-use practices **- Elevated TDG during involuntary spill** **- Mortality due to passage past up to 4 FCRPS projects**	**- Potential habitat degradation in plume** - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	- Some water quality and quantity degraded by tributary land-use practices **- Mortality due to passage past up to 4 FCRPS projects** - Incidental harvest in the mainstem Columbia River and tributaries	- Some quantity and quality degraded by tributary hydropower development and land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish
UWR steelhead	- Some access is reduced and quality is degraded by tributary hydropower and irrigation development and land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish	- Water quality degraded by tributary land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish	**- Potential habitat degradation in estuary and plume** - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	- Some water quality and quantity degraded by tributary land-use practices - Incidental harvest in the mainstem Columbia River and tributaries	- Some quantity and quality degraded by tributary hydropower development and land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish

Table 6.3-13 (continued). Effects of proposed action, current FCRPS operations (shown in **bold**), and other ongoing actions on critical habitat at species-level.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas—Growth/Develop	Adult Migration Corridor	Spawning Habitat
LCR steelhead	- Some access is reduced and quality is degraded by tributary hydropower development and land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish	- Water quality degraded by tributary land-use practices **- Mortality due to passage past 1 FCRPS project for a limited number of spawning aggregations**	**- Potential habitat degradation in plume** - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	- Some water quality and quantity degraded by tributary land-use practices **- Mortality due to passage past 1 FCRPS project for a limited number of spawning aggregations** - Incidental harvest in the mainstem Columbia River and tributaries	- Some quantity and quality degraded by tributary hydropower development and land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish
CR chum	- Some quality is degraded by tributary land-use practices	- Water quality degraded by tributary land-use practices **- Unknown mortality of smolts due to passage past 1 FCRPS project**	**- Potential habitat degradation in estuary and plume** - Exposure to avian predators in LCR estuary	- Some water quality and quantity degraded by tributary land-use practices **- Unknown mortality of adults due to passage past 1 FCRPS project** - Incidental harvest in the mainstem Columbia River and tributaries	- Some quantity and quality degraded by tributary land-use practices **- Access to Hamilton Creek and Spring Channel affected by FCRPS flows** **- Access to, quantity of, and quality of habitat at Ives Island affected by FCRPS flows**
SR sockeye	- Access is reduced and quality is degraded by land use and tributary hydropower and irrigation development	**- Mortality of smolts due to passage past 8 FCRPS projects** **- Potential exposure to predators in reservoirs**	**- Potential habitat degradation in plume** - Exposure to avian predators in LCR estuary	**- Mortality of adults due to passage past 8 FCRPS projects** - Incidental harvest in the mainstem Columbia River and tributaries	- Quantity and quality degraded by tributary land-use practices

7.0 CUMULATIVE EFFECTS

Cumulative effects, as defined in 50 CFR Section 402.02, include the effects of future state, Tribal, local, or private actions, not involving Federal activities, that are reasonably certain to occur within the action area (described in Section 1). Future Federal actions requiring separate consultations pursuant to Section 7 of the ESA are not considered here.

State, Tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives. Government and private actions may include changes in land and water use patterns, including ownership and intensity, any of which could affect listed species or their habitat. Even actions that are already authorized are subject to political, legislative, and fiscal uncertainties. These realities, added to the geographic scope of the action area, which encompasses numerous government entities exercising various authorities and many private landholdings, make any analysis of cumulative effects difficult and even speculative. This section identifies representative actions that, based on currently available information, are reasonably certain to occur. It also identifies goals, objectives and proposed plans by state and Tribal governments, however, NMFS is unable to determine at this point in time whether such proposals will in fact result in specific actions.

7.1 STATE ACTIONS

Regional

Each state in the Columbia River basin administers the allocation of water resources within its borders. Water resource development has slowed in recent years. Most arable lands have already been developed, the increasingly diversified regional economy has decreased demand, and there are increased environmental protections. If, however, substantial new water developments occur, cumulative adverse effects to listed fish are likely. NMFS cooperates with the state water resource management agencies in assessing water resource needs in the Columbia River basin. Through restrictions in new water developments, vigorous water markets may develop to allow existing developed supplies to be applied to the highest and best use. Interested parties have applied substantial pressure, including ongoing litigation, on the state water resource management agencies to reduce or eliminate restrictions on water development. It is, therefore, impossible to predict the outcomes of these efforts with any reasonable certainty.

In July 2000, the governors of Idaho, Montana, Oregon, and Washington released their "Recommendation for the Protection and Restoration of Fish in the Columbia River Basin," with the stated goal of "protection and restoration of salmonids and other aquatic species to sustainable and harvestable levels meeting the requirements of the Endangered Species Act, the Clean Water Act, the Northwest Power Act and tribal rights under treaties and executive orders while taking into account the need to preserve a sound economy in the Pacific Northwest." The recommendations include the following general actions:

1. **Habitat Reforms**
   a) Designate priority watersheds for salmon and steelhead.
   b) Provide local watershed planning assistance and develop the priority plans by October 1, 2002, and for all Columbia River basin watersheds by 2005.
   c) Integrate Federal, state, and regional planning processes with the NWPPC's amended Fish and Wildlife Program.
   d) Cooperate with Federal, Tribal, and local governments to implement the National Estuary Program for the lower Columbia River estuary, including creation of salmon sanctuaries.
2. **Harvest Reforms**
   a) Research the use of more selective fishing techniques and a license buyback program.
   b) Increase harvest selectivity through restrictions of harvest rates, gear, and timing for commercial and non-Treaty sport fisheries, consistent with ensuring survival of the species when combined with other recovery actions.
   c) Establish terminal fisheries below Bonneville Dam and in zone 6.
   d) Strengthen state law enforcement programs and coordinate them with habitat strategies to aid specific watersheds.
   e) Increase fishing opportunities for species that prey on, and compete with, salmon for food.
3. **Hatchery Reforms**
   a) Implement reforms recommended in the NWPPC's 1999 Artificial Production Review Report to congress.
   b) Support the region's fish managers and the Tribes' development of a comprehensive supplementation plan that includes intensive monitoring and evaluation.
   c) Mark hatchery fish that pose threats to listed fish, consistent with the Pacific Salmon Treaty.
4. **Funding and Accountability**
   a) Seek funding assistance for existing activities designed to improve ecosystem health and fish and wildlife health and protection.
   b) Work regionally to create a standardized and accessible information system to document regional recovery progress.

If these recommendations are implemented by the states individually and collectively, they should have beneficial effects on listed species and their habitat.

Oregon

Most future actions by the state of Oregon are described in the Oregon Plan for Salmon and Watershed measures, which includes the following programs designed to benefit salmon and watershed health:

- Oregon Department of Agriculture water quality management plans
- Oregon Department of Environmental Quality development of total maximum daily loads (TMDLs) in targeted basins; implementation of water quality standards

- Oregon Watershed Enhancement Board funding programs for watershed enhancement programs, and land and water acquisitions
- ODFW and Oregon Water Resources Department (OWRD) programs to enhance flow restoration
- OWRD programs to diminish over-appropriation of water sources
- ODFW and Oregon Department of Transportation programs to improve fish passage; culvert improvements/replacements
- Oregon Department of Forestry state forest habitat improvement policies and the Board of Forestry pending rules addressing forestry effects on water quality and riparian areas
- Oregon Division of State Lands and Oregon Parks Department programs to improve habitat health on state-owned lands
- Department of Geology and Mineral Industries program to reduce sediment runoff from mine sites
- State agencies funding local and private habitat initiatives; technical assistance for establishing riparian corridors; and TMDLs

If the foregoing programs are implemented, they may improve habitat features considered important for the listed species. In November 2000, however, Oregon voters approved a broad constitutional amendment requiring payment to private property owners for diminution in property values resulting from regulations. That measure essentially puts all Oregon regulatory initiatives into question. The Oregon Plan also identifies private and public cooperative programs for improving the environment for listed species. The success and effects of such programs will depend on the continued interest and cooperation of the parties. One such cooperative program, the Willamette Restoration Initiative (WRI), has been charged with developing the Willamette basin section of the Oregon Plan. The future of the WRI will be subject to discussion among the WRI board, the Oregon governor's office, and the Oregon legislature in the 2001 legislative session.

Washington

The state of Washington has various strategies and programs designed to improve the habitat of listed species and assist in recovery planning. Washington's 1998 Salmon Recovery Planning Act provided the framework for developing watershed restoration projects and established a funding mechanism for local habitat restoration projects. It also created the Governor's Salmon Recovery Office to coordinate and assist in the development of salmon recovery plans. Washington's "Statewide Strategy to Recover Salmon," for example, is designed to improve watersheds.

The Watershed Planning Act, also passed in 1998, encourages voluntary planning by local governments, citizens, and Tribes for water supply and use, water quality, and habitat at the Water Resource Inventory Area or multi-Water Resource Inventory Area level. Grants are made available to conduct assessments of water resources and to develop goals and objectives for future water resources management. The Salmon Recovery Funding Act established a board to localize salmon funding. The board will deliver funds for salmon recovery projects and activities

based on a science-driven, competitive process. These efforts, if developed into actual programs, should help improve habitat for listed species.

Washington's Department of Fish and Wildlife and tribal comanagers have been implementing the Wild Stock Recovery Initiative since 1992. The comanagers are completing comprehensive species management plans that examine limiting factors and identify needed habitat activities. The plans also concentrate on actions in the harvest and hatchery areas, including comprehensive hatchery planning. The department and some western Washington treaty Tribes have also adopted a wild salmonid policy to provide general policy guidance to managers on fish harvest, hatchery operations, and habitat protection and restoration measures to better protect wild salmon runs.

Washington State's Forest and Fish Plan may be promulgated as administrative rules. The rules are designed to establish criteria for non-Federal and private forest activities that will improve environmental conditions for listed species. The Washington legislature may amend the Shoreline Management Act, giving options to local governments for complying with endangered species requirements in marine areas.

The state is also establishing the Lower Columbia Fish Recovery Board to begin drafting recovery plans for the lower Columbia region. The future impacts of the board's efforts will depend on legislative and fiscal support. The Washington Department of Transportation is considering changing its construction and maintenance programs to diminish effects on stream areas and to improve fish passage. The program may qualify for a limit under NMFS' 4(d) rule to conserve listed species.

Water quality improvements will be proposed through development of TMDLs. The state of Washington is under a court order to develop TMDL management plans on each of its 303(d) water-quality-listed streams. It has developed a schedule that is updated yearly; the schedule outlines the priority and timing of TMDL plan development.

Washington State closed the mainstem Columbia River to new water rights appropriations in 1995. All applications for new water withdrawals are being denied based on the need to address ESA issues. The state established and funds a program to lease or buy water rights for instream flow purposes. This program was started in 2000 and is in the preliminary stages of public information and identification of potential acquisitions. These water programs, if carried out over the long term, should improve water quantity and quality in the state.

As with Oregon's state initiatives, Washington's programs are likely to benefit listed species if they are implemented and sustained.

Idaho

The Idaho Department of Environmental Quality will establish TMDLs in the Snake River basin, a program regarded as having positive water quality effects. The TMDLs are required by court

order, so it is reasonably certain that they will be set. However, the same agency is considering relaxing other water quality standards in Idaho streams, which could have negative effects on water quality.

The state of Idaho has created an Office of Species Conservation to work on subbasin planning and to coordinate the efforts of all state offices addressing natural resource issues. The state actions targeted by this office include the following:

1. Continue diversion screening, in cooperation with BPA and BOR
2. Improve flow augmentation for fish passage through state programs
3. Implement the Forest Practices Act to maintain forest tree species, soil, air, and water resources and provide a habitat for wildlife and aquatic life.
4. Complete cumulative watershed effects assessments on more than 100 watersheds to support watershed planning.
5. Require 30-foot buffers along Class II streams.

These state-directed actions, if continued, will have positive effects for listed species and their habitat.

Demands for Idaho's groundwater resources have caused groundwater levels to drop and reduced flow in springs for which there are senior water rights. The Idaho Department of Water Resources has begun studies and promulgated rules that address water right conflicts and demands on a limited resource. The studies have identified aquifer recharge as a mitigation measure with the potential to affect the quantity of water in certain streams, particularly those essential to listed species.

Montana

Montana is expected to undertake the following future state actions to benefit listed species in the Columbia River basin.

Under the State Water Quality Act, the Montana Department of Environmental Quality (MDEQ) is required to ensure that water quality restoration plans and permits are developed by 2007 for all waters on the 303 (d) list and within 10 years for any new water body added to the list. As part of the water quality restoration process, MDEQ and other agencies may provide financial grants to local water quality groups to implement pollution control measures. For non-point pollution sources, MDEQ plans to provide technical and financial support to local and regional watershed groups and allow them to take the lead in monitoring, developing plans, and implementing pollution controls. MDEQ's Remediation Division identifies water quality problems related to mining or other sources and coordinates cleanups with other resource management activities. This action may be part of a watershed restoration project carried out by local authorities.

Montana is implementing a new TMDL program to assess the quality of its water bodies and systematically implement water quality plans to restore and protect them. The plan calls for developing TMDLs for each of the 800 impaired water bodies on the 303 (d) list. Local watershed groups are asked to take responsibility for their own watersheds and work directly with MDEQ to develop TMDLs. These local watershed groups will also participate in the ranking and priority-setting process for watershed improvements to benefit listed species.

General

In the past, each state's economy depended on natural resources, with intense resource extraction. Changes in the states' economies have occurred in the last decade and are likely to continue, with less large-scale resource extraction, more targeted extraction, and significant growth in other economic sectors. Growth in new businesses, primarily in the technology sector, is creating urbanization pressures and increased demands for buildable land, electricity, water supplies, waste-disposal sites, and other infrastructure.

Economic diversification has contributed to population growth and movement in all four states, a trend likely to continue for the next few decades. Such population trends will result in greater overall and localized demands for electricity, water, and buildable land in the action area; will affect water quality directly and indirectly; and will increase the need for transportation, communication, and other infrastructure. The impacts associated with these economic and population demands will probably affect habitat features such as water quality and quantity, which are important to the survival and recovery of the listed species. The overall effect will be negative, unless carefully planned for and mitigated.

Some of the state programs described above are designed to address these impacts. Oregon also has a statewide, land-use-planning program that sets goals for growth management and natural resource protection. Washington State enacted a Growth Management Act to help communities plan for growth and address the effects of growth on the natural environment. If the programs continue, they may help lessen the potential for the adverse effects discussed above.

7.2 LOCAL ACTIONS

Local governments will be faced with similar and more direct pressures from population growth and movement. There will be demands for intensified development in rural areas, as well as increased demands for water, municipal infrastructure, and other resources. The reaction of local governments to growth and population pressure is difficult to assess without certainty in policy and funding. In the past, local governments in the three states generally accommodated growth in ways that adversely affected listed fish habitat. Because there is little consistency among local governments regarding current ways of dealing with land use and environmental issues, both positive and negative effects on listed species and their habitat are probably scattered throughout the action area.

In both Oregon and Washington, local governments are considering ordinances to address effects on aquatic and fish habitat from different land uses. The programs are part of state planning structures; however, local governments in Oregon are likely to be cautious about implementing new programs, because of the passage of the constitutional amendment discussed above. Some local government programs, if submitted, may qualify for a limit under NMFS' 4(d) rule, which is designed to conserve listed species. Local governments may also participate in regional watershed health programs, although political will and funding will determine participation and, therefore, the effect of such actions on listed species. Overall, unless beneficial programs are comprehensive, cohesive, and sustained in their application, it is not likely that local actions will have measurable positive effects on listed species and their habitat and may even contribute to further degradation.

7.3 TRIBAL ACTIONS

Tribal governments will participate in cooperative efforts involving watershed and basin planning designed to improve aquatic and fish habitat. The results of changes in Tribal forest and agricultural practices, in water resource allocation, and in land use are difficult to assess, for the reasons discussed in Sections 7.1 and 7.2. The earlier discussion of the effects of economic diversification and growth applies also to Tribal government actions. The Tribal governments have to apply and sustain comprehensive and beneficial natural resource programs such as the ones described below, to areas under their jurisdiction to have measurable positive effects on listed species and their habitat.

One Tribal program illustrates future Tribal actions that should have such positive effects. The *Wy-Kan-Ush-Mi Wa-Kish-Wit*, or "Spirit of the Salmon" plan is a joint restoration plan for anadromous fish in the Columbia River basin prepared by the Nez Perce, Umatilla, Warm Springs and Yakama Tribes. It provides a framework for restoring anadromous, or sea-going, fish stocks, specifically salmon, Pacific lamprey (eels), and white sturgeon in upriver areas above Bonneville Dam. The plan's objectives are as follows:

1. Halt the decline of salmon, lamprey, and sturgeon populations above Bonneville Dam within 7 years.
2. Rebuild salmon populations to annual run sizes of 4 million above Bonneville Dam within 25 years in a manner that supports Tribal ceremonial, subsistence, and commercial harvests.
3. Increase lamprey and sturgeon to naturally sustaining levels within 25 years in a manner that supports Tribal harvests.

The plan emphasizes strategies and principles that rely on natural production and healthy river systems. The plan's technical recommendations cover hydro operations on the mainstem Columbia and Snake rivers; habitat protection and rehabilitation in the basin above Bonneville Dam, in the Columbia estuary, and in the Pacific ocean; fish production and hatchery reforms; and inriver and ocean harvests.

The Nez Perce, Warm Spring, Umatilla, and Yakama Tribal governments are now seeking to implement this plan and salmon restoration in conjunction with the states, other Tribes, and the Federal government, as well as in cooperation with their neighbors throughout the basin's local watersheds and with other citizens of the Northwest.

Overall, the Spirit of the Salmon plan should have positive cumulative effects on listed species and their habitat.

7.4 PRIVATE ACTIONS

The effects of private actions are the most uncertain. Private landowners may convert their lands from current uses, or they may intensify or diminish those uses. Individual landowners may voluntarily initiate actions to improve environmental conditions, or they may abandon or resist any improvement efforts. Their actions may be compelled by new laws, or they may result from growth and economic pressures. Changes in ownership patterns will have unknown impacts. Whether any of these private actions will occur is highly unpredictable, and the effects are even more so.

7.5 SUMMARY

Non-Federal actions are likely to continue affecting listed species. The cumulative effects in the action area are difficult to analyze, considering the broad geographic landscape covered by this opinion, the geographic and political variation in the action area, the uncertainties associated with government and private actions, and ongoing changes to the region's economy. Whether those effects will increase or decrease in the future is a matter of speculation; however, based on the population and growth trends identified in this section, cumulative effects are likely to increase. Although state, Tribal, and local governments have developed plans and initiatives to benefit listed salmon and steelhead, they must be applied and sustained in a comprehensive manner before NMFS can consider them "reasonably foreseeable" in its analysis of cumulative effects.

8.0 CONCLUSIONS

The analysis in the preceding sections of this biological opinion forms the basis for conclusions as to whether the proposed action, the ongoing operation of the FCRPS, and the BOR projects identified in Table 1.0-1 satisfy the standards of ESA Section 7(a)(2). To do so, the Action Agencies must ensure that their proposed action is not likely to jeopardize the continued existence of any listed species or destroy or adversely modify the designated critical habitat of such species. Section 4 of this opinion defines the biological requirements and the current status of each of the 12 listed salmonid species. Section 5 evaluates the relevance of the environmental baseline to each species' current status. Section 6 details the likely effects of the proposed action, both on individuals of the species in the action area and on the listed population as a whole, across its range and life cycle. Section 7 considers the cumulative effects of relevant non-Federal actions reasonably certain to occur within the action area. On the basis of this information and analysis, NMFS draws its conclusions about the effects of the FCRPS and the BOR projects on the survival and recovery of the 12 listed salmonid species.

As discussed in Section 1.3 of this biological opinion, NMFS must now determine "whether the species can be expected to survive with an adequate potential for recovery under the effects of the proposed or continuing action, the environmental baseline and cumulative effects, and considering measures for survival and recovery specific to other life stages." The information available to NMFS for this determination is both quantitative and qualitative. For some species, such as SR spring/summer chinook salmon, the available information includes substantial quantitative data based on empirical observations. For other species, such as SR sockeye salmon, the available information is largely qualitative, based on the best professional judgment of knowledgeable scientists. Despite an increasing trend toward a more quantitative understanding of the critical life signs for these fish, critical uncertainties limit NMFS' ability to project future conditions and effects. As a result, no hard and fast numerical indices are available for any of these stocks on which NMFS can base determinations about jeopardy or the adverse modification of critical habitat (the Section 7(a)(2) standards). Ultimately, for all 12 ESUs, NMFS' conclusions are qualitative judgments based on the best quantitative and qualitative information available for each species.

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8.1 SNAKE RIVER SPRING/SUMMER CHINOOK SALMON

8.1.1 Proposed BPA, Corps, and BOR Action

The biological requirements of this stream-type salmonid, which migrates to the ocean as a yearling and spawns and rears in tributaries upstream of the FCRPS, are not being met, either in the FCRPS action area or at the life-cycle level. As discussed in Section 6.2, when passing through the FCRPS, individuals of this species are subjected to adverse habitat conditions that cause mortality or result in impaired fitness. Although recent improvements in the operation and configuration of the FCRPS have reduced overall mortality rates for the species, current survival through the FCRPS, as affected by operation of the BOR projects, is not sufficient to ensure the survival of the ESU with an adequate potential for recovery. Instead, continuing the proposed action for the long term, coupled with current prospects for survival and recovery across the range and life cycle of the ESU, is likely to appreciably reduce the likelihood of both its survival and its recovery.

Key effects of the proposed action on this species in the action area are summarized in Section 6.2.9. They include substantial ongoing juvenile and adult mortality associated with dam and reservoir passage and high TDG levels during periods of involuntary spill. Although the proposed action describes a process to develop performance standards for actions that would reduce mortality, it is not clear that mortality will be reduced enough or that critical habitat will be adequately protected.

At the species level, Table 6.3-12 indicates that at least 2%, and up to 33%, survival improvements are needed for 80% of index stocks to meet the indicator criteria. Substantial survival improvements, in addition to those likely to result from the proposed action and other measures for survival and recovery that affect other life stages, are required to ensure a high likelihood of survival and a moderate-to-high likelihood of recovery for the other spawning aggregates within this ESU. Some portion of additional survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices identified in the basinwide strategy. The degree to which these Federal survival and recovery measures will sufficiently augment the survival improvements expected from the proposed action is, however, highly uncertain. NMFS must also rely on progress in implementing non-Federal survival and recovery measures that affect other life stages. Furthermore, NMFS finds that survival improvements beyond those likely to result from the proposed action are reasonably available to the FCRPS Action Agencies. After reviewing the current status of SR spring/summer chinook salmon and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action, and cumulative effects, therefore, NMFS concludes that the proposed operation and configuration of the FCRPS and the BOR projects are likely to jeopardize the continued existence of this ESU and to adversely modify its designated critical habitat.

8.1.2 NMFS' Issuance of Section 10 Transportation Permit

After reviewing the current status of SR spring/summer chinook salmon and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action (particularly those described in Sections 6.2.3 and 6.2.8), and cumulative effects, NMFS concludes that the issuance of a Section 10 transportation permit, as proposed, is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat.

8.2 SNAKE RIVER FALL CHINOOK SALMON

8.2.1 Proposed BPA, Corps, and BOR Action

The biological requirements of this ocean-type salmonid, which outmigrates as a subyearling and both spawns and rears in the action area, are not met either in the FCRPS action area or at the life-cycle level. As discussed in Section 6.2, when passing through the FCRPS, individuals of the species are subjected to adverse habitat conditions that cause mortality or result in impaired fitness. Although recent improvements in the operation and configuration of the FCRPS have reduced overall mortality rates for the species, current survival through the FCRPS, as affected by operation of the BOR projects, is not sufficient to ensure the survival of the ESU with an adequate potential for recovery. Instead, continuing the proposed action for the long term, coupled with current prospects for survival and recovery across the range and life cycle of the ESU, is likely to appreciably reduce the likelihood of both its survival and its recovery.

Key effects of the proposed action on this species in the action area are summarized in Section 6.2.9. They include substantial ongoing juvenile and adult mortality associated with dam and reservoir passage, and high TDG levels during periods of involuntary spill. Although the proposed action describes a process to develop performance standards for actions that would reduce mortality, it is not clear that mortality will be reduced enough or that critical habitat will be adequately protected.

At the species level, Table 6.3-12 indicates that substantial survival improvements (6% to 64%), in addition to those likely to result from the proposed action and other measures for survival and recovery that affect other life stages are required to ensure a high likelihood of survival and a moderate-to-high likelihood of recovery for this ESU. Some portion of additional survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices identified in the basinwide strategy. The degree to which Federal survival and recovery measures will sufficiently augment the survival improvements expected from the proposed action is, however, highly uncertain. NMFS must also rely on progress in implementing non-Federal survival and recovery measures that affect other life stages. Furthermore, NMFS finds that survival improvements beyond those likely to result from the proposed action are reasonably available to the FCRPS Action Agencies. After reviewing the current status of SR fall chinook salmon and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action, and cumulative effects, therefore, NMFS concludes that the proposed operation and configuration of the FCRPS and the BOR projects are likely to jeopardize the continued existence of this ESU and to adversely modify its designated critical habitat.

8.2.2 NMFS' Issuance of Section 10 Transportation Permit

After reviewing the current status of SR fall chinook salmon and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action (particularly those described in Sections 6.2.3 and 6.2.8), and cumulative effects, NMFS concludes that issuance of a Section 10 transportation permit, as proposed, is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat.

8.3 UPPER COLUMBIA RIVER SPRING CHINOOK SALMON

8.3.1 Proposed BPA, Corps, and BOR Action

The biological requirements of this stream-type salmonid, which outmigrates as a yearling and both spawns and rears in tributaries upstream of the FCRPS, are not being met either in the FCRPS action area or at the life-cycle level. As discussed in Section 6.2, when passing through the FCRPS, individuals of this species are subjected to adverse habitat conditions that cause mortality or result in impaired fitness. Although recent improvements in the operation and configuration of the FCRPS have reduced overall mortality rates for the species, current survival through the FCRPS, as affected by operation of the BOR projects, is not sufficient to ensure the survival of the ESU with an adequate potential for recovery. Instead, continuing the proposed action for the long term, coupled with current prospects for survival and recovery across the range and life cycle of the ESU, is likely to appreciably reduce the likelihood of both its survival and its recovery.

The key effects on this species in the action area are summarized in Section 6.2.9. The effects include juvenile and adult mortality associated with dam and reservoir passage, and high TDG levels during involuntary spill. Juvenile and adult mortality in the action area is still substantial. Although the proposed action describes a process to develop performance standards for actions that would reduce mortality, it is not clear that mortality will be reduced enough or that critical habitat will be adequately protected.

At the species level, Table 6.3-12 indicates that substantial survival improvements (at least 45%), in addition to those likely to result from the proposed action and other measures for survival and recovery that affect other life stages, are required to ensure a high likelihood of survival and a moderate-to-high likelihood of recovery for this ESU. Some portion of additional survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices, identified in the basinwide strategy. The degree to which these Federal survival and recovery measures will sufficiently augment the survival improvements expected from the proposed action is, however, highly uncertain. NMFS must also rely on progress in implementing non-Federal survival and recovery measures that affect other life stages. Furthermore, NMFS finds that survival improvements beyond those likely to result from the proposed action are reasonably available to the FCRPS Action Agencies. After reviewing the current status of UCR spring chinook salmon and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action, and cumulative effects, therefore, NMFS concludes that the proposed operation and configuration of the FCRPS and the BOR projects are likely to jeopardize the continued existence of this ESU and to adversely modify its designated critical habitat.

8.3.2 NMFS' Issuance of Section 10 Transportation Permit

Only a small part of this population is affected by summer transportation from McNary Dam. After reviewing the current status of UCR spring chinook salmon and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action, and cumulative effects, therefore, NMFS concludes that issuance of a Section 10 transportation permit, as proposed, is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat.

8.4 UPPER WILLAMETTE RIVER CHINOOK SALMON

8.4.1 Proposed BPA, Corps, and BOR Action

Salmonids in this ESU spawn and rear in tributaries that enter the Columbia River downstream of all FCRPS dams. The only effects of FCRPS operation on this ESU are potential degradations of habitat in the estuary and plume. The extent of these effects is uncertain and appears to be minor, compared with other factors influencing the status of this species (Table 6.3-13). After reviewing the current status of UWR chinook salmon and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action, and cumulative effects, therefore, NMFS concludes that the proposed operation and configuration of the FCRPS and the BOR projects are not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat.

8.4.2 NMFS' Issuance of Section 10 Transportation Permit

UWR chinook salmon will not be affected by issuance of a Section 10 permit.

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8.5 LOWER COLUMBIA RIVER CHINOOK SALMON

8.5.1 Proposed BPA, Corps, and BOR Action

As discussed in Section 6.2, this ESU is distributed primarily in spawning and rearing areas below Bonneville Dam. Within the action area, the key effects on this species are summarized in Section 6.2.9. Effects of the FCRPS include passage mortality of juveniles and adults through one dam and reservoir for a limited number of subbasin populations. For the small portion of the ESU that spawns in the Ives Island area below Bonneville Dam, access to, and quantity and quality of, that spawning habitat can be affected by FCRPS flow regulation. At the species level, however, this ESU has multiple populations within the Columbia River basin, most of which are below FCRPS projects.

Per USFWS and NMFS' implementing regulations, adverse effects on constituent elements of critical habitat generally do not result in a determination of "adverse modification" unless that loss, when added to the environmental baseline, is likely to appreciably diminish the value of that critical habitat for both the survival and recovery of the listed species (50 CFR Sec. 402.02). As discussed in Section 4.1.5 and Appendix C, the principal factors for decline and existing bottlenecks to recovery of LCR chinook salmon are as follows:

- A pervasive influence of hatchery fish on most natural populations, including both spring- and fall-run populations
- Timber harvesting and associated road building, agriculture, and urbanization that have affected riparian vegetation, stream hydrology, and water quality in tributary spawning areas
- Access to substantial spawning habitat that has been blocked (or passage is substantially impaired) in the Cowlitz (Mayfield Dam), Lewis (Merwin Dam), Clackamas (North Fork Dam), Hood (Powerdale Dam), and Sandy (Marmot and Bull Run River dams) rivers

Given this context, NMFS must determine whether mainstem spawning habitat is an essential requirement of LCR chinook salmon. Because tule chinook salmon have been observed spawning in the Ives Island complex only once (October 1999), the answer to this question depends on whether mainstem spawning was, historically, a significant characteristic of the ESU and, if so, whether mainstem spawners made up independent populations (or, whether they were closely associated with populations in the lower ends of adjacent tributaries). The Willamette/Lower Columbia River Technical Recovery Team will consider these issues. However, at the present time, NMFS knows of no evidence that mainstem spawning was, historically, a significant characteristic of the ESU.

After reviewing the current status of LCR chinook salmon and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action, and cumulative effects, NMFS concludes that the proposed action is not likely to jeopardize the continued

existence of LCR chinook salmon or to destroy or adversely modify its designated critical habitat.

8.5.2 NMFS' Issuance of Section 10 Transportation Permit

LCR chinook salmon will not be affected by issuance of a Section 10 permit.

8.6 SNAKE RIVER STEELHEAD

8.6.1 Proposed BPA, Corps, and BOR Action

The biological requirements of this stream-type salmonid, which migrates to the ocean as a yearling and spawns and rears in tributaries upstream of the FCRPS, are not being met, either in the FCRPS action area or at the life-cycle level. As discussed in Section 6.2, when passing through the FCRPS, individuals of this species are subjected to adverse habitat conditions that cause mortality or result in impaired fitness. Although recent improvements in the operation and configuration of the FCRPS have reduced overall mortality rates for the species, current survival through the FCRPS, as affected by operation of the BOR projects, is not sufficient to ensure the survival of the ESU with an adequate potential for recovery. Instead, continuing the proposed action for the long term, coupled with current prospects for survival and recovery across the range and life cycle of the ESU, is likely to appreciably reduce the likelihood of both its survival and its recovery.

Key effects of the proposed action on this species in the action area are summarized in Section 6.2.9. They include substantial ongoing juvenile and adult mortality associated with dam and reservoir passage, and high TDG levels during periods of involuntary spill. Although the proposed action describes a process to develop performance standards for actions that would reduce mortality, it is not clear that mortality will be reduced enough or that critical habitat will be adequately protected.

At the species level, Table 6.3-12 indicates that substantial survival improvements (at least 56%), in addition to those likely to result from the proposed action and other measures for survival and recovery that affect other life stages, are required to ensure a high likelihood of survival and a moderate-to-high likelihood of recovery for this ESU. Some portion of additional survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices identified in the basinwide strategy. The degree to which these Federal survival and recovery measures will sufficiently augment the survival improvements expected from the proposed action is highly uncertain. NMFS must also rely on progress in implementing non-Federal survival and recovery measures that affect other life stages. Furthermore, NMFS finds that survival improvements beyond those likely to result from the proposed action are reasonably available to the FCRPS Action Agencies. After reviewing the current status of SR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action, and cumulative effects, therefore, NMFS concludes that the proposed operation and configuration of the FCRPS and the BOR projects are likely to jeopardize the continued existence of this ESU and to adversely modify its designated critical habitat.

8.6.2 NMFS' Issuance of Section 10 Transportation Permit

After reviewing the current status of SR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action (particularly as described in Sections 6.2.3 and 6.2.8), and cumulative effects, NMFS concludes that issuance of a Section 10 transportation permit, as proposed, is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify designated critical habitat.

8.7 UPPER COLUMBIA RIVER STEELHEAD

8.7.1 Proposed BPA, Corps, and BOR Action

The biological requirements of this stream-type salmonid, which migrates to the ocean as a yearling and spawns and rears in tributaries upstream of the FCRPS, are not being met, either in the FCRPS action area or at the life-cycle level. As discussed in Section 6.2, when passing through the FCRPS, individuals of this species are subjected to adverse habitat conditions that cause mortality or result in impaired fitness. Although recent improvements in the operation and configuration of the FCRPS have reduced overall mortality rates for the species, current survival through the FCRPS, as affected by operation of the BOR projects, is not sufficient to ensure the survival of the ESU with an adequate potential for recovery. Instead, continuing the proposed action for the long term, coupled with current prospects for survival and recovery across the range and life cycle of the ESU, is likely to appreciably reduce the likelihood of both its survival and its recovery.

Key effects of the proposed action on this species in the action area are summarized in Section 6.2.9. They include substantial ongoing juvenile and adult mortality associated with dam and reservoir passage and high TDG levels during periods of involuntary spill. Although the proposed action describes a process to develop performance standards for actions that would reduce mortality, it is not clear that mortality will be reduced enough or that critical habitat will be adequately protected.

At the species level, Table 6.3-12 indicates that substantial survival improvements (at least 17% to as high as 146%), in addition to those likely to result from the proposed action and other measures for survival and recovery that affect other life stages, are required to ensure a high likelihood of survival and a moderate-to-high likelihood of recovery for this ESU. Some portion of additional survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices identified in the basinwide strategy. The degree to which these Federal survival and recovery measures will sufficiently augment the survival improvements expected from the proposed action is, however, highly uncertain. NMFS must also rely on progress in implementing non-Federal survival and recovery measures that affect other life stages. Furthermore, NMFS finds that survival improvements beyond those likely to result from the proposed action are reasonably available to the FCRPS Action Agencies. After reviewing the current status of UCR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action, and cumulative effects, therefore, NMFS concludes that the proposed operation and configuration of the FCRPS and the BOR projects are likely to jeopardize the continued existence of this ESU and to adversely modify its designated critical habitat.

8.7.2 NMFS' Issuance of Section 10 Transportation Permit

Only a small part of this population is affected by summer transportation from McNary Dam. Therefore, after reviewing the current status of UCR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action (particularly as described in Sections 6.2.3 and 6.2.8), and cumulative effects, NMFS concludes that issuance of a Section 10 transportation permit, as proposed, is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat.

8.8 MIDDLE COLUMBIA RIVER STEELHEAD

8.8.1 Proposed BPA, Corps, and BOR Action

The biological requirements of this stream-type salmonid, which migrates to the ocean as a yearling and spawns and rears in tributaries upstream of the FCRPS, are not being met, either in the FCRPS action area or at the life-cycle level. As discussed in Section 6.2, when passing through the FCRPS, individuals of this species are subjected to adverse habitat conditions that cause mortality or result in impaired fitness. Although recent improvements in the operation and configuration of the FCRPS have reduced overall mortality rates for the species, current survival through the FCRPS, as affected by operation of the BOR projects, is not sufficient to ensure the survival of the ESU with an adequate potential for recovery. Instead, continuing the proposed action for the long term, coupled with current prospects for survival and recovery across the range and life cycle of the ESU, is likely to appreciably reduce the likelihood of both its survival and its recovery.

Key effects of the proposed action on this species in the action area are summarized in Section 6.2.9. They include substantial ongoing juvenile and adult mortality associated with dam and reservoir passage and high TDG levels during periods of involuntary spill. Although the proposed action describes a process to develop performance standards for actions that would reduce mortality, it is not clear that mortality will be reduced enough or that critical habitat will be adequately protected.

At the species level, Table 6.3-12 indicates that substantial survival improvements (at least 130%), in addition to those likely to result from the proposed action and other measures for survival and recovery that affect other life stages, are required to ensure a high likelihood of survival and a moderate-to-high likelihood of recovery for this ESU. This assessment is based on the similarity of the action's effects on UCR and MCR steelhead and the current status of MCR steelhead, which are at greater risk of extinction than UCR steelhead for the largest population whose risk can be assessed. Some portion of additional survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices, identified in the basinwide strategy. The degree to which these Federal survival and recovery measures will sufficiently augment the survival improvements expected from the proposed action is, however, highly uncertain. NMFS must also rely on progress in implementing non-Federal survival and recovery measures that affect other life stages. Furthermore, NMFS finds that survival improvements beyond those likely to result from the proposed action are reasonably available to the FCRPS Action Agencies. After reviewing the current status of MCR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action, and cumulative effects, therefore, NMFS concludes that the proposed operation and configuration of the FCRPS and the BOR projects are likely to jeopardize the continued existence of this ESU and to adversely modify its designated critical habitat.

8.8.2 NMFS' Issuance of Section 10 Transportation Permit

Only a small part of this population is affected by summer transportation from McNary Dam. After reviewing the current status of MCR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action (particularly as described in Sections 6.2.3 and 6.2.8), and cumulative effects, therefore, NMFS concludes that issuance of a Section 10 transportation permit, as proposed, is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat.

8.9 UPPER WILLAMETTE RIVER STEELHEAD

8.9.1 Proposed BPA, Corps, and BOR Action

This ESU spawns and rears in tributaries that enter the Columbia River downstream of all FCRPS projects. The only effects of FCRPS operation on this ESU are potential habitat degradations in the estuary and plume. The extent of these effects is uncertain and appears to be minor, compared with other factors influencing the status of this species (Table 6.3-13).

After reviewing the current status of UWR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action, and cumulative effects, therefore, NMFS concludes that the proposed operation and configuration of the FCRPS and the BOR projects are not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat.

8.9.2 NMFS' Issuance of Section 10 Transportation Permit

UWR chinook salmon will not be affected by issuance of a Section 10 permit.

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8.10 LOWER COLUMBIA RIVER STEELHEAD

8.10.1 Proposed BPA, Corps, and BOR Action

Key effects on this species in the action area, summarized in Section 6.2.9, include passage mortality of juveniles and adults through one dam and reservoir for spawning aggregations in a few subbasins. NMFS' quantitative evaluation of the effects of the proposed action and other ongoing Federal actions on this ESU's species-level biological requirements indicates a slight increase in the median annual population growth rate for summer steelhead in the Clackamas and Kalama subbasins due to recent harvest limitations on A-run steelhead (Table 6.3-10). For most of the spawning aggregations in this ESU, factors other than the FCRPS contributed to their decline and now limit their potential for survival and recovery (Table 6.3-13). After reviewing the current status of LCR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action, and cumulative effects, therefore, NMFS concludes that the proposed operation and configuration of the FCRPS and the BOR projects are not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat.

8.10.2 NMFS' Issuance of Section 10 Transportation Permit

LCR steelhead will not be affected by issuance of a Section 10 permit.

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8.11 COLUMBIA RIVER CHUM SALMON

8.11.1 Proposed BPA, Corps, and BOR Action

The biological requirements of this ocean-type salmonid, which outmigrates as a subyearling and both spawns and rears in tributaries upstream from the FCRPS and in the mainstem Columbia River, are not being met either in the FCRPS action area or at the life-cycle level. As discussed in Section 6.2, individuals of this species are subjected to adverse effects on spawning and rearing habitat in the Hamilton/Hardy creeks/Ives Island complex below Bonneville Dam that result in their mortality or impaired fitness. Continuing the proposed action for the long term, coupled with the current prospects for survival and recovery across the range and life-cycle of the ESU, is likely to appreciably reduce the likelihood of both its survival and its recovery.

Key effects of the proposed action on this species in the action area are summarized in Section 6.2.9. They include adverse effects of flow management on access to Hamilton Creek, Spring Creek, and the Ives Island spawning areas. The quantity and quality of habitat at the Ives Island spawning area are also adversely affected by FCRPS flow management. In contrast to the situation for LCR chinook, this ESU spawns in only two areas, meaning that FCRPS effects on habitat in one of these areas significantly affect the entire ESU. NMFS' quantitative evaluation of the effects of the proposed action and other ongoing Federal actions on this ESU's species-level biological requirements does not indicate any expected change in the median annual population growth rate (Table 6.3-11).

Ongoing Federal conservation efforts to improve habitat and hatchery practices, identified in the basinwide strategy, may improve survival rates. The degree to which these Federal survival and recovery measures will sufficiently improve the ESU's condition is, however, highly uncertain. NMFS must also rely on progress in implementing non-Federal survival and recovery measures that affect other life stages. Furthermore, NMFS finds that survival improvements beyond those likely to result from the proposed action are reasonably available to the FCRPS Action Agencies. After reviewing the current status of CR chum salmon and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action, and cumulative effects, therefore, NMFS concludes that the proposed operation and configuration of the FCRPS and the BOR projects are likely to jeopardize the continued existence of this ESU and to adversely modify its designated critical habitat.

8.11.2 NMFS' Issuance of Section 10 Transportation Permit

CR chum salmon will not be affected by issuance of a Section 10 permit.

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8.12 SNAKE RIVER SOCKEYE SALMON

8.12.1 Proposed BPA, Corps, and BOR Action

The biological requirements of this stream-type salmonid, which migrates to the ocean as a yearling and spawns and rears in lakes upstream of the FCRPS, are not being met either in the FCRPS action area or at the life-cycle level. As discussed in Section 6.2, when passing through the FCRPS, individuals of this species are subjected to adverse habitat conditions that cause mortality or result in impaired fitness. Although recent improvements in the operation and configuration of the FCRPS have reduced overall mortality rates for the species, current survival through the FCRPS, as affected by operation of the BOR projects, is not sufficient to ensure the survival of the ESU with an adequate potential for recovery. Instead, continuing the proposed action for the long term, coupled with the current prospects for survival and recovery across the range and life-cycle of the ESU, is likely to appreciably reduce the likelihood of both its survival and its recovery.

Key effects of the proposed action on this species in the action area are summarized in Section 6.2.9. They include substantial ongoing juvenile and adult mortality associated with dam and reservoir passage and TDG gas levels during periods of involuntary spill. Although the proposed action describes a process to develop performance standards for actions that would reduce mortality, it is not clear that mortality will be reduced enough or that critical habitat will be adequately protected.

Because the abundance of this ESU is so low, NMFS cannot perform a quantitative assessment of species-level effects of the proposed action and other ongoing Federal actions. However, the ongoing level of risk to this ESU is extremely high and it is likely to remain so if the proposed action continues. The captive breeding program provides short-term protection from extinction, but it is not sufficient to avoid extinction in the future. Some additional improvement in species status may result from ongoing Federal conservation efforts to improve habitat and hatchery practices, described generally in the basinwide strategy. The degree to which these Federal survival and recovery measures will sufficiently augment the survival improvements expected from the proposed action is, however, highly uncertain. NMFS must also rely on progress in implementing non-Federal survival and recovery measures that affect other life stages. Furthermore, NMFS finds that survival improvements beyond those likely to result from the proposed action are reasonably available to the FCRPS Action Agencies. After reviewing the current status of SR sockeye salmon and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action, and cumulative effects, therefore, NMFS concludes that the proposed operation and configuration of the FCRPS and the BOR projects are likely to jeopardize the continued existence of this ESU and to adversely modify its designated critical habitat.

8.12.2 NMFS' Issuance of Section 10 Transportation Permit

After reviewing the current status of SR sockeye salmon and the factors for its decline, the environmental baseline in the action area, the effects of the proposed action (particularly Sections 6.2.3 and 6.2.8), and cumulative effects, NMFS concludes that issuance of a Section 10 transportation permit, as proposed, is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat.

9.0 REASONABLE AND PRUDENT ALTERNATIVE

9.1 OVERVIEW OF THE ALTERNATIVE

This RPA for the FCRPS and for BOR's 19 projects, including the entire Columbia Basin project, identifies actions that, combined with other ongoing and anticipated measures in the Columbia River basin outlined in the Basinwide Recovery Strategy,[1] are likely to ensure a high likelihood of survival with a moderate-to-high likelihood of recovery for each of the listed species. Based on the best available scientific information, the following fundamental components of the RPA would allow the FCRPS to avoid jeopardizing the continued existence of the listed species or adversely modifying their critical habitat.

9.1.1 Performance Standards

The RPA defines certain performance standards that will meet the jeopardy standard described in Section 1.3.1.1 now and as it is fully implemented by 2010. Performance standards for this RPA, described in Section 9.2, are derived from biological requirements of the listed populations as a whole. As the Basinwide Recovery Strategy explains, performance standards are defined at three tiers. At the most general tier are the population-level performance standards. These state the performance needed for the listed population to achieve an adequate likelihood of survival and recovery. Life-stage-specific performance standards at the intermediate tier allocate the performance expectations needed across the life cycle to achieve the population level performance standards. This tier guides the determination of performance standards for particular categories of actions in habitat, harvest, hatcheries, and hydro, at the next level, such as performance standards for hydropower in this RPA. These third-tier standards are applicable to all activities of this type and are intended to achieve the life-stage-specific performance standards.

At the population level, performance will be evaluated in terms of population growth rate, abundance, genetic diversity, life history diversity, and geographic distribution. NMFS will apply these principles to the listed ESUs in the basin through its recovery planning process, which will include developing specific goals and measures for each ESU within 3 years.

Hydrosystem performance standards include specific adult and juvenile survival levels (direct and indirect) expected to result from implementing the best or most intensive actions that NMFS and the Action Agencies agree are biologically and technically feasible and within the authority

[1] NMFS is issuing the "Conservation of Columbia Basin Fish: Final Basinwide Salmon Recovery Strategy" (hereinafter the Basinwide Recovery Strategy). This document outlines the expected improvements in hydro, habitat, hatcheries, and harvest needed to meet the goals of the ESA at the same time as this biological opinion. The Basinwide Recovery Strategy is a conceptual recovery plan that NMFS intends to use as a guideline for evaluating actions that affect the listed species. Consistency with the Basinwide Recovery Strategy ensures that actions are both avoiding jeopardy and enabling the recovery of listed species.

of the Action Agencies. The Action Agencies are committed to attaining the hydro standards by 2010. Sections 6.1.1, 9.7.1, and Appendix D describe how the hydro performance standards were derived.

Offsite mitigation standards include the implementation of specific measures identified in the Basinwide Recovery Strategy and in Sections 9.6.2, 9.6.3, and 9.6.4. The Action Agencies are committed to implementing the offsite mitigation measures described in these sections. The Basinwide Recovery Strategy describes the level of additional improvements to be attained through actions that address other life stages (including, but not limited to, improvements made through offsite mitigation by the FCRPS Action Agencies).

9.1.2 Hydro Actions

Section 9.6.1 of this RPA describes a set of specific, hydro actions that NMFS has determined, on the basis of available scientific information, will achieve the FCRPS hydro performance standards. Most of the measures are aimed at improving passage survival through FCRPS dams and reservoirs by changing project operations and improving project configuration. The measures include the following:

1. Enhanced spill and spillway improvements to facilitate higher spill levels without exceeding harmful TDG levels

2. Improved flow management

3. Physical improvements to both juvenile and adult fish passage facilities

4. Increased use of barges and less reliance on trucks to transport summer migrants

5. Continuation of spill at collector projects to maximize the survival rate of inriver migrants

As determined through the planning process described in Section 9.4, NMFS may deem other combinations of measures sufficient to meet the performance standards and avoid jeopardy.

9.1.3 Offsite Mitigation Actions

Additional measures call for offsite mitigation, as discussed in Sections 9.6.2, 9.6.3, and 9.6.4. These additional actions are included to improve the productivity of the listed salmon populations beyond what would be possible through hydro actions alone. Even with survival improvements in fish passage at and between dams, significant mortality associated with FCRPS/BOR operations will continue to occur. NMFS, therefore, advises the Action Agencies that additional offsite mitigation for habitat, hatcheries, and harvest is needed to avoid jeopardy.

Action Agency implementation of measures in these other areas will increase the certainty and reliability of attaining the increased survival rate of listed ESUs.

Offsite mitigation provided by the Action Agencies will not preclude the need for improvements in habitat, hatcheries, and harvest by other Federal or Non-Federal parties, nor will it diminish the obligation of these other parties to seek improvements in furtherance of Section 7(a)(1) or Section 7(a)(2). Offsite mitigation is intended to complement, not displace, actions by other entities to address habitat, hatcheries, and harvest. Where there are overlaps between offsite mitigation activities of the Action Agencies and the responsibilities of other Federal and non-Federal entities, costs and implementation responsibilities will be shared and coordinated as appropriate.

9.1.4 Rolling 1- and 5-Year Plans

An annual, multiyear planning process to refine, implement, evaluate, and adjust ongoing efforts is critical to achieving the FCRPS hydro and offsite performance standards within the time frame covered by this biological opinion. This will be accomplished through development and implementation of 1- and 5-year plans to achieve both hydro performance standards and offsite mitigation performance standards. The plans will cover all operations, configuration, research, monitoring, and evaluation actions. The plans will also describe habitat, hatchery and harvest actions to be funded or otherwise carried out by the Action Agencies as offsite mitigation. The RPA allows for revision of the specific measures throughout its term, as long as the Action Agencies make steady progress toward meeting performance standards and remain on track for full attainment of the hydro standards by 2010. The 2003 annual plan will contain a comprehensive assessment of the success of the action agencies in obtaining the funding and authorizations and in further defining and implementing the actions called for in this RPA. NMFS will reinitiate consultation if there is lack of adequate progress at that time or in subsequent reviews. The annual planning process is outlined in Section 9.4.

9.1.5 Comprehensive 3-, 5-, and 8-Year Check-ins

Any assessment of future conditions presents the risk that the actions identified under this RPA will not be adequate to ensure long-term survival of the listed ESUs. To manage that risk, NMFS has included critical monitoring, evaluation, and performance measures, as well as action levels, to trigger additional measures if needed. The region must be prepared to move forward with these alternative measures, given the possibility that onsite and offsite measures will not have the predicted results, or that subsequent information will show the predicted improvements to be inadequate. Section 9.2 describes the performance standards and measures. Section 9.5 describes the steps for review and decision-making regarding the adequacy and effectiveness of the RPA. This RPA calls for annual progress reports; major progress evaluations in 2003, 2005, and 2008; and pursuit of other ways to avoid jeopardy in the future, including possible breaching of dams if necessary.

Another key element of the annual progress evaluations in 5 and 8 years is progress on resolving critical uncertainties. Resolution of critical uncertainties is necessary to assess progress, as described above, and to provide guidance on pending actions.

9.1.6 Monitoring, Evaluation, and Progress Reporting

Monitoring and evaluation is not merely the periodic collection of data. Rather, properly designed monitoring programs will provide data for resolving a wide range of uncertainties, including determining population status, establishing causal relationships between habitat (or other) attributes and population response, and assessing the effectiveness of management actions. The information gained through monitoring programs will be a cornerstone in identifying alternative actions and refining recovery efforts. Such programs are, therefore, critical to the successful implementation of this RPA.

For example, there is considerable uncertainty even in assessing the status of listed ESUs under current conditions. It is quite apparent that extinction risks were high under the baseline conditions that led to their listing, and they appear to remain quite high under current conditions. However, precisely quantifying population trends of wild, listed fish depends on knowing the proportion of observed fish that are hatchery fish spawning naturally, and the relative reproductive success of those fish. This information, particularly the latter point, is largely lacking. As a result, the range of uncertainty associated with NMFS' current estimates of risk is large. Recently many artificial production reforms, designed to reduce negative effects of hatchery production on natural populations while retaining its proven production and potential conservation benefits, have been implemented. An important component of any monitoring program will, therefore, be documenting the results and benefits from these recent and ongoing reforms while resolving population status.

In addition, despite full use of the best science available, substantial uncertainty remains about the effectiveness of measures available to meet the biological requirements of listed ESUs. In hydro, for example, the projected effect of the hydro measures, or of the alternative of breaching dams, depends largely on the degree to which there is delayed mortality associated with juvenile fish passage at those dams, either inriver or with barge transportation, and the degree to which that delayed effect would be mitigated with breaching of any particular dam or dams. The potential for delayed, pre-spawning mortality of adults and for survival effects related to estuary or plume conditions created through water management practices are also highly critical uncertainties. In habitat, critical uncertainties are associated with the feasibility of implementing protective measures in light of the existing institutional frameworks (e.g., addressing in-stream flow needs in over-appropriated streams). Uncertainty also exists concerning the magnitude of the expected biological response to habitat actions that achieve their physical objectives and the time frame for that biological response. In the area of artificial propagation, scientific knowledge regarding the effectiveness of hatchery supplementation as a means of speeding recovery is incomplete, but improving, as is the impact of hatchery supplementation on wild populations. Artificial production measures have proven effective in many cases at alleviating

near-term extinction risks, yet the potential long-term benefits of artificial production as a recovery measure are unclear.

To resolve these uncertainties, specific scientific studies must be undertaken with rigorous monitoring and evaluation, focusing on determining population status and the mechanisms that regulate salmon populations. The results from these studies and monitoring should provide better understanding about the status of the ESUs, about which measures work, and about which measures do not work. NMFS also requires monitoring and evaluation of measures to assess an Action Agency's progress in implementing its RPA and the benefits resulting from the Action Agency's implementation. The RPA establishes a schedule of measures, milestones, standards, and decisions subject to updating and refinement through annual planning, to ensure that this evaluation process is disciplined and rigorous. Progress on resolving these uncertainties will be a primary consideration in the annual and 5-year planning process as well as in the 3-, 5-, and 8-year check-ins. Monitoring and evaluation may lead to revisions in measures the Action Agencies undertake to meet performance standards, or in the performance standards themselves, to ensure that the overall program is sufficient to avoid jeopardy to listed ESUs.

9.1.7 Advance Planning for Breach or Other Additional Actions

NMFS has given significant consideration to the options involving breach of the lower Snake River and possibly other dams. Generally, any action that removes or eliminates a source of adverse effects from the listed species' life cycle increases the odds that survival rates will improve. By reducing the effects of one type of human activity, breaching the four lower Snake River dams would provide more certainty of long-term survival and recovery than would other measures.

This RPA requires Action Agencies to take specific actions under certain circumstances to ensure that alternative approaches are available. Such actions will allow for the possibilities that the hydro and offsite mitigation actions described here will not provide the anticipated survival rate increases, or that subsequent information shows the predicted improvements are inadequate. Although the RPA does not rely on breach of any dams to avoid jeopardy, it does require further development of breach as an option if future conditions warrant it. NMFS recognizes that breach is a major action requiring NEPA compliance, congressional authorization, and appropriations before it can be implemented. The specific actions described in Section 9.6.1.9 will reduce the time needed to seek congressional authorization for breach and will reduce the time needed for possible implementation, thereby avoiding delay should breach become a preferred approach.

9.1.8 Breach Triggers

The RPA establishes a schedule for determining whether to pursue breach as a means of avoiding jeopardy. This schedule addresses possible breach of one or a combination of hydroelectric projects. The schedule provides for a rigorous mid-point review of progress in 2005, another comprehensive review in 2008, and a determination under certain conditions to pursue breach if

NMFS issues a failure report on the RPA following one of these reviews. The mid-point evaluation process is described in Section 9.5.

9.1.9 Independent Peer Review

It is important that the public and the courts have confidence in the Action Agencies' activities and in the science that supports the RPA. Accordingly, NMFS, working through the Regional Forum and the Independent Scientific Advisory Board, will obtain independent scientific review of its 5- and 8-year evaluation reports.

9.1.10 Immediate Actions and Benefits

Because listed Columbia River basin anadromous fish are in such fragile condition, an immediate focus on areas and measures that provide gains within 1 to 10 years is essential.

Section 9.6.1 describes the hydrosystem measures intended to provide these short-term gains. Section 9.7.1 describes the expected effects of those actions on juvenile and adult survival levels. The Action Agencies are committed to implementing the specified hydro measures and/or additional measures as needed to fully attain these system survival levels by 2010.

For offsite mitigation, the discussions of habitat (Section 9.6.2), harvest (Section 9.6.3), and hatcheries (Section 9.6.4) describe early action items designed to produce immediate improvements. For habitat these include restoring tributary flows, screening water diversions, providing passage at obstructions, and securing additional riparian, wetland, floodplain, intertidal, or shallow-water habitats. Short-term gains in hatcheries are expected through implementation of conservation hatchery safety nets and hatchery reform, as explained in Section 9.6.4. Given the status and trends of a number of populations in the upper Columbia River and the Snake River basins, the potential benefits of intervening with artificial production actions may outweigh the risks of such intervention. NMFS will work with the Action Agencies on a method for recognizing and documenting the benefits of these efforts. The offsite action items also allow for a thorough assessment of the overall strategic approach by the mid-point progress reviews.

9.2 PERFORMANCE STANDARDS

The purpose of this RPA is to establish a course of action for FCRPS and BOR operations that avoids both jeopardy to the listed stocks and destruction or adverse modification of critical habitat and, thus, meets the standards of ESA Section 7(a)(2). In this biological opinion, NMFS establishes performance standards and associated performance measures that will be used to evaluate the actions implemented each year and proposed in the 1- and 5-year plans.

The RPA is also a major component of the conceptual recovery plan in the Basinwide Recovery Strategy. The Action Agencies' implementation of the RPA will ensure that the FCRPS avoids jeopardy and adverse modification of critical habitat, because the agencies' actions, when added to the other components of the plan, will enable the survival and recovery of the listed salmon and steelhead species. Performance standards are central to the program and depend on clear objectives, measurable results, and accountability.

Performance standards for the RPA derive from the biological requirements of the listed populations at the life cycle level and at each life stage. As the Basinwide Recovery Strategy explains, performance standards are defined in three tiers. The most general tier is the population level performance standards. They define the performance needed for the listed population to achieve adequate likelihoods of survival and recovery. Life-stage-specific performance standards at the intermediate tier allocate across the life cycle the performance expectations necessary to achieve the population-level standards. This tier guides the development of performance standards for categories of actions in habitat, harvest, hatcheries, and hydropower in this RPA. The third-tier standards are intended to achieve the life-stage standards.

NMFS will apply the performance standards when determining whether implementation of the RPA continues to satisfy ESA standards. Because the action-level performance standards derive from the population-level and life-stage-specific performance standards, NMFS will look at all performance standards when making its determination in years 3, 5, and 8.

9.2.1 Programmatic Performance Standards

In years 3, 5, and 8, NMFS will assess whether the Action Agencies have implemented the program of hydro, habitat, and hatchery improvements and the research, monitoring, and evaluation necessary for continuing assessment described in this biological opinion as required to ensure consistency with ESA. Programmatic performance standards include the actions and the schedule defined in the biological opinion and the annual planning process. Performance is measured by the Action Agencies' success in implementing the actions defined in the RPA and annual plans. Critical actions to be evaluated at the 3-, 5-, and 8-year reviews are further described in Section 9.5 and Appendix F. Progress against this standard will be formalized in

NMFS' review of the annual progress reports prepared by the Action Agencies, in the annual NMFS findings letter, and in comprehensive 3-, 5-, and 8-year evaluations. Further information on the 1- and 5-year planning process can be found in Section 9.4.

9.2.2 Biological Performance Standards

Biological performance standards fall into two categories:

- Standards intended to evaluate the status of the stocks (relevant to the population-level and life-stage-specific performance standards)

- Standards intended to evaluate how effectively the actions produce an expected biological response (most relevant to the performance standards that apply to actions)

Both types of evaluation depend on a robust and comprehensive research, monitoring, and evaluation program. NMFS will assess the development and implementation of this research, monitoring, and evaluation program in years 3, 5, and 8. The standards for evaluating stock status and actions will be used in years 5 and 8, when effects should be discernable.

9.2.2.1 Standards Related to ESU Status

The standards used to evaluate stock status reflect the biological requirements of the ESUs consistent with maintaining a high likelihood of survival and a moderate-to-high likelihood of recovery. Recovery standards will ultimately include measures of abundance, productivity trends, species diversity, and population distribution. While recovery standards are being established, NMFS will assess the likelihood of survival and recovery based on estimates of life-stage survival increases and annual population growth rate (e.g., lambda) for each identifiable population in the ESU, as well as previously defined interim recovery goals (see Table 1.3-1). Lambda is derived from observed population abundance and reflects a stock's current productivity. Thus, it addresses important factors likely to be included in future recovery standards.

Estimates of lambda used in this biological opinion were generated using standard techniques (McClure et al. 2000b). The estimates and techniques will be refined as NMFS adds information and researches critical uncertainties, such as the effectiveness of hatchery spawners in the wild. Section 9.5 describes a process for coordinated review of the scientific literature and selection of appropriate methodologies before the 5- and 8-year reviews.

NMFS recognizes that the lambda estimates express just one of several characteristics of a salmon population that must be examined when judging the health or risks it faces. Other characteristics are abundance, genetic diversity, life history diversity, and geographic distribution. NMFS intends to apply these principles to the listed ESUs in the basin through its

recovery planning process, which will develop specific recovery goals and measures for the ESUs by the 2003 check-in. NMFS expects that the goals may provide a scientific foundation for refining the population-level performance measures. Other estimates of population productivity include recruits per spawner (R/S) and smolt-to-adult returns (SARs). R/S estimates require information on age structure and cannot be applied to as many populations as lambda. Both estimates convey similar information. SAR is a useful measure, but it covers only part of the life cycle, while information on the entire life cycle is necessary to gauge population status.

In the July 27, 2000, Draft Biological Opinion (NMFS 2000b), NMFS proposed two action levels for the 5- and 8-year reviews. A level of 1.1 was considered favorable enough to continue implementation without further review, and a level of 0.95 was considered unfavorable enough by year 8 to receive an automatic failure report. A lambda level of 1.1 or higher means a population will double in 8 years. A lambda value of 0.95 means a population will halve in 14 years. One commenter favored the simplicity and clarity of those thresholds. Others, however, pointed to the difficulty of measuring changes in lambda resulting from the RPA by year 8 and the near certainty that the long-term average would still be below 1.1 by then. That would eliminate any ability of the test to discriminate between success and failure. NMFS agreed with many comments. NMFS was also concerned that using a single absolute threshold would not reflect differences in current population growth rates or in the growth rates needed to meet survival and recovery indicator metrics. For those reasons, NMFS revised the 5- and 8-year tests as described below.

In 2005, updated population growth rates will reflect natural variations in survival and the effect of actions taken in the 1990s, including actions taken under prior biological opinions that are incorporated into the jeopardy analysis of the proposed action in this opinion. The key question to be addressed at the 5-year checkpoint will be whether the population growth rate has improved enough relative to the level estimated in this biological opinion to maintain a high likelihood of achieving the 2008 performance standards. This question will be answered with a four-part comparison of average values. The increase does not have to be statistically significant because NMFS recognizes the high variability of the estimates and the difficulty of establishing statistical significance in only 5 years. The ESUs will not be placed at higher risk due to this simple comparison, because the purpose of the test is to trigger additional conservation measures.

For the 5- and 8-year reviews, this RPA establishes three separate tests related to the annual population growth rate (e.g., lambda)[2] and a fourth test related to abundance.

[2]In this discussion, lambda is used as shorthand for an estimate of the population growth rate. NMFS believes the best available information supports the use of lambda at this time. By referring to lambda, however, NMFS does not mean to exclude alternative measures that could be developed and applied in future analyses. As described above, the check-in process described in Section 9.5 includes a coordinated process for selection of appropriate methods based on scientific development before the 2005 evaluation and again before the 2008 evaluation.

- The first test assesses whether the annual population growth rate (e.g., lambda, or a future metric developed to replace it) is greater in 2005 and in 2008 than the base-period value of lambda today. This test will compare lambda on the date of this biological opinion (i.e., measured from 1980 to 2000)[3] with the value of lambda in 2005 (i.e., measured from 1980 to 2004) and again in 2008 (i.e., measured from 1980 to 2007). In each case, the test is passed if lambda has increased. If the newer value is lower, then additional review and actions will be triggered, as described in Section 9.5.

- The second test is whether, in 2005 and again in 2008, the annual population growth rate is greater than or equal to the projected growth rate based on improvements made and expected from actions taken in the 1995 biological opinion, reductions in harvest that occurred after the base period, and the survival standards in the Mid-Columbia Habitat Conservation Plan.[4] In essence, this test asks whether NMFS is actually seeing the positive results from these actions that have been incorporated into the analysis in this biological opinion. This test will compare the estimated current lambda (roughly 1993 to the present) to the actual measured lambdas in 2005 and again in 2008. If the actual lambda is greater, the test is passed. If it is smaller, then additional review will assess the significance of the time series used in this analysis compared to data from returns that benefitted from actions taken in 1995 and later. This could trigger additional actions, as described in Section 9.5.

- The third test will compare population growth rates in 2005 and 2008 against the rates needed to achieve the recovery metrics described in Section 1.3.1.2.2. The projected lambda will be based on the best available information about the effects actually being realized from hydro improvement and offsite mitigation measures included in this biological opinion and other changes being implemented in accordance with the Basinwide Recovery Strategy. The projections must meet or exceed the lambda necessary to achieve the 48-year recovery criteria, i.e., NMFS must be on track to meet these criteria. If not, additional review and, possibly, additional actions would be triggered, as described in Section 9.5.

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[3]The dates defining the various periods are approximate. In almost all cases, 1980 used as a starting date refers to the 1980 brood year. Ending dates vary by species and are intended to mean the most recent year for which adult returns are available at the time of the analysis. Thus 1980 to 1999 may mean the 1980 brood year through 1999 adult returns for one ESU, but 1980 to 1998 for another. Actions taken under the research, monitoring, and evaluation section are expected to improve on the timeliness of adult return information. Likewise, in the second test referred to in this section, the starting date is approximate and may vary by ESU based on the most recent year for which adult returns are available and on the variation in that ESU. The more variable the ESU, the longer the period necessary to produce an estimate of sufficient precision. In general, the methodology described in McClure et al. 2000c, that is the basis of the estimates in this biological opinion, requires at least 11 years to develop an estimate.

[4]Changes in harvest are based on current restrictions. Changes in passage survival at the five Mid-Columbia PUD dams are based on commitments by the PUDs to specific survival objectives for fish passage survival. In the case of the Douglas and Chelan county PUDs, the commitment is expressed in the form of an HCP that accompanies their application for an incidental take permit under ESA Section 10. A draft EIS on these applications is being readied for public comment in December 2000. Grant County has a signed settlement agreement that establishes comparable juvenile survival objectives.

- A fourth test, or true safety net test, will include a simple comparison of stock size (abundance) against current levels. Specifically, the test will compare the annual adult returns of wild fish for each ESU and population against the 5-year geometric mean as of the date of this biological opinion. Two consecutive annual returns below this level will trigger a concern that a critical population threshold may have been crossed. If returns fall short, additional review will include the degree and significance of this failure relative to population status information from recovery planning and other scientific information available at the time of the 5- and 8-year evaluation and could lead to additional actions, as described in Section 9.5.

Table 9.2-1 provides the best estimates of base period, estimated current, and recovery lambda values that will be applied at years 5 and 8. Table 9.2-2 provides the estimates of current abundance that will be applied in years 5 and 8. These tables report estimated values for seven ESUs; an eighth ESU that also depends on this RPA to avoid jeopardy (Snake River sockeye) is not included because there are too few fish to apply this type of quantitative analysis. The other four ESUs are not included because NMFS concluded in Section 8 that factors other than the FCRPS contributed to their decline and now limit their potential for survival and recovery (i.e., they are not jeopardized by the FCRPS due to its relatively small impact).

As recovery plans are completed for these ESUs, the specific spawning aggregations and the target abundance levels will be refined. These conclusions assume that the RPA, as a major component of the Basinwide Recovery Strategy, will improve the estimated current population growth rates. If the expectations of this and prior biological opinions are not realized as expected, additional FCRPS actions, such as preparations for breaching (preconstruction, engineering and design, and development of a socioeconomic mitigation plan) and additional structural or operational measures to improve juvenile or adult passage survival, would be triggered. See Section 9.5.

9.2.2.2 Standards Related to Effectiveness of Hydro and Offsite Actions

The Basinwide Recovery Strategy identifies actions expected to reduce the adverse effects of the environmental baseline and hydro, habitat, hatcheries, and harvest actions enough to allow the listed species to survive and recover. That expectation depends on the effectiveness of the identified actions in benefitting listed fish. The effectiveness of the actions in each sector of activity will require evaluation. Evaluations must be tailored to specific activities, but effectiveness must ultimately result in understanding the change in survival of listed fish in that life stage, which affects the population-level performance. The research, monitoring, and evaluation called for by the Basinwide Recovery Strategy and this biological opinion are intended to address the assessment of effectiveness.

9.2.2.2.1 FCRPS Hydro Performance Standards

Hydro performance standards are quantitative and include a timeline of 10 years for attainment. Hydro standards are defined as the estimated juvenile and adult survival levels throughout the

Table 9.2-1. Median annual population growth rate (lambda) estimated from years beginning in 1980, through most recently available year (1994, 1996, 1997, 1998, or 1999, depending upon stock); the expected lambda given continuation of current survival rates; and the lambda needed to meet recovery objectives as described in Section 1.3. Information obtained from Tables 6.3.1 through 6.3.3, 6.3-6 through 6.3-8, and 6.3-11, as well as A-2 through A-6.

Spawning Aggregation	Base Period Lambda (1980 brood year through the most recent year for which adult returns are available)		Estimated Current Lambda (base period adjusted for 1995 Biological Opinion, more recent harvest restrictions and Mid-Columbia HCP)		Recovery Lambda (growth rate needed to meet recovery objective in 48 years or, absent a recovery objective, 1.0)	
	Low	High	Low	High	Low	High
Snake River Spring/Summer Chinook						
Bear Valley/Elk Creeks	1.02	1.03	1.06	1.09	1.05	1.05
Imnaha River	0.88	0.92	0.92	0.98	1.04	1.04
Johnson Creek	1.01	1.03	1.06	1.10	1.03	1.03
Marsh Creek	0.99	1.00	1.03	1.06	1.07	1.07
Minam River	0.93	1.02	0.98	1.09	1.05	1.05
Poverty Flats	0.99	1.02	1.04	1.09	1.03	1.03
Sulphur Creek	1.04	1.05	1.09	1.12	1.07	1.07
Snake River Fall Chinook						
Aggregate	0.87	0.92	0.93	1.03	1.05	1.05
Upper Columbia River Spring Chinook						
Wenatchee River	0.80	0.92	0.81	0.96	1.06	1.10
Snake River Steelhead						
A-run Aggregate	0.74	0.85	0.78	0.92	>1.00	>1.00
B-run Aggregate	0.74	0.84	0.79	0.89	>1.00	>1.00
Upper Columbia River Steelhead						
Methow River	0.81	0.97	0.86	1.06	1.08	1.08
Mid-Columbia River Steelhead						
Deschutes River Sum	0.77	0.84	0.78	0.85	>1.00	>1.00
Warm Springs NFH	0.91	0.91	0.92	0.92	>1.00	>1.00
Umatilla River Sum	0.90	0.90	0.92	0.93	>1.00	>1.00
Yakima River Sum	1.01	1.04	1.00	1.04	>1.00	>1.00
Columbia River Chum Salmon						
Grays River west fork	1.23	1.23	1.23	1.23	>1.00	>1.00
Grays R mouth to head	0.96	0.96	0.96	0.96	>1.00	>1.00
Hardy Creek	1.05	1.05	1.05	1.05	>1.00	>1.00
Crazy Johnson Creek	1.16	1.16	1.16	1.16	>1.00	>1.00
Hamilton Creek	0.92	0.92	0.92	0.92	>1.00	>1.00
Hamilton Springs	1.11	1.11	1.11	1.11	>1.00	>1.00

Table 9.2-2. Estimates of current abundance by ESU and population for the most recent 5 years for which return data are available. Values in the wild only column will be applied in the 5- and 8-year check-ins.

Spawning Aggregation	5-yr. Geometric Mean Incl. Hatchery Fish	5-yr Geometric Mean Wild Only	Last Year of Mean	Data Type
Snake River Spring/Summer Chinook	8,736	3,469	1999	Dam Count
Bear Valley/Elk Creeks	90	90	1999	Run reconstruction
Imnaha River	215	106	1999	Run reconstruction
Johnson Creek	69	69	1999	Run reconstruction
Marsh Creek	13	13	1999	Run reconstruction
Minam River	113	66	1999	Run reconstruction
Poverty Flats	190	178	1999	Run reconstruction
Sulphur Creek	15	15	1999	Run reconstruction
Snake River Fall Chinook				
Aggregate	566	394	1996	Run reconstruction
Upper Columbia River Spring Chinook				
Entiat River	39	26	1998	Run reconstruction
Methow River	132*	123*	1998	Run reconstruction
Wenatchee River	164	144	1998	Run reconstruction
Snake River Steelhead	71,105	8,683	1998	Dam count
A-run Aggregate	56,210	7,885	1997	Dam count
B-run Aggregate	12,274	1,248	1997	Dam count
Upper Columbia River Steelhead	2,127	703	1996	Dam count
Methow River				
Mid-Columbia River				
Deschutes River Sum	10,824	1,301	1996	Total live count
Warm Springs NFH Sum	164	not avail.	1995	Weir count
Umatilla River Sum	1,811	1,239	1996	Total live count
Yakima River Sum	979	933	1997	Dam count
Columbia River Chum				
Grays River west	33	33	1998	Peak counts
Grays River mouth to head	106	106	1998	Peak counts
Hardy Creek	253	253	1998	Peak counts
Crazy Johnson Creek	168	168	1999	Peak counts
Hamilton Creek	14	14	1998	Peak counts
Hamilton Springs	90	90	1999	Peak counts

*The Methow River spring chinook geometric mean estimate includes wild fish taken as hatchery brood stock for the natural stock supplementation program (1996 to 1998).

FCRPS that are expected to directly or indirectly result from the best or most extensive actions that are biologically feasible and within the authority of the Action Agencies. The hydro standards described in Table 9.2-3 involve uncertainty and annual variation. Assumptions about future survival rates are inherent in any projection of the likelihood of survival and recovery (i.e., a jeopardy analysis). NMFS believes, therefore, that the assumptions on which the analysis is based should be explicit.

Table 9.2-3. FCRPS hydrosystem survival performance rates (%) for affected life stages.

ESU	Adult Survival Rate		Juvenile Survival Rate		
	FCRPS System	Per FCRPS Project[1]	FCRPS Inriver Only		FCRPS Combined[2] (Transport + Inriver + Differential Mortality of Transported Fish)
			System	Per Project[1]	
Chinook Salmon					
SR spring/summer	85.5	98.1	49.6	91.6	57.6
SR fall	74.0	96.3	14.3	78.4	12.7
UCR spring	92.2	98.1	66.4	90.3	66.4
UWR	N/A	N/A	N/A	N/A	N/A
LCR	98.1	98.1	90.7	90.7	90.7
Steelhead					
SR	80.3	97.3	51.6	92.1	50.8
UCR	89.3	97.3	67.7	90.7	67.7
MCR	89.3	97.3	67.7	90.7	67.7
UWR	N/A	N/A	N/A	N/A	N/A
LCR	97.3	97.3	90.8	90.8	90.8
CR chum salmon	N/A	N/A	N/A	N/A	N/A
SR sockeye salmon	88.7	98.5	N/A	N/A	N/A

Source: Adult standards taken from Table 9.7-2. Juvenile standards taken from Table 9.7-1.
[1] Per-project inriver survival rate calculated as the xth root of the system inriver survival rate (where x = number of FCRPS projects encountered). They are provided for illustrative purposes only. They are *NOT* intended to be interpreted as project-specific standards, or to be used in any way to support curtailment of survival improvement measures at an individual project.
[2] Values represent averages over the water years and D values in Table 9.7-1.

In 2005 and again in 2008, NMFS will compare the post-2000 average survival with the average survival estimates in this biological opinion and with the survival improvements expected from RPA measures implemented by 2005 (or 2008). The progress check might consist of a series of two-sample statistical tests on one-sided hypotheses about juvenile survival levels. The tests

would take into account uncertainty in both the 1994-to-1999 and the more recent averages. A first test could check whether the post-2000 estimate of survival was significantly lower than the 1994-to-1999 average, plus RPA improvements. The second test could check whether post-2000 survival was significantly higher than the 1994-to-1999 average. The purposes are to determine whether implemented actions are having the expected effects and to determine whether there is steady progress toward full achievement of the standard by year 10.

Because of the annual variability noted above, particularly in relation to environmental and hydrologic conditions and the limited years in the forthcoming progress evaluation, it may also be necessary to account for conditions that differ between the base period and the assessed period. That is, if conditions during the two periods are dissimilar, factoring may be necessary to ensure that the evaluation truly assesses the progress of actions undertaken and that the results are not masked by ambient conditions (environmental or hydrologic).

9.2.2.2.2 FCRPS Offsite Mitigation Performance Standards

FCRPS offsite mitigation builds on the hydro survival improvements called for in the hydro portion of the RPA, together with ongoing survival improvements from other habitat, hatchery, and harvest measures described in the Basinwide Recovery Strategy. The goal for FCRPS offsite mitigation is to improve fish survival over the life cycle beyond this base to help meet the biological requirements of the ESUs. Implicit in the analysis is the expectation that the combination of planned hydropower, hatchery, habitat, and harvest actions will result in enough survival improvements to meet ESA standards for the listed runs in the Columbia River basin.

Table 9.2-4 presents the estimated additional life-cycle survival improvements needed (relative to the survival and recovery metrics presented in Section 1.3.1.2), after accounting for the hydro survival improvements described above, and for estimated effects of changes in harvest and in passage survival at the Mid-Columbia PUD dams. The figures in the table come from the summary of effects over the full life cycle, presented by ESU in Section 9.7.2. Only ESUs for which NMFS concluded jeopardy are included in this table. SR sockeye are not included, because no quantitative analysis was possible. Additional improvements are also expected from actions taken by other Federal agencies described in the Basinwide Recovery Strategy, but which cannot be quantitatively estimated at this time. These improvements will likely contribute to the needed survival change. Offsite mitigation is expected to make up the remainder.

NMFS has determined that the offsite measures described in this RPA, as enhanced and modified through the 1- and 5-year planning process, and together with the measures identified in the Basinwide Recovery Strategy, are sufficient to achieve the biological requirements of the listed ESUs and, thus, sufficient to avoid jeopardy and adverse modification of critical habitat. This determination is made with full consideration of the additional increments of improvement needed, as reported in Table 9.2-4. However, NMFS determination is ultimately qualitative, informed (to the extent possible) by this standardized quantitative analysis. Due to substantial uncertainties, NMFS' determination is not currently placing a great deal of weight on the

Table 9.2-4. Estimated percentage change (i.e., additional improvement in life-

cycle survival) needed to achieve survival and recovery indicator criteria after implementing the hydro survival improvements in the RPA. (A value of 26, for example, indicates that the egg-to-adult survival rate, or any constituent life-stage survival rate, must be multiplied by a factor of 1.26 to meet the indicator criteria.)

Spawning Aggregation	Needed Survival Change	
	Low	High
Snake River Spring/Summer		
Bear Valley/Elk Creeks	0	0
Imnaha River	26	66
Johnson Creek	0	0
Marsh Creek	0	12
Minam River	0	28
Poverty Flats	0	0
Sulphur Creek	0	5
Snake River Fall Chinook		
Aggregate	0	44
Upper Columbia River Spring		
Wenatchee R.	51	178
Snake River Steelhead		
A-run Aggregate	44	214
B-run Aggregate	92	333
Upper Columbia River Steelhead		
Methow R.	0	110
Mid-Columbia River Steelhead		
Deschutes R Sum	102	226
Warm Springs NFH Sum	36	36
Umatilla R Sum	27	31
Yakima R Sum	0	0
Columbia River Chum Salmon		
Grays R. west fork	0	0
Grays R. mouth to head	18	18
Hardy Creek	0	0
Crazy Johnson Creek	0	0
Hamilton Creek	36	36
Hamilton Springs	0	0

Notes: Low and high estimates are based on a range of assumptions, as described in the text.

The values presented in this table are intended to provide perspective and enable NMFS to make a qualitative judgment regarding the potential to improve the productivity of listed ESUs enough to avoid jeopardy. As discussed in the text accompanying this table, the effects of this uncertainty are particularly significant for SR steelhead and UCR chinook and steelhead.

quantitative analysis that produced these estimates. These uncertainties are thoroughly described

in Sections 6 and 9 of this biological opinion. Of particular importance in considering the values in this table is the uncertainty related to the effects of hatchery fish. In general, the uncertainty between 20% and 80% effectiveness of hatchery spawners in the wild is responsible for much of the range between the low and high values in the table. The other assumption contributing to this uncertainty is the level of improvement in hydro survival between the baseline analysis and the adjustment for the effects of NMFS' 1995 Biological Opinion that are not included in the baseline due to the timing of adult return information. In addition, the applicability of the hatchery effectiveness assumption is questionable in some cases. For SR steelhead, for instance, many of the populations within the ESU are in areas not affected by hatchery fish. For these populations, the adjustment in the productivity of wild fish based on these assumptions may not even apply. However, since the CRI analysis relies on dam count information, these assumptions are applied to the ESU as a whole and probably result in overestimating the amount of additional survival improvement needed to satisfy the survival and recovery metrics for some populations.

NMFS plans to refine the analysis by addressing critical uncertainties and, eventually, by quantitatively defining and apportioning the life-cycle improvement necessary in specific life stages or sectors, including the FCRPS. Part of the additional, unquantifiable survival improvements in the Basinwide Recovery Strategy are expected to result from ongoing and prospective Federal actions in land management, hatchery reform, and estuarine restoration. FCRPS Action Agencies are responsible for the balance of the improvements necessary to ensure an adequate likelihood of survival and recovery to satisfy ESA Section 7 obligations for the listed stocks.

9.2.3 Physical Performance Standards

Physical performance standards supplement and sometimes serve as surrogates for biological performance standards. In the case of hydro actions, for example, some physical targets or goals are directed at measures such as mainstem flow objectives and water quality that are intended to guide water management decisions. These are described with the individual hydro actions in Section 9.6.1.

In the case of tributary habitat, physical standards might include instream flows; the amount and timing of sediment inputs to streams; riparian conditions that determine water quality, bank integrity, wood input and maintenance of channel complexity; and habitat access.

The Federal Action Agencies, working with CRI and EDT analysts, have established preliminary hypotheses linking habitat strategies and measures to key habitat attributes. The next steps will be as follows:

- Establish an initial set of performance standards and measures—ecological and management indicators—expressed as desired habitat trends.

- Implement pilot studies designed to test and confirm key assumptions that relate habitat improvements to life-stage survival improvements for listed fish species.

The studies needed to assess the specific ecological and management targets will be integrated into tier 3 of the research, monitoring, and evaluation program described in Section 9.6.5. The studies and the objectives may be refined in the first few years through targeted research, subbasin assessments, and finer-scale analysis. Subbasin assessments will use available tools for evaluating habitat quality and quantity and salmon productivity, including EDT, the Salmon Watershed Enhancement Model, and the CRI analysis. The initial 5-year plan (due on March 31, 2001) must include tests of intermediate-stage (egg-to-parr, parr-to-smolt) survival in selected places to check the effectiveness of habitat actions. The tests must be designed to support assessments at the 5- and 8-year checkpoints described in Section 9.5. They will enable policymakers to evaluate and refine hypotheses, adjust habitat measures, and reach further decisions on the contribution to recovery of habitat protection and restoration. They are high-priority projects for early implementation in fiscal year 2001.

Hatchery performance standards will be incorporated into the hatchery and genetic management plans (HGMPs). Standards will be developed in the following areas and measured over time for results:

- Genetic introgression: Local, within-ESU, broodstock is used in all propagation programs within critical habitat, unless associated with an isolated program. Hatchery broodstocks used in supplementation programs represent the genetic and life-history characteristics of the natural population(s) they are intended to supplement. Non-isolated hatchery programs regularly infuse natural-origin fish into the broodstock, as described in an approved HGMP.

- Hatchery-origin fish straying: For naturally spawning populations in critical habitats, non-ESU hatchery-origin fish do not exceed 5 percent; ESU hatchery-origin fish do not exceed 5 to 30%, unless specified in an HGMP for a conservation propagation program.

- Marking: Hatchery populations are properly marked so as not to mask the status of the natural-origin populations or the capacity and proper functioning of critical habitat.

- Viable and critical population thresholds: Hatchery operations do not appreciably slow a listed population from attaining its viable population abundance. Hatchery operations do not reduce listed populations that are at, or below, critical population abundance.

- Harvest effects: Federal hatchery mitigation fish produced for harvest do not cause subsequent overharvest of listed stocks such that their recovery is appreciably slowed. Harvesting reforms are implemented to maintain and enhance harvest of mitigation fish in consideration of the constrained productivity of listed stocks caused by the FCRPS and other development.

- Hatchery planning: Hatchery goals and objectives, operational protocols, monitoring and evaluation, anticipated effects, and relationship to other critical management and planning processes are fully described in approved HGMPs.

- Research: Scientific knowledge is increasing on the effects of hatchery supplementation and captive broodstock programs on the survival and recovery of natural-origin populations. The quality and survival of hatchery supplementation fish are increasing.

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9.3 SUMMARY OF OFFSITE MITIGATION PROGRAM

Offsite mitigation is used in this biological opinion to mean actions in the areas of habitat, hatcheries, and harvest that are expected to provide biological benefits to the listed stocks. In combination with efforts to reduce hydro mortality, improvements expected from other ongoing Federal actions, and the cumulative effects of state or private activities that are reasonably certain to occur, these actions should be sufficient to allow the FCRPS and BOR operations to meet the jeopardy standard. Offsite enhancement includes only measures that are within the current authorities of the Action Agencies.

Each of the Action Agencies currently has some authority to implement programs to benefit listed stocks that are outside of the scope of hydrosystem operations. BPA has authority pursuant to the Northwest Power Act to protect, mitigate, and enhance fish and wildlife affected by the construction and operation of the FCRPS. BPA implements this authority and fulfills its responsibility through the NWPPC's fish and wildlife program. Measures implemented under the program include actions in the areas of habitat, hatcheries, and, to a more limited extent, harvest. The Corps has existing authorities that provide opportunities for some hatchery and habitat improvements pursuant to the Lower Snake River Compensation Plan, the Columbia River Fish Mitigation Program, and other continuing authorities. The Corps is currently seeking authority to carry out habitat improvement activities in the estuary. BOR is authorized, pursuant to the Reclamation Act of 1902, to provide technical assistance to others to address instream habitat improvements; however, BOR only has authority to fund water acquisition and to supply technical assistance for screening and passage improvements. Additional BOR participation in implementing tributary habitat improvement actions is contingent upon acquiring such authority from Congress or acquiring funds to implement the actions from sources other than BOR appropriations.

The Action Agencies will exercise these authorities to implement offsite mitigation actions outside the operation of the hydrosystem. This will be an important contribution toward achieving the standards for offsite mitigation.

Offsite mitigation measures are identified in the RPA in the areas of habitat (Section 9.6.2), harvest (Section 9.6.3), and hatcheries (Section 9.6.4). These measures are intended to complement, not substitute, for actions on Federal lands by Federal land management agencies or actions in the hatchery and harvest arena by other Federal agencies consistent with the Basinwide Recovery Strategy and related biological opinions. The measures identified as offsite mitigation in this biological opinion are targeted at providing biological benefits for the listed ESUs that are the subject of this consultation and will be credited toward achievement of the offsite mitigation performance standards.

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9.4 DEVELOPMENT AND IMPLEMENTATION OF 1- AND 5-YEAR PLANS

This section outlines an annual process for developing and implementing 1- and 5-year plans to achieve both FCRPS hydro performance and offsite mitigation performance standards. The plans will cover all operations, configuration, research, monitoring, and evaluation actions for the FCRPS. The plans will also describe habitat, hatchery, and harvest actions to be funded or otherwise carried out by the Action Agencies as offsite mitigation. The advance planning process outlined in this section is critical to achieving the FCRPS hydro and offsite performance standards within the time-frame of this biological opinion.

9.4.1 Development and Implementation of the 1- and 5-year Plans

The following action describes in more detail the expectations for the development and implementation of the 1- and 5-year plans.

Action 1: The Action Agencies, coordinating with NMFS and USFWS, shall annually develop 1- and 5-year plans to implement specific measures in hydro, habitat, hatcheries, harvest, research, monitoring, and evaluation needed to meet and evaluate the performance standards contained in this biological opinion.

The annual planning process is expected to provide the following key benefits:

- A comprehensive plan that identifies progress made and actions needed to achieve FCRPS hydro and offsite mitigation performance standards
- Integration of all FCRPS operations, configuration, research, monitoring, and evaluation actions
- Specific actions to be carried out as offsite mitigation for the effects of the FCRPS and how they will be credited
- Priorities to guide regional planning and in-season actions
- A comprehensive plan to support funding requests

To the extent possible, the plans will be coordinated through established local, regional, and Federal processes. USFWS is referenced in this process to ensure coordination on actions that may affect USFWS hatchery and resident species responsibilities. The responsibility for meeting the performance standards in this biological opinion rests, however, with the Action Agencies. NMFS has the responsibility for determining the adequacy of the 1- and 5-year plans. Regional implementation forums that include participation by entities other than the Action Agencies are described in the following sections. The intent of these processes is to ensure the broadest

possible technical and policy input and information from the region's Indian Tribes and state fish and wildlife managers. While consensus on regional issues is a desired outcome of these processes, failure to reach consensus after full and measured discussion, or lack of participation by the other parties, is not intended to indicate a failure to comply with any of the RPAs.

The planning and implementation process described in this section has the following elements:

- The Action Agencies, with assistance from NMFS and USFWS, will develop a 5-year implementation plan that includes FCRPS and offsite mitigation measures. The hydro portion of the initial 5-year plan will include those specific measures in this RPA for hydrosystem operations, configuration, research, monitoring, and evaluation. The offsite mitigation portion will include specific additional measures in habitat, harvest, and hatcheries from this RPA and the Basinwide Recovery Strategy including research, monitoring, and evaluation. These additional measures are the responsibility of the Action Agencies to fund or carry out, and they include measures that would benefit from involvement and/or contribution of the Action Agencies.

- The 5-year plan will focus on the middle to long term, describing the Action Agencies' programs and how they are intended to meet FCRPS and offsite mitigation performance standards. The plan will detail, as specifically as possible, the measures in those programs, together with schedules and budgets. As a long-term planning tool, the 5-year plan will focus on out-year costs of the measures to ensure budgets and budget requests are adequate to carry out planned activities.

- The initial 5-year plan should be completed by March 31, 2001, and annually thereafter by September 1 (or as mutually agreed upon by the Action Agencies, NMFS, and USFWS).

- NMFS encourages coordination with the Columbia River basin's Indian Tribes and state fish and wildlife managers in development of the 1- and 5-year plans in order to gain the full benefit of cooperative adaptive management with the region's scientists.

- The 5-year plan will guide the Action Agencies, NMFS, and USFWS as they participate in various regional planning processes in which they are collectively or individually involved. Examples are the NWPPC's Fish and Wildlife Program prioritization process, Action Agency budget requests, and production discussions within *U.S. v. Oregon* (which do not directly involve the Action Agencies).

- The Action Agencies, with assistance from NMFS and USFWS, will complete a 1-year plan. The 1-year plan will provide the additional project-specific detail needed to implement the first year of the more general 5-year plan. Both new and ongoing activities should be identified. The first 1-year plan will be completed by September 1, 2001, and annually thereafter on a date that is mutually agreed upon by the Action Agencies, NMFS, and USFWS. The 1-year plan will incorporate, to the greatest extent possible, the measures

developed in regional planning and prioritization processes, but the Federal agencies will not necessarily be limited to only measures approved through those processes. Where differences exist, the plan will explain the differences.

- NMFS will review the 1-year plan for consistency with the biological opinion and issue a finding as to whether the plan is adequate.

- The 1- and 5-year plans will be implemented through a variety of processes. The FCRPS hydro action portion of the plans will be implemented through the existing NMFS Regional Implementation Forum process and, where appropriate, the BPA funding process. The offsite mitigation portions of the plans will be implemented through the BPA funding process, Action Agency budget requests, and other processes as appropriate.

- The Action Agencies are expected to participate in good faith in the regional forums and processes in order to seek agreement on the adaptive management steps necessary to avoid jeopardy. They may convene any additional meetings to gain input from affected parties. However, the Regional Implementation Forum will be the principal decision-making forum for issues related to this biological opinion.

- The Action Agencies may wish to develop one comprehensive plan that consolidates other program activities (e.g., the Columbia Basin Fish and Wildlife Program) with those being done for ESA purposes. If the plans are consolidated, the Action Agencies will specifically identify those measures in this RPA that are the responsibility of the Action Agencies to fund or carry out and those offsite mitigation actions they propose to implement to meet the performance standards.

The 1- and 5-year implementation plans and their priorities should consider the following factors:

- The current status of the various ESUs

- Recent data or results of research, monitoring, and evaluation actions

- Feasibility and timing of implementing each measure

- Probability of success for each measure. The 5-year plan should explain how all the actions together contribute to meeting the performance standards.

- State and Tribal plans and input from state and Tribal comanagers

9.4.2 Process for Developing and Implementing Key Elements of the 1- and 5-Year Plans

The following sections define the process of developing and implementing key elements of the 1- and 5-year implementation plans. The major elements of the plan and of the planning process (described in the following subsections) are as follows:

1. Hydrosystem Plan
2. Operations — Water Management Plan
3. Configuration — Capital Investment Plan
4. Water Quality Improvement Plan
5. Operations and Maintenance Plan
6. Offsite Mitigation — Habitat Plan
7. Offsite Mitigation — Hatcheries and Harvest Plans
8. Research, Monitoring, and Evaluation Plan
9. Tribal Coordination on Hydro and Offsite Mitigation Actions
10. Recovery Planning
11. Unanticipated Actions
12. Approval of Plans
13. Annual Progress Reports

9.4.2.1 Hydrosystem Plan

Action 2: The Action Agencies shall coordinate development and implementation of the hydro portion of the 1- and 5-year implementation plans through the Regional Forum, chaired by NMFS.

The hydro portion of the 1-year plan will describe specific actions to be taken in the coming year to achieve the hydrosystem performance standards. It will incorporate and integrate specific measures developed in the water management, capital investment, and water quality improvement plans, described below. Section 9.6.1 of this biological opinion describes objectives and a number of operational and structural measures that will serve as the basis for the initial operations and configuration actions in the hydro portion of the 1- and 5-year plans. Sections 9.6.1 and 9.6.5 also include research, monitoring, evaluation, and planning measures that, when completed, will guide future implementation decisions. The RPA anticipates that these research and planning actions, together with future decisions made through the 1- and 5-year planning process, will amend the RPA measures. NMFS will explicitly define and approve all such amendments in its written findings.

Development and implementation of the hydro portion of the 1- and 5-year plans will be coordinated through the NMFS Regional Implementation Forum, established in the 1995 Biological Opinion and led by the Implementation Team. The goal of this forum is to ensure the

broadest possible technical and policy input in planning, funding, and implementation decisions regarding the operation and configuration of the FCRPS. Consensus should be sought on issues affecting the region to foster cooperation in the adaptive management process and longevity of decisions. However, nothing in the Regional Implementation Forum process is intended to dilute or remove the authority of any agency. Membership on the Implementation Team is open to senior program and policy level personnel from the states, Tribes, and Federal agencies. The teams and subgroups operating under the Implementation Team's guidance are open to Federal, state, and Tribal representatives with technical expertise in hydroelectric operations and/or the effects of hydroelectric operations on fish, particularly on migrating juvenile and adult salmonids and native resident species, and water quality. In particular, the Action Agencies and NMFS have invited and encouraged participation by the four northwest states and Alaska, 13 Columbia River Tribes, CRITFC, USFWS, EPA, NWPPC, the Mid-Columbia PUDs, and Idaho Power Company. All meetings of the NMFS Regional Forum teams are professionally facilitated and are open to the public. Meeting minutes are distributed to members and the public and are available for review at the NMFS Hydro Division in Portland, or on NMFS' Northwest Region home page at www.nwr.noaa.gov/1hydrop/hydroweb/default.html.

The Implementation Team will meet monthly, or otherwise as needed, to oversee the activities and resolve disputes arising through the Technical Management Team, the System Configuration Team, and the Water Quality Team. The Implementation Team and each of the technical teams will regularly review and approve guidelines or procedural rules. Draft guidelines now in place will serve as default rules for the Implementation Team until it can adopt different rules. Copies of the guidelines are also available on the website or may be obtained from the NMFS Hydro Division in Portland, Oregon.

Given the development of the annual planning process, it may be appropriate for the Implementation Team and all technical teams operating under its guidance to review their guidelines, rules of procedure, and meeting structures to ensure that the teams are prepared to address the annual planning process. Further, it is anticipated that new subgroups may be needed to address resident fish and data management issues. Such subgroups are not described in this section, but may be developed through the Regional Forum and the annual planning process.

9.4.2.2 Water Management Plan

Action 3: The Action Agencies, coordinating through the Technical Management Team, shall develop and implement a 1- and 5-year water management plan and in-season action plans for the operation of the FCRPS.

The 1- and 5-year water management plans will define how the FCRPS will be operated to achieve the performance standards. It will also include a prioritized list of research, monitoring, and evaluation needs associated with implementing the annual water management plans. As an advance planning document, the 5-year water management plan will provide clear objectives, evaluation points, decision criteria, and priorities for the objectives. Given these priorities, the

plan will address any significant changes from prior year operating plans. It will specify any criteria being used to begin or end a particular planned operation. The plan should specifically address exceptions for emergencies declared to ensure the reliability of power supply and transmission service. In addition, the annual plan will include consideration of research, monitoring, and evaluation activities that require special operations. The 5-year water management plan must be incorporated into the 1-year plan by September 1 of each year to ensure timely consideration for funding of associated research, monitoring, and evaluation. This is well before runoff projections are available for the coming year. For this reason, the water management plan will have to contain objectives, priorities, and decision criteria for various water conditions.

This timeline for the 1- and 5-year water management plans does not allow for consideration of specific water-year information. Therefore, the Action Agencies will coordinate through the Technical Management Team to prepare more detailed spring/summer and fall/winter action plans that address spring runoff, summer flow augmentation, fall spawning, and winter incubation seasons. The spring/summer plan will be initiated with the January 1 forecast and updated each month as the new forecast information becomes available. The fall/winter plan will be initiated in September using the best currently available long-range hydrologic and oceanographic information and updated as better information becomes available.

Given the emphasis on advance planning, the Technical Management Team may have to meet only biweekly or monthly during the spring and summer migration and fall spawning seasons to advise the Action Agencies on the status of salmonid migrations and spawning activity, and to review dam and reservoir operations for optimal conditions affecting juvenile and adult anadromous salmonids. The water management plan and the more detailed spring/summer and fall/winter plans, together with the provisions of Section 9.6.1.2, will guide the Technical Management Team in-season management process.

NMFS received comments on a number of process issues related to the Technical Management Team, including frequency of meetings, retention of a meaningful role for the state and Tribal participants, and the need for more explicit provisions to deal with power supply and transmission system emergencies such as occurred in the summer of 2000. In general, NMFS believes that refinement of the in-season management process should be carried out through the established Regional Forum rather than specified as part of this biological opinion (such as occurred with the Technical Management Team's development of the September 22, 2000, "Protocols for Emergency Operations in Response to Generation or Transmission Emergencies"). Specific changes that should be considered through that process include assessing the continuing need for weekly meetings once the more detailed in-season action plans contemplated by this action are done, the venue for such meetings (e.g., annual meetings in Idaho and Montana to discuss potential site-specific impacts at key points during the season), and the need for some level of involvement by regional executives to address power supply or transmission system emergencies of exceptional magnitude or duration.

9.4.2.3 Capital Investment Plan

Action 4: The Action Agencies, coordinating through the System Configuration Team, shall annually develop and implement a 1- and 5-year capital investment plan for the configuration of the FCRPS projects.

The capital investment plan will prescribe investment, research, monitoring, evaluation, and O&M actions to achieve the performance standards. As an advance planning tool, the capital investment plan will address specific objectives and priorities for improving fish passage and water quality. Given the objectives and priorities, the plan will define research, development, and implementation of FCRPS facility improvements to improve anadromous fish passage survival. To the extent that any actions require special system or project operations, the implementation dates and operations will be coordinated with the Technical Management Team and the development of the annual water management plan. O&M needs and budgets associated with the capital investment plan will also be developed.

The SCT will meet monthly or as needed to consider the results of scientific and engineering studies and to develop and recommend FCRPS fish facility improvements, including their priority, implementation schedule, and budget needs.

9.4.2.4 Water Quality Plan

Action 5: The Action Agencies, coordinating through the Water Quality Team, shall annually develop a 1- and 5-year water quality plan for operation and configuration measures at FCRPS projects.

Numerous actions throughout the RPA improve fish passage and survival through measures to improve water quality. The water quality improvement plan will describe the objectives, priorities, and decision criteria for these measures and the specific implementation plans. Given these objectives and priorities, the plan will recommend FCRPS facility and operational improvements related to water quality, gas and temperature monitoring needs, and related studies. In developing the water quality improvement plan, the Water Quality Team will integrate and coordinate its recommendations with the annual water management and the capital investment plans.

9.4.2.5 Operation and Maintenance Plan

Action 6: The Corps and BPA, through the annual planning process, shall develop and implement 1- and 5-year operations and maintenance (O&M) plans and budgets that enhance the capability to operate and maintain fish facilities at FCRPS projects for listed salmonid stocks.

In recent years the Corps' O&M program budget for operations and maintenance of fish passage facilities at FCRPS projects has remained static and has not met increased needs. As a result, there is a growing backlog of needed maintenance actions. Enhanced preventive maintenance programs are needed to avoid costly and untimely repairs and to improve facility reliability. New fish passage facilities being installed will create new O&M needs. Other operational needs, such as increased juvenile fish barging, also raise annual O&M budget requirements. To address these needs, the O&M annual budget should reflect the 1- and 5-year plans to be developed by the Corps in coordination with FPOM and approved by the System Configuration Team. The 1- and 5-year plans will be based on the following:

- Development of a fish facilities preventive maintenance program
- Current requirements for updating aging facilities
- Requirements of new facilities scheduled to come on line each year
- Debris-handling needs and techniques
- Current operations and any anticipated changes.

The Corps' resource capability to undertake and implement O&M actions should also be considered.

9.4.2.6 Offsite Mitigation—Habitat Plan

Action 7: The Action Agencies, with assistance from NMFS and USFWS, shall annually develop 1- and 5-year plans for habitat measures that provide offsite mitigation.

The habitat portion of the initial 5-year plan will include programs and measures from the Basinwide Recovery Strategy that are the responsibility of the Action Agencies to fund or carry out. The plan will include schedules and costs associated with the habitat programs. The 5-year plan will also include an analysis of how the habitat measures will meet the performance standards established in this biological opinion. The Basinwide Recovery Strategy calls for the creation of a Federal Habitat Team. The Action Agencies should employ this mechanism to integrate offsite mitigation outlined in the initial 5-year plan with other federal habitat programs. Using the 5-year plan as guidance, and in consultation with the Federal Habitat Team, NMFS, USFWS and the Action Agencies will participate in regional planning and prioritization processes, but the Federal agencies will not necessarily be limited to only those measures approved through those processes.

NMFS expects to rely heavily on NWPPC's subbasin planning process for the identification and development of offsite habitat mitigation opportunities. This process capitalizes on the technical

expertise within the fish and wildlife agencies and Tribes and takes into account their management recommendations, includes technical review by the NWPPC's Independent Scientific Review Panel, and involves local communities and the public. The 1-year plan will incorporate, to the greatest extent possible, the measures developed in the regional planning and prioritization processes. The plan will explain any differences between measures contained in the plan and measures developed in other regional processes.

9.4.2.7 Offsite Mitigation—Hatcheries and Harvest Plans

Action 8: The Action Agencies, with assistance from NMFS and USFWS, shall annually develop 1- and 5-year plans for hatchery and harvest measures that provide offsite mitigation.

The harvest and hatchery portion of the initial 5-year plan will include those specific measures and programs from the Basinwide Recovery Strategy that are the responsibility of the Action Agencies to fund or carry out. The plan will include schedules and costs associated with the harvest and hatchery programs. The 5-year plan will include an analysis of how the harvest and hatchery measures will meet the performance standards established in this biological opinion. Using the 5-year plan as guidance, NMFS, USFWS, and the Action Agencies will participate in regional planning and prioritization processes. Those processes include, but are not limited to NWPPC's prioritization process, *U.S. v. Oregon* production discussions (NMFS and USFWS; not the Action Agencies), and budget requests.

The 1-year plan will incorporate, to the greatest extent possible, the measures developed in regional planning and prioritization processes, but will not necessarily be limited to actions approved through those processes. The plan will be consistent with any provisions established by *U.S. v. Oregon*. The plan will explain any differences between measures it contains and measures developed in other regional processes.

9.4.2.8 Research, Monitoring, and Evaluation Plan

Action 9: The Action Agencies, with assistance from NMFS and USFWS, shall annually develop 1- and 5- year plans for research, monitoring, and evaluation to further develop and to determine the effectiveness of the suite of actions in this RPA.

Research, monitoring, and evaluation will provide data for resolving a wide range of uncertainties, including determining population status, establishing causal relationships between habitat (or other) attributes and population response, and assessing the effectiveness of management actions. Progress on resolving these uncertainties will be a primary consideration in the 1- and 5-year planning process as well as in the 5- and 8-year check-ins. Monitoring and evaluation may lead to revisions in measures the Action Agencies undertake to meet performance standards, or in the performance standards themselves, to ensure that the overall program is

sufficient to avoid jeopardy to listed ESUs. Such programs are, therefore, critical to the successful implementation of this RPA.

Section 9.6.5 describes a framework for a comprehensive research, monitoring, and evaluation program. Many specific actions are already identified in that section, but the plan is not limited to those listed. NMFS expects the Action Agencies to start work on the listed actions concurrent with the development of the 1- and 5-year plans.

9.4.2.9 Tribal Coordination on Hydro and Offsite Mitigation Actions

The Action Agencies and NMFS encourage participation by the Tribes and Tribal organizations in all of the Technical Management Team, System Configuration Team, Water Quality Team, and Implementation Team processes, and in regional planning activities such as the CBFWA/NWPPC process where much of the planning for offsite mitigation activities will occur. Such participation will provide abundant opportunities at the technical level to collect, synthesize, and exchange information and to seek consensus on implementing the hydro and offsite mitigation actions identified in the biological opinion. Discussions at the policy level are also important and may occur through direct communications with Tribes or through policy level forums such as the Columbia River Basin Forum.

The Action Agencies, in keeping with their Federal trust responsibilities, will coordinate with and seek the input of appropriate Tribes during their development of the 1- and 5-year plans. The 5-year plan will be subject to NWPPC's public process, providing additional opportunities for input from Tribes, state fish and wildlife managers, and the public before the 1-year plan is drafted.

9.4.2.10 Recovery Planning

Action 10: The Action Agencies shall work with NMFS and others to promptly incorporate the results of recovery planning into annual Fish and Wildlife Program implementation funding, including support for incorporation of the results into the NWPPC's Fish and Wildlife Program.

As portions of recovery plans become final, NMFS and the other Action Agencies will incorporate applicable elements into the progress reviews and the 1- and 5- year plans described in this RPA. If the incorporation of such recovery plan elements could entail major changes in analyses or actions, the Action Agencies may reinitiate consultation with NMFS.

NWPPC recently amended its Fish and Wildlife Program to be implemented through a 3-year rolling provincial review. The NWPPC's intent is to identify and fund all actions in a province for 3-year periods. Provincial reviews will incorporate the findings of subbasin assessments and subbasin plans when they are complete. Ideally, NMFS' recovery plans would be available to

provide quantitative biological goals and spatial and action priorities to guide provincial reviews and subbasin plans toward achieving recovery. However, NMFS' recovery plans will lag behind the first round of provincial reviews. To address this timing problem, NMFS commits to working on provincial reviews and subbasin plans to optimize the Fish and Wildlife Program's ability to meet ESA needs before recovery planning. Responding to recovery plan goals and actions as they emerge may require some midcourse adjustments in areas with previously completed provincial reviews and subbasin plans. When BPA receives its annual fish and wildlife program recommendations from NWPPC, therefore, it should consider consistency with the latest ESA findings and priorities both in new, as well as in completed, provincial reviews in preparing its 1-year funding plans.

9.4.2.11 Unanticipated Actions

***Action 11*:** By September 30, 2001, the Action Agencies shall develop procedures for carrying out actions that could not be anticipated in the planning process, but that are necessary or prudent to achieve the performance standards.

Scientifically sound projects or operational measures of a limited duration and scale may arise that, for a variety of reasons, were not considered during the normal planning processes. Delaying their implementation to conform to those processes might be impractical or inconsistent with information needs associated with the midpoint evaluation process. To address this concern, the Action Agencies will, in collaboration with NMFS and USFWS, develop an expedited process for implementing new or unplanned activities that might result from new findings, that constitute emergency actions, or that present an unforeseen opportunity. Until the Action Agencies develop an explicit process, they will proceed with any necessary and prudent unanticipated actions after adequate informal coordination with and approval by NMFS.

Because the first 1-year plan under this RPA will not be completed until September 2001, a number of early-implementation, high-priority actions may be added to existing plans for fiscal year 2001. This will be particularly important for research, monitoring, and evaluation needed to assess performance standards.

9.4.2.12 Approval of Plans

Action 12: The Action Agencies shall coordinate with NMFS and USFWS in the review of the 1- and 5-year plans to facilitate timely review and approval as part of the annual decision process.

The responsibility for meeting the performance standards in the biological opinion rests with the Action Agencies, based on their implementation of the 1- and 5-year plans. NMFS and USFWS will participate in the development of the 1- and 5-year plans, considering consistency with their biological opinions; adequacy of the level of effort being undertaken in habitat, harvest, hatcheries, and hydro; priority of actions; and progress toward achieving performance standards

or objectives. Within 45 days of receipt of each 1-year plan, NMFS and USFWS will issue a findings letter to the Action Agencies regarding the adequacy of the plan. The letter will address the consistency of the proposed annual plan with the reasonable and prudent alternative of the biological opinion and, if appropriate, recommend needed changes. If NMFS finds the plan to be inadequate, the Action Agencies may proceed with those elements of the plan not identified by NMFS or USFWS as at issue, while discussions continue regarding how to align the plan with the biological opinion.

The plans will be carried forward into the appropriate Federal or regional planning process. The Action Agencies will expedite implementation unless there are technical or feasibility impediments that cannot be reconciled, or appropriations are not forthcoming from Congress.

9.4.2.13 Annual Progress Reports

Action 13: The Action Agencies shall issue annual reports to NMFS and USFWS on progress toward achieving the performance standards set out in this biological opinion, including comprehensive cumulative reviews in years 3, 5, and 8.

As part of the preparation for the annual planning process described in this section, the Action Agencies will prepare progress reports for NMFS' review. These annual progress reports will document the Action Agencies' findings regarding each of the following:

- Compliance by the Action Agencies with the measures and schedules described in this biological opinion and in 1- and 5-year plans, including a thorough discussion of any impediments to full implementation (e.g., lack of necessary authority or appropriation)

- Progress toward meeting the interim and long-term performance standards for hydrosystem improvements and offsite mitigation established pursuant to this biological opinion and any failure to meet such standards

- Projected progress toward full achievement of performance standards through future actions, or through future benefits of ongoing actions, and the risks that such progress will not be achieved

- Lessons learned, new information, and related adjustments made in actions, standards, or monitoring and evaluation, specifically including the following:

  - Results from pilot studies that may confirm or rebut key assumptions regarding the ability of habitat actions identified in this biological opinion and in the Basinwide Recovery Strategy, as necessary to improve life stage survivals of listed fish species

- Progress towards resolving critical uncertainties including the effectiveness of naturally spawning hatchery fish, delayed mortality associated with transport, and delayed mortality associated with in-river migration

- Current adult returns and population trends

NMFS, working through the Regional Forum and the Independent Scientific Advisory Board, will obtain independent scientific review of its 5-year and 8-year evaluation reports. The progress reports will better enable NMFS and the Action Agencies to assess progress and the possible need for additional measures.

To the extent the actions or programs are not being implemented as described in the RPA, or fall short of meeting performance measures such as needed improvements in hydrosystem survival, the Action Agencies will propose additional measures to address such shortcomings in their annual updates to the 1- and 5-year plans.

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9.5 DESCRIPTION OF MID-POINT EVALUATION PROCESS

9.5.1 Overview

Inclusion of a process to ensure that the required measures are implemented and effective is a critical feature of this RPA. The Action Agencies must be certain that the projects covered by this biological opinion continue to avoid jeopardy and adverse modification of critical habitat for the listed species. At the same time, the Action Agencies must monitor the status of the listed species to ensure that their condition does not worsen unexpectedly despite the actions of this RPA and other conservation measures. These are the purposes of the mid-point evaluation process.

This process overlays the 1- and 5-year planning process discussed in Section 9.4. It incorporates the annual progress reports required for development of 1- and 5-year plans. In years 3, 5, and 8, the agencies perform a more detailed assessment of the RPA's implementation and effectiveness. In years 5 and 8, NMFS will also reevaluate application of the jeopardy/adverse modification standard based on current information, simultaneously reassessing the current status of the listed stocks. NMFS will issue a report at each of these check-in years, documenting whether the RPA is on track or fails to meet expectations. The year 5 and 8 reports, along with the progress reports submitted by the Action Agencies, will be submitted for scientific peer review. Figure 9.5-1 illustrates the timeline for this review process. Figure 9.5-2 provides an overview of the decision structure for the mid-point evaluation process.

NMFS' reports will determine whether, on balance, the Action Agencies' implementation of the RPA is substantially meeting expectations (depicted in Figure 9.5-2 as the green zone). A probationary period (the yellow zone) is provided for implementation that is falling significantly short of expectations. For the RPA to be considered in such a probationary period, NMFS must determine that corrective actions are within the Action Agencies' current authority and can and will be implemented in a timely enough manner to avoid having a significant effect on full implementation of this RPA. If the Action Agencies have critically failed by not taking identified key actions, or if the performance of one or more stocks falls below expectations to the extent that RPA expectations cannot likely be met or confirmed through correction within current authority, NMFS will issue a failure report pursuant to Section 9.5.4 (the red zone).

The following sections describe the mid-point evaluation process.

FIGURE 9.5-1. TIMELINE FOR MIDPOINT EVALUATIONS

2000

2000 Biological Opinion Jeopardy Analysis

FCRPS Performance Standards

Hydro	Offsite

2001 to 2003

3/01 9/01	Initial 5-year (02 to 06) Implementation Plan 1-year (02) and 5-year (02 to 06) Implementation Plans	2000 adult return data
9/02	1-year (03) and 5-year (03 to 07) Implementation Plans	2001 adult return data
9/03	1-year (04) and 5-year (04 to 08) Implementation Plans including the following: *Cumulative assessment of implementation *Status of research on critical uncertainties *Status of implementation of habitat pilot studies *Updated bio. goals and objectives per TRT results *Site-specific offsite mitigation plans (based on completed subbasin assessment and other finer scale analyses)	2002 adult return data

2003 Progress Check-in

Question 1: What is the status of 1- and 5-year plan development and implementation?

2004 to 2005

9/04	1-year (05) and 5-year (05 to 09) Implementation Plans	2003 adult return data
9/05	1-year (06) and 5-year (06 to 10) Implementation Plan including the following: *Cumulative assessment of implementation *Results of research on critical uncertainties *Preliminary results of pilot studies	2004 adult return data NMFS reassessment of status, including population growth rates (λ)

2005 Progress Check-in

Question 1: What is the status of 1- and 5-year plan development and implementation?
Question 2: What is the status of stocks?
Question 3: How effective are hydrosystem actions?
Question 4: How effective are offsite mitigation actions?

2006 to 2008

9/06	1-year (07) and 5-year (07 to 11) Implementation Plans	2005 adult return data
9/07	1-year (08) and 5-year (08 to 12) Implementation Plans	2006 adult return data
9/08	1-year (09) and 5-year (09 to 13) Implementation Plans including the following: *Cumulative assessment of implementation *Results of research on critical uncertainties *Results of pilot studies	2007 adult return data NMFS reassessment of status, including population growth rates (λ)

2008 Progress Check-in

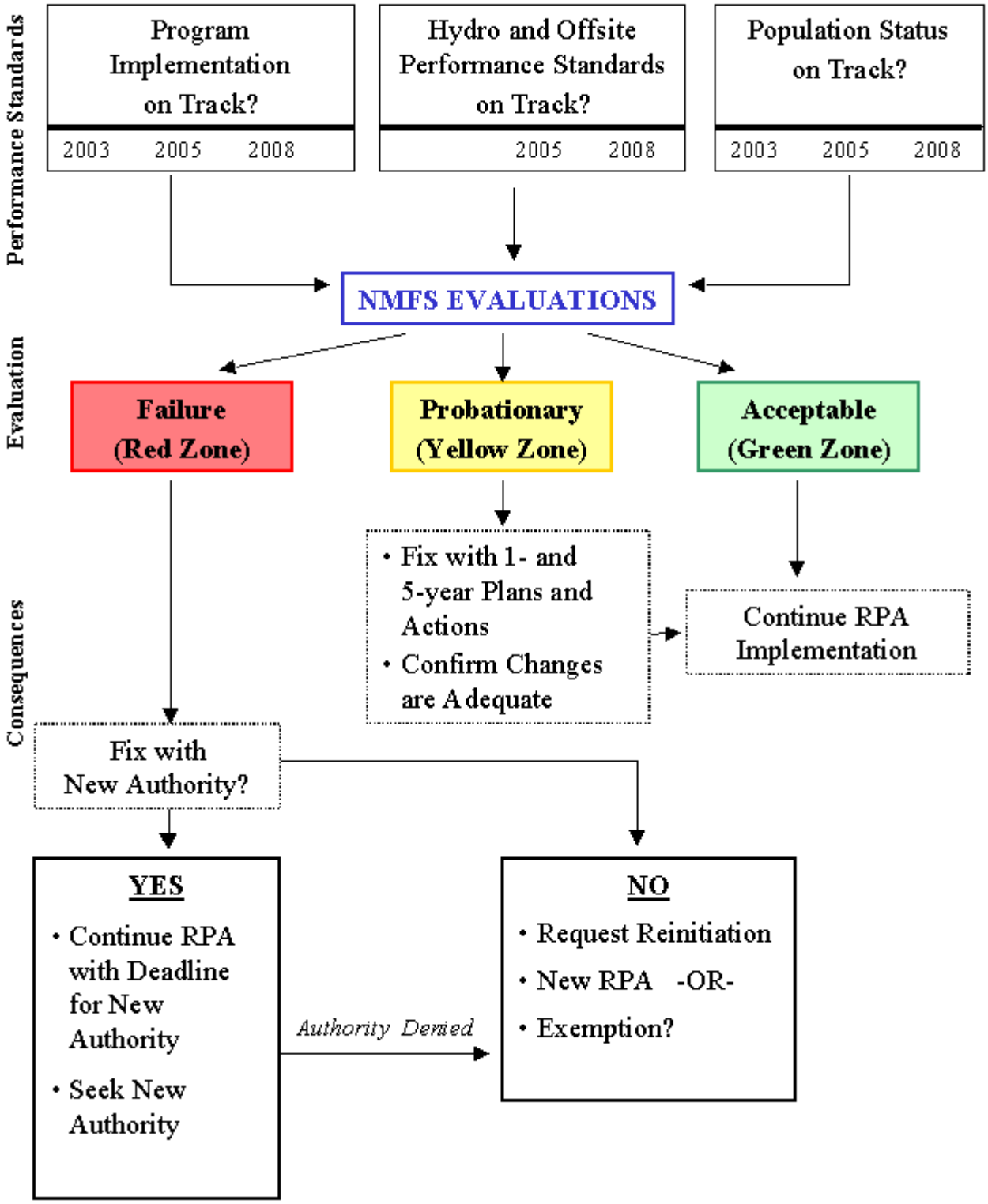
Question 1: What is the status of 1- and 5-year plan development and implementation?
Question 2: What is the status of stocks?
Question 3: How effective are hydrosystem actions?
Question 4: How effective are offsite mitigation actions?

2009 to 2010

9/09	1-year (10) and 5-year (10 to 14) Implementation Plans	2008 adult return data
9/10	1-year (11) and 5-year (11 to 15) Implementation Plans and new Biological Assessment reinitiating consultation	2009 adult return data

2011 Biological Opinion Jeopardy Analysis

Figure 9.5-2. Evaluation Flow Chart



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9.5.2 Implementation Progress Check-in 2003

9.5.2.1 Purpose

NMFS' 2003 implementation progress evaluation will focus primarily on the implementation of the RPA measures and, in particular, on the early implementation of hydro, offsite mitigation and research, monitoring, and evaluation measures that are essential to avoid jeopardy and adverse modification of critical habitat. The timely development of performance standards to evaluate the effectiveness of hydro and offsite mitigation measures by 2005 and 2008 is equally essential to ensure that the RPA continues to meet section 7(a)(2) standards. NMFS will consider whether any other new information relevant to species status indicates that the FCRPS/BOR operations are having a materially greater adverse effect than originally assessed and should be considered at this time. NMFS will also determine whether the Basinwide Recovery Strategy is being implemented in a manner likely to be effective, timely, and consistent with its scientific basis.

9.5.2.2 Contents of 2003 Annual Progress Report

In their 2003 annual progress report (due September 1, 2003), the Action Agencies will include a comprehensive and cumulative assessment of their success in implementing the actions called for in this RPA. In addition to the requirements for each annual progress report (as specified in Section 9.4.2.13), the 2003 annual progress report will document the Action Agencies' findings, developed in coordination with Federal agencies, regarding each of the following:

- Whether the Action Agencies have obtained the *funding and authorizations necessary for timely implementation of key actions* identified in this RPA and the annual planning processes and whether those actions are being implemented as expected or in a manner likely to be effective and timely as outlined in this biological opinion. Appendix F provides a summary of the actions, as of the date of this biological opinion, and the specific expectations for this progress check. Key actions are those that 1) are expected to result in near-term survival benefits for the listed stocks, 2) are preparations for implementation of additional survival improvement measures, or 3) are planning, research, and monitoring actions that are important for implementation and evaluation of progress by 2005 and 2008. These expectations are the programmatic standards against which implementation success will, in part, be evaluated. Modification of the list of actions in Appendix F is expected through the 1- and 5- year planning consistent with these criteria above.

- Whether the Action Agencies have initiated *adequate pilot studies, research, and monitoring* projects identified pursuant to Section 9.6.5.3 to confirm or rebut key assumptions. This documentation will include studies of the survival response to habitat actions identified pursuant to the RPA and the Basinwide Recovery Strategy as necessary to improve life-stage survivals of listed fish species.

- Whether *subbasin assessments* have been developed in accordance with Section 9.6.2.1 and *hatchery genetic management plans and safety net planning* have been completed pursuant to Section 9.6.4.2, as well as whether the results of these planning actions have been incorporated into site-specific plans for offsite mitigation.

- Whether the Action Agencies, in coordination with other Federal agencies, have adopted biological performance standards determined by NMFS, based on the best science available, as sufficient 1) to *evaluate the status of each ESU relative to survival and recovery indicator criteria*, using, in particular, ESU-specific recovery standards that incorporate measures of abundance, productivity trends, species diversity, and population distribution and 2) to *evaluate how effectively the actions produce survival improvements* to meet the offsite mitigation performance standard described in Table 9.2-4.

- Whether the Action Agencies have adopted detailed *site-specific, offsite mitigation plans* to meet the offsite mitigation performance standard described in Table 9.2-4, based on completed subbasin assessments, finer scale analyses, and the best available science, are implementing such plans in accordance with their provisions, and have adequate monitoring in place to evaluate their effectiveness.

- Whether the Action Agencies have established *measurable, objective physical performance standards* approved by NMFS based on the best available science to achieve habitat attributes and hatchery reforms through management actions that provide the life cycle survival improvements needed to achieve survival and recovery indicator criteria consistent with Sections 9.2.2.2.2 and 9.2.3.

- Whether the Federal agencies participating in the Federal Caucus (other than the hydro Action Agencies) have obtained the funding and authorizations necessary for the timely implementation of specific *action items identified in the Basinwide Recovery Strategy* and whether those action items are being implemented in a manner likely to be effective, timely, and consistent with the scientific basis for the Basinwide Recovery Strategy. Federal Caucus members will provide this information to NMFS and the Action Agencies as part of the Basinwide Recovery Strategy implementation.

9.5.2.3 NMFS' Evaluation of the 2003 Annual Progress Report

In 2003 NMFS shall evaluate the Action Agencies' implementation of the RPA as of that date based upon the 2003 Annual Progress Report and the best available science. NMFS will prepare an evaluation report in which it shall affirm or reject each of the Action Agencies' findings and present the basis for its evaluation.

NMFS will evaluate the implementation of Section 9.6.1 onsite FCRPS hydro actions, including the expected implementation schedule. NMFS will also evaluate the Action Agencies' success in developing 1- and 5-year plans in 2001, 2002, and 2003 and the implementation, or likely implementation, of the actions identified in those plans. NMFS' evaluation of offsite mitigation plans and description of action implementation will conclude whether or not they have been developed to a level of detail sufficient to evaluate and ensure their effectiveness. For habitat actions, this detail will be accomplished primarily through subbasin assessments and finer scale analyses; for hatchery actions, the details will be developed through hatchery genetic management plans and safety net planning. These planning activities must be completed and the results incorporated into site-specific and ESU-specific plans for offsite mitigation by the 3-year progress check. For both habitat and hatchery actions, the focus will be on early implementation priorities specified in the RPA and initial 5-year plan (due March 31, 2001). For research, monitoring, and evaluation studies, progress must include initiation of research on critical uncertainties and pilot studies to test key assumptions relating habitat improvements to life stage survival improvements for listed fish species. The pilot studies will specifically include focused efforts on intermediate stage survival (e.g., egg-to-parr and parr-to-smolt) in some carefully selected sites to provide an initial check on the effectiveness of habitat actions.

NMFS' report will determine whether, on balance, the Action Agencies' implementation of the RPA is substantially meeting expectations (green zone); not meeting expectations, but capable of timely restoration within current authority (yellow zone); or failing, although possibly rectifiable with additional authority (red zone) (Figure 9.5-2). The report will explain the basis for its determination using the best science available.

If the evaluation report shows that the implementation is neither timely nor sufficient, or is not adequate to address new information about species status, NMFS will determine whether the deficiency can be remedied by actions within current authority (i.e., the yellow zone). If NMFS determines that actions exist, within the full authority and capability of the Action Agencies, that can restore the timely and complete implementation of the RPA to the extent necessary to meet the expectations for the 2005 and 2008 check-in evaluations, then NMFS will indicate how the Action Agencies can revise RPA implementation through new 1- and 5- year plans to meet the hydro and off-site performance standards. For example, the plans could call for further efforts to reduce hydro system mortality.

If NMFS determines that the insufficiency of the Action Agencies' RPA implementation cannot be remedied through changes to the 1- and 5- year plans, NMFS will issue a failure report.

Insufficient implementation of key actions (see Section 9.5.2.2 and Appendix F) would necessarily result in a failure report. NMFS' failure report will identify any actions, in particular those not currently authorized for implementation by the Action Agencies, that NMFS has determined are necessary for the FCRPS and BOR projects to avoid jeopardizing the listed species and adversely modifying their critical habitat. The Action Agencies would then seek and obtain additional authority from congress to ensure that the actions continue to avoid jeopardy and adverse modification of critical habitat. For example, failure to implement enough estuary or tributary habitat improvements for Snake River ESUs could necessitate that the Action Agencies seek authorizations to breach Snake River dams (while continuing efforts to restore estuary and tributary habitat) to ensure that all options are available at the mid-point evaluation in 2005. If such actions exist, NMFS will also determine whether all of the listed salmonid ESUs are likely to survive, while retaining an adequate potential to recover, during the time reasonably necessary to obtain required authority and implement the action(s). If NMFS determines that even those additional actions would be insufficient, it may recommend reinitiation of consultation. The Action Agencies also may reinitiate consultation.

Because only limited, new empirical data and analyses are likely to be available in 2003, NMFS does not anticipate reassessing the jeopardy analysis during this evaluation, nor is a scientific peer review of the evaluation report likely to be warranted.

Failure to implement the RPA may also have consequences for consultations on other Federal agency actions that affect listed species in the Columbia River basin, particularly hatchery management and those actions that may affect the estuarine or tributary habitat of the affected ESUs.

9.5.3 The 2005 Evaluation

9.5.3.1 Purpose

In 2005, as in 2003, NMFS will check on the implementation of the key RPA measures. In this check-in, however, the status of the listed salmonid ESUs and biological and physical performance standards will be of equal importance to implementation actions. NMFS will reevaluate the listed ESUs based on performance standards, new monitoring data, results of research on critical uncertainties, and initial results from pilot studies. NMFS will assess whether the population growth rates are improving relative to the levels estimated in 2000 and whether population abundance levels are consistent with standards established in the RPA (see Section 9.2.2.1).

9.5.3.2 Contents of the 2005 Annual Progress Report

The Action Agencies shall provide the best available scientific information regarding each of the topics required for the 2003 annual progress report and, in particular, will include full and complete information about the issues presented in the subsections below.

9.5.3.2.1 Status of 1- and 5-year plan development and implementation. The Action Agencies shall update the information that was required for the 2003 check-in evaluation (see Section 9.5.2.2). NMFS expects that substantially more information about RPA implementation will be available in 2005. In particular this review will assess the timely and sufficient completion of key actions as prescribed by this RPA.

9.5.3.2.2 Status of the listed stocks. Enough new data shall be provided to allow NMFS to apply the performance standards provided in Section 9.2.2.1, including the abundance, productivity trends, species diversity (genetic and life history diversity), and population distribution for each listed ESU.

9.5.3.2.3 Effectiveness of hydrosystem actions. The Action Agencies shall provide enough information for NMFS to complete a thorough review of the adequacy of hydrosystem actions taken, a revision of juvenile and adult hydrosystem survival estimates, evaluations of delayed mortality of transported fish and inriver migrants, and assessments of the ability to improve juvenile fish passage survival through actions taken under the RPA, e.g., surface bypass development and evaluations of the effectiveness of 24-hour spill. Such evaluations should more clearly define the potential effectiveness of breach, transport, and inriver alternatives. The Action Agencies will document their conclusions as to whether they are making adequate progress to reach full attainment of the hydro performance standard by 2010.

9.5.3.2.4 Effectiveness of off-site mitigation actions. The Action Agencies shall review the offsite actions that have been implemented, list their benefits (specific to each ESU), and assess those offsite actions that are planned for implementation. The Action Agencies will provide enough information to enable NMFS to verify their findings and draw conclusions regarding the following key evaluations:

- Have the Action Agencies demonstrated (through pilot studies, historical data assessments, and implementation monitoring) that proposed actions can increase life stage survivals?

- Are the actions with demonstrated survival improvements being implemented at a scale sufficient to avoid jeopardy for each population and each ESU as appropriate, in light of the effects of all other actions that may affect the relevant population and ESU?

9.5.3.3 NMFS' Evaluation of 2005 Annual Progress Report

In 2005, NMFS will issue its evaluation affirming or rejecting each of the Action Agencies' findings in the annual report described above and will conduct comprehensive evaluations of Action Agency activities (and those of cooperating parties), the results of pilot studies, and the results of research on critical uncertainties. NMFS will also develop a complete reassessment of the status of each ESU, including population growth rates (e.g., lambda), abundance, geographic distribution, genetic diversity, and life history diversity. This reassessment will include a

specific review of performance relative to the survival and recovery indicator criteria. For the 2005 evaluation, the performance standards specified in Section 9.2 must be satisfied for this RPA to be considered successful.

As part of the review, NMFS will incorporate any additional information available through the 2004 returns and, for populations representative of each ESU, will provide the following:

- An updated extinction risk analysis based on estimates of the population growth rates (e.g., lambda) from 1980 to the present and incorporating updated estimates of abundance

- An extinction risk analysis based on estimates of the population growth rates (e.g., lambda) from the most recent year for which adult return data are available, going back a long enough time to make an adequately precise estimate (approximately 10 to 12 years)

- Expected population growth rates, abundance, distribution, and resulting extinction risks based on implementation of the RPA, specifying the effects attributable to offsite mitigation (including pilot studies) and the combined effects of all other actions (e.g., from the Basinwide Recovery Strategy) that may affect the populations

- Estimates of survival gains necessary to achieve recovery/survival indicator criteria

NMFS anticipates that methods of assessing annual population growth rates will have been refined, based on NMFS' research efforts, those of the Action Agencies, or those of independent scientists. In anticipation of this normal progress in scientific methods, NMFS does not now define a specific method by which population growth rate will be determined for its mid-point evaluations. By March 1, 2005, NMFS will choose the most appropriate method(s) to estimate population growth rate from the peer-reviewed literature, based on collaboration with the Action Agencies, USFWS, and the state and Tribal comanagers.

By 2005, the Action Agencies must have implemented the hydro, habitat, and hatchery projects specified in 1- and 5-year plans. In addition, the Action Agencies must have initiated research on critical uncertainties and implemented pilot studies to evaluate offsite mitigation benefits, particularly the kinds of life-stage-specific survival improvements that can be expected from their implementation. Based on best available science, NMFS will calculate expected future population growth rates and conclude whether the expected rates are consistent with the estimated level of improvement needed to achieve the survival and recovery indicator criteria. To do this, NMFS will use the improved information on project effectiveness from the pilot studies and improved information on the extent of implementation from the progress reports and compliance monitoring to estimate life-stage-specific survival improvements for all populations. Physical performance standards will remain important as measures of RPA effectiveness for habitat and hatcheries because of the lag times between these habitat actions and population response.

NMFS' report will document its findings related to all available measures of the status of the ESUs (e.g., abundance, distribution, and diversity), including those developed through the technical recovery team process for recovery planning. As the data available in 2005 may be too preliminary for conclusive analysis, NMFS may also recommend measures to refine its preliminary findings no later than the 2008 evaluation.

If the evaluation report finds the implementation is on track (i.e., in the green zone) then implementation will proceed unchanged. If NMFS' evaluation finds that implementation is neither timely nor sufficient, or if NMFS finds that the status of one or more of the listed species has worsened, it will determine whether the insufficiency falls into the probationary yellow zone. If it does, NMFS will then identify how the Action Agencies can revise their implementation through new 1- and 5-year plans to meet the hydro and offsite performance standards. For example, the plans could call for further efforts to reduce hydro system mortality, such as improved flow and spill. Also, if the Action Agencies have obtained additional authority (such as dam breaching authority [see Section 9.6.1.9]) pursuant to direction from the 2003 check-in, they may rectify the RPA's performance by exercising such authority immediately.

If NMFS determines that the RPA's implementation problems cannot be rectified through actions provided in 1- and 5-year plans, it will issue a failure report. The failure report will identify any actions not currently authorized for implementation by the Action Agencies, but that NMFS determines are consistent with the purposes of the FCRPS, technologically and economically feasible, and required to enable the FCRPS and BOR projects to be most likely to avoid jeopardizing the listed species and adversely modifying their critical habitat. The Action Agencies would have to seek and obtain additional authority from congress to ensure that they could continue to avoid jeopardy and adverse modification of critical habitat. For example, failure to implement enough of the estuary or tributary habitat improvements required for Snake River ESUs could mean that the agencies would have to seek authorizations to breach Snake River dams (while continuing efforts to restore estuary and tributary habitat) to ensure that all options are available at the next evaluation in 2008. If other such actions exist, NMFS would also determine whether all of the listed salmonid ESUs are likely to survive, while retaining an adequate potential to recover, during the time needed to obtain the required authority and to implement the action(s).

If NMFS determines that even those additional actions would be insufficient (red zone), it may recommend reinitiation of consultation. The Action Agencies also may reinitiate consultation.

Failure to implement the RPA may also have consequences for consultations on other Federal agency actions that affect listed species in the Columbia River basin, particularly hatchery management and those actions that may affect the estuarine or tributary habitat of the affected ESUs.

9.5.4 The 2008 Evaluation

9.5.4.1 Purpose

Although RPA implementation will still be important in 2008, achievement of performance standards, including the performance of the listed salmonid ESUs will be of primary concern in the 2008 evaluation. NMFS will reconsider all aspects of the evaluations made in 2003 and 2005, based upon the best scientific data available by 2008. In addition, NMFS will assess the population effects attributable to the measures implemented since 1995, based, in particular, on fish returns since 1995; life-stage survival improvements, including hydro survival improvements; and physical performance standards, especially for habitat and hatchery actions.

9.5.4.2 Contents of the 2008 Annual Progress Report

The Action Agencies will provide, in coordination with NMFS and USFWS, the information, findings, and conclusions for every element required in the 2005 evaluation, representing the best scientific data and analysis available by 2008.

9.5.4.3 NMFS' Evaluation of the 2008 Annual Progress Report

In 2008, NMFS will update and refine the analyses it performed for the 2005 evaluation based on the best science and analysis available by 2008. In addition, NMFS will estimate those conditions and population trends attributable to the significant changes in operations initiated with the 1995 biological opinion. Other measures of the status of the ESUs will also be evaluated, as defined through the recovery planning process. NMFS will issue its evaluation report, affirming or rejecting each of the Action Agencies' findings in the annual report, documenting its findings concerning the success or failure of the Action Agencies' implementation of the RPA. In particular, the 2008 evaluation must conclude that the performance standards specified in Section 9.2 are satisfied for the implementation of this RPA to be considered successful.

NMFS anticipates that methods of assessing annual population growth rates will have been refined, based on NMFS' research efforts, those of the Action Agencies, or those of independent scientists. In anticipation of this normal progress in scientific methods, NMFS does not now define a specific method by which population growth rate will be determined for its mid-point evaluations. By March 1, 2008, NMFS will choose the most appropriate method(s) to estimate population growth rate from the peer-reviewed literature, based on collaboration with the Action Agencies, USFWS, and the state and Tribal comanagers.

By 2008, habitat, hatchery, and hydro projects specified in the 1- and 5-year plans must have been implemented, and pilot studies should continue to validate the kinds of life-stage-specific survival improvements that can be expected from their implementation. Physical performance

standards will remain important due to lag times between these actions and population response. NMFS will have improved information on project effectiveness from the pilot studies and on the extent of implementation from the progress reports and compliance monitoring to estimate life-stage-specific survival improvements for all actions to be credited with such improvements and for all populations. Based on this information, NMFS will calculate expected future population growth rates and conclude whether or not the expected rates are consistent with the level of improvement estimated to be necessary to achieve the survival and recovery indicator criteria.

If NMFS determines that RPA implementation is not timely or sufficient, or if it finds that the status of one or more of the listed species has changed materially for the worse, NMFS will determine whether the RPA implementation can be revised through the 1- and 5-year planning process to meet the hydro and offsite performance standards. If so, the RPA implementation will be considered to be in the yellow zone, as in Figure 9.5-2, above. If the RPA can be restored, NMFS will recommend additional measures to address the changed status of the affected ESU(s) or the effects of inaction upon the ESU(s). For example, the plans could call for further efforts to reduce hydro system mortality, such as improved flow and spill. Also, if the Action Agencies have obtained additional authority, including dam breaching authority, pursuant to direction from the 2003 or 2005 check-ins, they may restore the RPA's performance by exercising such authority immediately.

If NMFS finds that any of the listed salmonid ESUs have failed to perform as expected by 2008 (see Section 9.2), it will conclude that the RPA is in the red zone, unless enough authority has become available for implementation in 2008. If NMFS determines that the RPA implementation cannot be remedied through changes to the 1- and 5-year plans, NMFS will issue a failure report. The failure report will identify any actions not currently authorized for implementation by the Action Agencies, but that NMFS determines are technologically and economically feasible, consistent with the purposes of the FCRPS and necessary to enable the FCRPS and BOR projects to be likely to avoid jeopardizing the listed species and adversely modifying their critical habitat. A failure report from NMFS, identifying such actions, would require the Action Agencies to seek and obtain additional authority from congress to ensure that the agencies continue to avoid jeopardy and adverse modification of critical habitat. For example, failure to implement estuary or tributary habitat improvements required for Snake River ESUs could mean that the agencies would have to seek authorizations to breach Snake River dams (while continuing efforts to restore estuary and tributary habitat). If NMFS determines that even those additional actions would be insufficient, it may recommend reinitiation of consultation. The Action Agencies may also reinitiate consultation.

Failure to implement the RPA may also have consequences for consultations on other Federal agency actions that affect listed species in the Columbia River basin, particularly hatchery management and those actions that may affect the estuarine or tributary habitat of the affected ESUs.

9.5.5 Procedural Options after a Yellow Zone or Red Zone Evaluation Report

At any of the evaluation points, NMFS may conclude that the RPA, as implemented by the Action Agencies, fails, or is in danger of failing, to satisfy the ESA Section 7(a)(2) requirement to avoid jeopardy and adverse modification of critical habitat for any of the listed species affected by the covered actions. In other words, NMFS may determine that the Action Agencies' implementation is in the yellow or red zones (see Figure 9.5-2). At year 3, that conclusion would most likely be based on failure of the Action Agencies to fully implement the actions called for in the RPA and its 1- and 5-year planning process. At years 5 or 8, this conclusion would be based primarily on the results of an updated jeopardy analysis, taking into account the current status of the listed species and the effectiveness of the RPA measures. At the 3-, 5-, or 8-year check-in, in a red zone situation, a determination can be made, under certain conditions, to pursue authority to breach one or more dams or to seek authorization and appropriations for additional actions necessary to address the situation for stocks that would not benefit from dam breaching. The procedures to address this situation are described in the next section.

9.5.5.1 1- and 5-Year Plan Amendments

The RPA is designed to respond to new information within the authority of the Action Agencies. Through the 1- and 5-year planning process, shortfalls in the performance of the RPA measures or adverse changes in the species' status must, at a minimum, be adequately addressed by plan modifications. If, for example, the Action Agencies implement a measure that is not effective, or they are unable to implement an expected measure, the planning process requires them to identify alternative measures, within their full authorities, to provide the necessary survival benefits to the listed species. The annual progress reports and the mid-point evaluations must ensure that such shortfalls are adequately addressed. Similarly, if the status of the stocks changes or is worse than originally assessed, the Action Agencies may identify additional RPA measures in their planning processes to ensure that the RPA will have the expected results. NMFS must ensure that enough scientific basis exists to ensure that the additional RPA measures will produce the results expected. Improvement in stock status that is due primarily to environmental variation, such as improved ocean conditions or high runoff years, will not be a basis for curtailing measures intended to address anthropomorphic factors for decline.

9.5.5.2 Continuance to Obtain Authority or Appropriations

If NMFS finds that the RPA fails to meet ESA Section 7(a)(2) standards despite the Action Agencies' exercise of their current authority, and thus the RPA is in the red zone, NMFS will identify additional actions that would satisfy those standards if implemented by the Action Agencies, even though the Action Agencies lack the necessary authority and/or appropriations. Such actions would likely include the breach of one or more dams for those Snake River stocks that would benefit from such actions. As of the date of this biological opinion, dam breaching may significantly improve the survival of Snake River ESUs and is a potential remedy for a failure to achieve performance standards, due to implementation failure or an adverse change in

stock status, for the Snake River ESUs. Thus, this biological opinion presumes that the Action Agencies would have to seek this additional authority for Snake River ESUs in the red zone. For Mid-Columbia and Upper Columbia ESUs, a comparable remedy may be appropriate, though the state of the science is not as well developed as of the date of this biological opinion. NMFS will make this red zone determination using the best science available at the time.

NMFS must be able to find, using the best science available, that the Action Agencies' continuing implementation of the RPA, as detailed in the 1- and 5-year plans, satisfies ESA Section 7(a)(2) standards for a long-enough time to obtain and exercise the necessary authority and appropriations. This is particularly appropriate for FCRPS and BOR projects because their operation is ongoing and cannot be stopped while new authority is obtained. In this situation, therefore, the Action Agencies may seek the authority and/or appropriations for the necessary measures, within the time specified by NMFS. During this time, they would otherwise continue to implement the RPA. Continued implementation of the RPA would remain essential to the survival of all ESUs in life stages not affected by dam breaching. NMFS' report, prepared in coordination with the Action Agencies, would provide the available scientific and technical data and analysis demonstrating the likely feasibility and effectiveness of the measure. Failure to obtain the requisite authority or appropriation within the specified time period would trigger a reinitiation of this consultation.

9.5.5.3 Reinitiation of Consultation

If NMFS finds that the RPA, as implemented, fails to avoid jeopardy to the listed species or adverse modification of their critical habitat, and neither of the preceding procedural options is available, this consultation must be reinitiated pursuant to Chapter 13 and the consultation regulations at 50 CFR Section 402.16. During a reinitiation of consultation, NMFS would reapply the ESA Section 7(a)(2) standards to the effects of the RPA implemented by the Action Agencies. In a new biological opinion, NMFS would reassess the status of the listed species, taking into account the likelihood of survival and recovery as affected by actions across the life cycle of each listed species. NMFS must conclude whether there is any RPA that avoids jeopardy as defined in 50 CFR Section 402.02. If not, then NMFS would document that, after a good faith, reasonable, and responsible effort, no RPAs could be developed within the authority of the Action Agencies, thereby making the actions covered by this opinion eligible for an ESA exemption.

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9.6 MEASURES TO AVOID JEOPARDY

9.6.1 Hydro Measures

9.6.1.1 Overview

Operational and structural fish passage improvements at FCRPS projects are proposed to increase the survival of listed fish. This section describes the specific hydro measures that NMFS has determined, based on the best scientific information, to be as follows:

- Biologically feasible and implementable
- Sufficient to achieve performance standards that represent the best the hydrosystem can do without dam breaching
- Sufficient to result in a high likelihood of survival and a moderate-to-high likelihood of recovery, combined with offsite mitigation defined in Sections 9.6.2, 9.6.3, and 9.6.4 of this biological opinion and with other improvements affecting the listed species described in the Basinwide Recovery Strategy

The hydrosystem measures are expected to reduce juvenile and adult salmonid mortality attributable to passage through the hydrosystem and to attain the hydro performance standards by 2010. Their main features are described briefly below.

Proposed measures for improving water management so as to provide direct and indirect survival benefits to salmon include the following:

- Meet flow objectives at Lower Granite, Priest Rapids, McNary, and Bonneville dams.
- Provide in-season management for operational flexibility and best use of available water volumes.
- Provide guidance on reservoir elevations in early spring, early summer, and at the end of the summer flow augmentation season.
- Coordinate with water releases from Canada, the upper Snake River, and the Hells Canyon Complex.
- Take specific actions to improve water management for salmon: 1) additional drafts of selected FCRPS reservoirs, 2) additional water from other sources, 3) shifts of flood control among projects, 4) implementation of VARQ flood control operations at Libby and Hungry Horse reservoirs, 5) review of system flood control objectives, and 6) continued research on summer-migrating SR fall chinook salmon population losses.

The following actions are prescribed for improving juvenile passage survival through the FCRPS to the ocean:

- Increase spillway passage using gas abatement and longer spill hours to allow greater spill volumes; also, refine spill patterns and evaluate removable spillway weirs (RSWs) as ways of improving spill efficiency.
- Conduct research on spillway passage to identify additional potential survival and passage improvements.
- Increase screen/bypass system effectiveness with extended screens, new outfalls, and improved hydraulic conditions.
- Develop and test surface bypass technology, with implementation as appropriate.
- Provide improved turbine designs and operating guidelines.
- Improve passage system operations and reliability.

Measures for improving juvenile reservoir survival, and thereby increasing the survival of downstream migrating salmon, include the following:

- Increase flow augmentation for summer migrants, particularly in the low water years.
- Manage reservoir and run-of-river projects to reduce extreme water level fluctuations.
- Manage predator populations (fishes, birds, and mammals).

Measures for improving adult survival are as follows:

- Develop actions to reduce fallback through turbines and over spillways.
- Increase facility reliability and the ability to maintain operating criteria.
- Investigate measures to protect steelhead kelts.
- Investigate prespawning mortality.

Measures for improving water quality include the following:

- Make structural and operational modifications at spillways (e.g., spillway deflectors, improved spill patterns) to help reduce TDG levels.

- Develop alternative fish passage measures (e.g., surface bypass).
- Release cool water from storage reservoirs (e.g., Dworshak Dam).
- Institute special powerhouse operations (e.g., McNary Dam).

NMFS proposes active investigation to reduce or resolve key uncertainties. Critical uncertainties relate primarily to the hypothesis of delayed mortality due to passage through the hydrosystem:

- Investigate delayed mortality of transported juvenile migrants (D-value when expressed relative to the survival of nontransported migrants below Bonneville Dam).
- Investigate delayed mortality of inriver juvenile migrants (extra mortality).
- Investigate delayed mortality or passage effects on adults.
- Investigate estuarine/ocean survival.

Measures are also proposed for enhanced O&M of fish passage facilities. Developing appropriate annual budgets through the annual 1- and 5-year planning process will help ensure continued high performance of fish passage facilities. Preventive maintenance planning and day-to-day operation of fish passage facilities can be improved by an increased commitment to excluding debris and operating within identified criteria.

NMFS believes the strength of these measures depends not only upon scientific analysis, but also on the joint decision-making processes defined in Section 9.4. Involvement and input from the region's fish and wildlife managers and Indian Tribes are necessary to ensure that all of the best scientific and technical information is considered in the effort to avoid jeopardy.

9.6.1.2 Water Management

9.6.1.2.1 Flow Management Objectives in Mainstem Columbia and Lower Snake Rivers

Action 14: The Action Agencies shall operate FCRPS dams and reservoirs with the intent of meeting the flow objectives (Table 9.6-1) on both a seasonal and weekly average basis for the benefit of migrating juvenile salmon.

This flow-management program uses three strategies:

- Limit the winter/spring drawdown of storage reservoirs to increase spring flows and the probability of reservoir refill.
- Draft from storage reservoirs during the summer to increase summer flows.

Table 9.6-1. Seasonal flow objectives and planning dates for the mainstem Columbia and Snake rivers.

	Spring		Summer	
Location	**Dates**	**Objective**	**Dates**	**Objective**
Snake River at Lower Granite Dam	4/03 - 6/20	85 - 100[1]	6/21 - 8/31	50 - 55[1]
Columbia River at McNary Dam[2]	4/10 - 6/30	220 - 260[1]	7/01 - 8/31	200
Columbia River at Priest Rapids Dam	4/10 - 6/30	135	NA	NA
Columbia River at Bonneville Dam	11/1-emergence	125–160[3]	NA	NA

[1] Objective varies according to water volume forecasts (see below).
[2] NMFS is contemplating moving the flow measurement location from McNary Dam to Bonneville or The Dalles dam by creating new objectives for Bonneville Dam (Conservation Recommendation 11.5).
[3] Objective varies based on actual and forecasted water conditions.

- Provide minimum flows in the fall and winter months to support mainstem spawning and incubation below Bonneville Dam.

Under the first strategy, the FCRPS storage reservoirs are operated to ensure a high probability of water surface elevations within 0.5 foot of the flood control rule curve by April 10 and to refill by June 30, except as specifically provided by the Technical Management Team. Before the 1995 Biological Opinion, FCRPS storage reservoirs were routinely drafted well below these levels to maximize hydropower generation during the fall and winter. Meeting the spring flow objectives occasionally requires reservoir drafting, but the spring flow objectives are primarily met by limiting winter drafting and reservoir refill rates. This operation allows for a more natural spring hydrograph by passing spring runoff through the storage reservoirs.

The second strategy is used to facilitate summer operations. FCRPS storage reservoirs are drafted as necessary within specified limits in an attempt to meet the summer flow objectives and to provide colder water for the benefit of migrating juvenile salmonids. These operations may also benefit adults in passage by moderating temperatures.

The third strategy has recently been integrated into the overall flow management objective to provide habitat for mainstem spawning chum and fall chinook. It includes subsequent flows to protect the redds from dewatering through their emergence in the spring, to the extent possible without impacting refill probabilities of FCRPS storage projects and spring flow objectives.

Data collected to date regarding the effects of flow on survival of fall chinook juvenile migrants (NMFS 2000h) indicate that flows ranging from 80 to 100 kcfs measured at Lower Granite Dam during the summer migration period would be optimal for these fish. Although juvenile fall chinook survival is correlated with streamflow, survival shows similar correlations to water temperature and turbidity (NMFS 2000h). For this reason, water quality, particularly water

temperature, should be considered in determining the optimum use of available stored water volumes for flow augmentation in the Snake River. NMFS is not revising the Snake River summer flow objectives to an 80- to 100-kcfs range at this time. The existing seasonal flow objectives established by the 1995 FCRPS Biological Opinion (NMFS 1995a) represent a fair balance between flow and water quality conditions.[6]

Spring Flows at Lower Granite Dam. Based on the April final runoff volume forecast at Lower Granite Dam for April to July, spring flow objectives will be determined as follows:

- When the volume forecast is less than 16 Maf, the flow objective will be 85 kcfs.
- When the volume forecast is greater than16 Maf and less than or equal to 20 Maf, the flow objective will be determined by a linear interpolation between 85 kcfs and 100 kcfs.
- When the volume forecast is greater than 20 Maf, the flow objective will be 100 kcfs.

Summer Flows at Lower Granite Dam. Based on the June final runoff volume forecast at Lower Granite Dam for April to July, summer flow objectives will be determined as follows:

- When the volume forecast is less than 16 Maf, the flow objective will be 50 kcfs.
- When the volume forecast is greater than 16 Maf and less than or equal to 28 Maf, the flow objective will be determined by a linear interpolation between 50 kcfs and 55 kcfs.
- When the volume forecast is greater than 28 Maf, the flow objective will be 55 kcfs.

Spring Flows at McNary Dam. Based on the April final runoff volume forecast at The Dalles Dam for April to August, spring flow objectives will be determined as follows:

- When the volume forecast is less than 80 Maf, the flow objective will be 220 kcfs.
- When the volume forecast is greater than 80 Maf and less than or equal to 92 Maf, the flow objective will be determined by a linear interpolation between 220 kcfs and 260 kcfs.
- When the volume forecast is greater than 92 Maf, the flow objective will be 260 kcfs.

Spring Flows at Priest Rapids Dam. The spring flow objective at Priest Rapids Dam will be 135 kcfs.

[6]The issue of providing water from BOR's upper Snake basin and Idaho Power Company's Hells Canyon projects to assist in achieving Snake River flow objectives will largely be addressed in separate, ongoing Section 7 consultations.

Summer Flows at McNary Dam. The summer flow objective at McNary Dam will be 200 kcfs. The best biological information supports flows of 200 kcfs for subyearling chinook salmon in the lower Columbia River. If the numbers of juvenile fish migrating during late August decrease sharply, however, the Technical Management Team should consider preserving some of the flow augmentation water to support the fall spawning operation below Bonneville Dam.

Action 15: The Action Agencies shall operate the FCRPS to provide flows to support chum salmon spawning in the Ives Island area below Bonneville Dam.

A spawning operation will be implemented as described below if the best hydrologic data available by early October indicate that precipitation, runoff, and reservoir storage are likely to support the operation from the start of spawning (late October or early November) until the end of emergence (generally through the start of the spring flow augmentation season in April). The spawning operation cannot adversely affect implementation of this RPA or the parties' ability to comply with the Vernita Bar agreement. That agreement protects natural production of unlisted fall chinook in the Columbia River Hanford Reach. If these conditions cannot be met, the Action Agencies will work with NMFS and regional salmon managers to identify operations that would benefit salmon while maintaining these other fish protection measures. Such operations may include intentional flows below what is necessary for mainstem spawning to discourage redds from being established in the area.

Real-time operating decisions will be made through the in-season management process described in Section 9.4. The Technical Management Team will recommend a managed daily average discharge level as information on natural flows and reservoir storage becomes available. The operation for Columbia River mainstem spawning chum salmon will include the following considerations:

- If the operation complies with the conditions described above, it will begin when chum salmon are found in the area around Ives and Pierce islands, but no later than November 1. From November 1 through December 31, FCRPS storage will be used to shape or augment natural flow to a 125 kcfs minimum instantaneous discharge from Bonneville Dam. To prevent spawning in areas that could be subsequently dewatered, the Action Agencies will maintain peak flows within 5 kcfs of the established minimum. For example, if the minimum flow is 125 kcfs, the instantaneous maximum would be 130 kcfs.

- NMFS recognizes that access to spawning habitat in the Ives Island area is primarily a function of the water surface elevation in the Ives Island and Pierce Island areas. Water surface elevation, is in turn, influenced by tides, flow of the Willamette River and discharge from Bonneville Dam. If the established managed discharge cannot be maintained on an instantaneous basis (e.g., during a low spring tide), the Action Agencies will manage FCRPS operations to maintain the water surface elevation in the Ives Island area above the highest redd established by the protection level developed through the in-

season management process. There may be times when this is best accomplished by managing to a Bonneville Dam tailwater gage height rather than to a flow level.

- When reservoir storage, baseflows, and predicted hydrologic conditions permit, a managed instantaneous minimum discharge greater than 125 kcfs may be adopted through coordination with NMFS and the Regional Forum. If such a higher minimum discharge is adopted, the Action Agencies will manage storage with natural flow to provide peak flows within 5 kcfs of the established minimum.

- During incubation and emergence (January 1 through the start of the spring flow augmentation program for the lower Columbia River on April 10), the Action Agencies will manage storage with natural flows to maintain the daily minimum discharge from Bonneville Dam or the adequate water surface elevation needed to protect the highest redd established by the operation and to maintain connectivity between spawning habitat and the mainstem for outmigrants. For example, if the highest redd established by the spawning operation was at an elevation corresponding to a Bonneville outflow of 125 kcfs, a discharge of at least 125 kcfs would be maintained through incubation and emergence. For all managed spawning flows 135 kcfs and above, the highest spawning flow minus 10 kcfs will be the managed minimum discharge during incubation and emergence. The highest managed daily average discharge that will be provided during the incubation and emergence period is 150 kcfs.

A restriction of a 5 kcfs flow range below Bonneville Dam may not be possible at all times. Hydropower operators have shaped flows to nighttime hours to keep spawning below targeted elevations in the mid-Columbia River. This shaping of flows (reverse load factoring) has proved effective in managing the elevations at which fall chinook salmon spawning occurs. However, the effect of shaping nighttime flows on limiting the spawning behavior of chum salmon has not been documented. To the extent that exceedances of the 5 kcfs range are unavoidable, night exceedances are preferable to day exceedances. Evaluation of the effect of shaping higher flows to nighttime hours on chum spawning behavior should be conducted. The Action Agencies should evaluate the effect when nighttime flows exceed the recommended flow range until such effects are better documented.

Several states noted that fluctuations in discharge from Bonneville Dam result in stranding of juveniles in the Ives Island complex. The extent and effect of these flow fluctuations is being assessed through an ongoing research program, and a preliminary recommendation for a ramping rate has been proposed. Continued evaluation of the need for an operation to limit juvenile stranding is required. When adequate information is developed, the appropriate operation shall be specified in the annual and 5-year hydro operations plan.

If in-season data on reservoir elevations and forecasted inflow indicate that operating FCRPS storage reservoirs to provide the flows specified above during chum incubation and emergence would jeopardize the ability to meet RPA items above and/or the ability of parties to comply

with the Vernita Bar agreement, the instantaneous minimum Bonneville outflow will be reduced as necessary to meet these requirements. The Action Agencies will ensure that flow reductions are coordinated through the Technical Management Team to ensure that adverse effects are minimized and to facilitate the development of emergency actions.

The provision of flow to support chum spawning creates a need to provide continual flow through the FCRPS to maintain the redds established below Bonneville Dam during the managed spawning operation. Hydrosystem modeling results suggest that conflicts will occasionally arise between providing the quantity of flow required to maintain established redds and the need to reduce discharge from Grand Coulee to achieve refill to the spring upper rule curve elevation. This potential conflict will be resolved on an annual basis. In general, achieving upper rule curve elevation by April 10 will be a higher priority.

Several states expressed concern that the flows being provided during the chum operation were minimal. Conversely, the Tribes commented that a flow of 125 kcfs is all that should be provided. NMFS maintains that an incremental approach of starting flows at 125 kcfs and increasing them as local base flows rise with seasonal precipitation is reasonable. This management approach provides connectivity with tributary spawning habitat, provides a percentage of mainstem spawning habitat, allows spring reservoir management objectives to be met with a high level of confidence, and is consistent with the concept that offsite mitigation can provide significant benefits to the chum population.

Action 16: The Action Agencies shall operate the FCRPS to provide access for chum salmon spawning in Hamilton and Hardy creeks.

During years when there is insufficient water in storage to maintain a mainstem spawning flow of at least 125 kcfs throughout the spawning season, enough flow will be provided during the chum spawning season at times to allow access to tributary creeks. Under these conditions, the Technical Management Team will develop a recommended operation through the in-season management process.

9.6.1.2.2 Planning and Management of Available Water to Support Mainstem Flow and Spill Objectives

Action 17: The Action Agencies shall coordinate with NMFS, USFWS, and the states and Tribes in preseason planning and in-season management of flow and spill operations. This coordination shall occur in the Technical Management Team process (see Section 9.4.2.2).

Flow objectives serve as a guide to manage available water resources during the juvenile and adult migration seasons and to provide a reference for comparing various operational scenarios that may affect inriver migration conditions. They are not hard constraints. Hydrologic conditions and other constraints may preclude meeting these objectives at all times. These

objectives may not represent optimal conditions and, therefore, may be exceeded if that is deemed the optimal use of water resources after considering the effects on all listed species. Likewise, flow augmentation should not be stopped or diminished once a seasonal average is met. Rather, the flow objectives provide general guidance to the Action Agencies and the Technical Management Team, discussed in Section 9.4.2.2, for in-season management considerations. Because water resources are insufficient to meet the fish flow objectives at all times under all conditions, in-season water management will strive to provide the greatest possible biological benefit from the available storage volumes and system flexibility. Although meeting the flow objectives is an important consideration, it is not an end in itself. The flow objectives are but one of many factors to consider when making decisions about river operations to benefit listed fish. The dates indicated in Table 9.6-1 are for planning purposes. Actual timing of flow measures will be determined in-season by the Technical Management Team.

The Action Agencies have multiple responsibilities affecting hydrosystem operations, including flood control, power production, protection of anadromous and resident fishes and wildlife, navigation, recreation, and irrigation, among other uses. In making operational decisions to meet other FCRPS project purposes and regulatory requirements, the Action Agencies will take all appropriate actions within their authorities to protect listed salmonids.

Several states and Tribes expressed the belief that flow objectives should be hard constraints and that this biological opinion makes too little progress toward securing the necessary water volumes to meet the flow objectives consistently. NMFS' direction to the Action Agencies is for the FCRPS to be managed with the intent of meeting flow objectives both seasonally and weekly. The volume of water available in any given year reflects both natural precipitation and the management of water held in storage. NMFS encourages the Action Agencies to secure the volumes of water needed from storage to increase the frequency of meeting the objectives and discourages actions that would decrease the likelihood of achieving the objectives. Since the achievement of flow objectives is highly influenced by natural precipitation and runoff, flow objectives cannot be hard constraints. Instead, they often serve as guides for the use of water on a seasonal or weekly basis.

9.6.1.2.3 FCRPS Reservoir Operations to Support Mainstem Objectives

Action 18: The Action Agencies shall operate the FCRPS during the fall and winter months in a manner that achieves refill to April 10 flood control elevations, while meeting project and system minimum flow and flood control constraints before April 10. During the spring, the Action Agencies shall operate the FCRPS to meet the flow objectives and refill the storage reservoirs (Albeni Falls, Dworshak, Grand Coulee, Hungry Horse, and Libby) by approximately June 30.

If both these objectives cannot be achieved, the Technical Management Team will make an in-season decision, weighing considerations unique to each particular year. Because research results indicate that flow augmentation has more direct survival benefits for summer than spring

migrants, modest reductions in spring flows to facilitate reservoir refill would generally be preferable to refill failure.

Operating the storage reservoirs to their upper (flood control) rule curve by April 10 will provide a more natural hydrograph and will increase the likelihood that spring flow objectives will be met and reservoirs refilled by June 30. Having reservoirs full on or about June 30, when natural runoff declines, results in the greatest amount of water available for the summer migration period. NMFS recognizes that meeting these flow objectives while refilling reservoirs may not be possible every year, particularly in low water years.

Interruptions or adjustments in water management actions may occur due to unforeseeable power system, flood control, or other emergencies. Such emergency actions should be viewed by the Action Agencies as a last resort and should not be used in place of the long-term investments necessary to allow full, uninterrupted implementation of the required reservoir operations while maintaining other project purposes, such as an adequate and reliable power system.

During winter power system emergencies, water being held in reservoirs for spring and summer flow augmentation may be drafted. Once the emergency is resolved, any flow augmentation water that was used should be replaced as soon as possible, to the maximum extent. During summer emergencies, storage reservoirs may be drafted below biological opinion draft limits, or bypass spill for fish may be reduced.

Discussion of emergencies with effects of exceptional magnitude or duration should include involvement of regional executives. Section 9.4.2.2 provides for the development of more specific process modifications to address these needs in the water management plans.

Action 19: The Action Agencies shall operate specific FCRPS projects as follows:

Hungry Horse Dam. The Action Agencies shall implement VARQ (Corps 1999d) as a flood control operational strategy by January 1, 2001, and upon completion of coordination with appropriate Canadian entities. Under the 1995 NMFS Biological Opinion, the Action Agencies limited fall and winter reservoir drafts to try to achieve a 75% probability of being at the flood control rule curve elevation by April 10 of each year. NMFS acknowledges the chances of achieving a 75% probability of refill to April 10 flood control elevation will be reduced with implementation of VARQ and higher minimum flows for bull trout. Based on hydrosystem modeling results, the probability is approximately 60% of being at the flood control rule curve elevation by April 10 of each year.

Hungry Horse Reservoir may refill later than the June 30 objective, e.g., early July, if necessary to avoid spill that would exceed the state water quality standard for TDG. BOR shall develop a powerhouse maintenance plan to provide full powerhouse capacity to ensure that the project refills in a timely manner without spill that causes TDG to exceed the state water quality standard.

As called for in the USFWS 2000 Biological Opinion, the Hungry Horse minimum outflow shall be determined monthly based on the official volume inflow forecast for Hungry Horse Reservoir for the April through August period as follows. When the April through August runoff forecast is greater than 1,790 kaf, the minimum flow shall be 900 cfs. When the forecast is less that 1,190 kaf, the minimum flow may be reduced to 400 cfs. When the monthly forecast is between 1,190 and 1,790 kaf, the minimum flow shall be determined by linear interpolation between 400 and 900 cfs. The minimum flow in the South Fork Flathead River can be lowered to the physical limit of 145 cfs when the river reaches flood stage at Columbia Falls (13 feet msl).

The minimum flow requirement of 3,500 cfs at Columbia Falls shall be adjusted similarly to between 3,200 and 3,500 cfs based on monthly runoff forecasts. Specifically, when the April through August runoff forecast for Hungry Horse is greater than 1,790 kaf, the minimum flow shall be 3,500 cfs. When the forecast is less that 1,190 kaf, the minimum flow may be reduced to 3,200 cfs. When the monthly forecast is between 1,190 and 1,790 kaf, the minimum flow shall be determined by linear interpolation between 3,200 and 3,500 cfs. These adjustments in minimum flows are necessary to balance the benefits of flow protection for bull trout in the South Fork Flathead River below the dam with reservoir refill and associated biological benefits in the Flathead and Columbia River systems.

The Action Agencies shall limit the reservoir draft to elevation 3,540 feet by August 31 for salmon flow augmentation. BOR shall coordinate drafts for salmon with NMFS, USFWS, the Action Agencies, and other entities through the in-season management process. As a guideline for salmon flow augmentation releases during July and August, Hungry Horse may be operated in a manner that reduces impacts to other listed species while also releasing water to meet salmon flow objectives. Reduction in a second flow peak operation may be achieved by discharging water earlier, or at a more constant rate, to provide the full volume available for salmon.

Libby Dam. The Action Agencies shall implement VARQ (Corps 1999d) as a flood control operations strategy by October 1, 2001, and upon completion of coordination with appropriate Canadian entities. The 1995 NMFS Biological Opinion required the Action Agencies to limit fall and winter reservoir drafts to achieve a 75% probability of being at the flood control rule curve elevation by April 10. NMFS acknowledges that the chances of achieving a 75% probability of refill to April 10 flood control elevation will be reduced with implementation of VARQ and minimum flows for bull trout. Based on hydrosystem modeling results, the probability is approximately 40% of being at the flood control rule curve elevation by April 10 of each year.

Libby may refill later than the June 30 objective, e.g., early July, if necessary to avoid spill that would exceed the state water quality standard for TDG. The Action Agencies shall limit the reservoir draft to elevation 2,439 feet by August 31 for salmon flow augmentation. The Corps shall coordinate drafts for salmon with NMFS, USFWS, the Action Agencies, and other entities through the in-season management process. If Libby is below elevation 2,439 feet on July 1, the Action Agencies shall provide the USFWS bull trout minimum flow or inflow during the July

and August salmon flow season. If this operation results in Libby storing above elevation 2,439 feet in July or August, that storage may be used for salmon flow augmentation before August 31.

As a guideline for salmon flow augmentation releases during July and August, Libby may be operated in a manner that reduces impacts to other listed species, while releasing water to meet salmon flow objectives. Reduction in a second peak operation can be achieved by implementation of a Canadian storage/Libby exchange of water or by releasing water earlier. However, operational flexibility should be retained to release water during the salmon flow season when fish timing or achievement of flow objectives warrant. This operation shall be consistent with winter/spring flood control needs and remaining on minimum or flood control flow during January through April.

Albeni Falls Dam. The action agencies shall continue the lake draw-up, kokanee egg-to-fry survival study at Lake Pend Oreille for the next 6 years. The evaluation shall begin in 2001 by drafting the lake to a fall/winter water level of elevation 2,051 feet. This operation is intended to allow winter storms to improve spawning gravel for kokanee along the shore of Lake Pend Oreille. During the fall/winter of 2002, the Corps shall maintain Lake Pend Oreille at elevation 2,055 feet until fry emerge from shoreline gravels.

By September 2003, USFWS shall secure independent scientific review involving the appropriate frequency of the lake draw up operation, i.e., from 1 to 3 years of draw up. Based on the findings of the independent scientific review of this evaluation, USFWS and NMFS shall provide written recommendations to the Action Agencies concerning fall/winter operations for the 2003 through 2006 period. During this 6-year evaluation period, the Action Agencies shall evaluate the effects of draw-up operations on all life stages of kokanee in Lake Pend Oreille and on predator-prey dynamics.

If, in September 2007, it is determined that lake level management above elevation 2,051 feet effectively improves kokanee production as bull trout forage, USFWS shall provide written recommendations on the frequency of Lake Pend Oreille draw-up for the remainder of this biological opinion.

Grand Coulee Dam. The Action Agencies shall implement VARQ as part of the system flood control operation as noted above at Hungry Horse and Libby. The Action Agencies shall limit fall and winter reservoir drafts to achieve an 85% probability of being at the flood control rule curve elevation by April 10. Grand Coulee may refill by July 4 if flow augmentation to meet flow objectives is not needed until after July 4. The Action Agencies shall draft the reservoir as needed to meet the summer flow objective at McNary Dam. Based on the July final April-to-August runoff volume forecast at The Dalles Dam, the Action Agencies shall limit the reservoir draft to the following end-of-August elevations: 1,280 feet in years when the forecast for The Dalles equals or exceeds 92 Maf and 1,278 feet in years when the forecast is less than 92 Maf.

Dworshak Dam. The Action Agencies shall attempt to refill the reservoir by June 30, while coordinating with the Technical Management Team to meet the spring flow objectives. The Action Agencies shall limit reservoir drafts to elevation 1,520 feet by August 31 to benefit the summer juvenile fish migration. The Action Agencies shall manage Dworshak discharge to attempt to maintain water temperatures at the Lower Granite Reservoir forebay dissolved gas monitoring station at or below 68°F (20°C). To facilitate refill and storage for next year's salmon operations, the Action Agencies shall discharge the established minimum one-turbine flow (about 1,500 cfs at present) following fisheries operations, unless higher flows are required for flood control purposes.

The Nez Perce Tribe expressed a concern that releasing cold water from Dworshak could inhibit the growth rate of wild fall chinook salmon in the Clearwater River. NMFS has attempted to manage the risks to these fish in recent years in its recommended summer flow and temperature operations at Dworshak Dam.

Action 20: The Corps shall operate the lower Snake River reservoirs within 1 foot of MOP from approximately April 3 until small numbers of juvenile migrants are present and shall operate the John Day pool within a 1½-foot range of the minimum level that provides irrigation pumping from April 10 to September 30.

The date for implementing MOP conditions may be delayed at the request of the Technical Management Team to facilitate drafting the pools to MOP to increase discharge at Snake River projects when such increased flows would be more beneficial to juvenile fish. Lower pools reduce the cross-sectional area, increasing water velocity at a given flow. Because juvenile migrants travel faster with increased water velocities, drawdown to MOP is expected to provide faster emigration and improved survival (NMFS 2000h).

Filling the lower three pools enables adult fishways to operate closer to the gate depth criteria of 8 feet at Lower Monumental Dam, 6 to 7 feet at Little Goose Dam, and 7 to 8 feet at Lower Granite Dam. However, recent information indicates that adult salmon pass the Snake River projects readily with gate depths lower than 7 feet (5.5 to 7 feet; low flows and low turbidity generally provide decreased passage times for adult migrants) (Blankenship and Mendel 1997, Bjornn et al. 1998). The effect of this operation will be evaluated during 2000 by the ongoing 2000 radio tracking study. A recommendation for refill of the lower three pools will be developed and included in the annual planning. This will include consideration of study results associated with fish passage. Lower Granite Dam should not be refilled until enough natural cooling has occurred in the fall, generally after October 1.

Action 21: The Corps shall routinely identify opportunities to shift system flood control evacuation volumes from Brownlee and Dworshak reservoirs to Lake Roosevelt and identify such opportunities for the Technical Management Team. The Corps shall implement flood control shifts as necessary to best protect listed fish, as

called for by NMFS in coordination with the Technical Management Team, taking into account water quality issues and the concerns of all interested parties.

Flood control shifts afford an opportunity to increase the frequency of meeting Snake River spring flow objectives while only slightly affecting mid-Columbia River flow conditions. Lesser flood control drafts would occur at Brownlee and Dworshak through March, affording an opportunity to increase flows in the Snake River during April.

Action 22: The Corps and BOR shall implement VARQ flood control operations, as defined by the Corps (1999d), at Libby by October 1, 2001, and at Hungry Horse by January 1, 2001. By February 1, 2001, the Corps shall develop a schedule to complete all disclosures, NEPA compliance, and Canadian coordination necessary to implement VARQ flood control at Libby.

VARQ reduces system flood control drafts at Libby and Hungry Horse reservoirs in years when flood control risks are moderate (average to below-average water years) and adds about 10,000 cfs to summer flows at McNary Dam without increasing flood risks. Impacts to power, flood control, and environmental conditions in Canada have not been fully identified and coordinated. The VARQ concept is a change in system flood control developed by the Corps (1991, 1995, 1997, and 1999d) in response to NWPPC's 1984 Fish and Wildlife Program (NWPPC 1984), the 1995 FCRPS Biological Opinion, and requirements for Kootenai River sturgeon and bull trout imposed by USFWS (1995, 2000a). Conformance with these biological opinions resulted in discharges from Libby Dam during the annual reservoir refill period that far exceeded those envisioned in existing flood control operating plans. These fishery operations can reduce the likelihood and frequency of refill, adversely affecting the availability of augmentation water. NMFS' 1995 Biological Opinion also required the Corps to carefully evaluate system flood control operations. The VARQ concept responds to all these biological opinion requirements.

Hungry Horse can be operated to store up to 400 kaf more water in the spring, and Libby can store up to 1.5 Maf more under VARQ than under current constraints. Local flood control and other effects are small. These operations will increase flow levels in the lower Columbia River and the frequency of achieving the flow objectives by improving conditions for migration.

Whereas many interested parties are aware of this potential operation, implementing VARQ flood control will require additional coordination with Canada, as well as environmental compliance.

Several states did not support the adoption of VARQ during fall spawning periods as a flood control measure due to concerns that it would decrease flows below Bonneville Dam. NMFS' assessment is that VARQ will have a negligible effect on the provision of spawning flows below Bonneville. The draft limit for the Libby Reservoir's end-of-December elevation does not change under VARQ. The end-of-December draft limit for Hungry Horse does change, but

operation of this reservoir in the fall is typically driven by meeting Columbia Falls minimum flows, which usually results in lower elevations than December flood control.

9.6.1.2.4 BOR Non-FCRPS Project Operations to Support Mainstem Flow Objectives

Action 23: BOR shall operate Banks Lake at an elevation 5 feet from full during August by reducing the volume of water pumped from Lake Roosevelt into Banks Lake by about 130 kaf during this time.

Banks Lake is a 27-mile-long equalizing reservoir for the Grand Coulee pump-generating plant. It also provides water to irrigate 672,000 acres of Columbia Basin Project lands. Banks Lake has an active storage capacity of 715,000 acre-feet. BOR indicates that the 130-kaf volume contained in the top 5 feet of Banks Lake storage (i.e., within its normal operating range) could be used to augment Columbia River flows during the summer migration period. This would be accomplished by reducing the volume of water pumped into Banks Lake from Lake Roosevelt and drafting it directly from Lake Roosevelt.

9.6.1.2.5 Non-Federal Project Operations Coordinated with FCRPS and BOR Projects to Support Mainstem Flow Objectives

Action 24: BPA and the Corps shall continue to request and negotiate agreements to annually provide 1 Maf of Treaty storage from January through April 15, release the water during the migration season, and seek additional storage amounts.

Action 25: BPA and the Corps shall continue to request, and negotiate with BC Hydro for storage of water in non-Treaty storage space during the spring for subsequent release in July and August for flow enhancement, as long as operations forecasts indicate that water stored in the spring can be released in July and August.

Flow objectives are met infrequently during the summer months in the lower Columbia River. Storing water during the spring runoff for release during the summer months increases the frequency of meeting the summer flow objectives.

Action 26: BPA and the Corps shall continue to evaluate, request, and negotiate with BC Hydro the shaping and release of water behind Canadian Treaty storage projects in addition to the non-Treaty storage water previously discussed during July and August.

This action may result in examination of various operational or configuration options for achieving this objective. Although not the only option, one long-term possibility for achieving this objective is installation of additional turbines in the powerhouses at Mica and Revelstoke dams. Once the side effects of these installations are addressed, flows could be shifted from

other time periods and be increased by up to 20 kcfs during the months of July and August without the need to spill from these projects.

Several states and Tribes believed the installation of turbines in Canadian projects should be a requirement in the biological opinion. These projects are operated by Canadian entities that are not subject to this biological opinion. Canada's acceptance of this proposal will require the Canadian government to address local issues that will impact the outcome of the turbine discussions.

9.6.1.2.6 Measures to Evaluate and Adjust the Amount of Water Available to Support Flow Objectives

BOR Projects Basinwide. BOR projects operating in the Columbia River basin contribute to streamflow depletions in the Columbia River during the juvenile salmon outmigration season. These depletions decrease the frequency of achieving flow objectives needed to protect migrating juveniles. The following measures specify actions within BOR's authority to reduce streamflow depletions at its projects.

Action 27: Before entering into any agreement to commit currently uncontracted water or storage space in any of its reservoirs covered by this biological opinion to any other use than salmon flow augmentation, BOR shall consult with NMFS under ESA Section 7(a)(2). Such consultations shall identify the amount of discretionary storage or water being sought, the current probability of such storage or water being available for salmon flow augmentation, and any plan to replace the storage volume currently available to salmon flow augmentation that would be lost as a result of the proposed commitment. Also, BOR shall consult with NMFS before entering into any new contract or contract amendment to increase the authorized acreage served by any irrigation district receiving BOR-supplied water. NMFS' criterion in conducting such reviews is to ensure that there be zero net impact from any such BOR commitment on the ability to meet the seasonal flow objectives established in this biological opinion. Replacement supplies should have at least an equal probability of being available for salmon flow augmentation as the storage space or water that is being committed.

Given that current rates of water deliveries adversely affect survival conditions in the migration corridor, further depletions should be avoided until recovery is achieved.

Action 28: BOR shall pursue water conservation improvements at its projects and shall use all mechanisms available to it under state and Federal law to ensure that a reasonable portion of any water conserved will benefit listed species.

This action item is aimed at developing cooperative mechanisms to put more water in the mainstem Columbia River during the juvenile salmon migration season (April through August).

Water conservation is one mechanism that can reduce total diversions and consumption without adversely affecting agricultural production. To be valuable to listed fish, water conservation must result in increased stream flow. Accomplishing this task will require the cooperation of water users and the exploration of opportunities under state law to protect such water from diminution.

Action 29: Within 2 years from the date this opinion is signed, BOR shall provide NMFS with a detailed progress report addressing possible instances where BOR-supplied water within the Columbia River basin is being used without apparent BOR authorization to irrigate lands. In the report, BOR shall indicate how it shall proceed to identify and address instances of unauthorized use.

Federal agencies are required to consult only on actions that are "authorized, funded, or carried out by such agency[.]" 16 U.S.C. Section 1536(a)(2). NMFS recognizes that unauthorized uses of BOR-supplied water are by definition not "authorized, funded, or carried out" by BOR. As BOR works within the limits of its authority to address any identified episode of unauthorized use of BOR-supplied water, NMFS recognizes that, in some instances, BOR will have to take contract actions and consult on them. Accordingly, in action item 27 above, NMFS set out how those consultations will proceed. This reporting requirement will help all parties understand the nature and extent of actual unauthorized use.

Action 30: For those BOR projects located in the Columbia River and its tributaries downstream from Chief Joseph Dam (Table 9.6-2), BOR shall, as appropriate, work with NMFS in a timely manner to complete supplemental, project-specific consultations. These supplemental consultations shall address effects on tributary habitat and tributary water quality, as well as direct effects on salmon survival (e.g., impingement, entrainment in diversions, false attraction to return flows, and others). These supplemental consultations shall address effects on mainstem flows only to the extent to which they reveal additional effects on the in-stream flow regime not considered in this biological opinion (e.g., flood control).

This biological opinion considered the likely effects of BOR's Columbia River basin irrigation projects on flow conditions in the mainstem Columbia River migration corridor. Other effects, such as tributary habitat, fish passage and entrainment, and water quality, have not been evaluated in this biological opinion. To further the intensive approach defined in this RPA, timely consideration of such effects and, if necessary, development and implementation of measures to avoid, minimize, or mitigate them are needed. Supplemental consultations for several of these projects are currently underway (e.g., the Yakima Project and Umatilla). These overarching needs are further defined in the project-specific measures identified in Table 9.6-2.

<u>Columbia Basin Project</u>. Grand Coulee Dam, which is an integral component of the Columbia Basin Project, is also one of the specific FCRPS projects addressed in Section 9.6.1.2.3. Because the Columbia Basin Project diverts water from and returns it to the mainstem Columbia River

above McNary Dam, its storage and diversion operations are not easily separated from the other operations at Grand Coulee.

Table 9.6-2. BOR projects in the Columbia River basin subject to supplemental consultations.

Project	Location	Subbasin or Stream
Upper Columbia River (Upstream of Snake River Confluence)		
Chief Joseph[1]	North-central Washington, from Canadian border to Wenatchee	Okanogan and Columbia rivers
Okanogan	North-central Washington, near Okanogan	Okanogan River
Yakima	Central Washington, near Yakima	Yakima River
Lower Columbia (Downstream of the Snake River Confluence)		
Umatilla	Northeast Oregon	Umatilla and Columbia rivers
Crescent Lake	Central Oregon west of Bend	Deschutes River
Crooked River	Central Oregon, north of Bend	Crooked River
Deschutes	Central Oregon, north of Bend	Deschutes River
Wapinitia	North-central Oregon, south of The Dalles	Deschutes River
The Dalles[1]	North-central Oregon, near The Dalles	Columbia River
Tualatin	Northwest Oregon, west of Portland	Tualatin River (Willamette River)

[1] This table identifies irrigation works BOR owns and operates. The Corps owns and operates Chief Joseph Dam and its powerhouse and The Dalles Dam and its powerhouse.

Action 31: BOR shall assess the likely environmental effects of operating Banks Lake up to 10 feet down from full pool during August. The assessment and NEPA compliance work shall be completed by June 2002 to determine future operations at this project by the summer of 2002.

An additional 130 kaf could be obtained from Banks Lake storage if the project is not filled 5 more feet using Grand Coulee storage, resulting in a total draft of 10 feet from full pool, during the summer. This would provide a total flow augmentation volume of about 260 kaf from Banks Lake. Because this total draft is beyond the normal project operating range, however, BOR will have to conduct a formal study and NEPA compliance review on this action before implementation.

BOR Upper Snake Projects and IPC Hells Canyon Complex

Action 32: The Action Agencies shall acquire water for instream use from BOR's Upper Snake River basin projects and Idaho Power Company's Hells Canyon Complex during the spring and summer flow augmentation periods to improve the likelihood of achieving spring and summer flow objectives at Lower Granite Dam.

Ongoing Section 7 consultations with BOR on the Upper Snake projects and with FERC and the Idaho Power Company on the Hells Canyon Complex will consider the need for releases of water or other operations at these projects to address their effects on listed Snake River salmon and steelhead. Upon completion of these consultations and related biological opinions, and to the extent additional water or operating flexibility is available, the Action Agencies will pursue acquisition of such additional water from willing sellers or operating flexibility as offsite mitigation for the effects of the FCRPS projects. Such additional water or operating flexibility would be used to improve the ability to achieve the Snake River flow objectives identified in Table 9.6-1.

Dworshak Hatchery and Reservoir Operations

Action 33: The Corps, in coordination with USFWS, shall design and implement appropriate repairs and modifications to provide water supply temperatures for the Dworshak National Fish Hatchery that are conducive to fish health and growth, while allowing variable discharges of cold water from Dworshak Reservoir to mitigate adverse temperature effects on salmon downstream in the lower Snake River.

The rationale for providing improvements to the hatchery water supply is to isolate the effect of Dworshak Reservoir operations on Snake River temperature control from the effect of hatchery operations. At present, Dworshak Reservoir cannot be operated for optimal temperature releases because of adverse effects on hatchery rearing performance. This problem would be resolved by making improvements in the hatchery water supply system to accommodate releases of cooler water from Dworshak to benefit salmonid migrants and water quality in the lower Snake River.

Action 34: The Action Agencies shall evaluate potential benefits to adult Snake River steelhead and fall chinook salmon passage by drafting Dworshak Reservoir to elevation 1,500 feet in September. An evaluation of the temperature effects and adult migration behavior should accompany a draft of Dworshak Reservoir substantially below elevation 1,520 feet.

The rationale for evaluating an additional 20-foot draft of Dworshak Reservoir in September is to determine whether cooling Snake River temperatures during September would provide an adult passage benefit. The potential benefits are 1) reduction in water temperature, 2) possible elimination of a thermal block that delays adult migration into and through the lower Snake River, and 3) improved gamete viability. An evaluation should be conducted to assess the effects of the September draft on lower Snake River temperatures and on the migratory behavior and passage timing of adult salmonids that are equipped with depth and temperature-sensitive tags. An evaluation of Dworshak refill probability indicates that this study operation would have little impact on reservoir refill by the end of June in the following year, i.e., two additional refill misses in BPA's 50-year hydrosystem study.

Flood Control Assessment

Action 35: The Corps shall develop and conduct a detailed feasibility analysis of modifying current system flood control operations to benefit the Columbia River ecosystem, including salmon. The Corps shall consult with all interested state, Federal, Tribal, and Canadian agencies in developing its analysis. Within 6 months after receiving funding, the Corps shall provide a feasibility analysis study plan for review to NMFS and all interested agencies, including a peer-review panel (at least three independent reviewers, acceptable to NMFS, with expertise in water management, flood control, or Columbia River basin anadromous salmonids). A final study plan shall be provided to NMFS and all interested agencies 4 months after submitting the draft plan for review. The Corps shall provide a draft feasibility analysis to all interested agencies, NMFS, and the peer-review panel by September 2005.

The primary objectives of this feasibility analysis will include reducing the effects of flood control operations on the spring freshet, particularly during average to below-average runoff years; minimizing flow fluctuations during fall chinook emergence and rearing; and achieving a high probability of reservoir refill, particularly at Dworshak, Grand Coulee, Hungry Horse, and Libby reservoirs, while maintaining acceptable levels of protection for developed areas within the active floodplain. This analysis will consider all aspects of flood control, including the flood control target flow(s), associated storage reservation diagrams, the method of calculating the initial control flow, and the timing and coordination of flood control management. The study will incorporate the best currently available forecast technology for estimating runoff and peak flows. Innovative concepts, such as using an expert system to define operations in real time, that would increase system flexibility or the ability to achieve the above stated objectives should be incorporated to the extent practical. New storage reservation diagrams should include mechanisms for interpolation to facilitate higher storage contents going into the spring in some years. The Corps will also identify those improvements necessary to facilitate higher flood control target flows and estimate the cost and time needed to implement such improvements.

This analysis will include all Federal, non-Federal, and Canadian projects currently operated for system flood control. Because modifying flood control operations would affect an array of interests, the Corps should consult with all interested state, Federal, Tribal, and Canadian agencies in developing its analysis. The final feasibility report will include a proposed action and respond to all concerns and comments on the draft.

System flood control strongly influences streamflow characteristics in the mainstem Snake and Columbia rivers. As described in Section 6 of this biological opinion, these hydrologic effects affect juvenile salmon survival. While current flood control operations routinely reduce even non-damaging floods, peak flows of historical magnitude (e.g., the 1948 Vanport flood) would result in substantial damage. The intent of this study is to refine flood control operations such that they cause the least possible reduction in runoff volumes and the probability of reservoir

refill while maintaining high levels of protection from damaging floods. Preliminary analysis of modifying system flood control showed that potentially much higher spring flows were possible (Corps 1997) in some years.

Much of the existing flood control operation plan dates to the 1960s, and a systematic review of flood control operations has not occurred since 1991. That study, however, was based on the fundamental premise *"that the existing flood control capability ...would remain unchanged after any rule curve modifications were made* (Corps 1991)." Thus, *"...it is conceivable that flood control criteria could be reduced substantially, and levees raised a corresponding amount to compensate."* A broader consideration of flood control options could identify operations that would benefit the fishery without increasing the likelihood of damaging floods.

New streamflow prediction techniques, including extended streamflow prediction (ESP) (NOAA River Forecast Center streamflow model) and remote sensing, have greatly improved since 1969. Computer improvements facilitate consideration of a broader range of alternatives and the ability to manage flood risks more closely to a real-time basis. A thorough investigation of new forecasting technologies would enhance system response and afford greater precision in system flood control operations.

Furthermore, flood control concepts are changing. Historically, efforts were made to protect all developed lands from flooding by using levees, revetments, and upstream storage. These efforts have effectively disconnected rivers from their floodplains and have had both ecological and human consequences (Benner and Sedell 1997). Ecologically, diverse and integral habitats are lost when structures isolate a river from its floodplain (Ligon et al. 1995, Corps 2000b). Riparian corridor simplification is a significant cause of salmon declines (Ligon et al. 1995, Corps 2000b). Also, by cutting off upstream floodplains from the river, vast flood storage potential is lost, and floodplain development is encouraged. Thus, when large floods occur, the outcomes in terms of property damage can be more severe than would have occurred if lesser flood protection efforts had been taken and floodplain development discouraged. By examining flood damage areas and flood protection structures throughout the river corridor, the Corps may identify opportunities to bring more connectivity to some areas of active floodplain (e.g., undeveloped land and farmland) and more effective flood protection to others (e.g., communities).

Libby Operations

Action 36: By October 1, 2002, the Corps shall develop and, if feasible, implement a revised storage reservation diagram for Libby Reservoir that replaces the existing fall draft to a fixed end-of-December elevation. One option is to evaluate variable drafts based on the El Niño Southern Oscillation Index (SOI) predictions or other forecast methodologies of runoff volume. To implement this change, the Corps shall complete successful coordination with Canada under the Columbia River Treaty.

Currently, a fall draft at this project is aimed at reaching a fixed end-of-December elevation to ensure that, given other project constraints, enough water can be evacuated to achieve desired levels by the end of April in all years. If lesser drafts were made, it could be difficult to achieve desired reservoir levels in the wetter years. Traditional snow-water surveys are not available until January, so Libby is drafted each year in the fall, assuming a wet-year condition. In low water years, this can result in drafts below the subsequent April 30 upper rule curve elevation (end of storage evacuation season) and result in the project being unable to refill by the end of June. Under current operating criteria, hydrosystem regulation studies (BPA 2000b) show that Lake Koocanusa does not achieve the 75% probability of refill proposed by the Corps in the biological assessment (BPA et al. 1999). These excessive drafts can increase the streamflow attenuation needed to achieve refill in the spring and reduce the probability of refill, placing additional risks on listed fish, particularly in the driest years when increasing discharge would be most valuable.

Recent advances in climatology have resulted in predictive tools that roughly estimate Pacific Northwest runoff volumes from meteorological conditions in the southern Pacific. The Corps has adopted an SOI-based runoff model as the best available forecast for Dworshak that uses this forecast to define Dworshak drafts from January through April. The Corps is investigating the use of a similar runoff model for Libby Dam. The Corps is also investigating operational changes that could alleviate the reason for avoiding all spills at Libby Dam, which is a contributing factor in the current fixed end-of-December reservoir draft. This action would expand the use of a SOI-based or a similar runoff prediction method into the fall at Libby Dam and could result in revision of the storage reservation diagram to allow reduced drafts in average-to-dry years.

9.6.1.2.7 Actions to Address Columbia Basin Project Effects Other than Flow Depletions and Storage Operations. Certain facilities and operations at the Columbia Basin Project present risks to listed salmon and steelhead other than those associated with mainstem flows. BOR will investigate the effects of these facilities and operations. Where adverse effects on listed salmon or steelhead are found, BOR will develop measures to avoid or minimize such effects in consultation with NMFS.

Action 37: BOR shall investigate the attraction of listed salmon and steelhead into wasteways and natural streams receiving waste water from the Columbia Basin Project. If listed fish are found to be attracted into these channels, BOR shall work with NMFS to identify and implement structural or operational measures to avoid or minimize such use, as warranted.

Action 38: By March 1, 2002, BOR shall install screens meeting NMFS' screen criteria at the canal intakes to the Burbank No. 2 and Burbank No. 3 pump plants. BOR shall connect the Burbank No. 3 intake canal to Burbank Slough to provide juvenile fish egress. BOR shall coordinate with NMFS on each of the actions identified above.

Action 39: BOR shall evaluate the water quality characteristics of each point of surface return flows from the Columbia Basin Project to the Columbia River and estimate the effects these return flows may have on listed fish in the Columbia River and in the wasteways accessible to listed fish. By June 1, 2001, BOR shall provide NMFS with a detailed water quality monitoring plan, including a list of water quality parameters to be evaluated. If the water quality sampling reveals enough water quality degradation to adversely affect listed fish, BOR shall develop and initiate implementation of a wasteway water quality remediation plan within 12 months of the completion of the monitoring program.

Return flows from BOR's Columbia Basin Project may reduce water quality in the Columbia River and may adversely affect aquatic life and listed salmon. Because of the potential for adverse effects on listed fish, detailed water quality monitoring and analysis are needed to define these water quality effects. Depending on the results of the water quality sampling, BOR should develop and begin implementation of a water quality remediation plan for BOR wasteways within 12 months of completing the water quality monitoring program and include the plan as part of the Action Agencies' annual and 5-year water quality improvement plans. This measure is intended to supplement the MOU between BOR, EPA, the Washington Department of Ecology, and the three Columbia Basin irrigation districts regarding surface water quality protection of the Federal Columbia Basin Project waters. Remediation measures will be consistent with the terms of that agreement to the extent possible.

9.6.1.3 Juvenile Fish Transportation

9.6.1.3.1 Strategy. This RPA requires transportation of juvenile salmon and steelhead migrants in spring and summer. During the spring migration, transport is required at Lower Granite, Little Goose, and Lower Monumental dams. During the summer migration, transport is required from the same three Snake River dams and is also required from McNary Dam. Spill is to be provided in accordance with Section 9.6.1.4.4 to provide the highest survival passage route for inriver migrants during the spring months and to provide for research in summer. Except as specifically provided for research, however, all collected fish are to be transported.

The spring transport strategy in this RPA requires both transport and spill at collector projects to spread the risk by ensuring favorable project passage conditions for inriver migrants. There is no attempt to manage to a specific transport/inriver ratio. Estimates of the proportion of SR spring/summer chinook that are expected to be transported under this strategy range from 43% to 91% depending on flow/runoff conditions.

The current strategy reflects a management program based on transportation research conducted to date. However, ongoing research using PIT tag technology will allow a much finer level of resolution to be obtained on the seasonal effects of transportation. The research results will be reviewed annually, and adaptive management changes may be made in the transportation strategy if definitive research results support a change in strategy.

The summer transport strategy is to maximize collection and transportation due to concerns about low inriver survival rates. During the summer, flow is frequently below the biological flow objectives established by NMFS, and water temperature is frequently above the water quality standards established by EPA and the state water quality agencies. As a result, fish spill is curtailed, and all collected fish are transported during the summer to improve overall juvenile fish survival.

The actions in this section are presented as follows:

- Current and near-term actions
- Studies, including research, monitoring, and evaluation
- Future actions

9.6.1.3.2 Current and Near-term Actions

Action 40: The Corps shall continue to transport all non-research juvenile salmonids collected at the Snake River collector projects. The Corps and BPA shall continue to implement voluntary spill at all three Snake River collector projects when seasonal average flows are projected to meet or exceed 85 kcfs.

If new information shows that survival through inriver migration, including returning fish to the river, is beneficial, these data will be reviewed and discussed during the annual planning process. In particular, BPA and the Corps, working with NMFS through the annual planning process, have to consider the scientific basis for the 85-kcfs voluntary spill trigger. Any resulting changes in the annual transport operations will be formalized through the consultation framework or a similar process.

Action 41: The Corps and BPA shall continue (pending results of the McNary Transport Evaluation) to bypass juvenile spring migrants collected at McNary Dam and shall provide the spring spill levels described for that project.

Transport of spring migrants from McNary was suspended in the 1995 FCRPS Biological Opinion (NMFS 1995a) because a review of the data indicated the benefit from transport was uncertain. This moratorium on spring transport from McNary was continued in the 1998 Supplemental FCRPS Biological Opinion (NMFS 1998) because the adult returns of detected PIT-tagged juvenile fish that passed through the McNary bypass system in 1994 were lower than expected. These data suggest there may be an undetected problem with the juvenile bypass system. This issue should be resolved before initiating the McNary spring transport evaluation.

Action 42: The Corps and BPA shall operate the collector projects to maximize collection and transportation during the summer migration (i.e., no voluntary spill except as NMFS deems necessary for approved research).

Past research evaluating fall chinook transport from McNary indicated the highest benefits occur during the summer low flow/warm water temperature periods. The 1982 research (Park et al. 1982) evaluated transport by truck during the early, middle, and late phases of the summer outmigration.

The early control group (June 25 to July 2) was released when daily average river flows were dropping from 444 to 372 kcfs, and water temperature averaged about 60°F (16°C). Based on survival to adulthood, transport yielded no benefit to the early phase (0.9:1).

The middle control group (July 6 to 22) was released when river flows ranged from 358 to 206 kcfs, and water temperatures ranged from 61° to 66°F (16 to 19°C). Based on survival data, there was a minor benefit to the middle phase (1.36:1).

The late control group (July 27 to Aug 5) was released when river flows were dropping from 218 kcfs to 158 kcfs, and water temperatures were 67° to 70°F (19 to 21°C). This group showed the highest transport benefit of 4.6:1. Available data, although limited, did not indicate a benefit from transport of summer migrants during early summer. A similar study was conducted in 1983 (Park et al. 1984), but marking did not begin until July 7 that year so the data were not comparable to the 1982 study. Results, however, showed a positive benefit from both barge and truck transport. Control groups in that study were released when river flows ranged from 169 to 232 kcfs.

Action 43: The Corps shall not initiate collection of subyearling fall chinook for transportation at McNary Dam until inriver migratory conditions are deteriorating (i.e., no longer spring-like).

In general, the switch from spring to summer operation will occur on or about June 20. Each year in the in-season management process, the Technical Management Team has the discretion to recommend a change in transportation operations at McNary Dam earlier or later based on in-season monitoring of inriver conditions. When more favorable spring-like flow and temperatures either end before or extend after the spill planning dates, the actual date to end spill at collector projects, and to initiate transport from McNary, will be modified, continuing to spread the risk of transportation versus inriver passage for spring migrants as long as spring-like river conditions persist.

Spring-like is defined as favorable flow and water temperature conditions; i.e., river flows are at or above the spring flow target (220 to 260 kcfs) at McNary Dam, and ambient water temperatures are below 62°F (17C°).

Action 44: The Corps shall extend the period of barge transportation from the lower Snake River dams and McNary to further reduce reliance on trucking.

Barge transport of spring migrants from the lower Snake River dams was extended approximately 3 weeks in 1998 to partially address regional concerns regarding truck transportation. The Corps has proposed to extend the barging period another 5 weeks (to around the end of July). NMFS views the proposed extension as a first step; however, a further extension is desired. NMFS recognizes that, as a result of prioritizing available O&M funds, a further extension of barging will have to be phased in over a period of years.

9.6.1.3.3 Studies (Including Research, Monitoring, and Evaluations)

Action 45: By the end of 2001, the Corps shall develop, in coordination with NMFS and the other Federal, state, and Tribal salmon managers, a McNary Dam transportation evaluation study plan specifically focusing on the response of UCR spring chinook and steelhead to transportation. Approved research should begin by 2002, if feasible.

Evaluation of spring transport from McNary shall be initiated in 2002, assuming that adult PIT-tag detectors will be installed at selected locations by spring 2002 and pending results of the McNary Dam juvenile fish bypass evaluation. Implementation of such research is a high priority and should serve to accelerate development and installation of adult PIT-tag detection capability in mainstem adult fishways. At a minimum, objectives of the study shall include the following:

- Identification of population and/or genetic composition of test fish
- The absolute return rates of transport and inriver groups
- The ratios of transport to inriver return rates and their relationships to river conditions
- The effects of transportation from McNary on homing
- Relationships between ratios of transport and inriver return rates and measurements of juvenile survival (D values) below McNary Dam

Action 46: The Corps and BPA, in coordination with NMFS through the annual planning process, shall evaluate transport to inriver return ratios for wild SR yearling chinook salmon and steelhead. In addition, the Corps and BPA shall also evaluate the effects of transportation on summer-migrating subyearling SR chinook salmon.

The research methodology currently used to evaluate spring-migrating fish is to mark and release wild fish at Lower Granite Dam and re-collect some of them for transport at Little Goose Dam. An inriver group of marked fish is allowed to continue their migration inriver. This study protocol was selected to handle the fewest wild salmon and to increase the undetected inriver sample group of fish. The existing study design should continue until wild Snake River

anadromous salmonids are abundant enough to conduct studies by PIT-tagging wild fish in natal areas above the lower Snake River dams.

If the decision for the long-term operation of FCRPS projects on the lower Snake River includes continued reliance on transportation, the Corps and BPA will continue transport survival studies for spring and summer migrants passing Lower Granite Dam in future years. Information from these studies will be the basis for modifications to the transportation program to increase salmon survival. Future transportation studies will include the evaluation of modifications made to the transportation system.

NMFS has adopted a spread-the-risk policy for transportation of spring migrants while studies are being conducted to evaluate the effects of the spring transportation program. In contrast, NMFS has chosen to maximize transportation of fall migrants because of the adverse conditions that exist for inriver migrants during the summer season. Historic data have demonstrated a benefit to transportation. Additional research should occur to reassess the effectiveness of transportation under more recent conditions.

The evaluation of summer transport will consist of determining the smolt-to-adult survival of subyearling fall chinook transported from Lower Granite Dam relative to marked study fish left to migrate inriver. This study will require adequate numbers of representative test fish (i.e., Lyons Ferry hatchery stock) and suitable inriver conditions for comparison with transportation. This includes spill at Snake River collector projects to reduce turbine mortality, alternative water management strategies to enhance flows and reduce water temperature, and more intensive predator management. To reduce the risks associated with an incorrect assumption about the effectiveness of either transportation or inriver migration, spill to enhance inriver conditions will be included as a test condition on an alternating annual basis. In this way, outmigrants will be subject both to inriver conditions that include spill at Snake River dams and maximum transport conditions across the duration of this study. The ability to provide summer spill at Snake River dams will require modifications of the electrical transmission system. These upgrades are expected to be completed by 2004. Pending completion of these upgrades, the inclusion of spill would start and would continue for several years. This study will start under current operations beginning in the summer of 2001.

The development of the specific study protocol should be coordinated through the Regional Forum and research processes. The Action Agencies will include these studies in the annual and 5-year hydrosystem plans.

Action 47: During all transport evaluations, the Corps and BPA, in coordination with NMFS through the annual planning process, shall include an evaluation of delayed mortality (D) of transported versus inriver migrating juvenile anadromous salmonids.

Considerable uncertainty exists concerning the levels of differential post-Bonneville Dam mortality of transported and non-transported fish. Evaluations of post-transport and post-bypass delayed mortality are high priorities. The highest priority is determining how much transportation mitigates for the loss of juvenile anadromous salmonids during passage through the hydrosystem. The mechanism for implementing this action (mark and recapture studies) is described in Section 9.6.5.3.5.1.

Action 48: The Corps and BPA shall evaluate the effects of prior transport as smolts on the homing of adults.

Past research was not designed to directly evaluate the effects of transportation on the homing of returning adults. Ancillary data derived from earlier studies suggested that transportation-induced homing impairment was minimal. Studies designed to directly and precisely compare homing capabilities of transported and non-transported fish are needed. This research will require the installation of adult PIT-tag detectors at several dams and hatcheries on the Columbia and Snake rivers.

Action 49: The Corps shall evaluate strategies to enhance post-release survival of transported fish; examples of such strategies include timing releases so that fish arrival at the estuary corresponds to minimal interactions with predators and maximum availability of forage and locating releases so as to decrease passage time through areas of high predation.

No consideration has been given to the timing of fish arrival in the estuary when scheduling fish transport operations. In the past, the preference for release of transported fish was after dark to reduce the potential for predation, but this does not occur on a regular basis. Additional information on spring chinook transported from the Snake River indicates that fish released to arrive at the saltwater interface during the ebb tide move rapidly into the Columbia River plume. Fish that reach the saltwater interface during high tide hold in the estuary and either move upstream in the navigation channels or hold over in the shallow water grassflats. In both cases, salmon are exposed to increased levels of avian predation.

9.6.1.3.4 Future Actions

Action 50: BPA and the Corps shall install necessary adult PIT-tag detectors at appropriate FCRPS projects before the expected return of adult salmon from the 2001 juvenile outmigration.

By October 2000, the Action Agencies will develop a schedule for installing adult PIT-tag detectors at projects by working through the annual planning process and the Regional Forum. The schedule will maximize the ability to conduct research identified in this biological opinion in a timely manner and will address the possibility of installing detectors at Bonneville and McNary dams by 2002. Adult detector installation identified in the annual planning process should be put

in place as soon as possible. If technical problems preclude installation of these adult PIT-tag detectors within this time frame, the evaluation of spring migrant transportation from McNary should be delayed until the detection systems are certain to be installed.

Action 51: If results of Snake River studies indicate that survival of juvenile salmon and steelhead collected and transported during any segment of the juvenile migration (i.e., before May 1) is no better than the survival of juvenile salmon that migrate inriver, the Corps and BPA, in coordination with NMFS through the annual planning process, shall identify and implement appropriate measures to optimize inriver passage at the collector dams during those periods.

Limited available data suggest that juveniles collected and transported early in the spring season do not survive as well as fish that are transported in May and thereafter. It may be that, because they are transported, those fish arrive in the estuary before they are physically prepared to enter saltwater, or alternatively, predator abundance may vary during the early ocean phase in different years. Additional data are needed to help reduce this uncertainty.

Action 52: The Corps shall identify and implement improvements to the transportation program.

Such improvements should include maintenance/upgrade of fish transport trailer chillers before the summer trucking season (as long as trucking continues) and daily transport of juvenile salmon exhibiting signs of *Columnaris* disease during the summer warm-water season, preferably in 5- to 10-ppt saline with minimal handling if transported by truck.

Action 53: The Corps shall evaluate and implement structural and operational alternatives to improve juvenile transportation at the collector dams.

These alternatives could include improvements to the juvenile bypass systems, holding and loading facilities, and construction of smaller barges for use during the summer.

9.6.1.4 Juvenile Fish Passage

The measures described in this section represent the best starting points for planning future capital investment in activities to improve the survival of juvenile salmon migrating past the Corps mainstem FCRPS dams. The specific list of measures to be implemented, their priority, and the method of evaluation will be developed in the 1- and 5-year plans described in Section 9.4. As determined through the annual planning process in Section 9.4, other combinations of measures may also be deemed sufficient to meet the juvenile and adult performance standards and, thus, to avoid jeopardy.

Based on information in the biological effects analysis in Appendix D, Bonneville, The Dalles, and Lower Monumental dams have the lowest juvenile fish passage survival rates in the FCRPS.

For this reason, improvements in juvenile dam passage survival at these mainstem dams should be an area of immediate focus.

Many of the measures described in this section are limited to prototype or facility development and evaluation and include statements that the Action Agencies are expected to implement an action based on study results as warranted. The intent in these cases is to proceed to implementation immediately upon completion of testing, unless the results present problems that have to be addressed through further testing before implementation. The fish passage survival analysis in Section 9.7 assumes that fish passage facility improvements would be implemented, not just tested. As a result, progress in moving from research and development to implementation will be a necessary and integral part of the annual planning and review process, and undue delay may require a reinitiation of consultation.

9.6.1.4.1 Juvenile Fish Passage Strategy. A primary objective of the biological opinion is to increase survival of juvenile outmigrants through the Federal hydrosystem. This objective should be accomplished consistent with two biological principles: 1) protecting biodiversity and 2) favoring fish passage solutions that best fit the natural behavior patterns and river processes (ISAB, 1999). This applies to fish passage through the eight FCRPS hydroelectric projects and their associated reservoirs. The purpose of this fish passage strategy statement is to provide general guidance on dam passage priorities for future annual implementation planning.

Spillway Passage. Spillway passage is the preferred passage method for juvenile salmonids that are not collected and transported. It should be the baseline against which other passage methods are measured. The body of research evidence indicates that juvenile survival is generally highest through this passage route and suggests it can reduce forebay delay. Therefore, measures that increase juvenile fish passage over FCRPS project spillways are the highest priority unless it can be shown that alternative passage improvements would provide comparable survival. This assumes that spillway passage is implemented in a biologically safe manner to maintain appropriate water quality, while ensuring adequate juvenile egress conditions in the tailrace and minimizing effects on adult passage.

Surface Bypass Passage. Surface bypass is defined as a surface-oriented route that provides an appreciable attraction flow-field and discharges juvenile fish directly to the project tailrace. Continued development and testing of surface bypass prototypes at mainstem FCRPS projects should be a high priority. A surface bypass at one or more spill bays, or through a surface bypass next to the spillway or powerhouse, may provide complementary survival benefits for fish that do not pass through a conventional spillway tainter gate. Surface bypass passage is a promising concept that may, with further testing and development, satisfy the intent of increasing safe passage through a high-flow conveyance similar to the spillway. It also has a potential benefit of providing fish passage with incrementally lower spill discharges and lower production of TDG.

Surface Collection Passage. In contrast to surface bypass, surface collection is defined as a surface-oriented route that entails collection at one or more entrances, followed by lateral routing

in a channel that guides fish away from turbine intakes. In this biological opinion, surface collectors are considered to be installed across a portion of, or over the entire upstream face of, the powerhouse at a given site. For fish that do not pass through either spillway or surface bypass routes, this option is expected to provide more natural passage conditions for those that approach the powerhouse. Similar to the surface bypass concept, surface collection is also a promising concept that may, with further testing and development, satisfy the intent of increasing safe passage through a high-flow conveyance. With successful development in the future (including reconciling concerns regarding high discharge outfalls), this option would be preferred to other powerhouse passage options (see below).

Powerhouse Intake Screen and Bypass Systems. Turbine intake screens and bypass systems provide the best protection for those fish that enter turbine intakes (as opposed to passing through other non-turbine routes). Increasing juvenile survival through collection and safe passage using this type of system continues to be a priority at many FCRPS hydro projects. This fish protection system will continue to be the primary powerhouse protection alternative at some projects until either surface bypass or surface collection is fully developed and constructed.

Turbine Passage. The least preferable route of passage for juvenile and adult fish is through turbines, where a generally higher mortality rate occurs due to direct mechanical injuries and adverse pressure changes incurred while passing through the turbine. Further, indirect mortality is likely a significant problem downstream of the powerhouse, where disoriented fish are vulnerable to predation. Efforts described above to reduce turbine passage notwithstanding, it is prudent to continue to research and, where appropriate, implement improved turbine designs that reduce direct and indirect mortality. Additional investigations are necessary to reduce the magnitude of direct and indirect turbine mortality, as well as continued evaluations of recent advances in turbine design such as minimum gap runners.

9.6.1.4.2 Overview of RPA Actions Project-by-Project. The following project-by-project overview is provided for ease of reference so that juvenile passage measures, which are detailed as actions in the following sections, can be viewed and understood from a broader context. This section also describes issues such as decision dates for alternative passage improvements and other considerations that may influence implementation.

Bonneville Dam. The dam passage survival rate at Bonneville Dam is currently one of the lowest of any Corps FCRPS project and is, therefore, the highest priority relative to the need for improvements. Existing spill levels, configurations, and facilities at Bonneville Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- A 24-hour spill; with nighttime spill limited to the TDG cap, and daytime spill limited to 75 kcfs for adult passage

- Standard-length screens at all 18 main units (at both powerhouses)

- A first powerhouse monitoring facility/bypass outfall that releases fish into the immediate tailrace and a new second powerhouse monitoring facility/bypass outfall that releases fish approximately 9,000 feet downstream of the powerhouse

- An ice and trash sluiceway at the first powerhouse

- An 18-bay spillway with deflectors on 13 bays

Bonneville First Powerhouse. The Corps will evaluate surface collector and extended submerged intake screen prototypes in 2000, followed by a decision to proceed with development of one alternative (or a hybrid of each); proceed to design and construction of the most promising option; complete minimum gap turbine runner installation and evaluation; continue to develop debris-control measures; and continue to develop improvements to the existing juvenile fish bypass system (including dewatering screens and outfall relocation).

Bonneville Spillway. The Corps will finish spillway deflector optimization development and implement deflector additions and improvements, develop optimum spill patterns and conduct juvenile survival studies, continue to evaluate adult spillway fallback and implement remedies as warranted, synthesize results to determine how to optimize spillway adult and juvenile project/spillway survival, and implement the most promising measures.

Bonneville Second Powerhouse. The Corps will develop and implement a surface bypass corner collector, pending high-flow outfall investigation results for increasing the high-flow impact velocity criterion, conduct outfall site selection evaluations, and design and construct a corner collector system by 2004 (if exceeding the velocity criterion does not increase juvenile mortality); continue intake screen guidance improvement investigations and implement them as warranted; implement auxiliary water improvement measures; investigate and implement debris control measures; investigate a less intrusive PIT-tag interrogation method for the new juvenile fish bypass system; and implement measures as warranted.

The Dalles Dam. Spill levels, configurations, and facilities at The Dalles Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- A 24-hour spill at 40% of river flow
- An ice and trash sluiceway operated as a surface bypass
- A 23-bay spillway, with a shallow spilling basin and no deflectors

The Corps will evaluate, identify, and implement the appropriate 24-hour spill levels (day and night considered separately) to optimize spring and summer juvenile survival; investigate surface bypass collection efficiency improvements (blocked trash racks) and sluiceway passage survival in 2001 and fully implement measures across the powerhouse as warranted; evaluate the juvenile survival benefit of sluiceway outfall relocation; and implement composite outfall relocation and auxiliary water emergency measures. If the spillway juvenile mortality rate is excessive at 40%

spill in 2000, the Corps will investigate mechanistic causes of physical injury, including potential construction of spillway deflectors. The Corps will defer an intake screen and bypass system implementation decision until other measures are fully evaluated and consider the installation of fish friendly turbine designs (e.g., minimum-gap turbine runners) as part of the turbine rehabilitation program.

John Day Dam. Spill levels, configurations, and facilities at John Day Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- A 12-hour spill from 6:00 p.m. to 6:00 a.m. (7:00 p.m. to 6:00 a.m., May 15th to July 31st), at 60% of the outflow up to the TDG gas cap
- Standard-length screens at all 16 main units
- A new juvenile fish monitoring facility that releases fish approximately 1,000 feet downstream of the powerhouse
- A 20-bay spillway, with new deflectors on 18 bays

The Corps will continue 24-hour spill investigations to determine juvenile passage and survival benefits; construct end deflectors by 2002 and assess water quality and fish survival benefits of deflector optimization; conduct surface bypass removable spillway weir prototype evaluation in 2002 as a surrogate for skeleton bay surface collection; continue to develop extended intake screen system; conduct prototype tests in 2001/2002; synthesize incremental juvenile survival benefits of all juvenile passage options in late 2002 and proceed with the most promising survival-improvement measures; and investigate less intrusive PIT-tag interrogation method for juvenile sampling facilities and implement them as warranted.

McNary Dam. Configurations and facilities at McNary Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- A 12-hour spill from 6:00 p.m. to 6:00 a.m. at the TDG cap
- Extended-length screens in all 14 main units
- Juvenile fish monitoring facility/collection and bypass, with the capability to either collect and transport fish via barge or truck, or release fish to the river
- A 22-bay spillway, with deflectors on 18 bays

The Corps will conduct spillway efficiency and effectiveness evaluations, spillway deflector optimization investigations, and surface bypass removable spillway weir prototype studies as appropriate (based on results at other locations); determine optimum spring migration juvenile

survival configuration and operations; implement promising measures; upgrade extended intake screens and implement gatewell screen cleaning and other juvenile bypass system improvements; investigate and implement remedies to address adult egress from juvenile bypass system; investigate a less intrusive PIT-tag interrogation method for juvenile sampling facilities; implement it as warranted; and evaluate the need for juvenile bypass outfall relocation.

Ice Harbor Dam. Configurations and facilities at Ice Harbor Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- A 24-four hour spill (with nighttime spill limited to the TDG at the cap and daytime spill limited to 45 kcfs for adult passage)
- Standard-length screens at all six main units
- A 10-bay spillway, with deflectors on 10 bays

The Corps will investigate and implement remedies to address adult egress from the juvenile bypass system; assess the provision of a less intrusive PIT-tag interrogation method for the Ice Harbor juvenile bypass system; consider, based on other studies, a surface bypass removable spillway weir (RSW); and consider the installation of fish-friendly turbines as part of the turbine rehabilitation program.

Lower Monumental Dam. Configurations and facilities at Lower Monumental Dam related to juvenile fish passage include the following operating criteria identified in this biological opinion or the Fish Passage Plan:

- A 24-hour spill at the gas cap
- Standard-length screens at all six main units
- Juvenile fish monitoring facility/collection and bypass, with the capability to either collect and transport fish via barge or truck, or release them to the river
- An eight-bay spillway, with deflectors on six middle bays

The Corps will continue the 24-hour spill; investigate a surface bypass RSW, spillway deflector optimization (including the addition of-end bay deflectors), and juvenile bypass system separator replacement, as well as making other system improvements; investigate a new juvenile bypass outfall location; investigate an extended intake screen system; and implement the most promising measures to increase juvenile survival.

Little Goose Dam. Configurations and facilities at Little Goose Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- A 12-hour spill (6:00 p.m. to 6:00 a.m.) up to the gas cap
- Extended-length screens at all six main units
- Juvenile fish monitoring facility/collection and bypass, with capability to either collect and transport fish via barge or truck or release them to the river
- An eight-bay spillway, with deflectors on six middle bays

The Corps will investigate a surface bypass RSW, spillway deflector optimization (including addition of end bay deflectors), and replacing the juvenile bypass system separator, as well as making other system improvements; upgrade extended intake screens; investigate the effectiveness of 24-hour spill, either separately or in conjunction with a surface bypass RSW; implement those measures with the greatest promise of increasing juvenile survival; determine the need and frequency of powerhouse debris containment boom use to reduce predation losses; and implement debris removal criteria.

Lower Granite Dam. Configurations and facilities at Lower Granite Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- A 12-hour spill from 6:00 p.m. to 6:00 a.m. up to the gas cap
- Extended-length screens at all six main units
- Juvenile fish monitoring facility/collection and bypass, with the capability to either collect and transport fish via truck or barge, or release them to the river
- Prototype powerhouse surface collector
- An eight bay-spillway, with deflectors on eight bays

The Corps will initiate surface bypass RSW studies in 2001; complete design of juvenile bypass system improvements to add open-channel flume, juvenile separation by size, and other system improvements; upgrade extended intake screens; investigate the effectiveness of 24-hour spill, either separately or in conjunction with a surface bypass RSW; investigate spillway deflector optimization and implement it as warranted; defer a decision on permanent powerhouse surface bypass collector until other measures are fully evaluated; implement measures with the greatest promise of increasing juvenile survival; and add additional transport barges as warranted.

9.6.1.4.3 Current and Near-term Actions

Spill Program

Action 54: The Corps and BPA shall implement an annual spill program, consistent with the spill volumes and TDG limits identified in Table 9.6-3, at all mainstem Snake and Columbia River FCRPS projects as part of the annual planning effort to achieve the juvenile salmon and steelhead performance standards.

The annual spill program will be based on the best available monitoring and evaluation data concerning project passage, spill, and system survival research. The Action Agencies, in consultation with the Technical Management Team and with the approval of NMFS, will conduct a preseason determination of the specific annual spill levels and dates at each project. The planning dates for the annual spill program are April 3 to June 20 and June 21 to August 31 for the spring and summer migration periods, respectively, in the Snake River, and April 10 to June 30 and July 1 to August 31 for the spring and summer migration periods, respectively, in the lower Columbia River. Initial estimates of project spill levels, and the basis for each estimate, are shown in Table 9.6-3.

The specific spill volumes listed in Table 9.6-3 must be viewed as approximate because the TDG levels measured at the monitoring site below each project, at a given spill level, can vary with such factors as river flow, forebay dissolved gas level, spill patterns, and water temperature changes. Spill levels at some projects may change as spill patterns are refined or if deflector optimization measures are implemented. There are also project-specific limitations on spill levels for reasons other than TDG, including adult passage, navigation, and research activities. These limitations are typically of short duration, but they can affect spill for fish passage to a limited degree.

Interruptions or adjustments in spill may occur due to unforeseeable power system, flood control, or other emergencies. The Action Agencies should view such emergency actions as last resorts, and they should not be used in place of the long-term investments necessary to allow full, uninterrupted implementation of the required spill levels while maintaining other project purposes, such as an adequate and reliable power system.

Discussion of emergencies with effects of exceptional magnitude or duration should include involvement of regional executives. Section 9.4.2.2 provides for the development of more specific process modifications to address these needs in the water management plans.

9.6.1.4.4 Project-by-project Spill Requirements

Lower Granite Dam. To achieve the desired fish passage efficiencies, the 1995 FCRPS Biological Opinion set the Lower Granite spill level at 80% of total instantaneous discharge for

12 hours per day. Under most conditions, however, this level of spill could not be implemented because the gas cap was reached at spillway flows of 40 kcfs (1998 Supplemental FCRPS Biological Opinion). More recent information suggests that the gas cap will be reached at about 60 kcfs; this level is the appropriate current spill limit. Based on radio-tracking studies with adult chinook, performed at Lower Granite Dam during 1996 and 1997, a spill level of 60 kcfs does not appear to affect adult passage adversely (Bjornn 1998, Bjornn 2000). It may be necessary to reduce spill to accommodate safety concerns when juveniles are being loaded directly onto barges for transportation downstream, and the barges must be docked for extended periods. Spill operations must also consider research needs critical to the ongoing evaluation of the surface bypass prototype (e.g., project operations in 2000 have been modified to spill for 24 hours per day instead of only at night, and powerhouse operations have been modified to provide the required hydraulic conditions in the immediate forebay).

Table 9.6-3. Estimated spill levels and gas caps for FCRPS projects during spring (all) and summer (nontransport projects).

Project[1]	Estimated Spill Level[2]	Hours	Limiting Factor
Lower Granite	60 kcfs	6 p.m. - 6 a.m.	gas cap
Little Goose	45 kcfs	6 p.m. - 6 a.m.	gas cap
Lower Monumental	40 kcfs	24 hours	gas cap
Ice Harbor	100 kcfs (night) 45 kcfs (day)	24 hours	nighttime - gas cap daytime - adult passage
McNary	120-150 kcfs	6 p.m. - 6 a.m.	gas cap
John Day	85-160 kcfs/60% [3] (night)	6 p.m. - 6 a.m.[4]	gas cap/percentage
The Dalles	40% of instant flow	24 hours	tailrace flow pattern and survival concerns (ongoing studies)
Bonneville	90-150 kcfs (night) 75 kcfs (day)	24 hours	nighttime - gas cap daytime - adult fallback

[1] Summer spill is curtailed beginning on or about June 20 at the four transport projects (Lower Granite, Little Goose, Lower Monumental, and McNary dams) due to concerns about low inriver survival rates.
[2] Estimated spill levels shown in the table will increase for some projects as spillway deflector optimization measures are implemented.
[3] The TDG cap at John Day Dam is estimated at 85 to 160 kcfs, and the spill cap for tailrace hydraulics is 60%. At project flows up to 300 kcfs, spill discharges will be 60% of instantaneous project flow. Above 300 kcfs project flow, spill discharges will be at the gas cap (up to the hydraulic limit of the powerhouse).
[4] Spill at John Day Dam will be 7:00 p.m. to 6:00 a.m. (night) and 6:00 a.m. to 7:00 p.m. (day) between May 15 and July 31.

BPA has specified 11.5 kcfs as a minimum powerhouse flow for system reliability. Because this minimum depends on the status of generation at other projects, it may not be necessary at all times.

Little Goose Dam. The 1995 FCRPS Biological Opinion set the Little Goose Dam spill level at 80% of total instantaneous discharge 12 hours per day (NMFS 1998). As at Lower Granite Dam, the Action Agencies could not usually implement this level because the gas cap was reached at spillway flows of approximately 35 kcfs. More recent information suggests that the gas cap will be reached at about 45 kcfs; this level is the appropriate current limit at Little Goose Dam. Based on radio-tracking studies with adult chinook performed during 1997, a spill level of 60 kcfs did not appear to affect adult passage adversely (Peery 1998).

BPA has specified 11.5 kcfs as a minimum powerhouse flow for system reliability. Because this minimum depends on the status of generation at other projects, it may not be necessary at all times.

Lower Monumental Dam. The 1995 FCRPS Biological Opinion set the Lower Monumental Dam spill level at 81% of total instantaneous discharge for 12 hours per day (NMFS 1998). Again, this level of spill was not provided voluntarily, because the gas cap was reached at spillway flows of approximately 40 kcfs. The estimate of spill at the gas cap has not changed. Spill levels to the gas cap will now, however, be provided for 24 hours per day. Based on radio-tracking studies with adult chinook performed during 1997, a spill level of 45 kcfs did not appear to affect adult passage adversely (Peery 1998, Bjornn 2000). Because the gas cap is currently reached at approximately 40 kcfs, no reduction in spill is necessary for adult passage.

Accelerated erosion in the spillway stilling basin apron has recently been noted as a concern by the Corps. NMFS is concerned that the Corps may decide, for safety reasons, to limit fish passage spill until the noted erosion is corrected. To ensure that 24-hour fish passage spill, as described above, is not limited, the Corps and BPA will respond to the problem by initiating timely corrective measures.

BPA has specified 11.5 kcfs as a minimum powerhouse flow for system reliability. Because this minimum depends on the status of generation at other projects, it may not be necessary at all times.

Ice Harbor Dam. The 1995 FCRPS Biological Opinion prescribed spill levels at Ice Harbor Dam of 27% in the spring and 70% in the summer, each for 24 hours per day. The 27% spring objective was often reached, even though the gas cap limited voluntary spill to flows of 25 kcfs. The summer target of 70% was also reached at the lower flow levels (NMFS 1998). Due to the installation of spillway flow deflectors, more recent information suggests that the gas cap will be reached at 100 kcfs. Based on research performed during the early 1980s, adult passage would become a concern at daytime (5:00 a.m. to 8:00 p.m.) spill in excess of 45 kcfs. Recent information from radio-tracking studies performed from 1996 to 1998 suggests that spill levels

from 55 to 70 kcfs did not appear to affect adult passage adversely (Peery 1998, Bjornn 2000). The 45-kcfs, adult-passage daytime cap may have to be reconsidered once the final study results are available. No change is now proposed, however, and the daytime limit remains 45 kcfs.

BPA has specified 7.5 to 9.5 kcfs as minimum powerhouse flows for system reliability. Because this minimum depends on the status of generation at other projects, it may not be necessary at all times.

McNary Dam. The 1995 FCRPS Biological Opinion set the McNary Dam spill level at 50% of total instantaneous discharge for 12 hours per day (NMFS 1998). Due to limited powerhouse capacity, and because the gas cap was reached at spillway flows of 120 kcfs, these spill levels were reached under most conditions. More recent information suggests that the gas cap will be reached at about 135 kcfs.

BPA has specified a minimum powerhouse flow of 50 kcfs to maintain power transmission system stability.

John Day Dam. The 1998 FCRPS Supplemental Biological Opinion set the John Day Dam spill level at 60% of total instantaneous discharge up to the gas cap during the nighttime hours. At project flows up to 300 kcfs, spill discharges will be 60% of instantaneous project flow during 12 hours per day. Above 300 kcfs, spill discharges will be the gas cap (up to the hydraulic limit of the powerhouse). With the completion of spillway deflectors and new spill patterns, gas cap spill flow has ranged up to170 kcfs. Spill limits of 25% minimum and 60% maximum are imposed to ensure adequate juvenile egress conditions from the spillway at low spill flows and from the juvenile bypass system during high spill flows. General physical model studies have indicated that spill percentages below 25% create poor egress conditions (eddies and slack water) in the spillway tailrace, and spill levels above 60% tend to create a large eddy in the tailrace below the powerhouse that can actually cause flow from the bypass to move upstream.

BPA has specified a minimum powerhouse flow of 50 kcfs to maintain power transmission system stability.

The Dalles Dam. The 1995 FCRPS Biological Opinion prescribed a spill level at The Dalles Dam of 64% for 24 hours (NMFS 1998). Spill survival studies NMFS conducted in 1997, 1998, and 1999 indicated that the 64% spill level can result in relatively low spillway survival compared to fish released below the project. These studies also indicated that a 30% spill level spillway survival was always as good or higher than the 64% level. Companion studies using radio-tagged fish and hydroacoustic monitoring indicated that reducing the spill percentage from 64% to 30% caused more fish to pass through the powerhouse sluiceway and turbines. Turbine survival has not been measured at this project, but it is assumed to be no better than that observed at other projects. Details of these studies and references can be found in NMFS 2000a.

Based on the available information, the ISAB recommended an evaluation of 24-hour spill levels at The Dalles in the 30% to 50% range (ISAB 2000). NMFS recommends an evaluation of 24-hour spill at the 40% level and expects to improve juvenile fish survival with this interim spill operation (see Section 9.6.1.4.5). Additionally, because reduced juvenile survival at higher spill levels may have been related to the daylight adult spill pattern, there is potential for higher than 40% nighttime spill with a juvenile passage pattern after The Dalles survival tests are concluded, and the results are evaluated. Upon completion of these tests, modified spill levels and patterns should be evaluated for adult passage and fallback.

BPA has specified a minimum powerhouse flow of 50 kcfs to maintain power transmission system stability.

Bonneville Dam. The 1998 FCRPS Supplement established a nighttime spill level at the TDG cap generally between 90 and 150 kcfs for the duration listed in the current Corps' Fish Passage Plan. The minimum spill level will be no less than 50 kcfs of the total river flow to provide good tailrace egress of juvenile migrants. Daytime spill levels are limited to 75 kcfs at Bonneville Dam due to concerns for adult salmonid fallback through the spillway. Recent evidence from adult radio-tracking studies conducted in 1996, 1997, and 1998 indicates that increases in adult fallback associated with increased daytime spill flows from 75 to120 kcfs range are relatively small. Juvenile passage benefits from the increased spill level would likely outweigh small adult losses that may be associated with the higher spill level. Further, spillway deflector optimization improvements may result in more uniform spill gate openings, which could reduce adult fallback rates. NMFS believes this issue warrants further investigation. Planned studies are described below.

BPA has specified a minimum powerhouse flow of 30 kcfs.

System Actions to Improve Spill Capability

Action 55: To improve the future flexibility of the transmission system, BPA's Transmission Business Line shall initiate planning and design necessary to construct a Schultz-Hanford 500-kV line or an equivalent project, with a planned schedule for implementation by 2004 or 2005.

This line would make additional daytime spill possible in the lower Columbia to help meet performance standards by restoring approximately 200 to 300 MW of California transfer capability. Because construction of this new line will require congressional and NEPA review, BPA's Transmission Business Line should begin this planning effort in 2000.

Action 56: BPA's Transmission Business Line shall continue efforts to evaluate, plan, design, and construct a joint transmission project to upgrade the west-of-Hatwai cutplane[7] and improve the transfer limitations from Montana.

Although the specific type of project to be implemented has not been identified at this time, this project is expected to be completed in the 2003-to-2004 time frame. This upgrade would make additional daytime spill possible at the Snake River dams to help meet performance standards by restoring approximately 500 MW of Montana transfer capability. Since this project will also require NEPA review, BPA's Transmission Business Line should begin this joint planning effort in 2000.

Action 57: BPA's Transmission Business Line shall continue to evaluate strategically located generation additions and other transmission system improvements and report progress to NMFS annually. BPA's Transmission Business Line shall also limit future reservations for transmission capacity, as needed, to enable additional spill to meet performance standards, while minimizing effects on transmission rights holders.

If additional spill is found to be appropriate at FCRPS projects (more than the capacity that the Schultz-Hanford project provides), further transmission system reinforcements may be required to enable obtaining it and restoring any additional lost capacity. BPA's Transmission Business Line has made only a cursory examination of these potential transmission system reinforcements. The most promising candidates are major 500-kV lines in the Interstate Highway 5 (I-5) corridor; however, such new lines would be very costly and challenging to site. If work on these projects started in 2002 (pending favorable results in ongoing spill studies), completion of these reinforcements would be expected in the 2007-to-2010 timeframe. In addition, several new gas-fired combustion turbines south of the John Day cutplane (with a total capacity of about 1,250 MW of base load generation) are being licensed and could be operational by the summer of 2002. If additional spill is found to be appropriate, and before long-term fixes can be implemented, BPA will limit future reservations for transmission capacity, as appropriate, to enable spill while minimizing effects on existing transmission rights holders.

Turbine Unit Operations

Action 58: The Corps and BPA, in coordination with the Fish Passage Operations and Maintenance Coordination Team (FPOM), shall operate all turbine units at FCRPS dams for optimum fish passage survival. Methods to achieve this

[7]Cutplanes are reference points on a set of transmission lines that define capacity restrictions under certain operating conditions or when facilities are out of service. These reference points, when linked together, form a line (or a plane) that defines an operating constraint in the transmission system. That is, there is a limit to the amount of electricity that can flow across this plane. Thus, they are identified with transmission constraints.

objective shall include, but are not limited to, activities outlined in the following paragraphs.

The Corps and BPA will operate turbines within 1% of peak efficiency during the juvenile and adult migration seasons (March 15 through October 31 in the Columbia River and March 15 through November 30 in the Snake River) as indicated by the load-shaping guidelines contained in the Corps' annual Fish Passage Plan. These guidelines will be updated through the Fish Passage Plan review process before February 1 each year. Operating turbines at peak efficiency is believed to provide the highest survival of anadromous species during passage through a turbine (Bell et al. 1981, Eicher 1987).

The Corps and BPA will continue efforts to index-test all families of turbine units specific to each project in the FCRPS to ensure that peak efficiency tables listed in the Fish Passage Plan reflect current operating conditions. This work will be completed by 2003. This will include index testing and development and implementation of operational cam curves. These curves will be developed and updated as necessary to reflect current fish passage conditions (screens, surface collectors, unit modifications, etc.). This work will be coordinated through FPOM.

Action 59: The Action Agencies, in coordination with the Regional Forum, shall determine the appropriate operating range of turbines equipped with minimum gap runners (MGRs) to increase survival of juvenile migrants passing through these new turbine designs.

The Action Agencies will evaluate the potential for exceeding the upper limit of the 1% efficiency band to improve fish survival related to passage through turbines with MGR technology. The evaluation will include an examination of indirect consequences (in terms of fish survival) of exceeding the 1% peak efficiency guidelines (including screen effects, gatewell hydraulics, draft tube and tailrace conditions, etc.). The Action Agencies will report results of this evaluation to NMFS by October 2003. Other turbine designs may be evaluated if study designs and priorities are approved as part of the annual planning process.

9.6.1.4.5 Studies (Including Research, Monitoring, and Evaluations)

Bonneville Dam

Action 60: The Corps and BPA shall evaluate adult fallback and juvenile fish passage under daytime spill to the gas cap at Bonneville Dam in 2002 and 2003, after deflector optimization improvements allow for increased spill above current levels. Research results will be considered, in consultation with NMFS through the annual planning process, to determine implementation of additional changes in spill to further improve fish survival.

Research goals will include rate of adult fallback and juvenile passage change between 75 kcfs and new gas cap spill levels attainable through deflector optimization. The future daytime spill level will depend on the results of this study. The study design for future spill evaluations, and the resulting changes in the annual spill operation, should be coordinated through NMFS' Regional Forum process.

Further modifications to spill operations suggested by the studies at this project for 2002 and beyond may be limited pending transmission system improvements expected to come on-line by 2005 or earlier by potential modifications to spill operations at The Dalles and John Day dams. Other actions may improve the flexibility and reliability of the transmission system by an earlier date.

Action 61: The Corps shall complete the ongoing prototype powerhouse system surface collection evaluations at Bonneville First Powerhouse in 2000. The Corps shall compare the prototype with screened bypass systems and, if warranted, design and construct permanent facilities after full consideration and resolution of biological and engineering uncertainties, especially high-flow outfall investigations.

Existing Bonneville First Powerhouse juvenile passage facilities guide a relatively low percentage of fish away from turbines, and guided fish are bypassed to an outfall site with predator aggregations. The full potential of a surface collection and high-flow bypass outfall system has to be identified, then weighed against other alternatives.

Action 62: The Corps shall complete Bonneville First Powerhouse prototype evaluations of extended submerged intake and gatewell vertical barrier screens, including an assessment of fry passage.

The Corps will continue design development of improved screens, a downstream migrant collection channel, and connection to the new juvenile bypass monitoring facilities and outfalls.

Action 63: The Corps shall complete the design of debris removal facilities for the Bonneville First Powerhouse forebay.

If the decision is made to install a new extended-length screen and bypass system at this powerhouse in 2001, the Corps will install debris-removal facilities as warranted. Special consideration should be given to potential predation and juvenile fish entrainment problems associated with debris booms.

Action 64: The Corps shall continue the investigation of minimum gap runners at the Bonneville First Powerhouse.

The Corps will continue investigation of the new minimum gap runners at Bonneville Dam First Powerhouse to ensure that the new runner environment provides improved survival for juvenile

migrants that pass through turbines. The Corps will submit a report to NMFS stating the findings of these investigations by February 2001.

Action 65: The Corps shall complete Bonneville Second Powerhouse post-construction evaluation of the new juvenile fish bypass outfall and address design and operational refinements as warranted.

Issues such as smolt survival, fry impingement and loss, and potential design deficiencies will have to be investigated and corrected, as necessary.

Action 66: The Corps shall continue design development and construction of a Bonneville Second Powerhouse permanent corner collector at the existing sluice chute, pending results of high-flow outfall investigations. The Corps shall construct new facilities if, and as soon as, evaluations confirm the optimum design configuration and survival benefits.

Prototype testing in 1998 showed that numerous juveniles entering the forebay were collected by the sluice chute. The decision to proceed with this measure is contingent on identifying whether an optimum bypass outfall location can be selected that will minimize mechanical and predation losses in the tailrace.

Action 67: The Corps shall continue Bonneville Second Powerhouse investigations of measures to improve intake screen fish guidance efficiency and safe passage through the gatewell environment. This work shall include an assessment of fry passage.

The Bonneville Second Powerhouse bypass system has a state-of-the-art fish conveyance system coupled with relatively low fish guidance efficiency. Improving guidance of this system is an obvious next step to improving powerhouse passage, pending decisions on the optimal mix of actions at the second powerhouse for contributing to the performance standard.

<u>The Dalles Dam</u>

Action 68: The Corps and BPA shall continue spill and passage survival studies at The Dalles Dam in 2001. Research results shall be considered, in consultation with NMFS through the annual planning process, to assess the need for additional changes in spill to further improve fish survival by 2002, if possible, but no later than 2005.

The goal of these studies is to evaluate spillway survival by using a spill level that balances the risks associated with high spill levels and increased turbine passage. These studies should also include evaluation of survival rates through the other routes of passage at this project. These studies should investigate the causes of spillway mortality. Subsequent studies should assess the need for remedial actions.

Future changes in spill levels at The Dalles will depend on the results of the ongoing survival and spill passage studies. The study design for any future studies, and the resulting changes in the annual spill operation, will be coordinated through the annual planning process.

Further modifications to spill operations suggested by the studies at this project for 2002 and beyond may be limited pending transmission system improvements expected to come on line by 2005 or, before then, on potential modifications to spill operations at Bonneville and John Day dams. Other actions may improve the flexibility and reliability of the transmission system by an earlier date.

Action 69: The Corps shall continue design development and 2001 prototype testing of upper turbine intake occlusion devices at The Dalles, with a goal of increased non-turbine passage rates through either the sluiceway or the spillway. The Corps shall install occlusion devices across the entire powerhouse, as warranted.

Occlusion of upper intakes is a promising method of reducing turbine entrainment and associated mortality.

Action 70: The Corps shall continue biological and engineering investigations and design of a composite ice and trash sluiceway outfall relocation and adult ladder auxiliary water system at The Dalles Dam and shall construct such devices as warranted.

The existing ice and trash sluiceway is a highly efficient surface collector. However, recent PIT-tag survival data suggest that survival is unacceptably low. Relocation of the outfall to improve passage survival will also provide the opportunity to develop a combined system whereby excess water can be used to augment the auxiliary water supply for the east adult fishway.

John Day Dam

Action 71: The Corps and BPA shall continue investigation of 24-hour spill at John Day Dam in 2001. Research results will be considered, in consultation with NMFS through the annual planning process, to determine implementation of daytime spill to further improve juvenile fish survival as needed for its contribution to the performance standard.

High spillway effectiveness and high daytime passage were noted during 24-hour spill in 1997 and 1999. The 1999 studies indicated a significant reduction in forebay residence time for chinook and smaller (primarily wild) steelhead. These observations and the study limitations imposed by ambient flow conditions in 1999 warrant further investigation during the spring and summer seasons in 2001.

The framework for the ongoing study is as follows:

- The study goals identify juvenile salmonid response to daytime spill in terms of spillway passage, forebay residence time, and overall passage survival.

- The scope of the study will include both spring and summer spill.

- Adult passage considerations and potential adult fallback will be considered in the study design.

- The study plan will be reviewed through the annual planning process.

Further modifications to spill operations suggested by project studies for 2002 and beyond will be coordinated through the annual planning process and may be limited pending transmission system improvements expected to come on line by 2005. Other actions may improve the flexibility and reliability of the transmission system by an earlier date.

Action 72: The Corps shall continue design development of a prototype RSW and extended deflector for testing at John Day in 2002. The Corps should synthesize evaluation results, determine the fish survival benefits of one or more RSWs or a skeleton bay surface bypass, and install the units as warranted.

Surface-oriented entrances, such as those provided by a prototype RSW, have the potential to pass a high percentage of juveniles, potentially more than if the same flow is passed through the deeper conventional spill gates.

Action 73: The Corps shall continue John Day prototype development and investigations of extended submerged intake screens, gatewell vertical barrier screens, and, if necessary, orifices to optimize guidance and safe passage through the system, including a gatewell debris cleaning plan. This work shall include an assessment of fry passage. The Corps shall design and construct new screen systems for safe passage of juvenile salmonids, as warranted. Juvenile bypass outfall survival investigations shall also be conducted.

Prototype investigations have indicated that extended screens have the potential to guide up to 28% more juvenile salmon away from the turbine intakes at this project when compared to standard-length screens. Unfortunately, gatewell hydraulics were found to injure an unacceptable number of the guided fish. Model and prototype investigations are necessary to resolve the injury problem and provide safe passage conditions observed at other projects with extended-length screens. To ensure improved guidance results and improved passage survival, bypass outfall survival investigations should also be conducted.

McNary Dam

Action 74: The Corps shall continue evaluations to assess the need for improvements of the existing intake screens, gatewell vertical barrier screen cleaning system, and bypass facilities (including debris containment and removal systems, separation, sampling, loading, and outfall facilities) at McNary to determine where improvements are necessary to reduce problems experienced during the 1996 flood, increase fish survival, and resolve holding and loading facility problems, including raceway jumping by juvenile salmon and steelhead and debris plugging of bypass lines. Additionally, the Corps shall evaluate whether the existing juvenile bypass system outfall should be relocated.

The McNary Dam juvenile fish intake screening and bypass system experienced the most adverse effects associated with 1996 flooding and is the passage facility most in need of upgrades. The Corps will implement improvements as warranted.

Action 75: The Corps shall investigate a surface bypass RSW at McNary Dam, based on prototype results at other locations, and shall install the unit in multiple spillway bays, as warranted.

The potential for improved spillway passage through use of RSWs has to be investigated in the context of current spillway passage percentages for spring migrants at McNary Dam, where there is currently no spring transportation program and no voluntary fish spill during the 12 daytime hours.

Lower Monumental Dam

Action 76: The Corps shall investigate, design, and construct, as warranted, a new juvenile bypass outfall at Lower Monumental Dam. Investigations shall be conducted in conjunction with spillway deflector and spill pattern optimization studies.

The existing outfall site is poor because the tailrace current frequently flows upstream toward the powerhouse, and the outfall facilities recently were damaged by a transport barge. The new outfall shall be designed to return both PIT-tagged fish and primary bypass flow to the river.

Action 77: The Corps shall investigate surface bypass (e.g., RSW) at Lower Monumental Dam, based on prototype results at other locations, and install in multiple spillway bays, as warranted.

Use of one or more RSWs at Lower Snake hydro projects will potentially increase safe spillway passage during periods of low to moderate spill.

Action 78: The Corps shall initiate design development and testing of extended submerged intake screens and vertical barrier screens at Lower Monumental Dam and construct units as warranted.

Lower Monumental Dam presently has standard screens. Improved fish guidance efficiency would enhance survival of fish entrained at powerhouse turbine intakes by diverting a higher proportion away from turbine passage where they are subject to direct mechanical and/or indirect mortality.

Little Goose Dam

Action 79: The Corps shall conduct a post-construction evaluation of the new debris containment boom at Little Goose to monitor populations and behavior of aquatic predators when debris accumulates at the log boom.

The Corps should develop criteria for initiation of debris removal at the new log boom before the 2002 passage season and assess log boom predator aggregation in both wet and dry years. The Corps will alter criteria and address predation, as warranted.

Lower Granite Dam

Action 80: The Corps shall continue the design development, fabrication/deployment, and testing of a prototype RSW at Lower Granite, in conjunction with the existing prototype powerhouse occlusion devices, including the forebay behavioral guidance structure (BGS) and upper turbine intake occlusion devices. As warranted by prototype test results, the Corps shall install one or more permanent RSWs and occlusion devices at appropriate lower Snake hydro projects, in coordination with the annual planning process.

Use of one or more RSWs, in possible combination with occlusion systems at lower Snake hydro projects, will potentially increase safe spillway passage and survival, reduce forebay residence time, reduce stress, and potentially reduce gas supersaturation due to higher spillway passage efficiencies.

Action 81: The Corps shall complete design for new juvenile bypass facilities at Lower Granite Dam, including enlarged orifices and bypass gallery, open-channel flow bypass, improved separator for juvenile separation by size, and improved fish distribution flumes and barge-loading facilities and shall proceed to construction, as warranted.

Lower Granite is the first mainstem dam on the Snake River encountered by migrating juvenile salmon and steelhead. This location offers the greatest potential for collecting the largest number of smolts for transportation. Unlike the other dams, there is presently no way to separate juvenile

fish by size. Such size separation is believed to reduce stress and enhance long-term survival. Juvenile collection/bypass facilities at all of the other collector projects have been upgraded with state-of-the-art improvements over the last decade. These improvements are necessary, while additional information on the benefits of transportation is collected.

9.6.1.4.6 System or General Studies (including Research, Monitoring, and Evaluations)

Action 82: The Action Agencies, in coordination with NMFS through the annual planning process, shall investigate the spillway passage survival of juvenile salmonids at appropriate FCRPS dams. These investigations shall assess the effect of spill patterns and per-bay spill volumes on fish survival, across a range of flow conditions. The Action Agencies shall develop a phased approach (including costs and schedules) and set priorities, in consultation with NMFS in the annual planning process, to continue spillway passage survival studies in 2001 and future years.

Spillway passage has become an increasingly important route for juvenile salmonids at FCRPS dams. These studies will ensure that each spillway is operated in a manner that results in the lowest possible direct and indirect mortality.

Action 83: The Action Agencies, in coordination with NMFS through the annual planning process, shall evaluate the effect of spill duration and volume on spillway effectiveness (percent of total project passage via spill), spill efficiency (fish per unit flow), forebay residence time, and total project and system survival of juvenile steelhead and salmon passing FCRPS dams. Studies shall include both collector and non-collector projects. Adult passage considerations and potential adult fallback shall also be considered in study designs. Little Goose and Lower Granite dams shall be specifically considered for daytime spill studies. An overall phased study approach for spill evaluations will be determined in the 1- and 5-year implementation plans.

Whereas the current nighttime spill regime is based on NMFS' understanding of hours of peak daily juvenile fish passage, it is clear that fish move throughout the day and that, as a result, longer spill hours may improve juvenile fish survival past the dams by increasing the proportion of fish passing in spill. Spill changes to improve fish survival may include reshaping current volumes or spilling increased volumes. There may also be operational changes associated with spill patterns or hourly project operations that influence the proportion of fish passed through spill.

It may also be possible to reduce delay when fish first encounter the dam and, thereby, limit exposure to predation in project forebays. Conversely, longer spill hours could have negligible-to-measurable adverse biological effects, such as delay, fallback of adults, or increased exposure to dissolved gas supersaturation. The intent of the efficiency and effectiveness information is to

ensure optimal use of current and future spill volumes to achieve the biological performance standards. Any resulting changes in the annual spill operation will be coordinated through the annual planning process.

The research actions called for above are proposed to further evaluate the fish spill program at selected projects. In addition, NMFS believes that obtaining and reviewing the results of these evaluations will assist in making appropriate future modifications in the spill program to improve both fish survival and water quality.

To the extent that greater spill duration and/or volumes are required for the purposes of spill evaluation at some projects, efforts will be made to minimize or offset additional effects to the power system.

Action 84: The Corps shall continue high-flow outfall investigations to determine whether it is appropriate to modify bypass outfall criteria in the context of high-discharge bypass discharges.

Development of high-flow outfalls for surface collector/bypass systems requires verification of negligible mechanical and predation losses as flow plunges into the tailrace at high velocities. This research is relevant at numerous sites.

Action 85: The Corps shall continue to develop and evaluate improved fish-tracking technologies and computational fluid dynamics (numerical modeling). The ability to integrate these technologies and fluid dynamics shall be assessed as a potentially improved means of determining fish responses to forebay hydraulic conditions.

More precise understanding of fish behavioral responses to forebay hydraulic and other conditions is required to optimize future fish collection and bypass system designs. Integrated use of improved fish tracking and numerical modeling offers the potential for research advances that will lead to survival enhancement measures.

Action 86: The Corps shall continue to investigate a way to increase entry rates of fish approaching surface bypass/collector entrances.

Deep, wide surface collector entrances, similar to the successful Wells Dam surface collector system, have been studied at Corps prototype sites, but performance has been marginal. Therefore, a study is needed to evaluate fish behavior and flow-fields of large surface-oriented entrances that are believed to be highly efficient and effective, such as The Dalles ice and trash sluiceway.

Action 87: The Corps and BPA shall assess less-intrusive, PIT-tag interrogation methods at FCRPS juvenile bypass systems with interrogation sites, including McNary, John

Day, and Bonneville dams. The Corps and BPA shall also assess providing a similar detection capability for the Ice Harbor juvenile bypass system.

The Corps and BPA should assess the use of full bypass flow PIT-tag detection, without the need to dewater and route fish through separators and sample flumes. This type of system reduces the potential for adverse survival effects of passage through these bypass systems.

Action 88: The Corps and BPA, in coordination with the Fish Facility Design Review Work Group and the Fish Passage Improvement Through Turbines Technical Work Group, shall continue the program to improve turbine survival of juvenile and adult salmonids.

Action 89: The Action Agencies shall investigate hydraulic and behavioral aspects of turbine passage by juvenile steelhead and salmon through turbines to develop biologically based turbine design and operating criteria. The Corps shall submit a report to NMFS stating the findings of the first phase of the Turbine Passage Survival Program by October 2001. Annual progress reports will be provided after this date.

Action 90: The Action Agencies shall examine the effects of draft tubes and powerhouse tailraces on the survival of fish passing through turbines.

The evaluation should include biological and hydraulic evaluations and, if warranted, implementation of measures to reduce the effects of turbine backroll on juvenile salmonid survival, as well as the potential for reducing physical and hydraulic predator habitat in the tailrace environment. Action should also be taken to close draft tube gate closure slots at dams where these exist.

Action 91: The Action Agencies shall remove all unnecessary obstructions in the higher velocity areas of the intake-to-draft tube sections of the turbine units.

Unnecessary obstructions include miscellaneous hardware attachment points, handles, bolt heads, etc. Methods to streamline escape ladders, flow splitters, and other necessary obstructions should be evaluated and implemented, if feasible.

Action 92: The Action Agencies shall consider all state-of-the-art turbine design technology to decrease fish injury and mortality before the implementation of any future turbine rehabilitation program (including any major repair programs, the ongoing rehabilitation program at The Dalles Dam, and any future program at Ice Harbor Dam). The Action Agencies shall coordinate within the annual planning process before making decisions that would preclude the use of fish-friendly technologies and to minimize any adverse effects of project downtime.

Action 93: The Action Agencies shall determine the number of adults passed through turbines, then, if warranted, investigate the survival of adult salmonid passage through turbines (including steelhead kelts).

This program will include baseline passage evaluation and survival estimates and an investigation of hydraulic and behavioral aspects of turbine passage. This information will be used to develop biologically based turbine design and operating criteria.

Action 94: The Corps shall continue to evaluate the need for improvements of the existing intake screens, gatewell vertical barrier screens' cleaning system, and bypass facilities (including debris containment and removal systems, separation, sampling, loading, and outfall facilities) at the four lower Snake River hydropower projects.

The objective of these investigations is to upgrade intake screen, bypass, and loading facilities to modify and/or incorporate new components, especially in cases where problems have been identified since original design and construction. This includes investigation and implementation of measures to reduce raceway jumping.

Action 95: The Corps shall complete investigations of improved wet separator designs in 2002. The Corps shall design and construct a new wet separator at McNary, Lower Monumental, and Little Goose dams, as warranted.

The Corps will conduct post-construction evaluations of improved juvenile fish separation performance.

Action 96: The Corps shall complete the extended submerged intake screen systemwide letter report and implement recommended improvements.

The Corps will complete an investigation of fish performance and engineering issues pertaining to the need for improved porosity-control panel and panel connection design and install improved panels in all extended submerged intake screens. In particular, the Corps will develop improved vertical barrier screen gatewell cleaning and inspection measures for McNary and John Day dams and implement them as warranted. Also, the Corps will develop improved debris handling measures in the forebays and screen/bypass systems to limit juvenile injury and mortality. The Corps will implement other measures related to extended-length screen improvements, as warranted.

9.6.1.4.7 Configuration Alternatives and Decision Dates

Bonneville Dam—First Powerhouse

Action 97: By January 2002, the Action Agencies shall develop an analysis that compares the relative passage survival benefits of an extended-length, intake screen bypass system, a surface-collection bypass system, and hybrid alternatives at Bonneville First Powerhouse. Through the annual planning process, the Corps shall determine which of these configurations to implement.

Two configuration alternatives are under evaluation for an improved bypass system at Bonneville First Powerhouse. One alternative completely upgrades the existing conventional bypass system by replacing the standard-length intake screens with extended-length screens, upgrading the collection gallery, and relocating the outfall. The other alternative employs the developing surface attraction and collection technology in front of the powerhouse and passes juveniles in a collection channel to a new outfall site downstream. Intake screens and surface collection may work best in tandem, suggesting that a hybrid of the two systems may be a third alternative configuration. The decision on which alternative to implement may be made as early as January 2001, but no later than January 2002.

John Day Dam

Action 98: By January 2003, the Action Agencies shall develop an analysis that compares the relative passage survival benefits of replacing existing standard-length intake screens with extended-length screens at the John Day Dam powerhouse to surface collection at one or more skeleton or spillway bays. Through the annual planning process, the Action Agencies shall then determine the need for, and the implementation priority of, these configuration alternatives.

Two different configuration alternatives are currently under evaluation at John Day Dam. Extended-length screens have been under development and evaluation for several years. Evaluation to date has indicated that the screens increase FGE. In 1999, research confirmed excessive mortality in the gatewells. Excessive gatewell turbulence is suspected as the cause of the mortality, and a new vertical barrier screen design is being developed. Surface collection technology has yet to be evaluated at John Day Dam. An RSW is under development for prototype evaluation in 2002. This requires that the Action Agencies make a determination by 2003, through the annual planning process, about the need for and implementation priority of these alternatives at John Day.

Lower Monumental Dam

Action 99: By January, 2003, the Action Agencies shall develop an analysis that compares the relative passage survival benefits of replacing existing standard-length intake

screens with extended-length screens at the Lower Monumental Dam powerhouse turbines to a removable RSW surface bypass system.

Twenty-four-hour spill was implemented at Lower Monumental Dam in spring 2000. Configuration alternatives include extended intake screens and one or more RSWs. Extended intake screen performances at other sites are known, and RSW fish passage efficiency will be studied at Lower Granite Dam in 2001. The Action Agencies will determine, through the annual planning process, which configuration alternatives to test or implement at Lower Monumental Dam.

9.6.1.5 Reservoir Passage

In general, juvenile mortality in reservoirs typically is associated with predation. While predation may be the primary cause of mortality, many factors contribute to vulnerability to predation, including water temperature, delay of passage or migration, TDG supersaturation, fish condition, disease, turbidity, lack of cover, etc. Various ongoing measures that directly reduce predation of juvenile outmigrants (e.g., Northern Pikeminnow Management Program) or may indirectly affect potential predation (water management, including releases of cool water, 24-hour spill, spill patterns, avian lines, water cannons, etc.) should continue. The Action Agencies should also develop other approaches that may contribute to reducing reservoir mortality.

9.6.1.5.1 Predator Control Strategy. The riverine ecosystems of the lower Snake and lower Columbia rivers have been altered dramatically by the development of the FCRPS. This development, and associated fish management practices, has created an environment that has benefitted a variety of species that prey on juvenile and adult salmonids. Studies cited in the Predation White Paper (NMFS 2000f) indicate that relatively large numbers of juvenile salmonid migrants are eaten by a variety of piscivorus fish, birds, and marine mammals. The northern pikeminnow alone is responsible for the loss of approximately 8% of the juvenile salmonid migrants in the system, and gulls were estimated to take 2% of all migrants passing one Columbia River dam. Marine mammal damage has been observed on up to 19% of the adult spring/summer chinook passing Lower Granite Dam. NMFS recognizes that death, injury, and health problems resulting from dam and reservoir passage and the presence of non-indigenous predator species are issues that will persist regardless of how predation is managed. It also recognizes that native predators are a part of the river ecosystem. Nevertheless, NMFS believes that some degree of predator control is necessary and that the following measures will help achieve the survival performance goals identified in this biological opinion, particularly related to the 10% reduction in reservoir mortality estimates.

9.6.1.5.2 Current and Near-term Actions

Action 100: The Action Agencies shall continue to implement and study methods to reduce the loss of juvenile salmonids to predacious fishes in the lower Columbia and lower Snake rivers. This effort will include continuation and improvement of the

ongoing Northern Pikeminnow Management Program and evaluation of methods to control predation by non-indigenous predacious fishes, including smallmouth bass, walleye, and channel catfish.

Northern pikeminnow, smallmouth bass, channel catfish, and walleye are important predators of juvenile salmon (Poe et al. 1991, Tabor et al. 1993). Various studies conducted in the 1980s indicated that northern pikeminnow predation in John Day Reservoir alone consumed between 1.4 and 3.3 million juvenile salmonids each year. Predator control efforts to date have focused on removing northern pikeminnow from the Snake and Columbia rivers and evaluating the behavior and distribution of predators in the near-dam and reservoir reaches. Additional emphasis should be placed on other predatory species in areas where those species cause significant loss of juvenile salmonids (see Section 9.6.1.5.3, below).

The effects of predator fish removal, habitat modifications, and management operations should be evaluated periodically as long as the programs continue. Such evaluation should include the effect on juvenile salmon survival, changes in target predator species population structures, and possible compensation by other predatory species.

Action 101: The Corps, in coordination with the NMFS Regional Forum process, shall implement and maintain effective means of discouraging avian predation (e.g., water spray, avian predator lines) at all forebay, tailrace, and bypass outfall locations where avian predator activity has been observed at FCRPS dams. These controls shall remain in effect from April through August, unless otherwise coordinated through the Regional Forum process. This effort shall also include removal of the old net frames attached to the two submerged outfall bypasses at Bonneville Dam. The Corps shall work with NMFS, FPOM, USDA Wildlife Services, and USFWS on recommendations for any additional measures and implementation schedules and report progress in the annual facility operating reports to NMFS. Following consultation with NMFS, corrective measures shall be implemented as soon as possible.

Bird predation marks are among the most common injuries observed on juvenile steelhead at smolt monitoring sites. During 1995 and 1996, 15% and 10%, respectively, of all the hatchery steelhead examined at John Day Dam exhibited bird predation marks (Martinson et al. 1997). These observations may indicate a high rate of juvenile steelhead predation that could be reduced with appropriate measures. The net frames at Bonneville Dam are no longer used for research and have become favored perching areas for fish-eating cormorants and gulls. The Corps will coordinate scoping and implementation of predator control measures with USFWS to ensure that the measures do not endanger bald eagles, osprey, and other bird species that are afforded Federal protection.

Any avian control measure involving capture or killing of migratory birds will require a permit issued by USFWS under the procedures and standards set out in the Migratory Bird Treaty Act and in USFWS's implementing regulations.

9.6.1.5.3 Studies (Including Research, Monitoring, and Evaluation)

Action 102: The Action Agencies, in coordination with the Caspian Tern Working Group, shall continue to conduct studies (including migrational behavior) to evaluate avian predation of juvenile salmonids in the FCRPS reservoirs above Bonneville Dam. If warranted and after consultation with NMFS and USFWS, the Action Agencies shall develop and implement methods of control that may include reducing the populations of these predators.

Gulls, terns, pelicans, common mergansers, and other birds consume juvenile salmonids in the Columbia and Snake rivers (Meacham and Clark 1979 in Bevan et al. 1994, Ruggerone 1986 in Bevan et al.1994, Bevan et al. 1994, and Wood 1987). The combined effect of this predation on listed stocks is unknown, but the increasing colonies of Caspian terns, California and ring-billed gulls, and white pelicans could have a substantial effect on limited fish populations. A study of gull predation in the upper Columbia River in 1986 indicated that 2% of the juvenile salmonids passing Wanapum Dam were consumed. Additional information on consumption rates, migration patterns, and the ultimate effect on fish populations is needed before sound management decisions can be made. This effort must be coordinated with ongoing avian control activities in the Columbia River estuary and with the USDA Wildlife Services and USFWS.

Action 103: The Action Agencies shall quantify the extent of predation by white pelicans on juvenile salmon in the McNary pool and tailrace. A study plan shall be submitted to NMFS by September 30, 2001, detailing the study objectives, methods, and schedule. Based on study findings, and in consultation with USFWS and NMFS, the Action Agencies shall develop recommendations and, if appropriate, an implementation plan.

Up to six dozen white pelicans have been observed along the Oregon shore a short distance below the McNary Dam juvenile facility during the spring migration. Additional data are needed to determine the extent of pelican predation on salmonids.

Action 104: The Action Agencies shall recover PIT-tag information from predacious bird colonies and evaluate trends, including hatchery-to-hatchery and hatchery-to-wild depredation ratios.

Evaluation of this information, when combined with bird and fish behavioral information, will help managers develop a better understanding of issues such as prey selection, stock-specific vulnerability, and potential long-term predation effects on specific listed stocks, including effectiveness of management actions to reduce predation by birds.

Action 105: The Action Agencies shall develop a pilot study to assess the feasibility of enhancing the function of ecological communities to reduce predation losses and increase survival in reservoirs and the estuary.

The pilot study should include a combination of hydrosystem operations, enhancement of mainstem and estuarine habitat, and directed fishery management options. Information for the near-term studies would serve as the basis for a longer-term effort to enhance habitat and community function within the mainstem corridor. Issues to evaluate include natural and manmade habitat alterations, reservoir level fluctuations during predator spawning seasons, sport fish management options, and sediment and nutrient transport.

Action 106: The Action Agencies, in coordination with NMFS, shall investigate marine mammal predation in the tailrace of Bonneville Dam. A study plan shall be submitted to NMFS by June 30, 2001, detailing the study objectives, methods, and schedule.

From 1990 through 1993, the annual incidence of marine mammal tooth and claw abrasions on fish examined at the Lower Granite adult trapping facility ranged between 14% and 19% for spring-summer chinook, and between 5% and 14% for steelhead. The proportion of adults examined that had open wounds ranged from 5% to 6% for chinook and 1% to 6% for steelhead (Harmon et al. 1994). The prevalence of these abrasions was generally higher during the earliest portion of the run, with reported incidence of 30% on the chinook in 1993 (Harmon et al. 1995). Based on the severity of the observed signs, NMFS speculates that many fish injured by marine mammals die before reaching this project. Marine mammal predation occurs in the near-ocean, estuary, and lower Columbia River up to Bonneville Dam. On many occasions, California sea lions have been observed feeding on adult salmon (primarily spring chinook) near the fishway entrances below Bonneville Dam. While predation by marine mammals in the lower river is not a result of the FCRPS, site-specific predation immediately below FCRPS dams (i.e., Bonneville) is, in part, a result of the presence and operation of the dam. Evaluation of this predator activity should include development of remedial methods that may include relocation or lethal removal. This effort must be coordinated with ongoing marine mammal control activities in the Columbia River estuary and near-ocean.

9.6.1.6 Adult Passage and Research

The actions described in this section represent the best starting point for planning future capital investment in measures to improve the survival of adult salmon migrating past the Corps mainstem FCRPS dams. The specific list of measures to be implemented, their priority, and the method of evaluation will be developed in the 1- and 5-year plans described in Section 9.4. As determined through the annual planning process in Section 9.4, other combinations of measures may also be deemed sufficient to meet the juvenile and adult performance standards and, thus, will avoid jeopardy.

In many cases, the measures described are limited to prototype or facility development and evaluation and include statements that the Action Agencies are expected to implement the results "as warranted." The intent of the measures in these cases is to proceed to implementation upon completion of testing, unless the results of the evaluation present additional problems that have to be addressed through further testing.

9.6.1.6.1 Adult Fish Passage Strategy. A primary objective of this RPA is to maximize direct survival of upstream migrating adult fish at the Federal hydrosystem dams with passage facilities and to minimize indirect (prespawning) mortality in intervening reservoirs and upstream of the hydrosystem. To achieve this objective, the RPA expands investigations of adult passage problems in order to identify direct and indirect mortality-related problems and implement needed improvements. The following research and configuration action items are meant to accomplish six objectives:

- Reduce site-specific and cumulative delay (including fallback over spillways, fallback through turbines and intake screen/bypass systems, and fallback/fallout from fishways).
- Identify correctable project-related direct mortality factors.
- Enhance headburn investigations.
- Protect downstream migrating adult steelhead post-spawners (kelts).
- Improve auxiliary water system diffusers to minimize risk of potential failure (and risks to adult migrants).
- Identify factors related to prespawning mortality of fish that have passed through the FCRPS hydrosystem.

9.6.1.6.2 Studies and Measures (including Research, Monitoring, and Evaluations)

Action 107: The Action Agencies shall conduct a comprehensive evaluation to assess survival of adult salmonids migrating upstream and factors contributing to unaccounted losses.

Broad objectives for such studies may include the following:

- Evaluate survival rates between dams and through the system.
- Partition interdam losses by factor.
- Assess causal mechanisms associated with losses.

- Assess reproductive success, including causal mechanisms associated with reduced reproductive success, if any.

- Identify measures, as appropriate, to address factors affecting passage, survival, and reproductive success.

More specific investigations may include the following:

- Fallback (operational related versus other factors)

- Passage delay (relative to project and reservoir operations, including turbines, spill, and peaking)

- Injury (resulting from passage, marine mammals)

- Headburn

- Homing/straying

- Mainstem spawning

- Tributary turnoff and spawning

- Effect of TDG supersaturation

- Effect of temperature (including use of cool water microhabitat)

- Energy expenditure

- Susceptibility to disease

- Unaccounted incidental mortality associated with harvest

- Cumulative effects (synergism)

Action 108: The Corps and BPA shall conduct a comprehensive evaluation to investigate the causes of headburn in adult salmonids and shall implement corrective measures, as warranted.

While the exact cause of headburn remains unknown (NMFS 2000e), Elston (1996) conducted clinical evaluations of fish with typical headburns from Lower Granite Dam and suggested that headburns were caused by mechanical abrasion and laceration, rather than by necrosis associated with subcutaneous emphysema from GBT. NMFS monitoring at Lower Granite Dam from 1993

through 1999 showed that the rate of incidence of adult spring chinook with headburn ranged from 0% to 9.8% (NMFS 2000e). Bjornn et al. (1995) found in 1993 that of 66 radio-tagged chinook salmon with head scrapes or injuries, 38% did not migrate to known spawning areas and were classified as possible prespawning mortalities. Thus, headburn could be related to a chinook prespawning mortality rate of approximately 2%. This was calculated by multiplying the average of the monitored incidence range (4.9%) times the percentage of head-injured chinook that did not migrate (38%) [4.9% x 38% = 1.9%]. This implies that corrective measures could potentially boost adult spring chinook survival as high as 2% on average.

An example of corrective measures would be investigating the potential benefit of replacing existing spill gate closure (sill) seals, in conjunction with improved connector designs, which are benign to large fish that fall back through the spillway. It is possible that this could reduce the incidence of headburn injury.

Action 109: The Corps shall initiate an adult steelhead downstream migrant (kelt) assessment program to determine the magnitude of passage, the contribution to population diversity and growth, and potential actions to provide safe passage.

Data acquired through sampling in the Lower Granite and Little Goose Dam bypass systems during the peak fallback season of April through June 2000 were used to arrive at a preliminary estimate of 16,745 steelhead kelts present in the Lower Snake River at Lower Granite Dam during the study period (Evans and Beaty 2000). This abundance level represents 22% of the 74,440 adult steelhead counted passing Lower Granite in 1999 (Fish Passage Center 2000, counts for 1999). Theoretically, reconditioning and/or kelt downstream transportation could significantly increase the likelihood of a second spawning opportunity for many of these fish. Also, their downstream in-river survival could be increased by simply providing more effective alternative passage routes to avoid the higher mortality associated with turbine passage.

Evaluations should be conducted to review available literature and develop pilot testing regarding reconditioning of kelts. The Corps will assess and conduct a short-term holding evaluation at a project site where kelt are more abundant and initiate a kelt transportation pilot study as a possible means of reducing dam passage mortality. The Corps will evaluate kelt passage associated with the RSW at Lower Granite Dam (described in Section 9.6.1.4), which will be prototype-tested in 2001 in the context of juvenile fish passage. The Corps will synthesize these work elements and report the magnitude of kelt passage, effects of passage on survival, and potential actions to improve survival, if deemed appropriate, to NMFS' Regional Forum by September 2003.

Action 110: The Corps shall use information from previous and ongoing investigations regarding the problem of adult steelhead holding and jumping in the fish ladders at John Day Dam, develop a proposed course of action, and implement it, as warranted.

This problem has been investigated in a fragmented manner for years. A more detailed collation of cumulative work to date is required, combined with an assessment of alternatives.

Action 111: The Corps shall investigate and enumerate fallback of upstream migrant salmonids through turbine intakes at all lower Snake and lower Columbia River dams. The Corps shall implement corrective measures to reduce turbine mortality, as warranted.

Between 1996 and 1998, fallback rates for spring/summer chinook were between 11 to 15% and 9 to 13% at The Dalles and John Day dams, respectively. In 1996 and 1997, fallback rates for steelhead were between 7 to 10% and 11 to 13% at The Dalles and John Day Dams, respectively (NMFS 2000e, p 88). Keefer and Bjornn (1999) used radio-tagged adults known to have passed Bonneville Dam in 1996 to estimate survival to tributaries or to the top of Priest Rapids Dam. Steelhead and spring/summer chinook salmon that did not fall back over any dam had survival rates that were 3.0 to 5.4% higher than fish that did fall back. Mendel and Milks (1996) estimated that the fallback of fall chinook salmon at Lower Granite Dam was 16 to 39% in 1993 and 30 to 41% in 1992. They estimated fall chinook fallback mortality at 26 and 14% in 1993 and 1994, respectively, for fish that fell back through one or more of the four lower Snake River dams. This higher mortality for fall chinook occurred during periods of no spill, when fallback was assumed to have been through turbines. This information on the rate of fallback and the reduced survival due to fallback can be used to estimate the theoretical gain in survival that could be achieved by corrective measures. For spring/summer chinook, multiplying the 11% observed average rate of fallback at John Day Dam between 1996 and 1998 times the 4.2% higher survival rate, on average, observed for fish that did not fall back implies a potential survival rate increase of .5% [11% x 4.2% = .46%]. For steelhead, multiplying the 12% observed average rate of fallback at John Day Dam between 1996 and 1997 times the 4.2% higher survival rate, on average, observed for fish that did not fall back implies a potential survival rate increase of .5% [12% x 4.2% = .50%]. For fall chinook, multiplying the 28% estimated average fallback rate at Lower Granite in 1993 times the 26% estimated mortality rate for fish that fell back through one or more of the Lower Snake dams in 1993 implies a potential survival rate increase of 7% [28% x 26% = 7.3%].

Corrective measures to reduce the mortality associated with fallback may include installation of extended-length screens (where feasible), extending the period during which the intake screens and juvenile bypass system are in operation, and modifying operations. Study plans, recommendations, and a schedule for accomplishing this action will be developed through the annual planning process.

Action 112: The Corps shall investigate ways to provide egress to adult fish that have fallen back into juvenile collection galleries and primary dewatering facilities at Ice Harbor and McNary dams. The Corps shall either install structural, or implement operational, remedies to minimize delay and injury of fish that fall back, as warranted.

Prespawn, summer-run steelhead are abundant near McNary Dam during the late fall and early winter months. Fallback through the juvenile bypass system at McNary Dam can exceed 50 steelhead per day before screen removal on December 15 (Paul Wagner, Washington Department of Fish and Wildlife, pers. comm.). These fish accumulate in the juvenile bypass system, and many are delayed for protracted periods. Timely and safe egress alternatives for these fish must be identified.

Action 113: The Corps shall investigate measures to reduce adult steelhead and salmon fallback and mortality through the Bonneville Dam spillway. A final report shall be submitted to NMFS stating the findings of these investigations and recommending corrective measures. Potential remedies shall be included in the annual planning process.

Keefer and Bjornn (1999) estimate, based on radiotelemetry, that ladder counts at Bonneville Dam are overcounted by 13.5 to 19.3% for spring/summer chinook salmon from 1996 through 1998, by 4.7% to 8.2% for steelhead from1996 through 1997, and by 12.6% for sockeye in 1997 when fallback and reascension are taken into account. Fallback rates at Bonneville Dam were 12 to 15% for spring/summer chinook (1996 to 1998), and 5 to 10% for steelhead (1996 to 1997). Assigning mortality associated with fallback to dam operations or behavior is difficult because some fish may have overshot and are returning to lower river tributaries. Bjornn et al. (1999) observed a fallback mortality of 8% for sockeye salmon at Bonneville Dam (a species with no spawning below Bonneville Dam). Keefer and Bjornn (1999) used radio-tagged fish known to have passed Bonneville Dam in 1996 to estimate survival to tributaries or the top of Priest Rapids Dam. Steelhead and spring/summer chinook salmon that did not fall back over Bonneville Dam had survival rates that were 3.8 to 5.2% higher than fish that did fall back (NMFS 2000e). Conceivably, corrective operations or facility changes which significantly reduce fallback at Bonneville Dam could increase the survival rate of spring/summer chinook to Lower Granite Dam by 0.7% [15% x 4.5% = 0.68%] and of steelhead by 0.5% [10% x 4.5% = 0.45%]. These estimates of potential survival increases are calculated by multiplying the fallback rate observed at Bonneville Dam in 1998 for spring/summer chinook, and for steelhead in 1997, times 4.5%, which is the average higher survival rate to Lower Granite Dam for adults that did not fall back at Bonneville Dam. Adult fallback through the Bonneville Dam spillway has been a long-standing concern. Further investigation is needed to determine factors affecting fallback and identify potential measures to reduce it.

Action 114: The Corps shall examine existing fish-ladder water temperature and adult radio-telemetry data to determine whether observed temperature differences in fishways adversely affect fish passage time and holding behavior. If non-uniform temperatures are found to cause delay, means for supplying cooler water to identified areas of warmer temperatures should be developed and implemented in coordination with the annual planning process.

Data collected by the Corps show that water temperatures at various sections of the John Day fishways differ from 1° to 4°C (34° to 39°F) at times. Effects of such differences on fish passage are unknown.

Action 115: The Corps and BPA shall conduct a comprehensive depth and temperature investigation to characterize direct mortality sources at an FCRPS project considered to have high unaccountable adult losses (either from counts and/or previous adult evaluations).

Previous radiotelemetry investigations have been two-dimensional and have attempted to characterize passage routes and timing of successfully passing fish. This study will also attempt to focus on those fish that do not successfully pass and determine whether a consistent source of mortality can be identified and corrected.

Action 116: The Corps shall investigate adult fish delay and fallback at ladder junction pools and implement remedies to reduce this problem, as warranted.

A large percentage of fish fall back from fishway junction pools at each FCRPS and other hydro projects studied to date. Cumulative delay and influence on prespawning mortality could be substantial. Modified hydraulic conditions and other possible remedies, coupled with behavior responses in these areas, may reduce this delay.

Action 117: The Corps shall evaluate adult count station facilities and rehabilitate where necessary at all projects to either minimize delay of adults or minimize counting difficulties that reduce count accuracy.

Some FCRPS hydro project fishway counting stations need design improvement to reduce delay. Cumulative delay and influence on prespawning mortality could be substantial. Rehabilitating counting stations could also improve the accuracy of adult fish counts.

Action 118: The Corps shall develop and implement a program to better assess and enumerate indirect prespawning mortality of adult upstream-migrating fish. Such mortality may be due to, or exacerbated by, passage through the FCRPS hydro projects. If measures are identified which will reduce the unaccountable adult loss rate and/or the prespawning mortality rate, the Corps shall implement these measures as warranted. The program should also enhance efforts to enumerate unaccountable losses associated with tributary turnoff, harvest, or other factors in FCRPS mainstem reservoirs and upstream of FCRPS projects.

Adult radiotelemetry has been used to estimate the survival of spring/summer chinook salmon from Ice Harbor Dam to the spawning ground or hatcheries. Bjornn et al. (1995) estimated that survival from Ice Harbor Dam to the spawning ground or hatcheries to be 54% in 1991 and 77% in 1993. In these same studies, survival from Ice Harbor Dam to Lower Granite Dam was

estimated to be 81% in 1991 and 86% in 1993. Calculating the difference in these estimated survival rates from Ice Harbor Dam to Lower Granite Dam and Ice Harbor Dam to spawning ground/hatcheries implies theoretical adult loss from Lower Granite Dam to spawning ground/hatcheries of 27% (1991) and 9% (1993) [81% - 54% = 27%; 86% - 77% = 9%]. While further studies will be needed to resolve the accuracy and cause of these preliminary observations, the significance of this level of adult loss above Lower Granite Dam to the prospect of recovery cannot be overstated. Furthermore, mere arrival at the spawning ground does not guarantee spawning success. If spawning success is diminished during upstream passage through the FCRPS, these adult loss estimates are conservative.

The program called for in this action should include studies to assess the effects of upstream migration of adults through the hydrosystem (including the thermal environment through which they must migrate) on their overall fitness and spawning success, including energy budgets, ability to complete spawning behavior, and successful production of quality gametes. Currently, little work has been completed to assess the magnitude and breadth of prespawning mortality of adult migrants, especially upstream of the FCRPS hydrosystem. New methods of assessment should be evaluated, including the investigation of long-term PIT-tag retention in maturing salmonids. The investigations are expected to identify measures at FCRPS hydro projects, and possibly in tributaries, that will lead to reductions in prespawning mortality throughout the Columbia River basin.

Action 119: The Corps shall ensure that alterations to fish ladders and adult passage facilities to accommodate Pacific lamprey passage do not adversely affect salmonid passage timing and success.

Followup evaluations are needed as a precaution.

9.6.1.6.3 Adult Fishway Operating Criteria. The Corps' annual fish passage plan stipulates operating criteria for FCRPS hydro project adult fishways. Where this criterion is not satisfied, incremental adverse effects to adult migrants (such as delay) may occur. Actions to enhance compliance with fishway criteria include auxiliary water system assessments and upgrades. Other actions address the issue of inadequate fishway entrance weir submergence during low tailwater elevations.

Action 120: The Corps shall develop improved operations for adult fishway main entrances at FCRPS dams so that the best possible attraction conditions are provided for adult migrants, both at the four Columbia River hydro projects and the four lower Snake hydro projects (where reservoir elevations are held near MOP). The Corps shall report the findings of fishway entrance flow-balancing investigations in a report to NMFS by the end of 2001 and shall continue to work through FPOM to evaluate and implement, as warranted, structural changes to satisfy fish passage plan fishway entrance criteria.

Current Fish Passage Plan fishway entrance criteria cannot be satisfied at some entrances at many FCRPS hydro project fishways during low tailwater periods. Concurrently, some entrances pass appreciably more attraction flow than other entrances at the same project. The Corps should, on an interim basis, conduct hydraulic evaluations and make operational changes to increase attraction flows at entrances not presently meeting fishway criteria at all tailwaters during the adult passage season. The Corps should also continue to investigate various operations (such as closing floating orifice gates or other operational alternatives) to improve adult entrance and passage conditions.

9.6.1.6.4 Reliability Enhancement. FCRPS hydro project fishways must operate in the optimum manner during fish passage periods to minimize the risk of injury and mortality. Actions to increase reliability include fishway assessments to identify aging facilities (and components) in need of replacement or redesign, improved debris handling capability, and emergency backup auxiliary water capabilities (related to satisfying fishway entrance attraction water supply criteria).

Action 121: The Corps shall develop and maintain an auxiliary water-supply, emergency-parts inventory for all adult fishways where determined necessary, in coordination with NMFS.

Emergency auxiliary water supplies are needed to maintain fishways within optimum criteria for passage in the event of turbine, pump, electrical, debris management, or water-control system component failures.

Action 122: The Corps shall continue design development and, subsequently, construct an emergency auxiliary water supply system at The Dalles Dam's east ladder.

The Dalles adult fishways pass the second-highest number of adult fish of any FCRPS hydro project. With aging auxiliary water turbines, generators, and transformers, there is an increasing risk of faulty adult fishway performance during primary passage periods. Emergency backup auxiliary water is vital to attract fish into the fishways, if a primary fishwater turbine failure occurs.

Action 123: The Corps shall continue to investigate alternatives to dewater adult auxiliary water system floor diffusers for inspection at The Dalles adult fishway powerhouse collection channel. The Corps shall implement design and construction of needed changes, as warranted.

Leaking fishway entrance gates at The Dalles Dam make it impossible to dewater the powerhouse adult collection channel to inspect aging facilities such as add-in diffusers. Several years ago, numerous adult salmon passing through diffusers were killed. This action will minimize the chance of the recurrence of this problem and reduce leakage from the auxiliary water system.

Action 124: The Corps shall investigate methods to provide additional emergency auxiliary water to The Dalles Dam north fishway when the normal auxiliary water supply is interrupted.

If the existing Northern Wasco County PUD turbine at the north shore fishway has a prolonged outage, gravity auxiliary water would have to be provided for fishway attraction flow. The current rock conveyance channel is deteriorated and unstable. This additional water could also be used as a source of auxiliary water to supply the second fishway entrance if adult passage studies indicate the entrance is needed.

Action 125: The Corps shall develop and implement an automated monitoring and alarm system at appropriate FCRPS projects, as determined in the NMFS Regional Forum, to monitor changes in head differential remotely between the primary auxiliary water supply conduits/channels and the adult collection channels and to minimize diffuser damage due to excessive differentials. The Corps shall ensure that diffuser gratings for all auxiliary water supply systems are securely fastened. The Corps shall work through FPOM to develop a monitoring program for inspecting diffuser gratings and grating fasteners.

Implementation of this action would help avoid undetectable diffuser failures and potentially significant adult fish losses. In the interim, the Corps will work through the FPOM coordination team to develop early detection measures and include these in the annual Fish Passage Plan before the 2001 fish passage season.

9.6.1.6.5 Fishway System Assessments. Additional fishway assessments are needed to address, in a more comprehensive manner, fishway systems at some FCRPS hydro projects that have aging facilities or ongoing, unresolved problems. These assessments will lead to a well-defined list of corrective measures.

Action 126: The Corps shall initiate an investigation and prepare a report on the Bonneville First Powerhouse Bradford Island and Cascade Island adult fishway auxiliary water system by the end of 2001. In the report, the Corps shall identify measures that will improve or replace aging components, thereby enhancing current and long-term performance and reliability.

The need for design changes and improvements will be evaluated, particularly with respect to elevated dissolved gas levels in the auxiliary water supply systems. Report recommendations should be implemented, as warranted.

Action 127: The Corps shall continue its investigation of the Bonneville Second Powerhouse adult fishway auxiliary water system and shall identify measures to satisfactorily address emergency backup auxiliary water needs.

Bonneville Second Powerhouse adult auxiliary water facilities failed in 1997 during the peak of the adult fall chinook and steelhead migrations. This action is intended to ensure that this does not occur again.

Action 128: The Corps shall initiate an engineering study to evaluate existing limitations relating to its inability to satisfy fish passage plan operating criteria at the John Day Dam north shore ladder.

The study scope should also assess backup auxiliary water system (AWS) needs, reliability, or enhancement design improvements and upgrade options for the AWS system. The Corps will implement corrective measures as warranted.

Action 129: The Corps shall complete adult fishway auxiliary water supply evaluations at each lower Snake River hydro project and implement corrective measures as warranted.

The objective of this measure is to ensure compliance with fishway entrance criteria, optimize emergency auxiliary water backup provisions, and ensure long-term reliability.

9.6.1.7 Water Quality

9.6.1.7.1 Water Quality Strategy. In developing the biological opinion, NMFS, in coordination with EPA, USFS, and the Action Agencies (the Corps, BOR, and BPA), has considered the respective ecological objectives of the ESA and the Clean Water Act (CWA). In many instances, actions implemented for the conservation of ESA-listed species will also move toward attainment of water quality standards (e.g., reducing TDG and temperature). The overlap of statutory purpose is extensive; however, there are additional actions that are appropriate in a water quality plan, but that are nonessential for the survival and recovery of the listed species. Thus, such actions are not required components of the ESA RPA. Further, the water quality plan is likely to require lengthy study and implementation exceeding the duration of this biological opinion.

Appendix B charts a course for development of a water quality plan for the mainstem Columbia and Snake rivers to address CWA objectives. The scope of the plan is broader than the FCRPS and would include additional actions to improve mainstem water quality by reducing TDG and temperature. Some of these actions are expected to be undertaken by entities other than the Action Agencies. Although Appendix B is not itself a water quality plan, it suggests the procedure for development of a plan and identifies actions the plan would likely contain to move toward attainment of water quality standards for the FCRPS.

Appendix B refers to items in Section 9.6.1.7.2 as a nucleus of actions for the water quality plan. These actions are essential for the survival and recovery of the listed species and, thus, are required components of the RPA that also serve to improve water quality by reducing TDG and water temperature.

Appendix B also identifies actions for the FCRPS that further CWA objectives, but that are not also called for in the ESA RPA. These long-term actions for water quality improvements are listed in Table B-3 of the Appendix. These are studies to investigate additional measures to reduce TDG and temperature that may be considered for implementation. These studies are appropriate as ESA conservation measures that will require further ESA consultation when they are developed, analyzed, and proposed for implementation.

Currently, voluntary spill for fish passage occurs at dams up to the TDG level of 120% in the project tailrace, or 115% TDG in the next downstream project forebays, as allowed by special variances to state and Tribal water quality standards. However, spill for fish passage that results in exceedances of the 110% gas standard is considered an interim strategy in the sense that the long-term goal is to keep TDG levels within water quality standards.

Accordingly, the 1995 FCRPS Biological Opinion mandated initiation of the DGAS. This multi-year comprehensive study by the Corps investigated and extended understanding of gas absorption and reduction associated with spill at Columbia and Snake river hydro projects. It also investigated short- and long-term operational and structural gas abatement alternatives, which resulted in installation of spillway flow deflectors at both John Day and Ice Harbor spillways. These improvements increased project survival at both sites and improved water quality during both voluntary and involuntary spill periods. The DGAS also developed numerical models to fully investigate the hydrosystem response to structural and/or operational changes. One outcome of DGAS was that no structural action was identified that would reduce TDG levels to meet the state or Tribal water quality standards without threat of adverse effects to passing fish.

To assess the feasibility of reducing TDG to the 110% standard while still meeting the survival objectives of listed salmon, EPA, NMFS, USFWS, and the Federal Action Agencies commit to continued efforts to identify water quality improvement actions (see Appendix B). These efforts will lead to decisions on whether structural or operational changes exist that will allow FCRPS projects to achieve both fish passage and water quality objectives, or to encourage changes in non-Federal Columbia River basin projects that have a cumulative effect of reducing TDG levels systemwide. Information developed from these studies may also provide a basis for future decisions concerning beneficial use and water quality criteria revisions. Such decisions will result from a coordinated effort between EPA and NMFS and discussions with states, Tribes, and other interested parties. The EPA, NMFS, USFWS, and the Federal Action Agencies will continue to work toward implementing a combination of actions that benefit both fish survival and water quality.

Part of the decision-making process to evaluate the structural and operational changes necessary to meet the 110% TDG standard will be based on a review of the existing data collected since the release of the NMFS 1995 Biological Opinion (see Section 6.2.6.1.1 for a summary of the risk assessment for the spill program described in the NMFS 2000 Biological Opinion). GBT in juvenile salmonids is observed at all gas supersaturation levels, but the overall incidence and

severity is low at FCRPS projects when managing fish passage spill to 115% to 120% TDG variance.

Without physical modifications to the dams beyond those that are presently under way, the long-term TDG goal cannot be attained between April and August at and between the eight mainstem FCRPS dams. This is a result of the need to rely on spill to safely pass juvenile salmon around those dams. A similar issue exists with Dworshak Dam, where, in some circumstances, spill is necessary to contribute to the attainment of spring and summer flow objectives for salmon migration and water temperature standards in the Clearwater and lower Snake rivers. In the near term, therefore, it will be necessary to conduct spill operations that cause exceedances of the 110% TDG gas standard. The Corps will take the actions necessary to implement the spill operation called for in this biological opinion, including spill in accordance with the special TDG conditions set forth below. NMFS will provide technical assistance, as necessary, to support the Corps' actions.

Special TDG Conditions for Juvenile Fish Passage. At the eight Columbia and Snake river mainstem hydro projects, and consistent with state and Tribal water quality variances, spill will be reduced as necessary when the average TDG concentration of the 12 highest hourly measurements per calendar day exceeds 115% of saturation at the forebay monitor of any Snake or lower Columbia river dam or at the Camas/Washougal station below Bonneville Dam. Spill will also be reduced when the 12-hour average TDG levels exceed 120% of saturation at the tailrace monitor at any Snake River or lower Columbia River dams or Dworshak Dam. Spill will also be reduced when instantaneous TDG levels exceed 125% of saturation for any 2 hours during the 12 highest hourly measurements per calendar day at any Snake, Clearwater, or lower Columbia river monitor.

The water quality plan in Appendix B includes the following basinwide goals for TDG and temperature. NMFS, EPA, and the Action Agencies commit to work toward these goals. They recognize, however, that reaching the goals may take more time than the duration of this biological opinion and that exceedances may, nevertheless, occur.

Total Dissolved Gas Goal. The long-term TDG goal (10 to 15 years) is to reach the 110% TDG standard in all critical habitat in the Columbia and Snake River basins while taking actions to recover listed species in the basins. For anadromous fish, achieving the goal would mean fish passage survival levels are consistent with the performance standards for the mainstem projects.

This goal is intended to guide operating and capital improvement decisions relating to TDG created during periods of spill. A systemwide approach is needed to address gas generated at mainstem projects where fish are present and at upstream facilities (i.e., outside the current range of listed salmon) in both the U.S. and Canada, the five PUD dams on the Columbia River between the Snake River and Chief Joseph Dam, and the Hells Canyon Complex on the Snake River. Some exceptions are noted in the ability to meet the state and Tribal TDG standard.

Water Temperature Goal. The long-term goal for water temperature is standard attainment in all critical habitat in the Columbia and Snake River basins. In the mainstem Columbia and Snake rivers, attainment of the temperature standard is very complex, due to a number of interrelated factors that affect water temperatures at certain times of the year and to the limited ability to alter water temperature in the mainstem. In the tributaries, attainment of the temperature standard is also complex, due to many of these same factors and the long time needed to realize the temperature benefits of remedial actions (such as riparian restoration). Therefore, in the near term, working with the state and/or Tribe with relevant regulatory authority, the interim goal is to move toward attaining the standard. Establishing TMDLs is expected to significantly promote progress toward the interim goal.

To ensure progress toward the long-term goals, the Corps, BOR, and BPA will also work with NMFS, USFWS, EPA, the Columbia River Tribes, and the states of Washington, Oregon, Idaho, and Montana through an adaptive management process as a part of the water quality plan described in Appendix B.

Perhaps none of the ongoing forums and/or water quality protection activities will provide the organizational structure desired to fully integrate the activities of the water quality plan as described in Appendix B. Therefore, final development and implementation of the water quality plan could be accomplished through reformulation of the Water Quality Team, consisting of senior policy analysts and supported by technical staff from Federal agencies, states, Tribes, and non-Federal entities.

9.6.1.7.2 Current and Near-term Actions and Studies

Total Dissolved Gas Measures

Action 130: The Corps shall complete its DGAS by April 2001. The results of this study will be used to guide future studies and decisions about implementation of some long-term structural measures to reduce TDG.

The DGAS was initiated in 1994 to examine potential methods to reduce TDG produced by spillway operations at the Corps' eight mainstem Snake River and Columbia River hydropower dams. The feasibility-level DGAS report is expected to be completed in spring 2001. The findings from this study have to be examined and discussed with interested parties in the region to guide future studies before making long-term implementation decisions about gas abatement alternatives.

Action 131: The Action Agencies shall monitor the effects of TDG. This annual program shall include physical and biological monitoring and shall be developed and implemented in consultation with the Water Quality Team and the Mid-Columbia PUDs' monitoring programs.

At a minimum, the physical monitoring components of this plan should include placement of physical TDG monitors in the tailraces and forebays of all lower Snake River and lower Columbia River dams, and daily recording of TDG data on the CROHMS database. This program should also include QA/QC components, including redundant and backup monitors at as many locations as the Water Quality Team determines necessary, calibration of monitoring equipment at least every 2 weeks, enough funding for spot-checking monitoring equipment during the fish passage season (number determined preseason by the Water Quality Team), an error checking, correcting, and recording function for CROHMS data, and daily data reporting. The QA/QC components should be reviewed annually and modified as improved information and techniques become available. The annual review should be conducted by the Action Agencies in coordination with the Water Quality Team.

At a minimum, the biological monitoring components will include smolt monitoring at selected smolt monitoring locations, adult monitoring at Bonneville and Lower Granite dams, and daily data collection and reporting.

Action 132: The Action Agencies shall develop a plan to conduct a systematic review and evaluation of the TDG fixed monitoring stations in the forebays of all the mainstem Columbia and Snake river dams (including the Camas/Washougal monitor). The evaluation plan shall be developed by February 2001 and included as part of the first annual water quality improvement plan. The Action Agencies shall conduct the evaluation and make changes in the location of fixed monitoring sites, as warranted, and in coordination with the Water Quality Team. It should be possible to make some modifications by the start of the 2001 spill season.

In past years, TDG monitoring in tailraces at mainstem dams produced variable results associated with differences in dam operations. Operational differences caused the proportion of spill and turbine-discharged water to change at measuring sites. This problem can be substantial and often causes unreliable extrapolation of TDG levels to downstream locations where spill and turbine flows are fully mixed. For this reason, TDG measurements in both forebays and tailraces have been monitored as part of the NMFS spill program. Forebay TDG monitors typically are located on the pier noses and other portions of hydro projects near turbine intakes or spillways. The tailrace stations, however, are located at various distances downstream from the hydro projects where spillway and powerhouse flows are mixed. One obvious deviation from the normal forebay monitoring location is the Camas/Washougal site. This site was chosen as a surrogate forebay monitor location for the river reach below Bonneville Dam because available data indicated that spill and powerhouse flows were normally well mixed at this point in the river.

In-season management of biological opinion spill to improve juvenile fish survival relies on the physical TDG and the biological GBT monitoring programs. Based on comments received on the draft opinion and a recent Corps review of possible biases in TDG monitoring data from TDG fixed forebay monitors at dams on the mainstem Columbia and Snake rivers, NMFS

believes some sampling locations may have to be altered to provide a more representative measure of TDG in the water mass passing through the dams.

Action 133: As part of DGAS, the Corps shall complete development of a TDG model to be used as a river operations management tool by spring 2001. Once a model is developed, the applications and results shall be coordinated through the Water Quality Team. The Corps shall coordinate the systemwide management applications of gas abatement model studies with the annual planning process, the Transboundary Gas Group, the Mid-Columbia Public Utilities, and other interested parties.

TDG, caused by large volumes of water spilling over dams, can result in injury or mortality of juvenile salmonids. Since the 1960s, increased hydraulic capacity at powerhouses of mainstem projects, increased water storage, and structural modification to spillways have substantially reduced this problem. High levels of dissolved gas have, however, been measured under some river conditions even in recent years, such as during periods of involuntary spill. Development and continued refinement of a systemwide TDG model would assist with in-season management of involuntary spill.

Action 134: The Corps shall continue the spillway deflector optimization program at each FCRPS project and implement it, as warranted. The Corps and BPA shall conduct physical and biological evaluations to ensure optimum gas abatement and fish passage conditions. Implementation decisions will be based on the effect of spill duration and volume on TDG, spillway effectiveness, spill efficiency, forebay residence time, and total project and system survival of juvenile salmon and steelhead passing FCRPS dams.

The spillway deflector optimization program shall have the following objectives:

- Increase juvenile fish passage survival at FCRPS projects by increasing the allowable spill discharge up to the TDG special condition gas cap level during voluntary spill periods (as defined by the NMFS annual spill program in Section 9.6.1.4.4).

- Decrease TDG levels during both voluntary and involuntary spill periods.

- Considering both juvenile and adult fish passage criteria, develop spill patterns that improve juvenile survival, reduce delay of juvenile salmon in forebays, optimize juvenile egress from tailraces, and provide good adult passage conditions downstream of fish ladder entrances.

Action 135: The Corps shall include evaluations of divider walls at each FCRPS project in the spillway deflector optimization program. Design development and construction

of divider walls would begin only after coordination within the annual planning process, and only if warranted.

Design development of divider walls is an option under consideration to potentially reduce entrainment of powerhouse flow into spillway flow. The degree to which powerhouse flow in the tailrace mixes laterally with spillway flow is an unresolved issue. Specifically, the extent to which powerhouse flow TDG levels are increased or decreased in the tailrace may be affected by mixing with water that has passed through the spillway. Additional investigation is required to increase understanding of this issue. Optimum deflector design development will include a full investigation of powerhouse flow entrainment with spillway flow and TDG uptake downstream of each project. Construction at an FCRPS project will be included in the deflector optimization program, if warranted, for the purpose of attaining water quality and fish survival benefits.

Action 136: The Corps shall continue to develop and construct spillway deflectors at Chief Joseph Dam by 2004 to minimize TDG levels associated with system spill.

To the extent feasible, the Corps, BOR, and BPA will treat Grand Coulee and Chief Joseph dams as a composite project to reduce the incidence of spill and TDG below Grand Coulee and other system projects by spilling proportionately more at Chief Joseph and shifting electrical load to Grand Coulee Dam.

Action 137: The Corps shall investigate TDG abatement options at Libby Dam, including the installation of spillway deflectors and/or additional turbine units. The Corps shall construct gas abatement improvements at Libby on the Kootenai River, as warranted, to reduce TDG levels below the project.

Through the use of numerical TDG modeling, the Corps should assess projected gas abatement benefits at Libby Dam on a site-specific and systemwide basis to improve the probability of refill and, if spill occurs, to avoid TDG levels above state water quality standards.

Action 138: The Corps shall continue to investigate RSWs, in conjunction with extended spillway deflectors, as a means of optimizing safe spillway passage of adult steelhead kelts and juvenile migrants.

While these prototype RSW evaluations continue, they have the potential to incrementally reduce both spill discharge and TDG levels downstream. Thus, development of RSWs (and other surface bypass concepts) have the potential to integrate implementation of actions to meet both ESA and CWA requirements. See also Section 9.6.1.4.5, Juvenile Fish Passage Studies.

Action 139: The Corps shall investigate TDG abatement options at Dworshak Dam and implement options, as warranted, in coordination with the annual planning process.

Implementation of TDG abatement measures at Dworshak has the potential to improve water quality when project discharges exceed current turbine capacity. Options may include increasing the number of turbine units at the powerhouse.

Action 140: The Corps shall design the spillway Number 1 (end bay) deflector at John Day Dam, and implement as warranted, in coordination with the annual planning process.

Absence of a spillway deflector at spill bay Number 1 results in fixed monitor station TDG readings that are unrepresentative relative to the entire spillway tailrace.

Water Temperature Measures. The Action Agencies, in coordination with EPA, NMFS, and USFWS, intend to abate or offset temperature effects associated with FCRPS operations and assess the feasibility of reducing temperature in ways beneficial to fish, based on the actions identified below.

Summer operations for temperature control in the Snake River are included in Section 9.6.1.2.3 under Dworshak Dam operations.

Modifications to make Dworshak NFH water supply rearing operations independent of Dworshak Reservoir temperature control releases in the summer are included in Section 9.6.1.2.6 under Measures to Evaluate and Adjust the Amount of Water Available to Support Flow Objectives.

Evaluations of fish ladder water temperature and adult passage data are included in the adult passage studies discussion in Section 9.6.1.6.2.

Action 141: The Action Agencies shall evaluate juvenile fish condition due to disease in relation to high temperature impacts during critical migration periods. This evaluation should include monitoring summer migrants at lower Columbia and lower Snake river dams to clarify the possible link between temperature and fish disease and mortality. This information will be used to assess the long-term impacts of water temperature on juvenile fish survival.

High water temperatures have been linked to stress and disease in fish. It is essential to acquire a better base of information to understand the sources of fish disease and mortality at the lower Columbia and lower Snake river dams during critical fish migration periods and high temperature events. This information could be used to better understand the effect of high water temperature on juvenile fish survival.

Action 142: The Corps shall work through the regional forum process to identify and implement measures to address juvenile fish mortality associated with high summer temperatures at McNary Dam. As a starting point, the Corps shall

assemble and analyze the temperature data that have been recorded in the McNary forebay, collection channel, and juvenile facilities. The Corps shall examine relationships among juvenile mortality, temperatures, river flow rates, and unit operations in detail. The Corps shall investigate the feasibility of developing a hydrothermal computational fluid dynamics model of the McNary forebay to evaluate the potential to determine optimal powerhouse operations or structural modifications for minimizing thermal stress of juvenile salmon collected in the summer and to conduct a modeling program, if warranted.

Thermal profile data have been routinely collected at McNary Dam for more than a decade. These data formed the basis for special project operations, such as north powerhouse loading operations during the summer-warm-water temperature period. The 1995 NMFS Biological Opinion required the Action Agencies to take measures to reduce the potential for reoccurrence of the 1994 thermal-related mortality observed at McNary Dam. Coutant (1999) suggested that the cause of the observed acute mortalities was a cumulative thermal dose of exposure to high-temperature water received over several days (NMFS 2000c).

Action 143: By June 30, 2001, the Action Agencies shall develop and coordinate with NMFS and EPA on a plan to model the water temperature effects of alternative Snake River operations. The modeling plan shall include a temperature data collection strategy developed in consultation with EPA, NMFS, and state and Tribal water quality agencies. The data collection strategy shall be sufficient to develop and operate the model and to document the effects of project operations.

The modeling plan should focus on water temperatures in the Snake River from Hells Canyon Dam and from Dworshak Dam on the North Fork of the Clearwater River to Bonneville Dam on the Columbia River. Predictive nodes should be located at the near-dam forebays and tailraces of each project. Both one- and multi-dimensional models (due to reservoir stratification) may be needed to fully define expected temperature conditions within the reach. The models should be developed to function both as a pre-season planning tool and to provide predicted outcomes of immediate operations in real time to assist in the in-season water management decision process.

Existing water temperature and meteorological data may be inadequate for this purpose. Existing data and statistical tools will be used to identify locations where additional or improved data collection, in terms of precision, accuracy and frequency, would be most beneficial.

9.6.1.8 Strategy to Improve Fish Facility Operations and Maintenance

The strategy to improve fish facility operations and maintenance addresses the need for adequate O&M budget and funding commitments by the Corps and BPA, coupled with the resource capability to undertake and implement needed O&M actions. The overall goal is to ensure that new and existing fish passage facilities perform at their designed level to increase both juvenile and adult fish survival. An improved O&M program should accomplish the following:

- Meet the increasing O&M needs of aging fish passage and spillway facilities.
- Incorporate new O&M requirements as new fish passage facilities are installed.
- Accommodate expanding annual budget requirements associated with operational changes and research needs.
- Implement preventive maintenance programs for fish passage facilities to assure long-term reliability.

9.6.1.8.1 Fish Passage Plan Development and Implementation. The Corps should continue to annually update the fish passage plan in coordination with NMFS and through the process established by FPOM. Comments developed by NMFS on the draft fish passage plan shall be reconciled by the Corps in writing to NMFS' satisfaction or implemented before release of the final fish passage plan. The Corps should continue to provide weekly and annual reports regarding implementation of the fish passage plan to NMFS.

All planned special facility operation activities that cause any facility to be out of compliance with the operations and criteria described in the main text of the fish passage plan (and expected to result in the take of listed salmon stocks) must be adequately coordinated with NMFS at least 1 month before the anticipated action date. Identifying special project operations in the fish passage plan does not mean that the action has undergone the requirements of an ESA Section 7 consultation. The effects of special operations on listed fish are usually not adequately specified in the fish passage plan, and NMFS requires further essential information, including a brief summary of the action, location, anticipated date and time, analysis of potential effect on listed salmon stocks, and potential alternative actions.

The Corps should work through the FPOM to identify needs and priorities in making hourly individual turbine unit and spill bay operation data available on its Web site, real time, during the juvenile migration season. NMFS needs these data to monitor compliance with operating criteria in the annual fish passage plan (e.g., unit operating priorities and spill patterns), as well as for agreed-upon special project operations for research or maintenance.

9.6.1.8.2 Actions to Improve Operation and Maintenance of Passage Facilities

Action 144: The Corps, in coordination with the Regional Forum, shall maintain juvenile and adult fish facilities within identified criteria and operate FCRPS projects within operational guidelines contained in the Corps' Fish Passage Plan. The Corps shall coordinate with NMFS on the development of these criteria and operational guidelines before the start of each fish passage season (generally February 1).

Insufficient ladder entrance water depth and insufficient entrance attraction velocity are factors that negatively affect adult fish passage (Bell 1991). Maintaining fishways within optimum

criteria for passage is likely to reduce dam passage delays for migrating salmon. Monitoring adult fishways frequently and improving the maintenance and repair of fishway components such as pumps, gear boxes, diffuser valves, and entrance gate controls are expected to improve system operational reliability.

The following are examples of Fish Passage Plan issues that have to be resolved before the 2001 fish passage season:

- The frequency of daily inspections for all fish passage facilities throughout the passage season
- A schedule for completion of identified maintenance needs and repairs
- A cleaning schedule and frequency table of juvenile bypass collection channel orifices in operating units during the high debris months (April through June)
- A schedule for closing floating orifices (which are to be closed before the main entrances) in adult fishways during emergency auxiliary water supply outages

Upgrading existing adult fish passage facilities will also aid the monitoring effort and contribute to maintenance of optimum criteria. The upgrade should include the following:

- Automation of control systems
- Placement of staff gauges (for determining water elevations) in areas that are accessible for both cleaning and reading
- Providing velocity meters in areas of known low velocity in the collection channels

Action 145: The Corps shall develop and implement preventative maintenance programs for fish passage facilities that ensure long-term reliability, thereby minimizing repair costs.

Action 146: The Corps shall address debris-handling needs and continue to assess more efficient and effective debris-handling techniques to ensure that the performance of both new and old fish passage facilities will not be compromised.

This effort should include the investigation of debris shear booms at all FCRPS Corps projects that pass listed fish. Design and construction of appropriate facilities should be undertaken as warranted. Shear booms keep as much debris as possible from accumulating at the upstream powerhouse face, where the debris increases fish injury and mortality and requires more labor-intensive handling and removal. These investigations will include assessment of predator cover

and potential guidance of juvenile salmonids away from fish passage facilities as a result of the boom structure.

9.6.1.9 Advance Planning for Possible Additional Actions

Action 147: As a contingency plan, the Corps (in cooperation with other Federal agencies) shall develop a project management plan to reevaluate more intensive hydropower-related actions (including breaching) for the four lower Snake River dams. The project management plan will identify the scope, schedule, costs, tasks, products, and responsibilities for the reevaluation study. The study should assess all significant changed conditions to the Lower Snake River Feasibility Report and Environmental Impact Statement (Corps 1999c). The project management plan should be consistent with direction from Congress, Corps authorities, and other legal requirements. The completed project management plan should be coordinated with the appropriate regional interests. The project management plan should include, but not be limited to, plans to mitigate disproportionate impacts to communities, industries, and Tribes, detailed water and air quality effects, implementation plans, and a complete public involvement program. The decision to start the reevaluation study should result from the NMFS check-in process in Section 9.5. The Corps will request funding or reprogramming to complete the project management plan within 1 year after NMFS' issuance of a check-in report indicating the need to seek additional authority. The study should result in a general reevaluation report and supplemental environmental impact statement, which would be used to seek authorization and/or appropriations to implement, recommended action(s), if needed. The general reevaluation report/ supplemental environmental impact statement will require approximately 2 years to complete.

Action 148: The Corps shall conduct detailed engineering and design work for improvements recommended in the general reevaluation report and supplemental environmental impact statement described in the preceding action. The Corps shall seek funding to allow initiation of the engineering and design work to occur immediately upon completion of the final general reevaluation report. The engineering and design work shall include only those activities on (or near) the implementation schedule critical path for the recommended actions, up to the award of the first construction contract. For a dam breach recommendation, the critical path activities shall include turbine physical modeling (for use as low level outlets), rock source explorations for embankment erosion protection (riprap), and hydraulic (physical) modeling for the embankment removal and channelization. Tentative milestones for the general reevaluation report/EIS and engineering and design work are as follows, based on the check-in process identified in Section 9.5:

Year 1	- Complete project management plan - Project management plan regional coordination
Year 2	- Initiate general reevaluation report/supplemental environmental impact statement
Year 3	- Complete final general reevaluation report/supplemental environmental impact statement - Initiate detailed engineering and design - Issue approval of general reevaluation report/supplemental environmental impact statement - Seek authorization and appropriations

Although breaching is not essential to implementation of the initial actions called for in the RPA, which constitute a non-breach approach, the RPA requires that the Action Agencies prepare for the possibility that breaching or other hydropower actions could become necessary. These actions will reduce the time needed to seek congressional authorization, if necessary, and thus reduce the time needed for possible implementation.

It is unacceptable to recommend a non-breaching alternative in the Lower Snake River feasibility report/environmental impact statement with a future contingency for breaching. Future decisions (whether they are made in 5 or 10 years) must be made with the best available information on the effects on all resources and users. Therefore, future decisions will require some reevaluation and NEPA compliance. In addition, any reevaluation of breaching must also consider all possible alternative actions as well.

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9.6.2 Habitat Actions

The habitat strategy is intended to accelerate efforts to improve survival in priority areas in the short term, while laying a foundation for long-term strategies through subbasin and watershed assessment and planning.

In the short term, Federal agencies commit in the Basinwide Recovery Strategy to focus immediate attention on priority subbasins, i.e., those with potential for significant improvement in anadromous fish productive capacity as a result of habitat restoration. The Basinwide Recovery Strategy identifies these short-term actions, timelines, and responsible Federal agencies. This biological opinion identifies the Action Agencies' contribution to the Basinwide Recovery Strategy. Where costs are stated in this biological opinion, they are estimates meant to help define the scale and pace of the action, not specific amounts the Action Agencies must actually spend to comply.

Over the long term, the habitat strategy has three overarching objectives: 1) protect existing high quality habitat, 2) restore degraded habitats on a priority basis and connect them to other functioning habitats, and 3) prevent further degradation of tributary and estuary habitats and water quality.

9.6.2.1 Actions Related to Tributary Habitat

When related to the basic habitat needs of listed anadromous fish, tributary habitat efforts have the following objectives:

- Water quantity—increase tributary water flow to improve fish spawning, rearing, and migration.
- Water quality—comply with water quality standards, first in spawning and rearing areas, then in migratory corridors.
- Passage and diversion improvements—address in-stream obstructions and diversions that interfere with or harm listed species.
- Watershed health—manage both riparian and upland habitat, consistent with the needs of the species.
- Mainstem habitat—improve mainstem habitat on an experimental basis and evaluate the results.
- Estuary improvement—improve and restore habitat conditions in the Columbia River estuary.

Action 149: BOR shall initiate programs in three priority subbasins (identified in the Basinwide Recovery Strategy) per year over 5 years, in coordination with NMFS, FWS, the states and others, to address all flow, passage, and screening problems in each subbasin over 10 years. The Corps shall implement demonstration projects to improve habitat in subbasins where water-diversion-related problems

could cause take of listed species. Under the NWPPC program, BPA addresses passage, screening, and flow problems, where they are not the responsibility of others. BPA expects to expand on these measures in coordination with the NWPPC process to complement BOR actions described in the action above.

The Federal agencies have identified priority subbasins where addressing flow, passage, and screening problems could produce short-term benefits. This action initiates immediate work in three such subbasins per year, beginning in the first year with the Lemhi, Upper John Day, and Methow subbasins. Subbasins to be addressed in subsequent years will be determined in the annual and 5-year implementation plans. NMFS will consider the level of risk to individual ESUs and spawning aggregations in the establishment of priorities for subsequent years. At the end of 5 years, work will be underway in at least 15 subbasins. The objective of this action is to restore flows needed to avoid jeopardy to listed species, screen all diversions, and resolve all passage obstructions within 10 years of initiating work in each subbasin. BOR is the lead agency for these initiatives and will facilitate their implementation. In addition, recognizing the critical importance of starting this work quickly, BPA will expand on measures under the NWPPC program to complement BOR's action. To support this work, NMFS will supply BOR with passage and screening criteria and one or more methodologies for determining instream flows that will satisfy ESA requirements. The Corps will use available funding and authorities to implement restoration actions in priority subbasins and in areas such as the Walla Walla basin, where water-diversion-related issues could cause take of listed species.

Action 150: In subbasins with listed salmon and steelhead, BPA shall fund protection of currently productive non-Federal habitat, especially if at risk of being degraded, in accordance with criteria and priorities BPA and NMFS will develop by June 1, 2001.

This opinion puts high priority on protecting habitat that is currently productive, especially if it represents a habitat type that already limits an ESU's productivity (e.g., summer rearing or over-wintering habitat). BPA should protect these habitats through conservation easements, acquisitions, or other means, working with non-profit land conservation organizations and others.

Action 151: BPA shall, in coordination with NMFS, experiment with innovative ways to increase tributary flows by, for example, establishing a water brokerage. BPA will begin these experiments as soon as possible and submit a report evaluating their efficacy at the end of 5 years.

Tributary flow problems are widespread. It is unclear whether and how solutions can be implemented through existing laws and administrative processes. To test new approaches to this problem, Bonneville will conduct experiments such as organizing a non-profit water brokerage to demonstrate transactional strategies for securing tributary flow—and, where feasible, addressing water quality—in streams with significant non-Federal diversions. The project would develop a

competitive process to supply water to increase flows and water quality at the lowest cost. Expectations for this project are as follows:

- In year 1, BPA will fund development of a methodology acceptable to NMFS for ascertaining instream flows that meet ESA requirements, establish a new non-profit entity or contract with a non-profit entity(ies) to carry out this project, require the non-profit entity(ies) to develop an operations plan, and initiate a trial round of water solicitations.

- In years 2 through 5, the non-profit entity should be fully operational, processing water solicitations and completing transactions according to the operations plan, and should explore possibilities for accomplishing water and other habitat objectives together.

An objective third-party evaluator will review the program after 5 years, and a decision will be made whether to continue it. The estimated BPA expenditure for this project is $2.5 million in the first year, $5 million in the second year, and $5 to $10 million per year thereafter, as justified by prospective transactions. NMFS and BPA should make joint decisions regarding funding beyond the $5 million-per-year base in years 2 to 5, in cooperation with the NWPPC's prioritization process. Recognizing recent amendments to the Columbia River Basin Fish and Wildlife Program regarding a land and water trust fund, BPA and NMFS will explore the possibility of integrating this action item with such a trust fund.

Action 152: The Action Agencies shall coordinate their efforts and support offsite habitat enhancement measures undertaken by other Federal agencies, states, Tribes, and local governments by the following:

- Supporting development of state or Tribal 303(d) lists and TMDLs by sharing water quality and biological monitoring information, project reports and data from existing programs, and subbasin or watershed assessment products.
- Participating, as appropriate, in TMDL coordination or consultation meetings or work groups.
- Using or building on existing data management structures, so all agencies will share water quality and habitat, data, databases, data management, and quality assurance.
- Participating in the NWPPC's Provincial Review meetings and Subbasin Assessment and Planning efforts, including work groups.
- Sharing technical expertise and training with Federal, state, Tribal, regional, and local entities (such as watershed councils or private landowners).
- Leveraging funding resources through cooperative projects, agreements and policy development (e.g., cooperation on a whole-river temperature or water quality monitoring or modeling project).

This effort would include funding implementation measures recommended in EPA- and state-approved tributary TMDLs that NMFS determines are essential to avoid jeopardy to the listed stocks.

Measures implemented by the Action Agencies to improve habitat can complement efforts by other Federal agencies, states, Tribes, and regional or local entities such as watershed councils. Similarly, endeavors by other Federal agencies, states, and Tribes can complement those of the Action Agencies. As an example of the former, information garnered from the studies and other measures implemented consistent with this opinion can be helpful to states and Tribes as they prepare 303(d) lists and TMDLs for tributaries in the Columbia River basin. Information obtained by states and Tribes as they develop TMDLs can be helpful to the Action Agencies as they study ways to improve water quality for fish through subbasin assessment and planning under the NWPPC's amended fish and wildlife program. More specifically, temperature monitoring stations installed by one entity could benefit all. Therefore, when Action Agency measures to improve habitat will complement efforts by states, Tribes, and local governments, and vice versa, the Action Agencies (as part of the subbasin planning process or management or implementation of the NWPPC's fish and wildlife program) shall consult with these entities to discern how their respective water quality efforts can complement each other and avoid duplication. Cost-sharing may be possible. The Action Agencies shall then implement measures as approved through applicable planning processes.

These actions are intended to improve Columbia River basin water quality, with the goal of being consistent with or complementing the NWPPC amended fish and wildlife program, the Clean Water Action Plan, the Unified Federal Policy for a Watershed Approach to Federal Land and Resource Management, the states of Washington and Oregon's Lower Columbia River Estuary Program Comprehensive Conservation and Management Plan, the Inter-Governmental Task Force for Monitoring principles, and state and local watershed planning efforts.

Action 153: BPA shall, working with agricultural incentive programs such as the Conservation Reserve Enhancement Program, negotiate and fund long-term protection for 100 miles of riparian buffers per year in accordance with criteria BPA and NMFS will develop by June 1, 2001.

Under certain farm incentive programs, farmers and ranchers may enter into 10- to 15-year contracts to plant riparian buffers or restore wetlands on streams that provide habitat for listed salmonids. Experience with similar programs suggests that these buffers can be made permanent, or at least long-term, by adding an increment to the contract price. Securing such protection adds value in terms of riparian corridor restoration and, where recognized by state law, instream flow restoration.

Action 154: BPA shall work with the NWPPC to ensure development and updating of subbasin assessments and plans; match state and local funding for coordinated development of watershed assessments and plans; and help fund technical support

for subbasin and watershed plan implementation from 2001 to 2006. Planning for priority subbasins should be completed by the 2003 check-in. The action agencies will work with other Federal agencies to ensure that subbasin and watershed assessments and plans are coordinated across non-Federal and Federal land ownerships and programs.

In the long term, habitat recovery and watershed restoration for non-Federal public, Tribal, and private lands require state and local stewardship. An overall framework for this stewardship can be created through subbasin and watershed plans and related recovery plans which establish goals, objectives, and priority actions that are coordinated across Federal and non-Federal ownerships and programs. BPA is funding the bulk of NWPPC's subbasin assessments and plans. These plans will provide an important context for classifying and prioritizing watersheds for protection and restoration. They will also provide the foundation for ESA recovery planning which will be conducted in a similar time frame. Several watershed scale efforts are underway. The Federal land management agencies are conducting watershed assessments in most watersheds with significant Federal land ownership. State and local governments are conducting assessments and developing plans at the watershed scale to meet ESA regulations, CWA TMDLs, and other needs. In its final 4(d) rule (July 10, 2000), NMFS committed to working with states to develop guidelines for watershed assessments and plans. As these steps are completed, priorities, targets, and schedules will emerge, and priorities can be adjusted. As described in the Basinwide Recovery Strategy, all the Federal agencies are committed to coordinating assessment, planning, and priorities across non-Federal and Federal land ownerships and programs. As subbasin and watershed plans are completed, the Action Agencies should identify habitat actions in annual and 5-year implementation plans and implement them.

Action 155: BPA, working with BOR, the Corps, EPA, and USGS, shall develop a program to 1) identify mainstem habitat sampling reaches, survey conditions, describe cause-and-effect relationships, and identify research needs; 2) develop improvement plans for all mainstem reaches; and 3) initiate improvements in three mainstem reaches. Results shall be reported annually.

Large-scale water development over the last 65 years has inundated and significantly degraded mainstem habitat. Populations such as fall chinook that were once highly productive spawned in the mainstem and in the lower reaches of major tributaries. Studies in other river systems in the Northwest indicate that mainstem habitat improvements can result in greater population and habitat diversity, complexity, and productivity. However, no systematic assessment of habitat modifications from dam construction has been done, nor have potential restoration sites and specific benefits to salmon and steelhead been identified. BPA, working with the Corps, will take immediate steps to begin to address these uncertainties by collecting baseline data, improving mainstem reaches in ways that mimic the range and diversity of historic habitat conditions as much as possible, and monitoring and evaluating the results. Results will be reported annually. After 5 years, NMFS and the Action Agencies, in consultation with NWPPC and others, will determine whether to make changes in this program.

Action 156: The Action Agencies and NMFS shall study the feasibility (including both biological benefits and ecological risks) of habitat modification to improve spawning conditions for chum salmon in the Ives Island area.

The objectives of the study will be to determine whether it would be beneficial to increase the frequency of access to spawning habitat or the areal extent of spawning habitat by means other than flow augmentation. The feasibility study will evaluate actions to alter the hydraulic control points that limit flow in the Ives Island area to provide the same areal extent and quality of sustainable spawning habitat (including characteristics such as upwelling through the gravels currently present at the site) at lower levels of Bonneville discharge; reconstruct spawning channels to increase the extent of habitat available at a given level of Bonneville discharge; and maintain hydraulic connections between tributary habitats and the mainstem Columbia River to allow entry for adults and emergence channels for juveniles.

Action 157: BPA shall fund actions to improve and restore tributary and mainstem habitat for CR chum salmon in the reach between The Dalles Dam and the mouth of the Columbia River.

The purpose of this action is to compensate for effects of FCRPS water management in the Ives Island area, which appreciably diminish the value of critical spawning habitat for the survival and recovery of CR chum salmon. The FCRPS has been a relatively important factor for decline of this ESU. Bonneville and The Dalles dams limit access to potential spawning habitat further upstream and Bonneville Reservoir drowned known historical habitat in Bonneville pool. Spawning is currently known in only two areas: the Grays River system in the Columbia River estuary and the Hardy/Hamilton creeks/Ives Island complex, downstream of Bonneville Dam.

Although most of the existing subbasin populations and the ESU as a whole are on a slightly positive growth trajectory (ESU-level lambda = 1.035), RPA water management operations will continue to limit the areal extent of spawning habitat in Bonneville pool and the Ives Island complex in most water years. Therefore, BPA will 1) fund surveys of existing and potential tributary and mainstem habitat in the Columbia River between The Dalles Dam and the mouth of the Columbia River for suitable protection and restoration projects, 2) develop and implement an effective habitat improvement plan, 3) protect, via purchase, easement, or other means, existing or potential spawning habitat in this reach and adjacent tributaries (i.e., protect, restore, and/or create potentially productive spawning areas). The overall goal of this effort will be to ensure the survival and recovery of CR chum salmon by ensuring the availability of diverse, productive spawning habitats over a wide range of water years.

9.6.2.2 Actions Related to Estuarine Habitat

Estuarine protection and restoration must play vital roles in rebuilding the productivity of listed salmon and steelhead throughout the Columbia River basin. The states of Oregon and Washington, with congressional authorization under the CWA, have developed a Comprehensive

Conservation and Management Plan through the Lower Columbia River Estuary Program (LCREP). The Federal agencies strongly support the actions of this plan that contribute to salmon recovery and seek to expand on them.

The following action items call on the Action Agencies, primarily the Corps and BPA, to play an important role in estuary restoration efforts. The Corps is meant to play a lead role, with BPA primarily providing cost-share funding. The Corps and BPA actions are not meant to hinge on LCREP approval, but they are meant to be fully coordinated with the LCREP.

Action 158: During 2001, the Corps and BPA shall seek funding and develop an action plan to rapidly inventory estuarine habitat, model physical and biological features of the historical lower river and estuary, identify limiting biological and physical factors in the estuary, identify impacts of the FCRPS system on habitat and listed salmon in the estuary relative to other factors, and develop criteria for estuarine habitat restoration.

A good deal is unknown about the ecology of the Columbia River estuary insofar as it affects listed species. It is important to develop a better understanding of historic salmon rearing patterns in the estuary; historic changes in the distribution, amounts, and classes of estuarine and floodplain habitat available to juvenile salmonids; variability in salinity, temperature, water depth, velocity, dissolved oxygen, and turbidity; habitat-salmon associations; sedimentation rates; salmon and habitat conditions in the transition zone; long-term variability and trends in the size, timing, and abundance of hatchery and wild outmigrants from the Columbia River; and the relative effects of inflow from upriver, changes in bathymetry due to the navigation channel, and changes in habitat due to other forms of development. Under this action item, the Corps and BPA are expected to develop programs to build an understanding of these matters and, in the relatively short term, to develop criteria for estuary habitat restoration on the basis of the best available information.

Action 159: BPA and the Corps, working with LCREP and NMFS, shall develop a plan addressing the habitat needs of salmon and steelhead in the estuary.

BPA and the Corps, working with LCREP and NMFS, will develop specific plans for salmon and steelhead habitat protection and enhancement. These plans should contain clear goals for listed salmon conservation in the estuary, identify habitats with the characteristics and diversity to support salmon productivity, identify potential performance measures, identify flow requirements to support estuarine habitat requirements for salmon, and develop a program of research, monitoring, and evaluation. The plans should be completed by 2003.

Action 160: The Corps and BPA, working with LCREP, shall develop and implement an estuary restoration program with a goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats over 10 years, beginning in 2001, to rebuild productivity for listed populations in the lower 46 river miles of the

Columbia River. The Corps shall seek funds for the Federal share of the program, and BPA shall provide funding for the non-Federal share. The Action Agencies shall provide planning and engineering expertise to implement the non-Federal share of on-the-ground habitat improvement efforts identified in LCREP, Action 2.

Much of the complexity of the estuary's historic shallow-water habitat and much of the estuary's saltwater wetlands have been lost due to the effects of local, navigational, and hydropower development. LCREP proposes a 10-year program to protect and enhance high-quality habitat on both sides of the river to support salmon rebuilding. A high priority should be put on tidal wetlands and other key habitats to rebuild productivity in the lower 46 river miles. Federal agencies will provide technical and financial support for this program and for efforts to implement on-the-ground activities identified in planning.

As more information is gained from inventory and analytical work, the 10,000-acre goal may be modified to ensure that habitats that are determined to be important to the survival and recovery of anadromous fish are addressed. Examples of acceptable estuary habitat improvement work include the following:

- Acquiring rights to diked lands
- Breaching levees
- Improving wetlands and aquatic plant communities
- Enhancing moist soil and wooded wetland via better management of river flows
- Reestablishing flow patterns that have been altered by causeways
- Supplementing the nutrient base by importing nutrient-rich sediments and large woody debris into the estuary
- Modifying abundance and distribution of predators by altering their habitat
- Creating wetland habitats in sand flats between the north and south channels
- Creating shallow channels in inter-tidal areas
- Enhancing connections between lakes, sloughs, side channels, and the main channel

The Corps and BPA will put high priority on improving access to and the quality of chum habitat, especially in the Grays River. The work outlined in this action is in addition to any mitigation/restoration work that may be connected to the Corps' channel-deepening project.

Action 161: Between 2001 and 2010, the Corps and BPA shall fund a monitoring and research program acceptable to NMFS and closely coordinated with the LCREP monitoring and research efforts (Management Plan Action 28) to address the estuary objectives of this biological opinion.

Action 162: During 2000, BPA, working with NMFS, shall continue to develop a conceptual model of the relationship between estuarine conditions and salmon population structure and resilience. The model will highlight the relationship among hydropower, water management, estuarine conditions, and fish response. The work will enable the agencies to identify information gaps that have to be addressed to develop recommendations for FCRPS management and operations.

Action 163: The Action Agencies and NMFS, in conjunction with the Habitat Coordination Team, will develop a compliance monitoring program for inclusion in the first 1- and 5-year plans.

Compliance monitoring is necessary to determine how well management actions are implemented. From a regulatory perspective, compliance monitoring is necessary to ensure that agencies and individuals responsible for mitigation or restoration activities complete their responsibilities. From a biological perspective, NMFS must know how well a management action is implemented. If salmon do not respond, NMFS will be able to distinguish between management that did not work and management that was not implemented.

Some compliance monitoring will be conducted during the monitoring and evaluation program outlined in Section 9.6.5. However, not all sites will be checked at the appropriate intervals during this program. Therefore, the agency or party conducting each action will be responsible for keeping a log book of implementation, which is entered monthly into a web-based data archive. NMFS will randomly send out field staff to check on the log books and validate their entries.

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9.6.3 Harvest Measures

9.6.3.1 Overview

Fisheries that affect listed fish originating in the Columbia River basin, whether in the tributaries, the mainstem, or the ocean, have been and continue to be subject to biological opinions addressing harvest. In all cases, fisheries must be operated to avoid jeopardizing listed species. This opinion addresses the operation and management of FCRPS, not harvest. Harvest management is not within the authorities of the Action Agencies; therefore, additional constraints cannot be imposed on fisheries by this biological opinion. Instead, this section outlines harvest measures the Action Agencies can facilitate to meet offsite mitigation goals for hydrosystem impacts and measures that may further reduce the take of listed species. The Action Agencies can contribute to the development and deployment of selective fisheries potentially reducing impacts on listed fish and allowing increases in harvest without raising impacts on listed fish. This section outlines changes in the fishery management system that are critical to the successful deployment of selective fishery measures and harvest reforms that will increase the certainty and efficacy of new and existing harvest management regimes, thereby raising the margin of safety afforded to listed fish.

Fisheries in the Columbia River basin have been significantly reduced in recent years in response to a number of factors that include a general decline in abundance, an increasing scientific and policy awareness of the importance of managing fisheries for natural stocks and stock groups, improved management capabilities, and the requirement to reduce impacts on listed species. Many reviewers of the draft biological opinion correctly pointed out that harvest managers have been implementing harvest reforms for many years. Weak stock management, abundance-based management, harvest rate and escapement goal management, and other kinds of major advancements (i.e., reforms) have been used for some time and continue to evolve and improve. Some reviewers believe that harvest managers have been responding to the declining status of natural fish caused largely by non-fishing factors, at great cost to their fisheries, economies, and cultures. They also point out that further reductions in harvest may benefit some species, such as Snake River fall chinook or Snake River steelhead, but that such additional reductions, even if achieved, will not help recover listed species.

The decline in the status and abundance of natural populations has many causes, including, but not limited to, the development and operation of FCRPS. It will take a long time for recovery efforts to show positive results. Thus, harvest constraints now in place must continue for some time so as not to thwart other recovery efforts. New and/or expanded harvest reforms, such as those that increase the selectivity of fisheries either by avoiding contact with listed fish or by reducing the mortality rate of listed fish released from fisheries, offer the potential to reduce impacts on some listed ESUs. It may be possible to realize this potential without net reductions in harvest and to increase total harvest without increasing impacts on listed ESUs. If successfully implemented, such reforms would provide easily quantified survival benefits for listed fish. The reforms provide potential opportunities for the Action Agencies to meet offsite

mitigation goals. To the extent that the reforms are facilitated by the Action Agencies, it should be possible to allocate these benefits.

For most of the listed ESUs, opportunities to improve survival through additional harvest reductions are limited because they are not affected, or are affected only minimally, by today's much-reduced fisheries. Impacts on those ESUs that still are affected by harvest occur in fisheries targeting healthy and abundant stocks, particularly hatchery stocks. Even for the ESUs affected by these incidental harvests, impacts already have been greatly reduced in recent years in response to declining abundance of nonlisted as well as listed species. As a result, even the complete elimination of all remaining fisheries would yield only limited benefits for many of the ESUs.

Some who commented on the draft opinion advocated further reductions in harvest, in some cases its complete elimination. They argued that reducing harvest is more cost-effective than other recovery measures, that it provides more certain benefits to listed fish, and that it more closely matches the intent of ESA because it prohibits the killing of listed species. Others disagreed, pointing out that extreme harvest reductions have already occurred, that the harvest sector has already paid more than its fair share, that additional harvest constraints can do little to change the basic productivity of natural stocks, and that current harvest constraints fail to meet Tribal obligations. NMFS acknowledges the validity in each of these views, but respectfully disagrees that they make a compelling case to implement any of the more extreme alternatives. The solution to the recovery problem cannot be found in the complete elimination of harvest, in sacrificing what little remains of an entire sector, or in further exacerbating an already extreme burden on the Tribes, as a prerequisite to changes in other sectors. Nor can it be found in allowing increases in harvest simply because harvest constraints have been "proven" not to recover listed species, or because reasoned arguments exist as to why the current allocation of the conservation burden is unfair.

NMFS' overall approach to recovery, and the reasoning that supports it, is described in greater detail in the Basinwide Recovery Strategy, which provides the broader context for this biological opinion. For harvest, the approach described in the Basinwide Recovery Strategy is to constrain ocean and inriver harvests at or below recently established rates to allow time for other recovery measures to take effect. As noted above, this opinion cannot mandate and, therefore, does not presume that additional reductions in harvest relative to those described in the Basinwide Recovery Strategy will occur. However, maintaining harvest constraints is critical to the success of recovery efforts. In a few cases, additional harvest reductions would substantially increase the prospects, and may actually be necessary, for recovery. The scientific risk assessments that inform this biological opinion assume that, at the very least, recently established harvest constraints and their associated survival benefits will be maintained. It is, therefore, both reasonable and prudent for the Action Agencies to contribute to measures to ensure that these constraints continue, to increase the certainty and efficacy of harvest management measures and, thereby, the margin of safety afforded listed fish, and to enable additional reductions through improved fishery selectivity. This is particularly true for the immediate future, since harvest

measures yield immediate benefits while other measures to increase survival of listed fish require more time to produce benefits.

This RPA does not assume that the Action Agencies will provide all of the funding necessary to implement the harvest actions described here, as some are clearly the responsibility of those with harvest management authority. As stated previously in this biological opinion, where offsite mitigation actions imposed on the Action Agencies by this RPA overlap with the responsibilities of other Federal and non-Federal entities, an appropriate sharing of costs and implementation responsibilities must be worked out.

9.6.3.2 Measures to Reform Harvest

This RPA defines harvest reform broadly; it includes implementing various kinds of harvest management reforms such as selective fishery management strategies (e.g., mark-selective fisheries), developing and applying alternative fishing methods and gear types, and creating or expanding fishing opportunities in areas or at times when listed fish are not present. As noted previously, many harvest reforms have already been implemented by the fishery managers. Realizing the full potential of harvest reforms, however, requires development and implementation of new and more broadly applied selective fishing techniques, as well as augmenting and/or modifying existing programs and tools for managing fisheries, including systems for monitoring and evaluating stock and fishery-specific impacts. Because most or all hatchery fish will have to be marked to improve information on the status of natural populations and/or to enable mark-selective fisheries, existing catch sampling and stock identification programs and methodologies will have to be modified and significantly augmented, both inside and outside of the basin. Existing management and assessment tools, including various models, analytical methods, procedures, and associated databases, will also have to be refined and/or replaced.

The Basinwide Recovery Strategy particularly emphasizes the development, implementation, and expansion of mark-selective fisheries. Mark-selective fisheries are not recovery tools, but rather means to allow fishing to continue. Used primarily in certain recreational fisheries, mark-selective fisheries also may provide significant economic benefits to commercial fisheries that use live-capture selective fishing techniques. Live-caught fish can be delivered to buyers in better condition, potentially enhancing their market value. Thus, mark-selective and other forms of selective fishing may contribute to meeting multiple objectives, including FCRPS mitigation mandates, FCRPS offsite mitigation responsibilities, and Tribal and non-Tribal fishery obligations.

Realizing the full potential of selective fishing depends on a number of elements, both technical and policy-level. Before the strategy would work in Tribal fisheries, social, economic, and cultural impacts would have to be addressed in ways the Tribes support. The fishers must fish in times or places where encounters with listed fish are minimal, or they must use gear and methods that allow fish to be caught alive, so that those needing protection can be released with a minimal

amount of handling loss. In selective fisheries based on live-catch strategies, it must be possible and practical for the fishers to visually sort between fish that are harvestable and those that are not. Sorting between different species—sockeye versus chinook, for example—is fairly straightforward and promising for certain fisheries in the Columbia River basin, including some that would sort between healthy natural stocks and listed stocks. However, selectivity directed towards the harvest of hatchery fish in mixed stock fishing areas, including the mainstem, will rely on mass marking of hatchery-produced fish. Fortunately, it is now feasible to mass-mark hatchery fish using new, relatively economical technologies, but those technologies must be widely used to make mark-selective fisheries feasible in mixed stock areas. Sufficiently precise and accurate methods must exist to estimate incidental mortalities on fish that are captured and released. Methods for maintaining critical management systems must be developed and deployed so that managers can maintain and enhance their ability to monitor and evaluate the effects of fisheries and the status of stocks.

Some selective fishing strategies are designed to avoid catching listed species in the first place. These can reduce the catch of listed species in fisheries targeting strong runs. An example of this strategy is the gill net exchange program recently developed by the Action Agencies, Tribes, and Federal agencies. This program, partially implemented in the autumn 2000 mainstem Tribal fishery, should be assessed for economic, legal, and social implications and, if appropriate and agreed to by the Tribes, expanded in the future. Canadian fishers and managers are engaged in an ongoing, multiyear program to develop and assess innovative techniques to minimize the catch of weak natural runs. One such technique involves using "weed lines" on gill nets in the Skeena River to reduce impacts on depressed steelhead runs in the commercial salmon fishery. These and other avoidance techniques should be investigated for application in Columbia River basin fisheries.

9.6.3.2.1 Measures to Develop or Expand Use of Selective Fishing Methods and Gear

Action 164: The Action Agencies shall work with NMFS, USFWS, and Tribal and state fishery management agencies in a multiyear program to develop, test, and deploy selective fishing methods and gear that enable fisheries to target nonlisted fish while holding incidental impacts on listed fish within NMFS-defined limits. The design of this program and initial implementation (i.e., at least the testing of new gear types and methods) shall begin in FY 2001. Studies and/or pilot projects shall be under way and/or methods deployed by the 3-year check-in.

The purpose of this action is to enable the development and deployment of selective fishing gear and methods so some level of fishing can continue even when listed fish are present. Because it will take time to develop, test, refine, and deploy different types of methods and gear in various conditions, this action necessarily will involve a continuing, multiyear program.

The effectiveness of new selective fishing gear and methods depends to a large degree on whether they are accepted by the fishers. The program to develop and test selective fishery

options should engage members of the fishing community, drawing on their proven abilities to find innovative and practical solutions to fishing-related problems. Funding should be made available and proposals solicited from agencies, Tribes, industry, and the public to develop and test selective fishing methods and/or gear using carefully designed and monitored applied experiments. Live-capture fishing gear and methods such as traps, seines, tangle nets, and revival tanks should be explored. The program should be implemented as soon as possible, building on the experiences of the Canadians, states, and Tribes. Strategies that work should be deployed as broadly and quickly as possible. The program also should include exploration of methods and strategies to reduce incidental fishing mortalities in fisheries, regardless of whether they use conventional or live-capture gear types.

9.6.3.2.2 Measures to Address Effects of Selective Fishing on Fishery Management Systems (e.g., Fishery Management and Stock Assessment Models)

Action 165: The Action Agencies shall work with NMFS, USFWS, Tribal and state fishery managers, and the relevant Pacific Salmon Commission and Pacific Fishery Management Council (PFMC) technical committees to develop and implement methods and analytical procedures (including revising and/or replacing current fishery management and stock assessment models based on these methods and procedures) to estimate fishery and stock-specific management parameters (e.g., harvest rates). The Action Agencies shall place particular emphasis on current methods and procedures affected by the transition to mass marking of Columbia River basin hatchery produced fish and/or deployment of selective fishery regimes in the Columbia River basin, addressing these concerns within a time frame necessary to make the new selective fishing regimes feasible. Specifically, the Action Agencies shall facilitate the development of models, methods, and analytical procedures by the 3-year check-in.

Current harvest management strategies and stock assessment tools, especially including the models used to implement and monitor them, evolved in the context of non-selective fisheries. These models have long played a crucial role in the management of ocean and freshwater fisheries and in stock assessment programs. Most of them are based on data acquired over the last two decades from the coastwide CWT program. The models include the coastwide chinook model the United States and Canada used to implement and monitor the chinook regime contained in the Pacific Salmon Treaty and similar models developed and used by the PFMC and the *U.S. v. Oregon* Technical Advisory Committee. These modeling tools were not designed to accommodate selective fisheries; they evolved in the context of non-selective fisheries, using the basic assumption that the catch in a fishery represents a random removal of fish from the fishery population. With the advent of mass marking and selective fishing, this key assumption is no longer valid. Because it is more critical than ever to sustain and enhance the stock and fishery-specific information and analyses that these tools provide, the models and associated analytical techniques must be substantially revised or replaced. This will be a significant but necessary undertaking. Besides maintaining and enhancing critical fishery management and stock

assessment capabilities, this action will help ensure compliance with the Pacific Salmon Treaty and other agreements.

Fishery management models and related management systems in the various areas and fisheries are interdependent. Changes in ocean fisheries management and strategies affect river fisheries and vice-versa. Clearly, this action item involves matters that overlap with the responsibilities of the fishery managers. As stated previously, an appropriate sharing of costs and implementation responsibilities must be worked out among the relevant parties.

Action 166: The Action Agencies shall work with NMFS, USFWS, the Pacific States Marine Fisheries Commission, and Tribal and state fishery management agencies to implement and/or enable changes in catch sampling programs and data recovery systems, including any required changes in current databases (e.g., reformatting) and associated data retrieval systems, pursuant to the time frame necessary to implement and monitor mass marking programs and/or selective fishery regimes in the Columbia River basin. Specifically, the Action Agencies shall facilitate the revision of programs and systems, as needed, by the 3-year check-in.

Changes in fishery monitoring and data systems will be necessary to provide the degree of resolution required to monitor the status of listed populations while enabling some continued fishing. For years, the adipose fin clip was used solely to identify fish that carry a CWT. Now, fish with an adipose clip may or may not carry a CWT, and a fish that has a CWT may or may not have a fin clip. For this reason, significant changes must be made in sampling and monitoring programs. Most notably, electronic tag detectors will be needed to detect and recover CWTs from a broad range of fisheries, natural spawning areas, and hatchery escapements to maintain critical stock-specific and fishery-specific information provided by the CWT system. Fishery management databases, including the coastwide databases maintained by the Pacific States Marine Fisheries Commission on behalf of the states, Tribes, the United States Federal government, and Canada, will have to be modified and reformatted and new protocols adopted to accommodate changes in data types, collection methods, access methods, and use.

Action 167: The Action Agencies shall work with NMFS, USFWS, and Tribal and state fishery management agencies to develop improved methods for estimating incidental mortalities in fisheries, with particular emphasis on selective fisheries in the Columbia River basin, doing so within the time frame necessary to make new marking and selective fishery regimes feasible. The Action Agencies shall initiate studies and/or develop methods by the 3-year check-in.

Even selective fisheries cause some level of incidental mortality on listed fish; obtaining sufficiently accurate and precise estimates of this mortality will be critical to the successful implementation of many selective fisheries. For years, incidental mortalities have been estimated from very limited data. For example, a single estimate of hook-and-release mortalities formerly was used to cover ocean fisheries coastwide, regardless of species or type of hook and line used.

Estimates have improved significantly in recent years, but could be improved even more. The same may be true for mark-selective recreational steelhead fisheries. The weak link in estimating incidental mortalities lies in estimating the encounter rate; existing methods for estimating fishery-specific rates must be improved. In the context of listed fish, where even low levels of mortality can affect the prospects for survival and recovery, accurate and precise estimates of incidental mortalities will be essential for determining the extent to which selective fisheries can accomplish their intended purposes. Studies must be conducted in specific fisheries to better estimate these mortalities as a function, for example, of the type of gear used, how it is fished (e.g., net gear "soak time"), water temperatures, and other variables. Estimating the effects of multiple captures of listed fish is a particularly difficult, but critical-to-solve, problem. Failure to do so could undermine the viability of selective fisheries strategies for some species and/or fisheries. In addition to improving estimates of immediate mortalities resulting from catch and release fisheries, studies are needed to focus on the effects of these encounters on subsequent reproductive success.

9.6.3.3 Procedures for Crediting Reductions in Impacts on Listed Fish

Action 168: The Action Agencies shall work with NMFS, USFWS, and Tribal and state fishery management agencies to develop methods for crediting harvest reforms, and the survival benefits they produce, toward FCRPS offsite mitigation responsibilities. A crediting approach shall be agreed upon by the 3-year check-in.

The methods should identify, for example, how much reduction in take occurs as a result of the reforms. Consideration should be given to the extent to which FCRPS contributes funding for development and application of reform measures. Methods must be included for monitoring and evaluating estimated survival benefits over time. The methods for crediting specific reform measures likely will vary. Allocation of survival benefits enabled by harvest reforms is also likely to vary with circumstances. For example, the survival benefits derived from achieving greater selectivity in a given fishery can potentially be used for either or both of two objectives: 1) achieving a higher catch of nonlisted abundant stocks while staying within a harvest rate limit on listed fish, or 2) further reducing the rate of incidental harvest impacts on listed fish while maintaining a particular level of total catch. It is not possible to maximize both objectives simultaneously, i.e., to minimize impacts on listed fish at the same time as maximizing the catch of nonlisted fish.

In some cases, depending on the status of the listed fish, all survival benefits flowing from greater harvest selectivity should accrue solely to escapements. In other cases, however, a portion of the benefits of greater selectivity could accrue to the fishery as a higher total catch. The Action Agencies and the harvest managers should develop and agree to formulas that accommodate both objectives—increases in escapement and increases in total catch—thereby better aligning the interests of the FCRPS with those of the harvest sector. For action items other than those involving the development and implementation of selective fishery methods

(where it is relatively easy to quantify survival benefits to listed fish), survival credit to the Action Agencies will be more qualitative. An appropriate crediting formula for offsite mitigation for harvest reforms should take into account a number of considerations, including the extent of reductions in take of listed species enabled by the reforms, the reasons the reforms are necessary, the relative responsibilities of the affected parties and actions they have already taken, and the extent to which the Action Agencies contributed to speeding the pace of the reforms, or the margin of safety they provide.

9.6.4 Artificial Propagation Measures

9.6.4.1 Overview

An extensive amount of artificial production of salmon and steelhead occurs in the Columbia River basin today. Many hatchery programs started decades ago specifically to replace natural production lost as a result of the FCRPS and other development, not to protect and rebuild natural populations. The original design and operation of many programs and facilities reflect scientific knowledge and policy decisions of a previous era. Traditionally, the objective of those hatchery programs was to provide harvest opportunities, a mitigation obligation that remains today. Most were never called upon to produce fish that are viable in nature. To a large degree, the programs succeeded in producing harvestable salmon and steelhead to maintain fisheries, even as natural production declined.

In recent years, changing policies reflect the importance of natural populations and the potential negative effects of hatcheries. As many reviewers of the draft opinion noted, numerous artificial production reforms have been implemented. These reforms strive to reduce negative effects of hatchery production on natural populations while retaining its proven production and potential conservation benefits. For example, hatchery programs are in the process of phasing out use of improper brood stocks, such as out-of-basin or out-of-ESU stocks, replacing them with fish derived from, or more compatible with, locally adapted populations. Producing fish that are better suited for survival in the wild is the explicit objective of programs such as the Yakama Nation's Cle Elum hatchery. Many programs incorporate improved production techniques, such as the NATURES rearing program used by the Nez Perce Tribe. The basic thrust of many of these reforms has been to produce fish that pose less risk to natural populations, either by minimizing interactions with natural populations or by making hatchery fish more compatible with them.

Nevertheless, recovery cannot be achieved simply by releasing more hatchery-produced fish in natural production areas, regardless of their ancestry or how they are produced. Hatcheries cannot provide the productive conditions necessary to restore self-sustaining populations in their natural habitats. It is also recognized that some artificial programs and facilities could be further reformed because they still have deleterious effects on natural populations and/or mask their status. The overarching goal of the reforms described here is to reduce or eliminate adverse genetic, ecological, and management effects of artificial production on natural production while retaining and enhancing the potential of hatcheries to contribute to basinwide objectives for conservation and recovery. The goal still includes providing fishery benefits to achieve mitigation mandates, but now must also include an increased emphasis on conservation and recovery, a mission for which many older programs were not designed. Reforms of existing hatchery programs and facilities that began several years ago must be accelerated and broadened to apply a variety of new and improved artificial production techniques that include supplementation, captive brood stock, and other strategies designed to minimize the risk of artificial production and/or maximize its conservation benefits.

These reforms require substantial and costly changes in existing programs and facilities, beginning with a rigorous review of their goals and objectives. An implicit but fundamental premise of the approach described in the Basinwide Recovery Strategy and this biological opinion is that artificial production programs can be operated consistent with, and complementary to the goals of the ESA, while still achieving fishery mitigation objectives. Because there is a range of scientific and policy opinions regarding the purpose and appropriate application of artificial production in specific circumstances, a number of strategies, coupled with an adaptive management approach, are warranted and, with the help of the Action Agencies, are prescribed here.

In applying the ESA to listed species, NMFS focuses on biological requirements. NMFS' understanding of these requirements derives from many sources, including the general conservation literature, specific NMFS studies of salmon, as well as by others, and recommendations of the Tribes, state, and other Federal fish and wildlife agencies and experts. NMFS recently published a compilation of scientific information in "Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units" (McElhany et al. 2000). This document identifies criteria and guidelines relevant to the needs of salmonid populations. Hatchery programs can affect these biological needs. Accordingly, subsequent to the listings, NMFS began to address these programs in biological opinions issued or still in progress under Sections 7 and 10 of the ESA for hatchery programs throughout the Columbia River basin. In those biological opinions, as in this one, NMFS focuses on reducing the deleterious effects of artificial production on listed species. Deleterious effects must be eliminated or reduced enough to avoid jeopardizing listed species and to provide for their survival and recovery. NMFS' biological opinions have led to substantial changes in artificial production programs throughout the region.

In determining the extent of necessary reforms of hatchery programs, and the rate at which they must occur, NMFS considers a number of factors. These include, but are not limited to, the amount of benefit to listed fish accruing from the proposed reform, the extent of improvement already achieved from earlier reforms, the cost of the reforms (both economic and in terms of impacts on other goals and objectives), how quickly they can be implemented, how soon they will produce results, and how well the benefits to the fish can be measured. While all these factors must be considered in hatchery biological opinions, a consistent approach to hatchery reforms should be employed throughout the Columbia River basin, always with the result being a determination that each proposed hatchery program will be operated in a way that does not jeopardize listed fish.

Because the difference between jeopardy and no jeopardy is seldom a bright line, the consultation process also focuses on the margin of safety that artificial production programs should achieve and the pace at which reforms must be implemented. This is an area where the Action Agencies have a substantial opportunity to contribute to the survival of listed species. To the extent that the Action Agencies contribute additional resources (i.e., resources beyond those that they are already obliged to provide to comply with hatchery biological opinions and, thus,

continue to meet their mitigation responsibilities), they can satisfy survival goals within the meaning of this biological opinion.

In addition to reforms of current hatchery programs, another opportunity exists for the Action Agencies to contribute to the survival of listed species. Numerous populations in the upper Columbia and upper Snake river basins are in such bad condition that extinction may be imminent in the near term. Actions in the habitat and hydrosystem sectors designed to improve the status of these populations may not occur due to lack of resources, or may not have the intended effect soon enough to avoid extinction. Given the status and trends of these populations, the potential benefits of intervening with artificial production actions, i.e., safety-net programs, may outweigh the risks of such intervention. The Action Agencies can provide resources to implement such strategies where NMFS determines they are appropriate. Credit should accrue to the Action Agencies for artificial production actions undertaken specifically to avoid extinction, as this clearly constitutes a positive contribution to the survival of the listed populations.

Scientific knowledge regarding the benefits and risks of artificial production is incomplete, but improving. Artificial production measures have proven effective in many cases at alleviating near-term extinction risks, yet the potential long-term benefits of artificial production as a recovery tool are unclear. Scientific uncertainty remains about whether and to what extent hatcheries, as they are currently operated, pose a continuing risk to natural populations. The Action Agencies can further achieve the offsite mitigation goals by investing in research, monitoring, and evaluation to address these uncertainties. These investments may eventually manifest themselves in improved survival of listed fish. NMFS will work with the Action Agencies on a method for recognizing the benefit of these efforts.

A number of studies and reviews of artificial production in the Columbia River basin have occurred in recent years; some are described later in this section. Although their scope is different from NMFS' focus under the ESA and in this biological opinion, their findings and recommendations generally are consistent with the measures identified here. In general, the standards and guidelines that emerge from these reviews are aimed at improving the effectiveness of artificial production programs, minimizing deleterious impacts on natural populations, meshing hatchery production and policies with harvest objectives, and increasing accountability and efficiency in hatchery programs. Integrating hatchery and harvest policies is especially important to meeting obligations for Tribal and non-Tribal fisheries.

9.6.4.2 Actions to Reform Existing Hatcheries and Artificial Production Programs

Recent studies recommending hatchery reform include the NWPPC's Artificial Production Review, several scientific reviews such as the NRC's Upstream Report (NRC 1996), the NWPPC's "Return to the River Report" (ISG 1996), and others found in the literature. NMFS also has published several papers relevant to artificial production, including the Interim Policy on Artificial Propagation of Pacific Salmon under the Endangered Species Act (April 5, 1993, 63

FR 17573), and the previously mentioned VSP report. In general, these studies reach similar conclusions about the types of reforms necessary to reduce deleterious effects while still allowing continued use of hatchery production to provide Tribal and non-Tribal harvest opportunities.

The detrimental impacts of artificial production can be categorized into 1) genetic effects resulting from domestication, artificial selection, inbreeding, straying, and stock transfers; 2) ecological interactions such as competition and predation; and 3) management effects, such as occur when fisheries are managed at high rates to take hatchery fish, resulting in excess harvest of natural fish. In addition, there is the masking effect of hatchery fish that confounds NMFS' ability to determine the status of natural populations. While many hatchery reforms have been or are in the process of being implemented, much remains to be done.

From the recent studies, a fairly extensive menu of measures has been identified, and specific actions to implement the measures have emerged. This does not imply that they are all ready to go. In fact, the process of hatchery reform involves a systematic review, program-by-program and hatchery-by-hatchery, to determine on a case-by-case basis which of the measures and actions to apply and when and how they should be implemented. The actual implementation of these measures and actions, whether they involve capital expenditures, operation and maintenance improvements, staffing, and/or other matters constitutes what is meant by artificial production reform throughout this opinion. Efforts to apply these reforms, already underway in many cases, must be expanded and accelerated to programs and facilities throughout the Columbia River basin. Hatchery reform should occur within a broader context of planning in the Columbia River basin designed to clarify goals, objectives, and performance criteria of a basinwide approach for all species to improve accountability and effectiveness. This broader approach includes the development of subbasin plans for management of all species and recovery plans for listed species. They will include, among other things, a better integration of hatcheries and harvest objectives and strategies. The menu of reform measures and actions is represented in the following list:

- Reform measures to clarify the goals, objectives, and performance criteria of hatchery programs to improve accountability and meet subbasin and recovery plan objectives:
  - Develop, clearly articulate, and commit to specific artificial propagation plans.
  - Identify and implement specific monitoring and evaluation protocols at all relevant scales (i.e., varying from basinwide to facility-specific protocols).
  - Apply adaptive management principles by linking future activities to research, monitoring, and evaluation outcomes.

- Reform measures to manage genetic risks to listed species and meet subbasin and recovery plan objectives:
  - Discontinue interbasin transfers of stocks.
  - Phase out inbred, domesticated, and inappropriate composite broodstocks.

- Produce fish derived from locally adapted stocks to the extent feasible and appropriate.
- Employ mating protocols designed to avoid genetic divergence from the biologically appropriate population.
- Manage the number of hatchery-produced fish that escape to spawn naturally, employing limits that will vary depending on the origin of the broodstock, the management objective, and the status of the affected natural populations.
- Employ hatchery practices that reduce unwanted straying of hatchery fish, for example by acclimating them to desired return areas.

• Reform measures to manage ecological risks to natural populations and meet subbasin and recovery plan objectives:
  - Minimize competition between hatchery and natural fish, for example, by avoiding production that exceeds the carrying capacity of limiting habitats.
  - Minimize predation and other negative interactions between hatchery and natural fish, for example, by producing fish similar in size, behavior, and life history characteristics to the naturally produced fish in the same waters.

• Reform measures to improve hatchery effectiveness and meet subbasin and recovery plan objectives:
  - Design hatchery facilities to mimic natural incubation and rearing conditions.
  - Design facilities for acclimation and release of smolts to improve homing fidelity.

• Reform measures to avoid management risks associated with hatchery production and meet subbasin and recovery plan objectives:
  - Design, implement, monitor, and evaluate the hatchery program consistent with a comprehensive restoration plan.
  - Design and conduct fishery augmentation programs so that fish can be harvested without undue impacts on weaker runs.
  - Mark hatchery-produced fish to distinguish natural from hatchery fish on spawning grounds, in dam counts, and in fisheries.

To facilitate the application of hatchery reforms to specific artificial production programs and projects, NMFS supports what is called a hatchery and genetic management plan (HGMP). NMFS developed the HGMP in collaboration with other Federal agencies, states, and Tribes. It provides a standardized approach and a consistent body of relevant information about artificial production programs. A NMFS-approved HGMP contains a clear statement of the purpose and goals of the program or project and its relationship to harvest and other management goals. It comprehensively addresses facility and operational details relevant to reform measures and action items identified above. It requires that an appropriate monitoring and evaluation plan be developed and implemented for that facility or program. Research critical to the success of the project must also be identified.

NMFS considers an approved HGMP to be a necessary step in assessing artificial propagation programs. It is anticipated that HGMPs will evolve over time into more comprehensive and detailed documents as additional focus and resources are brought to bear on hatchery reform and as new information becomes available.

The development of NMFS-approved HGMPs is a substantial task that must be completed before many actual reforms can be implemented. Additionally, the process of hatchery reform does not end with a completed NMFS-approved HGMP. Rather, hatchery reform will be a continuing process of implementing, monitoring, evaluating, and revising the HGMP plans. Priority should be assigned to circumstances that affect populations in the most critical condition.

There is also an immediate need to enable differentiation between hatchery and naturally produced salmon. As explained in the critical research section, uncertainty about the number of hatchery-origin versus natural-origin fish on the spawning grounds confounds our ability to assess and monitor natural population status and growth rates. This masking problem can be addressed by marking hatchery production, but must also include improved sampling efforts and specific experiments (e.g., radio tagging) to determine relative distribution and timing of hatchery and natural spawners. It is particularly urgent to mark the most at-risk species such as spring chinook and steelhead.

Action 169: The Action Agencies shall fund the development of NMFS-approved HGMPs for implementation, including plans for monitoring and revising them as necessary as new information becomes available. HGMPs have to be completed first for the facilities and programs affecting the most at-risk species (Upper Columbia and Snake River ESUs), followed by those affecting mid-Columbia, and then the Lower Columbia ESUs. HGMPs for all the Columbia basin hatchery programs and facilities should be completed (and approved by NMFS) by the 3-year check-in.

Action 170: Using new authorizations and appropriations and/or BPA funds as necessary and appropriate, the Corps, working with USFWS, shall oversee the design and construction of capital modifications identified as necessary in the HGMP planning process for Lower Snake River Compensation Plan anadromous fish hatchery programs. These improvements shall begin immediately after the relevant HGMPs are completed and approved by NMFS, and shall be completed as expeditiously as is feasible. BPA shall provide for the operations and maintenance costs of these reforms and shall reimburse the Federal Treasury for an appropriate share of the capital costs. The Corps shall have begun to implement reforms for programs affecting the most at-risk species by the 3-year check-in.

Action 171: BOR shall implement the reforms identified in the HGMP planning process for the Grand Coulee mitigation anadromous fish hatchery programs, beginning

immediately following completion of the relevant (NMFS approved) HGMPs and completing the work as expeditiously as feasible. BPA shall fund the operations and maintenance costs of the reforms and shall reimburse the Federal Treasury for an appropriate share of the capital costs. BOR shall have begun to implement reforms for programs affecting the most at-risk species by the 3-year check-in.

Action 172: The Corps shall implement the reforms identified in the HGMP planning process for the Corp's Columbia River basin mitigation anadromous fish hatchery programs, beginning immediately after the relevant HGMPs are completed and are approved by NMFS. The work shall be completed as expeditiously as feasible. BPA shall fund the operations and maintenance costs of the reforms and shall reimburse the Federal Treasury for an appropriate share of the capital costs. The Corps shall have begun to implement reforms for the programs affecting the most at-risk species by the 3-year check-in.

Action 173: BPA shall implement the reforms identified in the HGMP planning process for Federal and Federally funded hatcheries, beginning immediately after the relevant HGMPs are completed and approved by NMFS. The work shall be completed as expeditiously as possible. BPA shall have begun to implement reforms for the programs affecting the most at-risk species by the 3-year check-in.

BPA is currently responsible for the power-allocated share of O&M and capital costs associated with reforms that will be required under hatchery biological opinions. To the extent that the Action Agencies seek credit for reforms above and beyond this level, appropriate cost-sharing arrangements will have to be worked out between them and other entities involved in funding the particular hatchery program.

Funding for necessary reforms at Mitchell Act facilities will be sought through congressional appropriations. To the extent that such additional appropriations are not forthcoming, or are insufficient to accomplish all needed reforms as rapidly as possible, however, offsite mitigation crediting could occur at any artificial production facility if the Action Agencies make funds available for that purpose.

Action 174: Working through regional prioritization processes to the extent feasible and in coordination with NMFS, BPA shall collaborate with the regional, state, Tribal, and Federal fish managers and the Pacific States Marine Fisheries Commission to enable the development and implementation of a comprehensive marking plan. Included in this action are the following four steps:

1. Develop a comprehensive marking strategy for all salmon and steelhead artificial production programs in the Columbia River basin by the end of 2001.

2. Provide funding by March 1, 2001, to begin marking all spring chinook salmon that are currently released unmarked from Federal or Federally funded hatcheries.

3. Provide funding, beginning in FY 2002, to implement the Action Agencies' share of the comprehensive marking plan for production not addressed in (2) above.

4. Obtain funding contributions as appropriate for additional sampling efforts and specific experiments to determine relative distribution and timing of hatchery and natural spawners.

9.6.4.3 Actions to Create an Artificial Propagation Safety-net Program

As noted previously, a number of salmon and steelhead populations in the upper Columbia and Snake river basins are at particularly depressed levels, with many facing a high risk of extinction in the near term. For many of these, new safety-net projects designed to intervene with artificial production techniques may be appropriate to prevent extinction. Designed only to prevent extinction, these are not intended to be permanent projects, and they do not serve as substitutes for addressing the factors of decline.

A four-step process will generally be applied to an individual population being considered for a safety-net project, starting with an extinction risk analysis to identify populations that are candidates for intervention. Second, intervention options will be developed, and a proposed strategy will be outlined. Third, a benefit-risk analysis for the proposed strategy will be conducted to determine whether intervention is warranted. Fourth, an HGMP will be developed to guide implementation of the safety-net project. Planning for a safety-net program must be conducted on an accelerated basis so that, if warranted, the project can be implemented expeditiously. The planning process will necessarily rely on available information that will vary significantly between populations and species. The purpose of the safety-net program will not be achieved, and additional populations may go extinct, if the process suffers from excessive delay, or awaits additional information that may not exist or be available for some time.

A factor that clearly will affect the scope of the safety-net program over time is future environmental conditions, especially ocean conditions. If environmental conditions improve significantly, the number of populations needing safety-net interventions will decrease. Alternatively, if environmental conditions remain poor or worsen, then more populations will require intervention to arrest further decline in abundance. Given the high costs involved, and the uncertainty over future environmental conditions, and the considerable uncertainty of the benefits and risks of intervention, the safety-net approach necessarily and appropriately will involve a mix of strategies. Some projects should begin as soon as possible, while others will not occur unless populations continue to decline. Safety-net projects may be as intensely intrusive as the Stanley Basin sockeye recovery program, which anticipated taking the entire

population into a captive broodstock program for several years. Others may involve short-term interventions for one or two generations, using more conventional artificial propagation methods such as supplementation using appropriate broodstocks. Preferably, intervention will occur before a population declines to the point that highly intrusive techniques are necessary.

Additional work is needed to identify candidates for the safety-net program, but the individual populations identified below are currently thought to warrant intervention. All are located in the Snake River basin, and some intervention may already have begun. Although some of the most at-risk populations are in the upper Columbia River, the immediate safety-net needs in that area are being addressed pursuant to existing and planned processes tied to non-FCRPS mitigation programs, including commitments from the mid-Columbia PUDs. The need for additional safety-net actions in any part of the Columbia and Snake river basins, and the FCRPS' responsibility to support those actions, depend on future assessments of population status.

Action 175: BPA shall, in coordination with NMFS, USFWS, and the relevant state and Tribal comanagers, fund the four-step planning process described above as quickly as possible and, if so determined by that process, implement safety-net projects as quickly as possible at least for the following salmon and steelhead populations: 1) A-run steelhead populations in the Lemhi River, main Salmon River tributaries, East Fork Salmon River, and Lower Salmon River; 2) B-run steelhead populations in the Upper Lochsa River and South Fork Salmon River; and 3) spring/summer chinook populations in the Lemhi, East Fork, and Yankee Fork Salmon rivers, and Valley Creek.

This action item should be included in a package of early implementation projects. The required planning process should be completed by the end of 2001 so implementation of high-priority, safety-net actions can begin with brood year 2002. [Note: the populations identified in this action item are consistent with those identified by the Tribes on the "A" list of projects.]

Action 176: BPA shall, in coordination with NMFS, USFWS, and the relevant state and Tribal comanagers, fund the development of HGMPs for the Grande Ronde and Tucannon spring/summer chinook safety-net programs.

Based on previous risk assessments, conservation hatchery programs consistent with the safety-net concept already have begun for three populations of spring/summer chinook on the Grande Ronde River and for the single Tucannon River population. Portions of these programs have been accommodated temporarily, but unsatisfactorily, by crowding into existing facilities, with resultant compromises with other ongoing programs. Each conservation hatchery program would benefit from development of an HGMP that identifies the capital and operational needs for these programs and implementation of the HGMP's findings. The Nez Perce Tribe and Confederated Tribes of the Umatilla Indian Reservation are well along in planning for the North East Oregon Hatchery. Coordination between the existing LSRCP safety-net program and North East Oregon Hatchery planning processes is already occurring to a large degree and should

continue among USFWS, NMFS, the states of Oregon and Washington, and the Tribes to provide the best, most efficient and expedient, integration of hatchery programs to meet the resource needs of this region. This safety-net action item should be completed by the end of 2001 to accommodate facility development beginning in 2002.

Action 177: In 2002, BPA shall begin to implement and sustain NMFS-approved, safety-net projects.

This action funds the actual implementation and operation of safety-net projects. Depending on the planning results, specific measures may include funding modifications to existing facilities, or construction and operation of new facilities. The obligation to fund the safety-net program, including O&M, monitoring, and evaluation, will continue indefinitely, as circumstances warrant.

Action 178: BPA shall commit to a process whereby funds can be made quickly available for funding the planning and implementation of additional safety-net projects for high-risk salmon and steelhead populations NMFS identified during the term of this biological opinion.

Additional safety-net interventions to prevent extinction of listed populations may be required in the future. The annual offsite mitigation planning process discussed in Section 9.4 (development and implementation of 1- and 5-year plans) may be the appropriate mechanism for providing urgent and quickly needed resources for these interventions. NMFS and USFWS will work with BPA to begin the four-step planning process described above for populations that may require intervention, but that were not addressed in the initial round of projects. Depending on the outcome of the additional assessments and future environmental conditions, resources may be urgently needed for additional populations.

In rare cases, there may be emergency actions that need immediate response, such as unforeseen catastrophic events. In these cases, it may not be possible to wait to complete the HGMP planning process, but will require funding for immediate intervention. In anticipation of these situations, NMFS will work with BPA and the fishery comanagers to devise an appropriate strategy.

9.6.5 Research, Monitoring, and Evaluation Plan

The research, monitoring, and evaluation program that is part of this biological opinion must encompass both the entire salmonid life cycle and the different management areas through which fish pass. This RPA calls for actions affecting fish survival in the hydropower corridor, in tributary habitat, and in the estuary and nearshore ocean environment. In addition, actions in one management arena (other life stages and Hs) may affect the outcomes of FCRPS actions in the hydrosystem corridor (and vice versa). Due to the variety of actions and potential interactions between them, determining the effectiveness of the suite of actions in this RPA will require that a comprehensive (Basinwide Recovery Strategy) monitoring and evaluation program be developed (see action below). Equally important, the performance measures and standards to which actions are being held cannot be determined or judged appropriately in the absence of such a program. Therefore, in the context of this biological opinion, research, monitoring, and evaluation must address five areas:

Population status monitoring. This consists of determining what areas are occupied by juvenile salmonids and spawning adults, assessing the status of the population (i.e., abundance, trend, distribution, and variation), and reviewing status changes through time. Population status monitoring will also provide a baseline against which management actions can be assessed.

Environmental status monitoring. This consists of assessing environmental influences, including non-native species, potentially affecting salmonid populations, and determining whether they change through time, if associations occur between environmental attributes and salmonid population status, and whether these associations suggest that particular management actions should be studied further. Environmental status monitoring will also provide baseline information against which the effectiveness of management actions can be assessed.

Effectiveness monitoring. This consists of assessing whether management actions have the intended effects on the aquatic system and the response of salmonid populations to those effects.

Quality of regional databases. This consists of assessing the accuracy and comprehensiveness of currently available databases that represent habitat quality throughout the basin. This will play an important role in prioritizing what habitat actions should be implemented in which locations.

Compliance monitoring. This consists of assessing whether management actions have been properly implemented and maintained (see also Section 9.6.2).

Overall survival through the life cycle (annual population growth rate) will be a critical measure assessed in the research, monitoring, and evaluation program. Annual population growth rate is a fundamentally important measure of population health. Its use is advisable for the following reasons:

- Use of a population growth rate allows a more biologically meaningful assessment of the effectiveness of an action (or actions) than population size.

- The collective effect of all management actions that serve to improve population health, even if indirectly, can be assessed via growth rate.

- Given that trends or growth rates will be included in recovery goals, it is simple to determine the change in population growth trajectory needed to meet the target and the probability of detecting the effect of actions in a set time frame.

Due to the normal salmonid return times and naturally high variability in salmonid populations, however, it will be difficult to detect population responses using life-cycle response alone. In addition to current juvenile survival monitoring, therefore, the following must have high priority for monitoring and evaluation:

- Developing short-term measures of stock performance that can serve as proxies for standard metrics such as recruits per spawner

- Developing short-term measures of stock performance that focus on the life history stages identified as critically important to population growth in the cumulative risk initiative analysis, i.e., egg-to-smolt, estuarine, and early ocean growth, as well as survival

These short-term measures will determine salmon population growth and, as such, will provide explicit links between population processes and the condition of salmonid habitat. They will also contribute to the performance standards necessary to continually reassess the assumptions inherent in the opinion about the potential gains through offsite mitigation.

Discrete hypothesis testing and resolution of critical uncertainties are very important in the near term to assess the status of the ESUs. They should be central elements of research in the annual plan and will enable determining the measures needed to enhance species survival and recovery in the ESUs. For example, understanding the extent and reproductive success of natural spawning of hatchery fish and the delayed mortality of fish passing dams, either by transportation or inriver, are critical needs. Such information is needed to form meaningful conclusions in the other categories of monitoring and evaluation described above. Progress on resolving these uncertainties is a primary consideration in the biological opinion, for annual and 5-year planning, and for the 5- and 8-year check-ins.

The following sections describe elements of a research, monitoring, and evaluation program that the Action Agencies will implement under this RPA. First, a framework for population identification and establishing recovery goals is provided (Section 9.6.5.1). Second, general principles and guidelines for assessing population and environmental status are described (Section 9.6.5.2). This section includes a discussion of specific site sampling in two levels of detail, or tiers. Section 9.6.5.3 describes a general scheme for effectiveness monitoring and lists,

in detail, a number of studies essential for resolving critical uncertainties in the areas of population status, tributary habitat, hatchery management, the hydrosystem corridor, and the estuary/nearshore life-history stages. FCRPS activities and offsite mitigation affect all these areas. Compliance monitoring is addressed both in this section and in Section 9.6.2.

The research, monitoring, and evaluation actions specified in this section are intended to address the need to evaluate the species' status, environmental status, and response to management actions. Such a complete monitoring program is also necessary to establish performance standards and appropriately allocate changes in population status to management actions or environmental conditions. The FCRPS agencies and other Federal and non-Federal entities are expected to contribute to this comprehensive monitoring. The FCRPS agencies are responsible for monitoring and evaluating their actions under the RPA in this biological opinion, as amended by annual and 5-year plans, as well as providing for baseline monitoring necessary to detect changes in population or habitat trends. NMFS anticipates that the cost and implementation of the research, monitoring, and evaluation will be shared among these entities, commensurate with their responsibilities, and will be coordinated through applicable regional processes.

The Action Agencies shall continue or start work on the actions in this RPA concurrent with developing the research, monitoring, and evaluation plan. Actions are not limited to those outlined below if agreement is reached that other actions address critical uncertainties and should begin before the research, monitoring, and evaluation plan is completed. NMFS anticipates that the plan outlined below, and in Appendix G, will be followed, but that it may be modified by identification of other priority actions agreed to by the Action Agencies. The plan may also be modified through the development of the 1- and 5-year implementation plans.

9.6.5.1 Population Identification and Establishment of Recovery Goals

Action 179: The Action Agencies and NMFS shall work with affected parties to establish regional priorities within the congressional appropriations processes to set and provide the appropriate level of FCRPS funding to develop recovery goals for listed salmon ESUs in the Columbia River basin. Tasks shall include defining populations based on biological criteria and evaluating population viability in accordance with NMFS' viable salmonid population approach. These tasks shall be completed by 2003.

Biologically based populations must be defined to establish recovery goals for listed ESUs. Assessing population status (or viability) will be important to gauge needed changes and progress toward those goals. This effort will include assessing genetic differentiation (allele frequencies), environmental and habitat characteristics, life history and morphological traits, demographic information, estimates of straying or migration, and geographic distribution. The Action Agencies will obtain these data for all jeopardized ESUs in the Columbia River basin.

The technical recovery teams will be responsible for developing specific recovery goals by assessing the data compiled through the research, monitoring, and evaluation efforts described above. The Interior Columbia Basin Technical Recovery Team will be convened by late spring 2001 to address recovery planning for all listed ESUs in the interior Columbia River basin. It will probably include separate subgroups to focus on the Snake, Upper Columbia, and Middle Columbia rivers. A separate Willamette and Lower Columbia River Technical Recovery Team has already been formed. Once technical recovery teams convene, tasks should be completed within 18 months. The specific timeline for the relevant tasks is shown in Table 9.6-4. Data collection during ongoing subbasin assessment processes will facilitate this action.

Ultimately, NMFS will describe recovery goals in its recovery plans. As this portion of the plans becomes final, NMFS will use the goals in its analysis of agency actions, and the Action Agencies will take the recovery goals into account in their annual plans for the FCRPS. If the goals entail major changes in analyses or actions, the Action Agencies may have to reinitiate consultation.

Table 9.6-4. Timeline of tasks for establishment of recovery goals.

Task	Product(s)	Completion Date
1. Identify populations.	Population list	Months 3-4
2. Characterize populations (historical and current) based on the following:	Population list with characteristics (a-d).	
a. Abundance/productivity		Months 4-6
b. Diversity		Months 4-6
c. Spatial structure		Months 4-6
d. Habitat capacity		Months 9-10
3. Estimate viability of populations.	Population list with viability status (a-c) and criteria for achieving (if not presently viable)	
a. Abundance/productivity		Months 11-12
b. Diversity		Months 11-12
c. Spatial structure		Months 11-12
4. Provide scenarios that achieve ESU-level viability.	Description of each population's characteristics (a-c above) necessary for ESU viability (multiple scenarios)	Months 12-18
5. Identify factors for decline.	Critical life-stage list	Months 14-15
	Potential factors affecting mortality at different stages	Months 15-18

9.6.5.2 Population Status and Environmental Status Monitoring—Tiers 1 and 2

Action 180: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriation processes to establish and provide the level of FCRPS funding to develop and implement a basinwide hierarchical monitoring program. This program shall be developed collaboratively with appropriate regional agencies and shall determine population and environmental status (including assessment of performance measures and standards) and allow ground-truthing of regional databases. A draft program including protocols for specific data to be collected, frequency of samples, and sampling sites shall be developed by September 2001. Implementation should begin no later than the spring of 2002 and will be fully implemented no later than 2003.

The region will deploy a hierarchical monitoring program in both freshwater and estuarine systems. Appendix G outlines this program, and Table 9.6-5 summarizes the entire monitoring scheme. The monitoring program, including sampling protocols, will be developed by a collaborative effort of the Northwest Forest Science Lab and other regional agencies with monitoring expertise. The participants should have experience implementing comprehensive monitoring and evaluation programs and should include the EPA, the Oregon Coastal Salmon Restoration Initiative, and the Abernathy Fish Technology Center. Technical Recovery Team participation in this process will also be vital, since these data will provide the basis for implementing and confirming specific recovery plan actions. NMFS anticipates that state, Tribal, and local agencies, with Action Agency funding, will have primary responsibility for data collection in this program. The portion of this program implemented in the estuary and nearshore ocean environments must also be coordinated with the Conservation Reserve Enhancement Program, the Columbia River Estuary Study Task Force, and the Corps' analysis of the feasibility of altering flood control rule curves and operations to address mainstem flow objectives.

At a minimum, monitoring developed and conducted under this action will include the two levels of detail, or tiers, outlined below (and in Appendix G) in both freshwater and estuarine/nearshore ocean environments. Performance standards will be defined in terms of measures at both these tiers, enabling future assessment of recovery progress. Data collected at these tiers will also contribute to the Technical Recovery Team process. Specific details of the scheme, such as the distribution of sampling sites, protocols, or procedures to adapt monitoring programs, will be developed during the monitoring and evaluation program development process.

Tier 1. Tier 1 site sampling is the broadest of the sampling levels, comprising the greatest number of sites, sampled at the lowest frequency. It is designed to give the broadest picture of salmonid population status and the condition of the habitats in which they are found. Tier 1 data will contribute to population and environmental status monitoring, database quality, and compliance monitoring. It can contribute to effectiveness monitoring when the expected population response is range expansion. Specific goals associated with this tier are as follows:

Table 9.6-5. Outline of proposed monitoring and evaluation sampling design.

	Tier 1	Tier 2	Tier 3	Landscape imagery	Compliance logbook
Sampling frequency	Once every 3-4 years	Annually	Frequency dependent upon study; minimum annually	Once every 3 years	Once every 6 months (action agency); arbitrarily to monthly (regulatory agency)
Relevant to monitoring types*	1,2,3,4,5	1,2,3,4,5	3,5	2	5
Goals#	A, B	B, C	C, D	B	
Number of sites	To cover all potentially used areas in a population	To be determined by power analyses	Minimum three per ESU; minimum two for each major management action	Entire Columbia Basin	All management actions
Data type -- salmonid population	Presence/ absence	Counts of juveniles and spawners	Dependent on management action; Hatchery spawner reproductive success	None	None
Data type -- habitat	General, qualitative	Qualitative and quantitative	Quantitative, dependent on management action	Landscape-level attributes	None

*Relevant to monitoring types: 1 = population status monitoring, 2 = environmental status monitoring, 3 = effectiveness monitoring, 4 = quality of regional databases, 5 = compliance (implementation) monitoring
Goals: a = establish fish habitat use or range; b = establish associations between environmental characteristics and population status; c = estimate population growth rates or stage-specific survival rates; d = establish mechanistic links between management actions and salmon population response.

- Define areas currently used by adults and juveniles.
- Detect altered status of populations due to range expansion or shrinkage.
- Identify associations between salmon presence and habitat attributes.
- Ground-truth regional habitat quality databases (used in prioritizing management actions and areas for those actions).

Tier 1 sites will be sampled on a 3- to 4-year rotation, with each site being sampled once in that time period. Sites will be distributed to sample the full range of habitats in the area potentially

occupied by the population of interest. Distribution should be stratified by channel type, but other stratification may be necessary. A seasonal component will be important, particularly for juvenile surveys, to determine habitat use and availability at different times of the year.

In the estuary, Tier 1 sites will contribute to NMFS' understanding of juvenile salmonid usage of the lower river mainstem, side channel, and estuarine habitats. Of special importance is the extent to which restoring shallow-water estuary habitat might mitigate the additional flood risk resulting from altered rule curves. In addition, this sampling will contribute to developing appropriate indicators of physical and biological change that connect FCRPS flow management operations to the estuarine conditions of salinity, temperature, and suspended particulate matter.

Tier 2.

Tier 2 site monitoring will give a more detailed picture of population status and will allow researchers to assess relationships between environmental characteristics and that status. Tier 2 data will form the backbone of population and environmental status monitoring. It may also contribute to effectiveness and compliance monitoring. Tier 2 data can also be used to compare the status of different populations. Data collected will also function as performance measures (see Appendix G).

For freshwater systems, specific tier 2 goals are defining population growth rates, detecting changes in those growth rates or in relative abundance in a reasonable time, estimating juvenile freshwater abundance and survival rates, and identifying associations between population status or stage-specific survival and environmental attributes (particularly with changes in those attributes over time).

Specific goals associated with tier 2 sampling in the estuary are estimating relative smolt abundance in estuarine/nearshore ocean environments and survival rates during the estuarine phase, detecting changes in relative abundance and survival rates between years, identifying associations between changes in rates of smolt abundance (or survival) and environmental attributes, and identifying associations between history (dam passage route) or parentage (wild versus hatchery) and smolt abundance or survival rates.

Tier 2 sites will be sampled annually. The number of sites to be sampled in each life stage or habitat will be determined by a power analysis. ESUs made up of populations that fluctuate widely will require more tier 2 sites than ESUs with less variable spawner counts. Sites will be distributed probabilistically within a population, ensuring that both good and bad sites are appropriately represented. Some stratification may have to be included (i.e., channel type) in site distribution to obtain the best data.

Juvenile and spawner or redd counts will ultimately provide a measure of egg-to-smolt survival. This will improve estimates of population growth rate and can serve as a baseline for other monitoring efforts (see tier 3).

Action 181: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for a program to acquire and digitize aerial or satellite imagery of the entire Columbia River basin once every 3 to 5 years.

Watershed or sub-watershed level data are critical to prioritize areas for management actions. In addition, these types of data can provide a baseline against which to measure management actions. Finally, large-scale data can contribute to analyses of associations between potentially important watershed-level characteristics and salmon population status. However, much of the relevant large-scale data is not appropriately collected on the ground. This landscape-level data collection will allow a more detailed assessment of land use and land cover variables than is currently available for the region. In addition, the repeated assessment of the variables through time will allow changes in environmental characteristics to be associated with changes in salmonid population status. These data will have value for resource and wildlife management well beyond listed salmon species.

9.6.5.3 Detailed Studies and Effectiveness Monitoring—Tier 3

Several more specific studies, in addition to those outlined in Section 9.6.5.2, will be needed to assess the impact of the management actions undertaken in this RPA and compliance with performance standards. In particular, effectiveness monitoring for hydropower corridor actions, effects of hydropower actions outside the corridor, and effects of offsite mitigation will be critical for determining performance standards. In addition, reducing the uncertainty around the reproductive success of naturally spawning hatchery fish (and, therefore, the current status of wild populations) will require more detailed study.

NMFS anticipates that the Technical Recovery Teams, while coordinating efforts with monitoring and evaluation program development, will prioritize actions and populations for effectiveness monitoring or other detailed study. Below, general guidance for third tier (more detailed) monitoring is outlined. Following that, specific studies that are in progress, that address established critical uncertainties, or that are important to initiate immediately are described in more detail. They fall in the areas of population status, habitat, hatcheries, and hydropower effects on migration, the estuary, and nearshore ocean. The studies described below are those that are not directly associated with a single action (a specific passage improvement, for example), but that are associated with indirect or multiple effects, or more general actions. Monitoring associated with a particular action is described with that action.

9.6.5.3.1 Detailed Studies—General Considerations

Effectiveness monitoring and other more detailed studies can be considered a third tier of a comprehensive monitoring program. To be most effective, these studies must be conducted within an explicit experimental (hypothesis-testing) framework, including both treatment and control sites.

The experimental design of each study will be determined by a variety of factors. When possible, however, these studies should be conducted in the context of a before-and-after control impact (BACI) design, which incorporates temporal and spatial controls, allowing environmental impacts such as ocean cycles to be filtered out. Studies conducted under tier 1 and tier 2 monitoring programs will aid in identifying the important variables by which control and treatment sites should be paired or stratified. Information from other monitoring tiers (especially tier 2) will also provide important controls against which changes in tier 3 studies can be assessed.

Specific sites for these actions (and for controls for those actions) should be identified by considering important environmental factors (or strata), but pragmatic concerns may play a role in choosing some sites. For instance, historically sampled index stocks will be especially valuable contributors to the tier 3 network because their historical time-series offers special opportunities for distinguishing responses to management from chance fluctuations. Local groups may also plan and fund management activities that provide opportunities for detailed effectiveness monitoring.

While the specific data to be collected at this third tier will be tailored to the management action being studied, some general guidelines should be followed. For instance, each study must assess appropriate age-specific survival. In many cases, this may involve several life stages. Sediment reduction, for example, may affect both egg-to-fry and fry-to-smolt survival rates. Whenever possible, PIT tags or other individual marking techniques should be used to follow the fates of individual fish as a function of their history. Such individual studies are important for identifying the effects of environmental conditions that are realized at later life stages. Similarly, size or growth rates, as well as demographic rates, may be important parameters in these studies. In addition, both habitat and population response to the management action should be assessed to identify the factors causing any fish population responses. Finally, as above, appropriate control sites must be paired with the treatment sites to establish unambiguous causal links between actions and environmental or salmon population responses.

9.6.5.3.2 Population Status, Tier 3—Reproductive Success of Naturally Spawning Hatchery Fish is a Critical Uncertainty

Action 182: The Action Agencies and NMFS shall work within regional priorities and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for studies to determine the reproductive success of hatchery fish relative to wild fish. At a minimum, two to four studies shall be conducted in each ESU. The Action Agencies shall work with the Technical Recovery Teams to identify the most appropriate populations or stocks for these studies no later than 2002. Studies will begin no later than 2003.

Naturally spawning hatchery fish mask the population trajectory of wild populations. This masking not only obscures population status, but also makes it difficult to determine population

goals and performance standards with certainty. These studies should identify both the genetic contribution of hatchery-origin spawners to subsequent generations and the temporal and spatial distribution of those spawners.

9.6.5.3.3 Habitat, Tier 3—Effectiveness Monitoring

Because offsite mitigation is required as part of this RPA, and habitat performance measures will be assessed, habitat effectiveness monitoring is necessary. Objectives for this monitoring should be set at a subbasin or smaller scale. Habitat research areas should be identified by assessments and should include management or project actions of greatest potential significance to salmonid productivity in that region. The subbasin assessment template should provide the background context to identify specific monitoring objectives for each region.

In addition, critical information can be gained by initiating experimental studies on readily identifiable general classes of habitat improvement actions. Monitoring and evaluation studies should be initiated in the first 2 years to take advantage of selected opportunities to gain information on the effectiveness of these types of actions in terms of physical standards and juvenile survival criteria or standards (e.g., egg-to-parr survival, egg-to-smolt survival). Study design and selection should take into account the relative change in survival expected in a particular setting, the existence of baseline information, and the ability to detect improvements over the range of life history patterns (e.g., upstream and downstream rearing areas).

Action 183: Initiate at least three tier 3 studies (each necessarily comprising several sites) within each ESU (a single action may affect more than one ESU). In addition, at least two studies focusing on each major management action must take place within the Columbia River basin. The Action Agencies shall work with NMFS and the Technical Recovery Teams to identify key studies in the 1-year plan. Those studies will be implemented no later than 2003.

Each major habitat or hatchery management action should be assessed immediately to obtain enough information for a complete evaluation at the 5- and 8-year check-in points. Management actions falling in this category include the following:

- Attainment of minimum instream flows
- Compliance with water quality standards
  - Alteration of grazing practices
  - Reduction of sediment through road closures
- Enhanced levels of marine-derived nutrients
- Improved riparian conditions
  - Alteration of grazing practices
  - Active stream restoration

9.6.5.3.4 Hatchery, Tier 3—Effectiveness Monitoring

Action 184: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for a hatchery research, monitoring, and evaluation program consisting of studies to determine whether hatchery reforms reduce the risk of extinction for Columbia River basin salmonids and whether conservation hatcheries contribute to recovery.

This action item is intended to address the overall research, monitoring, and evaluation needs for artificial propagation in the basin. It exceeds research, monitoring, and evaluation needs associated with specific hatchery programs, projects, or facilities that derive from HGMPs. Reform measures and associated actions are described in Section 9.6.4.2. A conceptual framework for conservation hatcheries is also described by Flagg and Nash (1999).

Initially, the objectives for hatchery research, monitoring, and evaluation will include identifying and evaluating current hatchery production goals and level of effort and ensuring that the goals and level of effort are appropriate to the ecological and genetic effects of hatchery production in the local system. This assessment has several components, including the following actions:

- Estimate (if possible) the carrying capacities of rearing habitat and the migration corridor.
- Determine numbers of naturally spawning first-generation hatchery fish (i.e., hatchery escapement).
- Determine the relative reproductive success of naturally spawning hatchery fish compared to those of wild origin.
- Monitor the size, age, health, and smolt quality (growth), as well as release locations, timing, and life stages of hatchery fish.
- Assess (if possible) the frequency and magnitude of ecological interactions between hatchery and wild fish.
- Assess the genetic variability of populations and metapopulations.

Given these elements of the biological context in which each hatchery program exists, it will be possible to design and/or improve upon hatchery protocols. The goal of hatchery reforms is to reduce or eliminate adverse genetic, ecological, and management effects of hatchery production on natural populations to meet basinwide objectives for conservation and recovery. Thus, the concomitant research, monitoring, and evaluation program would assess the following aspects of natural populations:

- Reduced genetic variation
- Potential transfer of genetic traits from hatchery to wild stock
- Reduced genetic population structure
- Increased ecological interaction with hatchery fish (competition, predation, and disease)
- Masking of natural population status by the presence of naturally spawning hatchery fish

Ultimately, the monitoring and evaluation program must identify hatchery and natural population interactions and isolate their effects on the growth rate of natural populations. To do so, the evaluation program must consider the cumulative effects of hatchery production across the appropriate subbasin, as well as throughout the entire life cycle of the fish. This will require that a relationship be developed between the productivity of the natural populations (as represented, for example, by lambda) and the total production of hatchery fish, which will depend on such factors as survival and productivity during freshwater rearing and seaward migration, ocean residence, and return. Such assessment will provide the statistical power to detect incremental risk of extinction or rates of recovery.

Therefore, for hatchery operation, performance standards must address genetic integrity, abundance, and productivity (recruits per spawner) of both hatchery and wild fish. The information provided by these metrics defines the standards to minimize genetic and ecological risks to listed fish. Flagg and Nash (1999) identify strategies for minimizing genetic and ecological risks. Many of these postulated reforms will require applied research and field testing. Hatchery monitoring and evaluation objectives will operate primarily on a subbasin or smaller scale. The monitoring and evaluation must be tailored to each species produced and address practices that impact the scale of effects (i.e., release practices, logistics of broodstock recovery, and straying of hatchery fish).

9.6.5.3.5 Hydropower, Tier 3—Hydroelectric Project and Reservoir Passage Monitoring and Critical Uncertainties

Research, monitoring, and evaluation programs designed to detect the indirect and direct effects of the hydrosystem are fundamentally different than those associated with hatchery and habitat actions. Rather than recovery-goal-directed actions, operation of the FCRPS is ongoing. Whereas it is important to develop and implement experimental operational or system configuration actions within the FCRPS, long-term monitoring and evaluation of background conditions are also essential in light of the demonstrated and hypothesized effects on salmonids. Therefore, the primary goal of the hydrosystem monitoring and evaluation program is to determine survival rates of migrating juvenile and adult salmonids and to identify factors that contribute to mortality, both direct and indirect. These measures will form the basis for evaluating progress toward attainment of the performance standards for hydro survival.

9.6.5.3.5.1 Juvenile Monitoring and Evaluation

Action 185: The Action Agencies shall continue to fund and expand, as appropriate, fish marking and recapturing programs aimed at defining juvenile migrant survival for both transported and nontransported migrants and adult returns for both groups. These studies shall also compare the SARs of transported and nontransported fish to calculate the differential delayed mortality (D), if any, of transported fish.

Documenting juvenile migrant survival is an important measure of performance objective attainment. Current estimates of D have wide confidence intervals, and D values are one of the critical uncertainties that have to be resolved. This action provides the mechanism for implementing Action 47 (Section 9.6.l.3.3), which requires the Action Agencies, in coordination with NMFS, to evaluate delayed mortality of transported versus nontransported fish.

Action 186: The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for comparative evaluations of the behavior and survival of transported and downstream migrants to determine whether causes of D can be identified for the reach between Bonneville Dam and the mouth of the Columbia River.

In addition to further refining estimates of D, investigations are needed to determine if delayed mortality occurs between Bonneville Dam and the mouth of the Columbia River. Differences in estuarine passage timing, behavior, survival, susceptibility to bird predation, and ocean entry timing should be evaluated to determine whether any delayed mortality occurs before ocean entry. Studies linking timing of transport release to passage past predatory bird colonies in the estuary should be conducted. Timing barge releases to pass the bulk of the fish past the bird colonies when birds are not actively feeding might significantly reduce estuarine mortality, particularly for steelhead. Methodologies could include PIT-tag deployments and radio and sonic tracking. This study should be coordinated with other behavioral studies of smolts in the estuary and nearshore ocean.

Action 187: The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies and analyses to evaluate relationships between ocean entry timing and SARs for transported and downstream migrants.

Limited data from transportation studies indicate that adult return rates for transported and downstream migrants can vary greatly by season, by week, and perhaps by day. In general, adult return rates of transported fish are lower for fish moved during the early portion of the outmigration, but return rates can increase substantially for fish transported later. Inriver migrant return trends are the opposite, starting out high and decreasing throughout the season. Understanding the causes of these variations could lead to improved adult returns by relating the

effects of fish transport or nontransport to fish condition or to the physical and biological environment of the Columbia River plume at the time of ocean entry. Linking ocean entry timing to conditions at the time of entry would improve NMFS' understanding of aspects of the plume environment that influence early ocean survival. This could lead to better management practices that would improve survival rates, such as smolt entry timing and flow volume.

Action 188: The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies of PIT-tagged wild stocks from the lower river streams. The studies shall be used to contrast stock productivity and hydrosystem effects.

Schaller et al. (1999) conclude that differences in productivity between upstream and downstream stocks are due to the number of dams through which each stock must pass. Comparing the outmigration timing, physiology, health, and condition of PIT-tagged wild fish from systems such as the John Day River with PIT-tagged wild fish from the Snake River in ongoing studies would enable comparisons between the two groups and assessment of similarities and differences.

Action 189: The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to investigate the causes of discrepancies in adult return rates for juvenile salmonids that have different passage histories through the hydrosystem.

Adult returns from 1995 through 1998 indicate that SARs for smolts that have passed through the hydrosystem vary by year, number of juvenile bypass systems encountered, and specific bypass system, when compared with juveniles that were never detected when passing through the hydrosystem. To date, this is the only empirical evidence of delayed mortality associated with inriver passage through the hydrosystem. In general, SARs decreased as the number of bypass passages increased. These data suggest that juvenile bypass systems may affect adult return rates. In addition, return rates for fish that passed only through Lower Granite Dam are similar to those never detected in the hydrosystem, suggesting that individual bypass systems treat fish differently. This could be caused by a number of factors, including poor outfall locations, increased stress, reduced fitness associated with passage through mechanical components of the systems (such as separators and the PIT tag detection systems), and the tendency for mechanical screen guidance efficiency to increase for fish with BKD. Studies relating the passage histories of individual smolts to changes in physiological parameters, behavioral responses, and survival rates are needed to determine the causes for the observed SARs and identify potential solutions. Furthermore, experimental management of the hydrosystem should be considered to address discrepancies in adult returns associated with passage history. These experiments might include pulling all screens at a dam to eliminate passage through bypass systems, or routing fish directly to outfall sites with full bypass flow so that little to no dewatering occurs.

Action 190: The Action Agencies shall continue to fund studies that monitor survival, growth, and other early life history attributes of Snake River wild juvenile fall chinook.

The Action Agencies, in coordination with NMFS through the annual planning process, will continue to provide funding to monitor wild juvenile fall chinook survival, growth, and other early life attributes. Knowledge of wild fish survival, migration timing, and growth rates is critical as a baseline comparison for studies involving juvenile hatchery fall chinook used as surrogates for wild fish. Supplementation of juvenile fall chinook above Lower Granite Dam is, in addition, resulting in increased parr densities. At some point, decreased growth may occur, affecting the survival of wild fish.

9.6.5.3.5.2 Adult Monitoring and Evaluation

The adult monitoring enhancements in this section are intended to improve basic knowledge about upstream passage survival. They complement and enhance the more specific studies to evaluate and improve adult upstream passage survival called for in Section 9.6.1.6.

Action 191: The Action Agencies shall continue to implement adult salmonid counting programs at FCRPS dams, but shall improve the reporting of these counts.

In addition to the daily counts already provided, the Action Agencies will work through FPOM to improve reporting of winter passage counts for all projects where winter counting currently occurs. These counts will be reported in the same manner as other in-season counts (except that 3-day updates will be acceptable). These changes in reporting methods will be implemented no later than the winter 2000-2001 adult migration. Prespawn, summer-run steelhead are abundant near McNary Dam during the late fall and early winter months. Fallback through the juvenile bypass system at McNary can exceed 50 steelhead per day before screen removal on December 15 (P. Wagner, Washington Department of Fish and Wildlife, pers. comm.). Large concentrations of steelhead have also been observed in late fall near John Day Dam, and adult steelhead are known to pass Bonneville Dam all winter. The reporting requirements described above are designed to provide the level of information needed for decision-making during both normal and emergency fish passage management and consultation, especially during the winter maintenance period.

Action 192: As set out in Action 50 (Section 9.6.1.3.4), BPA and the Corps shall install necessary adult PIT-tag detectors at appropriate FCRPS projects before the expected return of adult salmon from the 2001 juvenile outmigration. These adult PIT-tag detectors shall be used as needed for calculating transport benefits, conversion rates, and SARs for listed salmon and steelhead.

This action, set out in RPA 49 (Section 9.6.1.3.4), is repeated here because it is an important part of the system-wide research, monitoring, and evaluation program. The ability to enumerate PIT-tagged adult salmon and steelhead will allow more accurate assessments of critical adult passage

information, including conversion rates between dams, steelhead kelt survival rates, travel time, and fallback rates with minimal adult handling mortality. This will enable making estimates of SAR transport and other survival studies specified in this biological opinion. Coordination of the schedule for installing adult PIT-tag detectors at FCRPS projects is necessary to ensure that the various studies requiring adult PIT-tag detection capability can be implemented in a timely manner.

Action 193: The Action Agencies shall investigate state-of-the-art, novel fish detection and tagging techniques for use, if warranted, in long-term research, monitoring, and evaluation efforts.

Fish tagging, detection, and tracking technologies suitable for use in assessing juvenile and adult salmonid survival, behavior, and distribution are limited. Key components of this tagging effort are as follows:

- The need to discriminate between hatchery and wild fish (not all hatchery fish are currently marked)
- The ability to differentiate populations and their use of different ocean productivity zones
- The ability to determine growth and survival characteristics based on population, location, and oceanographic characteristics

Development of new technologies may enhance opportunities to conduct necessary research, monitoring, and evaluation activities identified in this biological opinion. Development and application of new technologies should be coordinated with other entities to take into account needs across all life stages of salmonids.

9.6.5.3.6 Hydropower, Tier 3—Monitoring Effects of Hydropower Operations on Estuarine and Early Ocean Habitat

An important, but often overlooked, aspect of the biology of Columbia River basin salmonids is the effect of the FCRPS on their use of estuarine and ocean (plume and nearshore) environments. The FCRPS can have a direct and substantial impact on conditions in these habitats through its alteration of the hydrograph, water quality, and other impacts. Regional analyses have identified these environments as critical to population growth potential and, thus, as appropriate for mitigation actions.

Unfortunately, little is known about salmonid use of these habitats. Of primary importance are the following:

- The contribution of juvenile survival during the estuary/early ocean phase to overall ocean survival

- Cause-and-effect links between estuary/early ocean resources and juvenile survival
- Cause-and-effect links between estuary/ocean resources and adult survival
- The spatial distribution of each stock in the estuary/ocean and the temporal contribution to survival
- The influence of natural variation versus that of humanly caused changes in environmental conditions affecting juvenile and adult survival in the estuary/ocean phase

The distribution of each stock in the estuary/early ocean, survival rates, and natural variation in those rates will largely be addressed through tier 2 population and environmental status monitoring. However, tier 3 studies will be necessary to determine causal links between FCRPS alterations of the estuarine and nearshore ocean environments and salmon population response. In addition, several important studies addressing the following are also needed:

- Enhance and benchmark plume modeling; establish a long-term plume monitoring station.
- Partition the role of the estuary habitat from that of the nearshore ocean in juvenile survival.
- Identify and differentiate physical/chemical versus biological factors that cause mortality.
- Evaluate the influence of altering volume and timing of the historical hydrograph, hydrosystem operations, and the physical condition (bathymetry and structure) of the lower Columbia River and the estuary, as well as the effect on juveniles of the size, shape, and beneficial use of the Columbia River plume in the nearshore ocean environment.
- Determine the extent of indirect, humanly caused mortality in these environments; for example, assess how tern and cormorant populations are affected by hatchery and hydrosystem operations.

To address these critical needs, the following ongoing activities will be conducted:

Action 194: The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to develop a physical model of the lower Columbia River and plume. This model will characterize potential changes to estuarine habitat associated with modified hydrosystem flows and the effects of

altered flows where they meet the California Current to form the Columbia River plume.

Physical characteristics of the estuary such as river flow, hydrograph, velocity, bathymetry, salinity intrusion, and circulation patterns define estuarine conditions. It is, therefore, important to characterize the physical aspects of the estuary and to compare existing and future physical attributes with historical conditions to assess the potential effect of hydrosystem flow regimes on estuarine habitat. Physical changes to the estuary will affect its ecology and, potentially, how salmonids use the estuary for migration, growth, and development. The plume habitat as an extension of the estuary, or as a unique habitat important to Columbia River salmon, will be similarly affected by actions of the FCRPS. Characterization of these effects to assess the importance of historical and current conditions will help facilitate the recovery of all salmon stocks.

Action 195: The Action Agencies shall investigate and partition the causes of mortality below Bonneville Dam after juvenile salmonid passage through the FCRPS.

A long-term research, monitoring, and evaluation plan should be developed to measure mortality that may occur after smolts have passed through Bonneville Dam. The plan will include post-Bonneville mortality that may be associated with passage of smolts through the Federal hydrosystem and the extent of delayed mortality, which is uncertain and central to decisions about hydrosystem configuration and the role of juvenile salmonid transportation. These evaluations should attempt to establish how much of the post-Bonneville mortality is natural and how much is related to other factors, such as hydrosystem passage and fitness.

Action 196: The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River estuary. These studies support the actions to develop criteria for estuarine restoration (Action 158), restoration planning (Action 159), and implementation (Action 160) in Section 9.6.2.2.

Estuary use potentially has a major effect on salmonid survival to adulthood. The estuarine ecology of salmon in general and the use of Columbia River estuarine habitat in particular are poorly understood. Juvenile distributions relative to habitat type, food habits, prey preferences, and the growth and physiological condition of juveniles entering and leaving the estuary are important aspects of salmonid ecology in the estuary. Information on these aspects of all salmonid life histories is needed to develop an understanding of salmonid estuary use and any influences of the hydrosystem on flows, turbidity, and nutrient delivery that might, in turn, affect salmonid ecology in the estuary.

Action 197: The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate

level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River plume.

Plume dynamics and interaction with the California Current can potentially have a major effect on salmonid survival to adulthood. The plume ecology of salmon and use of the plume habitat are poorly understood. Juvenile distribution in terms of food availability, predators, and performance (fitness, growth, and health) must be assessed in relation to plume dynamics. Information on all salmonid life histories is needed to develop an understanding of salmonid use of the plume and any influences of the hydrosystem on turbidity, nutrient delivery, and habitat attributes that might affect salmonid ecology and survival in the plume.

Evaluating juvenile and adult use of the estuarine and nearshore environments will require monitoring techniques still in the early phases of development. In particular, the use of acoustic (sonic) tags with fixed, towed, or buoyed detector arrays is recommended, as is the continued development of existing technologies such as PIT-tag detector flowthrough trawl surveys. The immediate value of a concerted sampling effort in the estuary and nearshore regions will be development of cause-and-effect relationships between FCRPS flow management and physical conditions (e.g., bathymetry, suspended particulate matter, and temperature) that affect the availability of suitable habitat for juvenile salmonids. NMFS will use this information to recommend changes in flow management operations to improve juvenile survival.

9.6.5.4 Data Management

Action 198: The Action Agencies, in coordination with NMFS, USFWS, and other Federal agencies, NWPPC, states, and Tribes, shall develop a common data management system for fish populations, water quality, and habitat data.

The application of performance standards and measures and the use of offsite mitigation as partial compensation for unavoidable hydrosystem effects will require additional data collection and analysis. Validation of the approach, and of the specific actions taken, will require continual confirmation that these measures are sufficient to avoid jeopardy and facilitate recovery of listed salmonids. Evaluations of actions taken, the feasibility of future actions, and factors affecting mortality will depend on the availability of scientifically defensible findings. Development and implementation of offsite mitigation will require close coordination with relevant state actions such as water management and water quality compliance mechanisms. It will also require close coordination with Federal land managers and EPA. NMFS' past year of work on the CRI analysis has focused the need for a single comprehensive system to ensure integration of monitoring and evaluation information described in this section with information from other sources. This includes, but is not limited to, requirements described in other sections of this biological opinion.

9.6.5.5 ESA Section 10 Permit Authorization for Research/Monitoring Pursuant to the RPA

Scientific research and monitoring are critical parts of the overall program to minimize take of ESA-listed anadromous fish species resulting from the operation of mainstem FCRPS projects on the Columbia and Snake rivers. These activities are necessary to satisfy elements of the RPA described in individual subsections. In addition, specific terms and conditions related to research and monitoring efforts are proposed for inclusion in the incidental take statement of this biological opinion. The required research/monitoring activities will provide data and information necessary to develop annual management strategies to help mitigate hydropower system impacts and to answer important questions related to system operations. Special project operations for required research/monitoring activities that deviate from normal operations described in the Corps' Fish Passage Plan will, however, continue to be coordinated with interested parties through the annual planning process and in subsequent ESA-related coordination with NMFS.

The identified scientific research/monitoring activities are only a subset of the activities that will be funded by the Action Agencies, primarily BPA and the Corps. Those agencies are also responsible for complying with Section 7 of the ESA because they fund activities that may affect threatened or endangered species or designated critical habitat. To streamline the permitting process and avoid delaying critical research, monitoring, and evaluation measures, this biological opinion considers the effects of the activities that would be funded and will fulfill each individual Action Agency's Section 7 consultation requirement. Not all activities are included, because not all are well-enough defined to identify the proposed methods and, from that, the estimated levels of take. As new study plans are developed in accordance with this RPA, NMFS anticipates the need for additional Section 10 research permits.

While some research/monitoring activities associated with the RPA cannot be determined in sufficient detail until annual plans are prepared and approved, the following describes specific research activities that can be anticipated now, based on the elements of the RPA described in Section 9.6.1.

Action 199: The Action Agencies shall implement the specific research/monitoring actions outlined in Appendix H.

9.7 ANALYSIS OF EFFECTS

The effects of the RPA are evaluated with respect to action-area biological requirements in Section 9.7.1 and with respect to species-level biological requirements in Section 9.7.2. These sections parallel those used to evaluate the proposed action in Section 6. Additionally, in Section 9.7.3, the effects of the RPA are compared to effects that would probably occur as a result of breaching four Snake River dams. This comparison is included because dam breaching is an alternative that was specified for consideration in the 1995 FCRPS Biological Opinion, and it is the main alternative to the RPA that the Federal agencies have considered (Corps 1999c). It is also included because Section 9.5 describes breaching as a likely alternative action if the status of stocks has declined and/or the RPA is not as effective as expected, when assessed through the mid-point evaluation process. This analysis supports the elements of the RPA that require continued engineering and other preparations for possible future breaching.

9.7.1 Effects of RPA Measures on Action-Area Biological Requirements

As in Section 6.2, NMFS first evaluates the effects of the RPA within the action area. Effects are evaluated with respect to juvenile passage survival, adult passage survival, transportation, and various aspects of critical habitat within the action area.

9.7.1.1 Juvenile Salmonid Passage

Juvenile passage routing and survival are evaluated with respect to the various routes of passage at FCRPS dams. This section emphasizes changes from the proposed action that are expected from implementation of the RPA.

9.7.1.1.1 Turbine Units. Significant numbers of listed juvenile salmonids will continue to pass through FCRPS powerhouse turbines even with the relatively high proportion of fish passage through alternative routes (e.g., spill, bypass systems, and transportation). Previous FCRPS Biological Opinions (1995 and 1998) have required operation of turbines within guidelines that are expected to reduce mortality of juvenile migrants passing through turbines. These opinions also required investigations of juvenile and adult turbine passage mortality and investigation of turbine designs that reduce this mortality. Evaluation of a new turbine design using a minimum gap runner at Bonneville Dam has indicated a small but positive improvement (0 to 3%) in juvenile passage survival compared to the older runner design. These results are preliminary, and future evaluations are necessary before survival improvements can be statistically quantified.

This RPA calls for research to answer these questions. In addition, this RPA includes the following:

1. Investigations to improve fish survival in the tailrace

2. Examination of the potential fish survival benefits of operating minimum gap runner turbine units at or beyond the current guidelines of turbine operation established to maximize fish survival

3. Removal of unnecessary obstructions in the high-velocity areas of the turbine

4. Periodic index testing of turbine families to ensure that the operating guidelines reflect current conditions

These studies will provide better understanding of the complicated interaction between fish survival and turbine design and operation. This knowledge will probably lead to improved turbine design and operation to benefit fish survival. Considering the information available to date, NMFS expects that installation of minimum gap runners at the Bonneville Dam First Powerhouse would produce a 2% improvement in turbine survival at that project. Therefore, juvenile passage survival through the turbines at Bonneville First Powerhouse is expected to increase for both yearling spring and subyearling summer and steelhead migrants from 90%, under the current action (Appendix D, Tables D-1 to D-3), to 92% under the RPA (Appendix D, Tables D-4 to D-6).

9.7.1.1.2 Bypass Systems. The RPA is expected to increase FGE and bypass system survival at many of the FCRPS dams. The following section lists the expected increases at each dam for yearling spring migrants and subyearling summer migrants. The values estimated under the current configuration and operations can be found in Appendix D, Tables D-1 to D-3. The passage estimates expected under implementation of the RPA measures that were used in the SIMPAS passage survival modeling are shown in Appendix D, Tables D-4 to D-6.

Lower Granite Dam. Yearling and subyearling chinook and steelhead survival rates are expected to increase from 98% under the current action to 99% under the RPA, with juvenile fish bypass improvements.

Lower Monumental Dam. Yearling chinook FGE is expected to increase from 49% under the current action to 78% under the RPA with installation of extended-length intake screens and new vertical barrier screens. Bypass survival would increase from 95% to 98% with juvenile fish bypass improvements and outfall relocation. Subyearling FGE would increase from 49% to 56% with installation of extended-length intake screens and new vertical barrier screens. Steelhead FGE would increase from 82% to 84%.

McNary Dam. Yearling and subyearling chinook and steelhead bypass survival is expected to increase from 98% under the current action to 99% under the RPA with juvenile fish bypass improvements.

John Day Dam. Yearling chinook FGE is expected to increase from 73% under the current action to 82% under the RPA with installation of extended-length intake screens and new vertical

barrier screens. Subyearling FGE is expected to increase from 32% to 60% with installation of extended-length intake screens and new vertical barrier screens. Steelhead FGE is expected to increase from 85% to 94%.

Bonneville First Powerhouse. Yearling FGE is expected to increase from 39% under the current action to 72% under the RPA with installation of extended-length intake screens. Bypass survival is expected to increase from 90% to 98% with juvenile fish bypass improvements. Subyearling FGE is expected to improve from 9% to 35% with installation of extended-length intake screens. Bypass survival would increase from 82% to 98% with juvenile fish bypass improvements. Steelhead FGE is expected to improve from 41% to 85%. Bypass survival would increase from 90% to 98%.

Bonneville Second Powerhouse. Yearling FGE is expected to increase from 48% under the current action to 60% under the RPA, with improved intake flows and screen performance. Subyearling FGE is expected to increase from 28% to 40% with improved intake flows and screen performance. Steelhead FGE is expected to increase from 48% to 60% under the RPA.

9.7.1.1.3 Spillway and Sluiceway Systems. In several ways, the RPA improves the current juvenile fish passage spill program, as defined in the 1995 FCRPS Biological Opinion and the 1998 Supplemental FCRPS Biological Opinion. The RPA includes:

- Implementation of 24-hour spill at Lower Monumental Dam
- Evaluation of 24-hour spill at John Day Dam
- Evaluation of raising the daytime spill cap at Bonneville Dam
- Reduction of 24-hour spill at The Dalles Dam

The evaluations at John Day, The Dalles, and Bonneville dams may lead to additional changes in the spill program as the study results are assessed and implemented. These changes may occur as early as the 2002 spill season, but may be limited by transmission system constraints that will be addressed no later than 2005. These changes are expected to improve inriver survival of all juvenile salmon migrants by reducing passage through turbines. Decreased predation is also anticipated as a result of reduced juvenile residence time in predator-rich forebays. In the case of The Dalles Dam, immediate survival benefits are expected as a result of spill reduction. Lower amounts of spill combined with improved spill patterns are expected to help reduce physical injury and predation in the river immediately below the spillway.

The FCRPS fish passage spill program improvements included in the RPA are estimated to result in a systemwide inriver survival rate increase of approximately 4% and 1% for yearling and subyearling migrants, respectively. These values represent a relative increase of 8% and 10% over the existing system inriver survival rate as estimated for each respective chinook stock.

These estimated survival rate improvements do not include further spill increases made possible through additional or modified spillway deflectors, nor do they include pool survival increases that may result when migrants spend less time in project forebays as a result of 24-hour spill. The greatest portion of the survival rate increase expected as a result of the RPA spill changes is expected at The Dalles Dam, where spill passage survival is estimated to increase approximately 8% to10%.

New structural measures to pass juveniles in surface water are under development at several FCRPS dams. These surface bypass efforts are expected to increase spill efficiency, reduce stress related to dam passage, and potentially reduce dissolved gas supersaturation levels. Increased spill efficiency means that water spilled for fish passage is more efficiently used or, in other words, more fish are passed per unit volume of water. Stress and delay are reduced when fish use surface routes through dams. Fish pass more readily through direct surface routes, whereas passage through deeper routes takes them longer. Reducing delays in forebays reduces juvenile exposure to predators. Reduction in predation and passage stress is expected to increase survival.

Current FCRPS project pool mortality estimates were reduced by 10% in the SIMPAS model runs under RPA conditions (Table 9.7-1) in order to characterize this expected survival increase. The expected 10% reduction in pool mortality is primarily based on reduced exposure of smolts to predators, both from project operations and predator control programs. This expected benefit is further explained in Section 9.7.1.5 below.

9.7.1.2 Adult Salmonid Passage

The RPA calls for a number of actions to better assess the effect of passage through the FCRPS hydropower system on adults and their spawning success, better account for adult losses, and identify and implement measures to reduce adult delays, injuries, and mortalities related to FCRPS passage. Aging adult fishway facilities will be updated, and spare parts for critical components will be procured to ensure proper operations during the passage season and avoid injurious facility failures. The identification and implementation of structural and operational measures are expected to reduce inadvertent adult fallback and related mortalities. For those adults that intentionally fall back, including downstream migrating adult steelhead kelts, identification and implementation of corrective operations and facilities will increase their survival. Identification of the cause of adult headburn will lead to corrective measures to reduce this source of injury to spring/summer chinook salmon. Potential benefits, including reduced water temperature, reduced passage delays, and improved gamete viability, for SR steelhead and fall chinook may be identified through the evaluation of Dworshak Reservoir cold water releases in September.

Table 9.7-1. Project and system survival of transported juvenile SR spring/summer and fall chinook salmon and steelhead outmigrants[1] under the RPA.

YEAR	Project Survival (% Dam + Pool Survival)								% Inriver Survival (LGR to BON)	% Inriver Survival (MCN to BON)	Prop. ESU Transported	% Total System Survival	% Total System Survival with D	
	LGR	LGS	LMN	IHR	MCN	JDA	TDA	BON						
SR spring/summer chinook salmon													D= 0.63	D= 0.73
1994	94.7	84.4	88.6	89.8	87.5	79.8	91.1	86.8	35.1	55.2	90.9	89.5	56.5	65.4
1995	91.7	89.0	95.1	94.0	94.5	87.0	93.6	90.9	51.1	70.0	43.4	67.7	52.0	56.2
1996	97.8	92.9	95.5	88.1	88.5	86.3	92.8	90.4	48.9	64.0	58.0	75.5	54.5	60.2
1997	92.4	94.4	92.5	90.1	90.4	85.1	91.7	89.5	45.9	63.2	51.7	69.9	51.1	56.2
1998	93.5	98.3	88.6	95.9	96.4	84.3	94.1	91.8	54.7	70.2	50.3	73.7	55.5	60.4
1999	94.9	95.1	95.1	95.3	95.9	87.1	95.7	94.7	61.9	75.7	51.8	77.9	59.1	64.2
6-YR Avg.	94.2	92.3	92.6	92.2	92.2	84.9	93.2	90.7	49.6	66.4	57.7	75.7	54.8	60.4
SR fall chinook salmon													D=0.24	
1994	No data collected in 1994.													
1995	69.9	89.5	81.4	88.8	83.7	77.4	89.6	85.1	22.4	49.4	62.8	62.3	15.6	
1996	52.8	90.3	79.8	88.4	84.1	76.2	89.2	84.4	16.2	48.3	47.1	46.9	11.8	
1997	41.4	60.4	67.5	66.9	58.8	40.8	71.7	57.4	1.1	9.9	31.7	31.1	7.5	
1998	60.0	78.8	92.4	88.8	84.3	77.3	89.6	85.0	19.2	49.6	52.2	51.9	13.0	

Table 9.7-1 (continued). Project and system survival of transported juvenile SR spring/summer and fall chinook salmon and steelhead outmigrants[1] under the RPA.

	Project Survival (% DAM + Pool Survival)													
YEAR	LGR	LGS	LMN	IHR	MCN	JDA	TDA	BON	% Inriver Survival (LGR to BON)	% Inriver Survival (MCN to BON)	Prop. ESU Transported	% Total System Survival	% Total System Survival with D	
1999	78.9	69.3	89.6	82.1	76.5	64.4	84.4	76.1	12.7	31.6	64.7	64.0	15.8	
5-YR Avg.	60.6	77.7	82.1	83.0	77.5	67.2	84.9	77.6	14.3	37.7	51.7	51.2	12.7	
SR steelhead													D= 0.52	D= 0.58
1994	91.4	87.6	93.6	91.6	89.7	83.3	92.3	89.0	42.1	61.3	89.9	88.3	46.0	51.3
1995	95.1	91.6	97.8	93.2	93.6	89.8	94.5	92.7	58.4	73.6	48.4	74.8	52.1	55.0
1996	94.2	95.1	96.6	89.9	90.2	87.6	93.1	91.3	52.3	67.2	59.3	76.8	48.9	52.4
1997	96.8	97.7	93.6	92.0	92.2	86.8	92.3	90.7	54.6	67.0	58.1	78.3	51.0	54.4
1998	93.5	94.5	92.4	90.2	90.6	85.0	96.1	95.5	51.9	70.6	52.1	73.0	48.4	51.5
1999	91.9	94.1	94.7	92.0	92.3	93.1	90.6	85.6	50.2	66.6	52.2	71.8	47.3	50.3
6-YR Avg.	93.8	93.4	94.8	91.5	91.4	87.6	93.1	90.8	51.6	67.7	60.0	77.2	49.0	52.5

[1] A range (1994 to 1999) of flow conditions was estimated using NMFS' spreadsheet model (SIMPAS). Values shown are estimates, based on juvenile survival studies rather than adult returns, and representing performance of mixed (wild + hatchery) runs. Spring/summer chinook salmon are yearling migrants; fall chinook salmon are subyearling migrants. Details on how these survival estimates were developed can be found in Appendix D.

Corrective measures at all the FCRPS projects which significantly reduce inadvertent fallback and the mortality associated with fallback through turbines are expected to increase the survival of all listed salmonid species that originate above Bonneville Dam. The analyses in the RPA concerning fallback, Subsection 9.6.1.6.2, estimate that with corrective measures spring/summer chinook and steelhead direct passage survival to Lower Granite Dam could increase by about 0.5%, while Snake River fall chinook direct passage survival could increase by 7%. Increased passage delay is also associated with fallback. Keefer and Bjornn (1999) reported that the median dam passage time for all seven dams studied in 1996 was higher for spring/summer chinook salmon that fell back at a dam one or more times. Conceivably, indirect delayed mortality and diminished spawning success could result from increased passage times due to fallback.

Corrective measures that significantly reduce the incidence of headburn could conceivably increase the survival of SR spring/summer chinook and UCR spring chinook by as much as 2% on average (see analyses in the RPA, Subsection 9.6.1.6.2).

A preliminary estimate of steelhead kelt abundance in the Lower Snake River in 2000 was 16,745 (Evans and Beaty 2000), which is approximately 22% of the total count of steelhead that passed upstream of Lower Granite Dam in 1999. The RPA requires studies to identify and implement measures to increase the survival of kelts so that the rate of repeat spawners will improve. Reconditioning, downstream transport, and reduced turbine entrainment passage alternatives will be evaluated.

Information from adult passage studies was used in the RPA analyses in Subsection 9.6.1.6.2 to arrive at preliminary estimates of 27% (1991) and 9% (1993) for spring/summer chinook salmon adult loss between Lower Granite Dam and the spawning ground or hatchery. While further studies will be needed to resolve the accuracy and determine the cause of these preliminary estimates, the significance of these loss estimates to recovery prospects cannot be overstated. Furthermore, mere arrival at the spawning ground does not guarantee spawning success. If spawning success is diminished during upstream passage, these adult loss estimates are conservative. Adult loss and diminished spawning success above Lower Granite Dam could be due to any number of causes suggested in the RPA, including delays, injuries, and elevated water temperatures experienced during passage through the FCRPS dams, or perhaps predation, illegal harvest, gillnet interactions, and disease. The RPA expects to better account for the sources of adult loss above Lower Granite Dam and downstream, assess spawning success, and implement identified measures to increase adult survival and reproduction.

Based on the foregoing reasoning and analyses, the RPA measures are expected to increase minimum survival estimates by at least 3% over the current condition minimum survival rates listed in Table 6.1-1 for SR spring/summer chinook, fall chinook, and steelhead that pass through eight FCRPS dams. For those species passing through four or fewer FCRPS dams, the expected survival increase from implementing the RPA is scaled down according to the number of dams. For example, for UCR steelhead and spring chinook that pass through four FCRPS dams, the

RPA measures are expected to increase the current minimum survival rate by at least 1.5%. For those species that pass only through Bonneville Dam, such as LCR steelhead and spring chinook, the expected survival rate increase is at least 0.5%. Table 9.7-2 summarizes the estimated minimal survival rates under current conditions and those expected under the RPA for the listed species. In addition to the increased passage survival rate, the RPA expects to identify, quantify, and reduce indirect mortality and diminished spawning success that may be due to passage through the FCRPS projects.

9.7.1.3 Water Regulation and Impoundments

BPA assessed the effects of water management measures specified in Section 9.6.1.2 using its Hydrosim hydroregulation model. The Hydrosim model simulates operations at the FCRPS and other Columbia basin projects to meet an array of purposes including flood control, anadromous and resident fish protection, projected energy loads, Columbia basin Treaty obligations, and other project-specific, non-power requirements. Hydrosim simulates operations for 14 time steps each year (10 months plus two time steps each for April and August) over a 50-year (August 1929 to July 1978) hydrologic record. Outputs of interest to NMFS include mean monthly discharge at various locations and end-of-month reservoir elevations for the major storage projects. A summer (June 30) reservoir refill priority was assumed in the modeling.

This approach to estimating the outcomes of alternative project operations implies that hydrologic conditions recorded in the past are reasonable estimates of future conditions. Hydrologic conditions are highly variable. The longer the historical period of record used, the more likely the simulation will capture the range of future conditions likely to occur. Although there is growing evidence that the earth's climate is changing, it is unlikely that such changes would substantially violate the assumption that future hydrologic conditions will be similar to past conditions during the 10 years this biological opinion will be in effect.

The base case model run placed priority on meeting the reservoir operating provisions specified in NMFS' 1995 and 1998 FCRPS Biological Opinions and USFWS' 1995 Biological Opinion on Kootenai River sturgeon. A summary of the base case (proposed action) model results are shown in Table 6.2-5. Subsequent modeling scenarios evaluated the effects of including VARQ and modified flood control curves, providing deeper reservoir drafts at selected FCRPS projects, and increasing the Mica and/or Revelstoke project's discharge during the summer period. Model output consisted of 50-year monthly flows at various projects and a summary of the effect of project operations by enumerating the frequency with which the NMFS flow objectives are met on a monthly and seasonal basis at Lower Granite, Priest Rapids, McNary, and Bonneville dams. The effect of flow operations on the frequency of storage reservoirs achieving upper (flood control) rule curve on April 10 and refill by June 30 was also summarized. Table 9.7-3 summarizes operational criteria for the hydrosystem regulation study representing foreseeable RPA water management actions in the next 4 to 5 years.

Table 9.7-2. Estimates of minimum adult survival and unaccounted loss based on radio-tracking studies through the FCRPS projects.

	Multi-Year Radio-Tracking Studies		Single Year Reach Studies			Current Condition				RPA Condition	
	1995 BiOp	1998 BiOp	RT 96[1]	RT 97[1]	RT 98[1]	Mean Loss[2]	Minimum Mean Survival[3]	Number of Dams	Per-Project Survival[4]	Minimum Mean Survival[11]	Per-Project Survival
Chinook Salmon											
SR spr/sum chinook	0.209[5]	0.252	0.161	0.158	0.130	0.175	0.825	8	0.976	0.855	0.981
SR fall chinook	0.393				0.187	0.290	0.710	8	0.958	0.740	0.963
UCR spr chinook[6]							0.907	4	0.976	0.922	0.981
LCR spr chinook[6]							0.976	1	0.976	0.981	0.981
LCR fall chinook[7]							0.958	1	0.958	0.963	0.963
Steelhead											
SR steelhead		0.208	0.270	0.204		0.227	0.773	8	0.968	0.803	0.973
UCR steelhead[8]							0.878	4	0.968	0.893	0.973
MCR steelhead[8]							0.878	4	0.968	0.893	0.973
LCR steelhead[8]							0.968	1	0.968	0.973	0.973
SR sockeye salmon	0.154[9]			0.132[10]		0.143	0.857	8	0.981	0.887	0.985

[1] T. Bjornn, pers. comm., November 2000 (data from 1996, 1997 and 1998 radio-tracking studies).
[2] Average of 1995 and 1998 Biological Opinion and radio-tracking studies.
[3] 1 minus mean loss.
[4] Calculated by taking the 8th root of the eight dam minimum mean survival estimates.
[5] Not included in loss/survival estimates (1998 Biological Opinion estimate is an update of the 1995 Biological Opinion estimate).
[6] Calculated from SR spring/summer chinook salmon per-project survival rates.
[7] Calculated from SR fall chinook salmon per-project survival rates.
[8] Calculated from SR steelhead per-project survival rates.
[9] Based on count analyses (1985 to 1994) (1995 Biological Opinion).
[10] Sockeye passage to Wells Dam.
[11] Minimum mean survival for RPA condition is 3% higher than current condition for SR species passing through eight projects, 1.5% higher for species passing through four projects, and 0.5% higher for species passing only through Bonneville Dam.

Table 9.7-3. Summary of criteria for hydrosystem regulation study of RPA actions (Study 00FHS33wo).

Criteria added to base case (00fsh30) operations
1. Additional Grand Coulee draft in low water years (to elev. 1,280 feet if Apr to Aug runoff ≥92 Maf and to elev. 1,278 feet if Apr to Aug runoff < 92 Maf).
2. Banks Lake–reduced storage of 5 feet–water returned when most convenient for power and fishery purposes.
3. 2000 Biological Opinion spill levels.
4. VARQ flood control operation at Libby and Hungry Horse dams and USFWS minimum flows (with sliding scale minimum flows at Hungry Horse).
5. Albeni Falls is operated to elevation 2,051 feet from November through April.
6. Fall spawning flows below Bonneville Dam.

9.7.1.3.1 Probability of Achieving NMFS Flow Objectives. Table 9.7-4 provides a summary of the percent of years flows at Lower Granite, Priest Rapids, McNary, and Bonneville dams expected to meet or exceed NMFS flow objectives under the RPA. In comparing the results of Table 9.7-4 to Table 6.2-5, there are little or no changes to monthly flows at Lower Granite Dam. In general, Snake River flows meet or exceed NMFS flow objectives during the spring migration except in the lowest 20 water years. In the summer months, NMFS flow objectives are not achieved in the Snake River except in the highest 10 water years.

At McNary Dam on the Columbia River, there is little or no change in meeting NMFS flow objectives under the RPA compared to current operations in the months of April, May, July, and August. However, there is a 6% increase in achieving the flow objective under the RPA during June, from 50% to 56%. Similarly, the 135 kcfs spring flow objective at Priest Rapids Dam is exceeded in 90% of the years in June, compared to 78% under current operations, a 12% increase. Under the RPA operation, the spring seasonal flow objective is achieved 88% of the time, while the 200 kcfs seasonal flow objective in the summer is exceeded 28% of the time at McNary Dam.

Fall and winter flows at Bonneville Dam for LCR chinook and CR chum salmon spawning and incubation through emergence were also evaluated. A flow objective of at least 125 kcfs was achieved in November in 74% of the years under both the RPA and the proposed action, compared to only 30% if Albeni Falls is held at elevation 2,055 feet for a kokanee spawning evaluation. This flow objective was achieved in 90% of the years in December, a similar frequency as under the proposed action. In January through March, the flow objective was also met with a similar frequency under the RPA as under the proposed action, e.g., 76% to 86% during this period.

Table 9.7-4. Percent of years flows at Lower Granite, Priest Rapids, McNary, and Bonneville dams are expected to meet or exceed specified flow objectives under RPA based on 50-year continuous hydrosystem simulation (1929 through 1978).

Period	Project			
	Lower Granite	Priest Rapids	McNary	Bonneville
January	N/A	N/A	N/A	86
February	N/A	N/A	N/A	78
March	N/A	N/A	N/A	76
April	38	58	48	N/A
May	60	84	64	N/A
June	68	90	56	N/A
July	40	N/A	46	N/A
August	0	N/A	10	N/A
September	N/A	N/A	N/A	10
October	N/A	N/A	N/A	20
November	N/A	N/A	N/A	74
December	N/A	N/A	N/A	90

Source: BPA Hydrosim Run 0Y00.00FSH28.OPER.

9.7.1.3.2 FCRPS Reservoir Effects. Based on the results of BPA's hydrosystem modeling, effects on FCRPS storage reservoir operations under the RPA compared to the proposed action (base case) are summarized below.

Grand Coulee. The 50-year hydrosystem study results indicate the RPA-proposed draft of an additional 2 feet below elevation 1,280 in years when the April-to-August forecast is less than 92 Maf does not affect either 1) refill probability in subsequent years, or 2) the project's ability to achieve elevation 1,283 or above by the end of September (see Section 9.6.1.2.3 for a description of Grand Coulee operations). For example, the modeling results for the RPA operation indicate that FDR Lake refills or reaches its upper rule curve elevation on June 30 in all 50 water years, and the project has a 50-year average elevation of 1,283.5 feet by the end of September. In addition, the 50-year average draft of Grand Coulee reservoir by August 31 is to elevation 1,279.5 feet.

Banks Lake and Columbia Basin Project Pumping. Under the RPA operation, pumping from FDR Lake into Banks Lake is reduced in August by an equivalent volume of the top 5 feet (127 kaf) of storage in Banks Lake in years when this water is needed to meet the McNary Dam flow objective (see Section 9.6.1.2.4 for a description of Banks Lake operations). Additional water is pumped from FDR Lake in the following January-April period to return Banks Lake elevation to its original elevation.

Libby. Libby Reservoir either refills or reaches its upper rule curve elevation by June 30 in 16 years (32%) under the RPA operation as under the proposed action operation (see Section

9.6.1.2.3 for a description of Libby operations). In addition, the 50-year average draft of Libby reservoir at the end of August is elevation 2,442 feet under the RPA operation, as compared to elevation 2,439 feet under the proposed action. At the end of August, the reservoir refills in 2 years under the RPA compared to no years under the proposed action.

Hungry Horse. Hungry Horse Reservoir either refills or reaches its upper rule curve elevation on June 30 in 7 more years, 34 years versus 27 years, in the RPA operation than under the proposed action (see Section 9.6.1.2.3 for a description of Hungry Horse operations). Under both the RPA and the proposed action, the 50-year average draft of Hungry Horse Reservoir at the end of August is 3,543 feet. In addition, the reservoir elevation is between 3,550 feet and 3,560 (full pool) feet on August 31 in 5 years under the RPA, as opposed to 4 years under the proposed action.

Albeni Falls. Except for the USFWS kokanee spawning evaluation during the next 6 years, the RPA operates the Albeni Falls project to elevation 2051 feet during October through April of each year to assist in meeting chum salmon flow needs in the lower Columbia River (see Section 9.6.1.2.3 for a description of Albeni Falls operations).

Dworshak. In the RPA operation as in the proposed action, Dworshak drafts to elevation 1520 feet by the end of August of each year, if needed to support Lower Granite Dam flow objectives and water temperature control (see Section 9.6.1.2.3 for a description of Dworshak operations). In September, the RPA also proposes to draft the project an additional volume of 244 kaf, but no lower than elevation 1,500 feet, to reduce temperature and to meet flow objectives in the lower Snake River as part of an adult fish passage evaluation (see Section 9.6.1.2.6 for a description of Dworshak's September temperature and adult passage evaluation operation). A 50-year hydroregulation study of Dworshak refill probability indicates the September adult study operation, when it is conducted, would have little effect on reservoir refill by the end of June in subsequent years, i.e., there are only two additional refill failures at Dworshak on June 30, and the average of these three refill misses is less than 12 feet from full pool, with two of these misses within 9 feet of full pool. For comparison, the single refill miss under the proposed action was 15 feet from full pool.

9.7.1.4 Water Quality

Gas abatement measures in the RPA will reduce TDG levels and thereby improve water quality and reduce the risk to listed salmonids. Installation of flow deflectors at Chief Joseph Dam will reduce gas entrainment and TDG levels downstream during spill periods at that project. This measure will improve water quality conditions for UCR spring chinook and steelhead adults and juveniles downstream of Chief Joseph Dam. It will also help ensure that spill programs for passage of juvenile UCR spring chinook and steelhead at Wells, Rocky Reach, and Rock Island dams are not affected by elevated gas levels originating at Chief Joseph.

The deflector optimization program at the lower Snake and lower Columbia FCRPS projects will improve water quality and reduce gas entrainment during voluntary juvenile fish passage spill and during involuntary spill periods.

Temperature reduction measures identified in the RPA will help reduce elevated water temperature conditions in the lower Snake River and in fish bypass facilities to improve migration conditions and survival rates of subyearling fall chinook. For example, modifications to water supply intake facilities at Dworshak National Fish Hatchery would eliminate the current operating restrictions on releases of cooler water from Dworshak Reservoir, which would allow for flow volume increases and lower water temperatures in the lower Snake River to improve migratory conditions for summer migrating juvenile fall chinook. Hatchery supply water that is cooler than 54°F (12°C) has been shown to negatively affect the growth of juvenile fish reared at the hatchery. When the required modifications to the hatchery water supply system are completed, it will be possible to augment Snake River flows using Dworshak discharges with temperatures as low as 48°F (9°C), providing a greater cooling effect downstream.

Thermal-related stress is known to contribute to juvenile fish collection mortality at McNary Dam. Hydrothermal computational fluid dynamics (CFD) modeling has the potential to provide quantitative information that would enable the Corps, NMFS, and fishery comanagers to determine the physical effects on water temperature of selected project operation and/or structural modifications at McNary Dam. CFD modeling could help evaluate the potential ability of alternative powerhouse operations to decrease the inflow of elevated summertime water temperatures into gatewells, the juvenile fish collection channel, and raceways.

9.7.1.5 Effects of Predator Control

Improvements in predator control include improvements to the Northern Pikeminnow Management Program and evaluations of avian and marine mammal predation near and above Bonneville Dam. These evaluations may lead to actions that can be implemented to reduce predation. The direct effects of these predator control efforts on juvenile survival are difficult to quantify. However, on the basis of information in the Predation White Paper (NMFS 2000f), NMFS estimates that implementing the RPA measures will reduce FCRPS project pool mortalities of both yearling and subyearling juveniles by an average of approximately 10%. Accordingly, NMFS applied the 10% average reduction in the SIMPAS model.

To illustrate: estimated mortality for yearling spring/summer chinook in John Day Reservoir is approximately 12% (Table 6.2-8). A 10% reduction in mortality would therefore be an absolute change of 1.2%. The White Paper cites an estimate that approximately 7.3% of all juvenile salmonids entering John Day Reservoir annually are lost to northern pikeminnow predation. Table 10 of the White Paper lists model predictions for the expected reduction in the pikeminnow predation rate due to continuation of the predation control program. At John Day, for the years 2000 to 2006, the model estimates that the predation rate will be reduced by approximately 9% annually. Reducing the estimated current pikeminnow predation loss of 7.3% by 9% gives an

approximate 0.66% annual reduction in pool mortality due to the predator control program alone. This is about half of the 10% (1.2% absolute) assumed in the RPA analysis.

Other measures in the RPA, such as spill operations and future surface passage facilities, are all expected to further reduce delay at the dam, and therefore exposure to predators. In addition, measures to reduce mortalities due to other piscine and avian predators will also reduce pool mortality rates. Although the pool mortality reduction rate expected from these other measures cannot be quantified at this time, it appears reasonable to expect that these measures, when combined with the reduction expected from the pikeminnow control program, will be sufficient to result in a 10% reduction in pool mortality.

9.7.1.6 Juvenile Transportation Program

9.7.1.6.1 Percentage of Each Species Transported. Under the RPA, the proportion of the SR mixed stock yearling chinook population potentially collected and transported from the three Snake River collector dams is estimated to average about 58%, with a range from 43% to 91% depending on river conditions. For summer migrating SR fall chinook, the proportion transported is lower than that for yearling chinook because of significant mortality that occurs before these fish first reach Lower Granite Dam. The proportion of fall chinook potentially collected and transported is estimated to average about 52%, with a range from 32% to 65% depending on river conditions. Similar estimates for SR steelhead average 60%, with a range from 48% to 90% (Table 9.7-1).

9.7.1.6.2 Survival Benefits to Each Species. Without transportation, the average inriver survival of combined mixed stock SR yearling chinook salmon from Lower Granite Dam to below Bonneville Dam is estimated to be nearly 50%, with a range from 35% to 62% depending on river conditions. With transportation, combined transport and inriver survival to below Bonneville Dam is estimated to be about 76%, with a range from 68% to 90%. For summer migrating SR fall chinook, the proportion of the population surviving to below Bonneville Dam without transportation is estimated to be about 14%, with a range from about 1% to 22%. With transportation, the proportion of the population surviving to below Bonneville Dam is about 51%, with a range from 31% to 64%. Similar estimates for SR steelhead average almost 52% without transportation (range 42% to 58%), and 77% (range 72% to 88%) with transport (Table 9.7-1).

9.7.1.6.3 Effects of Extended Barging Season. This measure addresses the concerns of the Independent Scientific Advisory Board and others in the region regarding potential adverse effects on juvenile fish that are transported by truck as compared to barging. Collected juveniles that migrate early and late in the season have been transported by truck for release below Bonneville Dam. Unlike the summer migrants, which are trucked, all of the early transported migrants are released from the shoreline at selected locations thought to afford the best available release conditions (strong downstream current, deep water in close proximity, no avian predators). Due to safety concerns, trucked fish are routinely released during daylight, a period

when avian predators are most active. In contrast, barged fish are released at various midriver locations under more favorable hydraulic conditions where predators have less opportunity to forage.

9.7.1.6.4 Potential Release of Trucked Fish from New Bonneville Juvenile Fish Bypass Outfall. As described above, juvenile fish that are trucked at the beginning of the season are released from the shoreline, where there is increased likelihood of consumption by predators. The new Bonneville juvenile fish bypass outfall was sited to afford bypassed fish a higher survival rate. If the post-construction evaluation of the new outfall does not show any problems, there should be a survival advantage for trucked fish released from that location.

9.7.1.6.5 Transportation from McNary Dam. The potential benefits to listed Upper Columbia species are unknown. Transportation around the remaining three lower Columbia dams would avoid FCRPS-related mortality in that reach and thereby increase their relative survival. On the other hand, collection and transportation from McNary may result in indirect mortality. Evaluations of transport benefits conducted during the 1980s relied on juvenile fish collected by sampling from the juvenile facility. Those fish were most likely a mix of upper Columbia and Snake River fish.

Currently, transport barges from the lower Snake River bypass the McNary Dam juvenile facility and arrive below Bonneville earlier than would otherwise occur. More barged fish are released in daylight instead of after dark, which was the case before transport was suspended.

More juvenile salmon and steelhead that migrate in June would remain inriver to complete their migration if the decision to initiate transportation is based on a daily average riverflow and water temperature criteria. In the past 2 years, collection and transport began when inriver migratory conditions were more favorable to their survival through the lower Columbia River. Because spring migrant transport operations at McNary will continue to be suspended until new studies demonstrate positive benefits, there is no scientific basis for transporting summer migrants passing the project under springlike conditions. Available data do not show a transport benefit for summer migrants transported during the early portion of the migration, and only a slight benefit for the middle segment of the run. Studies in the 1980s were conducted when fish-handling facilities and practices were less favorable than they are now, and the mainstem dams were operated without juvenile fish protection considerations. Future evaluations are desirable to help determine whether summer migrants should be removed from the river under good inriver migratory conditions.

Installation of adult PIT-tag detectors in main fishways at McNary Dam will allow collection of adult return data without any handling. These facilities are essential to conduct transport research at McNary.

9.7.1.6.6 Improvements to Transportation Program. Planning transport operations at the dams so that fish are released from specific areas at specific times to enhance their post-release

survival has the potential to reduce estuarine-related predation. At present, fish barges at the uppermost dam are loaded on the day shift in the morning. That schedule determines the barge loading schedule at the downriver projects. No consideration is given to the optimum times that fish would need to be released below Bonneville to ensure the survival rate. Staff resource and safety issues are the primary considerations. Researchers have speculated that survival at the saltwater interface may be higher if transported fish arrive at the estuary concurrent with an outgoing tide. This could reduce delay and potential negative interactions with avian predators (i.e., at Rice Island).

9.7.1.6.7 NMFS' Issuance of Section 10 Permits for Juvenile Transportation Program and Smolt Monitoring Program. The juvenile transportation program is an integral component of the proposed action in this biological opinion. The Corps' existing permit expires on December 31, 2000. Issuance of a new Section 10 permit for the transportation program will be necessary for 2001 and beyond. Effects of bypass and collection of smolts on SR steelhead, UCR steelhead, and SR spring/summer chinook survival are described in Section 6.2.3. Effects of adult fallback through bypass systems are assessed in Section 6.2.4. Effects of transportation, in terms of direct survival to below Bonneville Dam and relative survival to adulthood compared to inriver migrants, are discussed in Section 6.2.8. Biological information regarding all aspects of the transportation program and its effect on listed steelhead and salmon is included in the Transportation White Paper (NMFS 2000i).

The smolt monitoring program is also an integral component of the current action. Issuance of the Section 10 permit for the smolt monitoring program is also necessary for 2001 and beyond (see Appendix H).

9.7.1.7 Summary: Effects of RPA on Juvenile and Adult Survival

The information in Table 9.7-5 summarizes the effects of the RPA on the listed salmon and steelhead juvenile survival rates, estimated using the SIMPAS model, and minimum adult survival rates, estimated from radio-tag study results and listed in Table 9.7-2. Also included in Table 9.7-5, for comparison purposes, are summaries of the effects of the current action on juvenile survival rates, estimated using the SIMPAS model and listed in Appendix D, Tables D-1 through D-3. Minimum adult survival rates, estimated from radio-tag study results, are listed in Table 6.1-1.

Table 9.7-5. Summary of estimated effects of the RPA in the action area.

ESU	Estimated Inriver Juvenile Survival through FCRPS		Estimated Inriver and Transport Juvenile Survival With D through FCRPS		Estimated Adult Survival through FCRPS	
	Current	RPA	Current	RPA	Current	RPA
Chinook Salmon						
SR spr/sum chinook (D = 0.63-0.73)	0.27-0.52	0.35-0.62	0.50-0.64	0.51-0.65	0.83	0.86
SR fall chinook (D = 0.24)	0.005-0.16	0.01-0.22	0.06-0.15	0.08-0.16	0.71	0.74
UCR spring chinook	0.46-0.66	0.55-0.76	N/A	N/A	0.91	0.92
UWR chinook	N/A	N/A	N/A	N/A	N/A	N/A
LCR chinook-spring	0.83-0.91	0.87-0.95	N/A	N/A	0.97	0.98
LCR chinook-fall	0.50-0.80	0.57-0.85	N/A	N/A	0.96	0.96
Steelhead						
SR steelhead (D = 0.52-0.56)	0.32-0.46	0.42-0.58	0.45-0.52	0.46-0.55	0.77	0.80
UCR steelhead	0.57-0.64	0.61-0.74	N/A	N/A	0.88	0.89
MCR steelhead	0.57-0.64	0.61-0.74	N/A	N/A	0.88	0.89
UWR steelhead	N/A	N/A	N/A	N/A	N/A	N/A
LCR steelhead	0.85-0.92	0.86-0.96	N/A	N/A	0.97	0.97
CR chum salmon	0.50-0.80	0.57-0.85	N/A	N/A	0.96	0.96
SR sockeye salmon	N/A	N/A	N/A	N/A	0.86	0.89

9.7.2 Analysis of Effects of Proposed Action on Biological Requirements Over Full Life Cycle

Appendix C describes the median annual population growth rate (lambda) and the risk of absolute extinction at the ESU and, in some cases, the population level. In this section, NMFS looks at the likely effects of the proposed action on the risk of extinction and likelihood of recovery (Section 1.3.1.1 and 6.1.2). Although the jeopardy standard is ultimately a qualitative assessment of whether there is a high likelihood of survival with an adequate potential for recovery, NMFS considers the specific level of improvement needed to achieve particular risk levels as one indication of population status relative to that jeopardy standard (Sections 1.3.1.1 and 6.1.2). These risk levels (≤5% risk of extinction in 24 and 100 years; ≥50% likelihood of meeting interim recovery abundance levels in 48 and 100 years; ≥50% likelihood that population growth rate will be stable or increasing) are referred to subsequently as "survival indicator criteria" or "recovery indicator criteria." This standardized analysis is used to evaluate the importance of the effects described in the preceding section, as likely to occur in the action area in the context of the full life cycle. The data for some of the ESUs considered in this biological opinion are too scarce or are not of adequate quality to permit a quantitative life-cycle analysis of this type. For some of those ESUs, inferences can be drawn from the quantitative results described for the other ESUs.

Details of the quantitative analyses used to evaluate the effects of the proposed action on biological requirements over the full life cycle are described in Section 6.1.2 and Appendix A. Quantitative and qualitative estimates are summarized for several ESUs in the following sections.

9.7.2.1 Snake River Spring/Summer Chinook Salmon

Evaluation of species-level effects of the RPA requires placing the action-area effects in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of SR spring/summer chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range, including habitat degradation in many areas due to timber harvest, grazing, and mining practices (loss of pools, high temperatures, low flows, poor overwintering conditions, and high sediment loads).

In this section, NMFS evaluates quantitatively the action-area effects associated with the hydrosystem component of the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

9.7.2.1.1 Populations Evaluated

NMFS evaluated 43 spawning aggregations of SR spring/summer chinook salmon. Seven of these are the "index stocks" described in the June 27, 2000, draft biological opinion, previous NMFS analyses (McClure et al. 2000b), and PATH reports (Marmorek et al. 1998). The remaining spawning aggregations were the subject of new analyses in McClure et al. (2000c). NMFS has not yet determined which, if any, of the index stocks and additional spawning aggregations represent populations, as defined by McElhany et al. (2000), but all are treated as independent populations because of the statistical assumptions inherent in the analysis.

9.7.2.1.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. NMFS also estimated the change from the base period lambda necessary to achieve ≥50% likelihood of meeting interim recovery abundance levels (NMFS 1995c) in 48 and 100 years using the most current estimates of lambda and methods described in Appendix A. Interim recovery abundance levels have only been defined for three ESUs and, in the SR spring/summer chinook ESU, only for the seven index stocks. Therefore, NMFS estimated the change in lambda necessary to meet an alternative recovery indicator criterion of lambda ≥1.0 (Appendix A) for all other spawning aggregations. Details of each of these estimates are included in Appendix A.

NMFS also investigated the effects of adding preliminary returns in 2000 and an estimate of expected returns in 2001 (based on jack abundance) to the time-series used to estimate lambda in each of the calculations described above. Estimates are included in McClure (2000b). These preliminary returns were included in the lowest estimates of necessary survival changes.

9.7.2.1.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from 1980 to 1999 will continue indefinitely. However, in Section 6.3.1.3, NMFS estimates that current survival represents a 24%-to-32% improvement over the average survival rate influencing base period adult returns. The range represents two methods of estimating survival change. One relies entirely on PATH results, and the other relies on a combination of PATH and SIMPAS model estimates (Section 6.3.1.3). Implementing the hydrosystem component of the RPA will proportionally increase adult survival beyond the current level by an additional 3.7%, based on information in Table 9.7-5. The hydrosystem component of the RPA will also increase juvenile survival to below Bonneville Dam, including differential post-Bonneville survival of transported fish (D) of 63% to 73%, by approximately 1% (Table 9.7-5). The product of the proportional survival improvements associated with the current conditions and the RPA results in an expected survival improvement of 30% to 38% (1.30 to 1.38 times the average base period survival rate), as described in Appendix A.

No other quantifiable survival rates changed significantly between the average base period condition and the current condition. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival, estuary survival, and adult survival above Lower Granite Dam that may have resulted from habitat and hatchery management actions, so no change in those survival rates is included in this quantitative analysis. In Section 9.7.2.1.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.1.4 Additional Necessary Survival Changes

Table 9.7-6 shows the effect of the 30% to 38% survival rate increase expected from the hydrosystem component of the RPA on the future median annual population growth rates for 43 SR spring/summer chinook spawning aggregations. In some cases (e.g., Marsh Creek), the resulting population growth rate is expected to change from a declining trend (lambda <1.0) to a stable or increasing trend. In spite of the expected improvement in population growth rate, at least 22, and possibly as many as 25, of the 43 spawning aggregations require additional survival improvements to meet the survival and recovery indicator criteria. Table 9.7-6 displays the additional improvements in survival that would be necessary, beyond the 30% to 38% improvement associated with the RPA, to reduce the 100-year extinction risk to 5% and either increase the likelihood of recovery in 48 years to 50% or increase the likelihood of achieving a stable or increasing population growth rate to 50%. These indicator criteria were presented because, if they are achieved, all the survival and recovery indicator criteria will be achieved.

Values in Table 9.7-6 less than or equal to 1.0 indicate that no further survival improvements are necessary to meet the survival and recovery indicator criteria. Values greater than 1.0 represent the multiplier by which survival would have to improve to achieve these criteria. For example, the survival change necessary to reduce the risk of extinction in 100 years to 5% (columns 8 and 9 of Table 9.7-6) is 0.85 to 1.05 for the Sulphur Creek index stock. This means that the RPA, combined with expected survival in other life stages (see Section 9.7.2.1.6, below), is sufficient to reduce the 100-year extinction risk to 5% or less under the highest estimate of the expected survival change and the lowest estimate of the needed improvement. On the other hand, under the lowest estimate of the expected survival change and the highest estimate of the needed survival change, an additional 5% survival improvement (1.05 times expected survival rate) is necessary. This means that an additional 5% increase in egg-to-adult survival, or any component life-stage-specific survival rate, would be necessary to achieve no more than a 5% risk of extinction in 100 years for this index stock under the most pessimistic assumptions evaluated by NMFS.

Table 9.7-6. Snake River spring/summer chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing RPA.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		*Additional Change In Survival Needed to Achieve:* 5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	0.82	0.91	1.30	1.38	0.86	0.98	1.46	1.56	1.12	1.89
Index Stocks:										
Bear Valley/Elk Creeks	1.02	1.03	1.30	1.38	1.07	1.10	0.72	0.77	0.79	0.89
Imnaha River	0.88	0.92	1.30	1.38	0.93	0.99	0.84	1.16	1.26	1.66
Johnson Creek	1.01	1.03	1.30	1.38	1.07	1.11	0.72	0.77	0.70	0.83
Marsh Creek	0.99	1.00	1.30	1.38	1.04	1.07	0.74	0.89	0.98	1.12
Minam River	0.93	1.02	1.30	1.38	0.99	1.10	0.72	1.13	0.84	1.28
Poverty Flats	0.99	1.02	1.30	1.38	1.05	1.11	0.72	0.77	0.73	0.90
Sulphur Creek	1.04	1.05	1.30	1.38	1.10	1.13	0.85	1.05	0.78	0.87
Additional Aggregations:										
Alturas Lake Ck	0.75	0.75	1.30	1.38	0.79	0.80	N/A	N/A	2.68	2.86
American R	0.91	0.91	1.30	1.38	0.96	0.98	N/A	N/A	1.11	1.19
Big Sheep Ck	0.85	0.88	1.30	1.38	0.90	0.92	N/A	N/A	1.29	1.58
Beaver Cr	0.95	0.95	1.30	1.38	1.01	1.02	N/A	N/A	0.90	0.96
Bushy Fork	0.98	0.98	1.30	1.38	1.04	1.05	N/A	N/A	0.79	0.84
Camas Cr	0.92	0.92	1.30	1.38	0.98	0.99	N/A	N/A	1.04	1.11
Cape Horn Cr	1.05	1.05	1.30	1.38	1.12	1.13	N/A	N/A	0.58	0.61
Catherine Ck	0.78	0.85	1.30	1.38	0.83	0.84	N/A	N/A	1.50	2.31
Catherine Ck N Fk	0.92	0.92	1.30	1.38	0.98	0.99	N/A	N/A	1.04	1.12
Catherine Ck S Fk	0.80	0.80	1.30	1.38	0.84	0.86	N/A	N/A	2.01	2.14
Crooked Fork	1.00	1.00	1.30	1.38	1.06	1.07	N/A	N/A	0.73	0.78
Grande Ronde R	0.77	0.84	1.30	1.38	0.82	0.83	N/A	N/A	1.58	2.42
Knapp Cr	0.89	0.89	1.30	1.38	0.94	0.96	N/A	N/A	1.22	1.30
Lake Cr	1.06	1.06	1.30	1.38	1.12	1.14	N/A	N/A	0.56	0.60
Lemhi R	0.98	0.98	1.30	1.38	1.03	1.05	N/A	N/A	0.81	0.86
Lookingglass Ck	0.72	0.79	1.30	1.38	0.77	0.78	N/A	N/A	2.02	3.25
Loon Ck	1.00	1.00	1.30	1.38	1.06	1.08	N/A	N/A	0.71	0.76
Lostine Ck	0.87	0.90	1.30	1.38	0.92	0.94	N/A	N/A	1.15	1.44
Lower Salmon R	0.92	0.92	1.30	1.38	0.97	0.99	N/A	N/A	1.07	1.14
Lower Valley Ck	0.92	0.92	1.30	1.38	0.98	0.99	N/A	N/A	1.03	1.10
Moose Ck	0.94	0.94	1.30	1.38	1.00	1.02	N/A	N/A	0.93	1.00
Newsome Ck	1.03	1.03	1.30	1.38	1.09	1.10	N/A	N/A	0.64	0.68
Red R	0.91	0.91	1.30	1.38	0.96	0.98	N/A	N/A	1.10	1.18
Salmon R E Fk	0.94	0.94	1.30	1.38	1.00	1.01	N/A	N/A	0.96	1.02
Salmon R S Fk	1.06	1.06	1.30	1.38	1.12	1.14	N/A	N/A	0.56	0.60
Secesh R	0.98	0.98	1.30	1.38	1.03	1.05	N/A	N/A	0.80	0.86
Selway R	0.91	0.91	1.30	1.38	0.97	0.98	N/A	N/A	1.08	1.15
Sheep Cr	0.80	0.80	1.30	1.38	0.85	0.86	N/A	N/A	1.97	2.10
Upper Big Ck	0.97	0.97	1.30	1.38	1.03	1.04	N/A	N/A	0.87	0.89
Upper Salmon R	0.90	0.90	1.30	1.38	0.96	0.97	N/A	N/A	1.13	1.21
Upper Valley Ck	1.03	1.03	1.30	1.38	1.09	1.11	N/A	N/A	0.63	0.67
Wallowa Ck	0.86	0.86	1.30	1.38	0.91	0.92	N/A	N/A	1.42	1.51
Wenaha R	0.84	0.90	1.30	1.38	0.89	0.91	N/A	N/A	1.14	1.66
Whitecap Ck	0.90	0.90	1.30	1.38	0.96	0.97	N/A	N/A	1.14	1.22
Yankee Fork	0.88	0.88	1.30	1.38	0.94	0.95	N/A	N/A	1.26	1.35
Yankee West Fk	0.99	0.99	1.30	1.38	1.05	1.06	N/A	N/A	0.76	0.81

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically, except for the Imnaha (50% as effective). For index stocks, it also includes preliminary 2000 and projected 2001 returns in time series used to estimate lambda.
[3] Low represents estimation of juvenile survival improvement based on a comparison of PATH retrospective and prospective (A2) results.
[4] High represents estimation of juvenile survival improvement based on a combination of PATH and SIMPAS results.
[5] Low represents the low 1980-to-1999 lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-1999 lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A, including preliminary 2000 and projected 2001 returns for index stocks) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A, including only final returns through 1999) divided by the low estimate of the expected survival improvement.

Three of the seven index stocks require no additional survival changes beyond those expected under the RPA to meet the survival and recovery indicator criteria. The other four index stocks require additional survival improvements ranging from 0% to 66%. For the additional spawning aggregations, data were insufficient for estimating extinction risk, and no interim recovery levels have yet been determined. For the spawning aggregations, the necessary survival change is that which will result in lambda of 1.0. Under all assumptions, 21 of the 36 spawning aggregations require additional survival changes, ranging from 3% to 239%. One additional spawning aggregation needs no additional survival change under the best-case assumptions that NMFS evaluated, but needs a 2% survival change under the worst-case assumptions. The remaining 14 spawning aggregations require no additional survival improvements under any of the assumptions evaluated.

These results are similar to those of PATH (Marmorek et al. 1998, Peters and Marmorek 2000), with respect to the need for additional survival improvements after the hydrosystem component of the RPA is implemented, in order to meet approximations of the survival and recovery indicator metrics. However, the magnitude of the necessary changes differs between the two approaches and among different PATH reports. Section 6.3.1.4 compares the NMFS and PATH analyses of modeling scenarios approximating the proposed action. Implementation of the hydrosystem RPA does not fundamentally change the discussion in that section. Briefly, PATH (Peters and Marmorek 2000) and NMFS generally estimate a similar range of extinction risk, and PATH (Marmorek et al. 1998) and NMFS results suggest that a relatively small survival improvement is necessary to meet the recovery indicator metric for the sixth-worst stock. However, the PATH experimental management analysis (Peters and Marmorek 2000) suggests that well over a 100% improvement in survival is needed for the worst stock to meet the recovery indicator metric.

9.7.2.1.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the RPA's ability to achieve survival and recovery indicator criteria. The substantial comments primarily questioned the estimates of hydrosystem survival associated with the RPA (addressed in Section 9.7.1), the method of estimating the expected proportional change in the juvenile survival rate from the average associated with base period returns (addressed in Section 6.3.1.3 in one new and one modified method of estimating the expected change), the assumption that the effectiveness of hatchery-origin spawners may have been as low as 20% of that of wild-origin spawners (addressed in Section 6.3.1.5), and the analytical assumption that all survival changes are achieved instantaneously. This last point is addressed below.

The simple analytical approach used in this biological opinion assumes that all survival changes are instantaneous (McClure et al. 2000c). To the extent that improvements are implemented gradually, the analysis underestimates the survival change that will ultimately be required. The magnitude of the additional change depends on the stock under consideration and the length of

the delay. To demonstrate the effect of this assumption, NMFS evaluated a 10-year delay in implementing the hydrosystem component of the RPA and of achieving any survival improvements in other life stages (Appendix A). The analysis also assumed that there has been no change from average base period survival as a result of current hydrosystem operations (which NMFS estimates as a 24%-to-32% improvement in Section 6). Further, the survival changes associated with current operations are assumed not to occur for 10 years. NMFS applied this extremely pessimistic assumption to the Imnaha River stock, which is the SR spring/summer chinook stock requiring the greatest survival improvement. Given these assumptions, a 58% to 95% survival improvement would be necessary at the end of 10 years to meet the recovery indicator criteria. In contrast, the estimate from the present analysis is a survival improvement of 26% to 66%. NMFS considers that effect qualitatively in making a jeopardy determination.

This analysis also contains assumptions that may make the results overly pessimistic. Three of these are the analytical assumptions that all spawning aggregates behave as independent populations; that all supplementation programs cease immediately; and that background survival will continue as it has since 1980. These assumptions are discussed in detail in Section 6.3.5.

9.7.2.1.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-6 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for SR spring/summer chinook salmon. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival, estuary survival, and prespawning adult survival above Lower Granite Dam. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. The RPA also provides mechanisms for pursuing additional, more intensive, actions, including possible dam breaching, within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.2 Snake River Fall Chinook Salmon

Evaluation of species-level effects of the RPA requires placing the action-area effects in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of SR spring/summer chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. Specifically, almost all of the historical spawning habitat in the Snake River basin is blocked by the Hells Canyon Complex. Other irrigation and hydroelectric projects block access to habitat in tributaries to the Columbia River below Hells Canyon. Habitat quality is degraded by agricultural water withdrawals, grazing, vegetation management, and forestry and mining practices (lack of pools, high temperatures, low flows, poor overwintering conditions, and high sediment loads).

In this section, NMFS quantitatively evaluates the action-area effects associated with the hydrosystem component of the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

9.7.2.2.1 Populations Evaluated

NMFS analyzed the single aggregate Snake River fall chinook population. The analysis was based on Lower Granite Dam counts, so it does not include spawning areas in the Tucannon River and in the mainstem below some Corps dams.

9.7.2.2.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. NMFS also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the aggregate population interim recovery abundance level (based on NMFS 1995c; specifics in Appendix A) in 48 and 100 years using the most current estimates of lambda and methods described in Appendix A.

9.7.2.2.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from the base period will continue indefinitely. However, in Section 6.3.2.3, NMFS estimates that current survival represents a 31%-to-63% improvement over the average survival rate influencing base period adult returns. The range represents four methods of estimating the survival change. One estimate of the juvenile passage survival change relies entirely on PATH results, whereas the other relies on a combination of PATH and SIMPAS model estimates (Section 6.3.2.3). One

estimate of the change in harvest rate relies on PATH estimates, whereas the other relies on a PSC model estimate. The lowest survival improvement results when both juvenile survival and harvest are estimated using only PATH results. The highest survival represents the combination of PATH and SIMPAS juvenile modeling and the PSC harvest modeling results.

Implementing the hydrosystem component of the RPA will proportionally increase adult survival beyond the current level by an additional 4.2%, based on information in Table 9.7-5. The hydrosystem component of the RPA will also increase juvenile survival to below Bonneville Dam, including an assumed differential post-Bonneville survival of transported fish (D) of 24% (Section 6.2.3.3) by approximately 9% (Table 9.7-5). The product of the proportional survival improvements associated with the current conditions and the RPA results in an expected survival improvement of 49% to 86.0% (1.49 to 1.86 times the average base period survival rate), as described in Appendix A.

No other quantifiable survival rates changed significantly between the average base period and the current condition. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival, estuary survival, and adult survival above Lower Granite Dam that may have resulted from habitat and hatchery management actions, so no change in these survival rates is included in this quantitative analysis. In Section 9.7.2.2.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.2.4 Additional Necessary Survival Changes

Table 9.7-7 shows the effect of the 49%-to-86% increase in survival rate expected from the RPA on the future median annual population growth rates for the aggregate SR fall chinook population. The resulting population growth rate is expected to change from a declining trend (lambda <1.0) to a stable or increasing trend (lambda = 1.07) under the highest estimate of survival change. However, under the lowest estimate of improved survival, the population growth rate is still expected to decline. No additional survival improvements are necessary to meet the survival indicator criteria under any of the assumptions considered in this analysis. Nor are any additional survival improvements required to meet the recovery indicator criteria when the highest expected change in survival is coupled with the lowest estimate of the necessary survival improvement. However, an additional 44% survival change is required when the low estimate of the expected survival change is coupled with the highest estimate of the needed survival improvement.

The results of the NMFS Snake River fall chinook analysis for the hydrosystem component of the RPA are generally consistent with the PATH assessments of a similar action. Both assessments indicate that no additional survival changes are needed to meet alternative survival indicator criteria, given similar assumptions regarding annual climate/environmental variability, harvest rates, and differential mortality for transported smolts. However, both assessments

Table 9.7-7. Snake River fall chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
Aggregate SR fall chinook	0.87	0.92	1.49	1.86	0.96	1.07	0.66	0.94	0.93	1.44

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low represents estimation of juvenile survival improvement based on PATH retrospective and prospective (A2) results and change in harvest rate based on PATH.
[4] High represents estimation of juvenile survival improvement based on a combination of PATH and SIMPAS and harvest rate change based on PSC modeling.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

indicate that additional survival improvements would be required to meet the 48-year recovery indicator criterion under the full range of assumptions considered in each analysis.

PATH evaluated an action (A2) that incorporated most of the elements of the hydrosystem component of the RPA with respect to SR fall chinook (Peters and Marmorek 2000). The action A2 incorporated the changes in hydropower operations called for in the 1995 FCRPS Biological Opinion. While it incorporates similar juvenile survival assumptions, the PATH analysis does not include the adult survival improvement anticipated from the RPA. PATH evaluated actions under a range of assumptions regarding post-Bonneville Dam differential delayed mortality of transported fish relative to nontransported fish (expressed as a differential survival factor D). The ability of action A2 to meet PATH survival and recovery criteria depended on the assumption regarding D. If D is relatively high or if it had improved substantially over base values, PATH projected that A2 would readily exceed survival and recovery criteria used in the assessments. Under the assumption that D has remained at approximately 20%, approximating the level used in the current NMFS analysis (see Section 6.2.3.3), action A2 was projected to meet survival criteria but to fall short of recovery targets. Specifically, the PATH analysis projected the mean likelihood of reaching recovery goals in 48 years as 34%, 16 percentage points below the 50% likelihood associated with the recovery indicator criterion.

9.7.2.2.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate

of the RPA's ability to achieve survival and recovery indicator criteria. Most comments were not specific to SR fall chinook salmon, but many of the points raised for SR spring/summer chinook salmon may also apply to SR fall chinook salmon. Substantial comments primarily questioned 1) the estimates of hydrosystem survival associated with the RPA (addressed in Section 9.7.1), 2) the method of estimating the expected proportional change in the juvenile survival rate from the average associated with base period returns (addressed in Section 6.3.2.3 through introduction of one new and one modified method of estimating the expected change), 3) the method of estimating the change in harvest rate (addressed in Section 6.3.2.3 through introduction of one new and one modified method), 4) the assumption that the effectiveness of hatchery-origin spawners may have been as low as 20% that of wild-origin spawners (addressed in Section 6.3.2.3), and 5) the analytical assumption that all survival changes are achieved instantaneously. This last point is addressed below.

The simple analytical approach used in this biological opinion assumes that all survival changes are instantaneous (McClure et al. 2000c). To the extent that improvements are implemented gradually, the analysis underestimates the survival change that will ultimately be required. The magnitude of the additional change depends on the stock under consideration and the length of the delay. To demonstrate the effect of this assumption, NMFS evaluated a 10-year delay in implementing the hydrosystem component of the RPA and of achieving any survival improvements in other life stages (Appendix A). The analysis also assumed that there has been no change from average base period SR fall chinook survival as a result of current hydrosystem operations (which NMFS estimates as a 33%-to-64% improvement in Section 6). Further, the survival changes associated with current operations are assumed not to occur for 10 years. Given these assumptions, a 16%-to-69% survival improvement would be necessary at the end of 10 years to meet the recovery indicator criteria. In contrast, the estimate from the present analysis is a 0%-to-44% survival improvement. NMFS considers this effect qualitatively in making a jeopardy determination.

This analysis also contains assumptions that may make the results overly pessimistic. Two of these are the analytical assumptions that all supplementation programs cease immediately and that background survival will continue as it has since 1980. These assumptions are discussed in Section 6.3.2.5.

9.7.2.2.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-7 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for SR fall chinook salmon. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival, estuary survival, and prespawning adult survival above Lower Granite Dam. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. Further, the RPA provides mechanisms for pursuing additional, more intensive, actions, including possible dam breaching, within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.3 Upper Columbia River Spring Chinook Salmon

Evaluation of species-level effects of the RPA requires placing the action-area effects in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of UCR spring chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. Chief Joseph Dam and Grand Coulee Dam prevent access to historical spawning grounds farther upstream. Local problems relate to irrigation diversions and hydroelectric development, as well as degraded riparian and instream habitat from urbanization and livestock grazing along riparian corridors.

In this section, NMFS quantitatively evaluates action-area effects associated with the hydrosystem component of the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

9.7.2.3.1 Populations Evaluated

NMFS analyzed the three populations identified by Ford et al. (1999) as components of this ESU: the Wenatchee River population, the Methow River population, and the Entiat River population. Ford et al. (1999) identified interim recovery goals for each population and included the criterion that all three must meet these goals for delisting.

9.7.2.3.2 Necessary Survival Change

McClure et al. (2000b,c) and Cooney (2000) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. Cooney (2000) and NMFS (Appendix A) also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the three population interim recovery abundance levels (Ford et al. 1999) in 48 and 100 years using the most current estimates of lambda and methods described in Appendix A. The CRI analytical approach (McClure et al. 2000b) and the QAR analytical approach (Cooney 2000) produce different estimates of needed survival changes for these populations. NMFS considers both approaches to have advantages and disadvantages and uses results from both to define a range of necessary survival change.

NMFS also investigated the effects of adding 1999-to-2000 preliminary and 2001 projected returns to the time-series used to estimate lambda in each of the calculations described above. The 2001 projections are based on recent jack counts. Estimates are included in McClure et al. (2000b) and Cooney (2000). These preliminary returns were included in the preliminary estimates are included in the lowest estimates of necessary survival changes.

9.7.2.3.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from 1980 to 1998 will continue indefinitely. However, the Basinwide Recovery Strategy identifies implementation of the Mid-Columbia HCP at five PUD projects as a probable element of recovery planning that is, therefore, included in the analysis, consistent with step 4 of the jeopardy analysis framework described in Section 1.3. The Basinwide Recovery Strategy estimates that this action will be implemented within 2 to 5 years. Cooney (2000, Table 20) estimates that implementing the HCP will improve survival 28% for the Wenatchee population, 40% for the Entiat population, and 49% for the Methow population.

In addition, in Section 6.3.3.3, NMFS estimates that current FCRPS hydrosystem survival, combined with implementation of the Mid-Columbia HCP, represents a 7%-to-41% improvement over the average survival rate influencing base period adult returns. The range represents different effects of the HCP on each population and a range of estimates of the historical differential post-Bonneville survival (D = 0.8 to D = 1.0) in years when fish were transported from McNary Dam. Implementing the hydrosystem component of the RPA will proportionally increase adult survival through the FCRPS projects beyond the current level by an additional 1.5%, based on information in Table 9.7-5. The hydrosystem component of the RPA is also expected to proportionally increase juvenile survival to below Bonneville Dam by 15.5% (Table 9.7-5; Appendix A). The product of the proportional survival improvements associated with the current conditions, implementation of the HCP, and implementation of the hydrosystem RPA results in an expected survival improvement of 25% to 65% (1.25 to 1.65 times the average base period survival rate), as described in Appendix A.

No other quantifiable survival rates changed significantly between the average base period and the current condition. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival (other than those associated with the HCP; Cooney 2000), estuary survival, and adult survival above the upper dam that may have resulted from habitat and hatchery management actions, so no change in these survival rates is included in this quantitative analysis. In Section 9.7.2.3.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.3.4 Additional Necessary Survival Changes

Table 9.7-8 shows the effect of the 25%-to-65% survival rate increase expected from the proposed action on the future median annual population growth rates for the three UCR spring chinook populations. These effects vary according to whether the QAR analytical approach (Cooney 2000) or the CRI analytical approach (McClure et al. 2000c) is used to estimate the current population growth rate and the necessary change. The CRI approach indicates that the population growth rate will continue to be negative for all three populations after HCP implementation and continuation of the proposed action, except for the Methow River population under the highest expectation (lambda = 1.01). Additional survival improvements ranging from 32% to 178% (1.32 to 2.78 times the average base period survival rate) will be necessary to meet the recovery indicator criteria. The QAR approach yields slightly more optimistic results, indicating that at least one, and possibly all three populations (under most optimistic assumptions), will have positive growth rates after HCP implementation and continuation of the proposed action. However, additional survival improvements ranging from 24% to 116% (1.24 to 2.16 times the average base period survival rate) will be necessary to meet the recovery indicator criteria.

9.7.2.3.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. Most comments were not specific to, or in some cases relevant to, UCR spring chinook salmon. However, three comments of particular relevance were that NMFS should not assume that the Mid-Columbia HCP will be implemented and achieve its survival goals within the time described in the Basinwide Recovery Strategy; that the analysis is overly optimistic because it assumes that all survival changes are achieved instantaneously; and that the analysis is overly optimistic because NMFS rejected the assumption of 80% effectiveness of hatchery-origin natural spawners. As described in Section 6.3.3.5, NMFS considers the full range of hatchery spawner effectiveness in this biological opinion.

Table 9.7-8. Upper Columbia River spring chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

							Additional Change In Survival Needed to Achieve:			
	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
Spawning Aggregation	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate - CRI	0.84	0.85	1.36	1.54	0.90	0.94	1.20	1.41	1.32	1.58
Methow River - QAR	0.90	0.90	1.46	1.65	0.98	1.14	0.80	0.91	1.24	1.41
Entiat River - QAR	0.89	0.89	1.37	1.55	0.96	0.99	1.01	1.15	1.36	1.55
Wenatchee R. - QAR	0.88	0.92	1.25	1.42	0.93	1.09	0.99	1.40	1.51	2.16
Methow River - CRI	0.85	0.89	1.46	1.65	0.93	1.01	1.29	1.66	1.32	1.90
Entiat River - CRI	0.81	0.89	1.37	1.55	0.88	0.99	0.98	1.66	1.32	2.19
Wenatchee R. - CRI	0.80	0.85	1.25	1.42	0.84	0.92	1.22	1.83	1.84	2.78

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically and inclusion of preliminary and projected returns through 2001 for CRI estimates.
[3] Low represents an estimate of juvenile survival improvement based on assumption of historical D=0.8 from McNary Dam.
[4] High represents an estimate of juvenile survival improvement based on assumption of historical D=1.0 from McNary Dam.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A, including preliminary 2000 and projected 2001 returns for all except Methow QAR and Entiat QAR) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A, including only final returns through 1999) divided by the low estimate of the expected survival improvement.

The first comment applies to implementation of the proposed Mid-Columbia HCP. CRITFC believes that anticipated HCP survival rates will not be achieved at all five PUD dams for at least 10 years because long-term gas-abatement projects are needed to achieve the necessary spill levels. NMFS agrees that there is some uncertainty about the exact schedule for achieving all survival improvements anticipated in the HCP, but the proposed HCP for the Chelan and Douglas PUDs and the draft EIS anticipate that the survival improvements will be achieved by the end of Phase I (2003). If this does not occur, it is reasonable to anticipate additional changes under the terms of the proposed HCP.

Regardless of the exact implementation schedule, the analysis described above does assume that HCP and hydrosystem RPA survival improvements are achieved immediately, which is not the case. NMFS conducted a sensitivity analysis on the effect of a 10-year delay in implementing *any* survival improvements over the base period average survival rate (Section 6.3.3.5; Appendix C). Under this worst-case scenario, the CRI estimate of necessary survival change for the Wenatchee population increases from the estimate in Table 9.7-8 (additional 84% to 178% change) to a 265% to 368% change (Appendix A). This extreme scenario is unlikely, since some improvements associated with the HCP have already been achieved, but NMFS considers the

implications of delayed implementation qualitatively in reaching jeopardy conclusions for this ESU.

This analysis also contains assumptions that may make the results overly pessimistic. Two such assumptions are that all supplementation programs cease immediately, and that background survival will continue as it has since 1980. These assumptions are discussed in Section 6.3.3.5.

9.7.2.3.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management, other than effects anticipated in the HCP. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-8 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for UCR spring chinook salmon. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival, estuary survival, and prespawning adult survival above Lower Granite Dam. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. The RPA also provides mechanisms for pursuing additional, more intensive, actions, including possible dam breaching, within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.4 Upper Willamette River Chinook Salmon

Evaluation of the species-level effects of the RPA requires placing the action-area effects of the RPA in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of UWR chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include the loss of habitat due to inundation or blockages resulting from the construction of numerous tributary hydroelectric and irrigation facilities, and habitat degradation due to timber harvest, development (agricultural, municipal, and industrial), dam development, and river channelization and dredging. Many of these

activities result in poor water quality, high sediment loads, altered thermal regimes, and a large reduction in available spawning and rearing habitat.

In this section, NMFS quantitatively evaluates the action-area effects associated with the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions could increase annual population growth rates such that survival and recovery are likely.

9.7.2.4.1 Populations Evaluated

NMFS quantitatively evaluated one spawning aggregation, the McKenzie River above Leaburg Dam. Adequate information was not available for similar analyses for additional spawning aggregations. NMFS has not yet determined which, if any, of the UWR chinook spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the McKenzie River aggregation as an independent population satisfies the statistical assumptions inherent in the analysis.

9.7.2.4.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria for the McKenzie River spawning aggregation. NMFS also estimated the change from base period lambda necessary to achieve $\geq$50% likelihood of meeting the recovery indicator criterion of lambda $\geq$1.0 for this spawning aggregation. Details of these estimates are provided in Appendix A.

9.7.2.4.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for UWR chinook salmon, referenced above, assumes that the life-stage survival rates that influenced the base period adult returns will continue indefinitely. NMFS cannot identify any significant changes in survival rates under the RPA compared with those that influenced the base period adult returns, because survival changes due to implementing the proposed action can be quantified only for species that migrate past mainstem dams (which excludes UWR chinook salmon). NMFS was also unable to quantify potential changes in egg-to-smolt survival, estuary survival, or adult survival that may have resulted from recent or ongoing habitat and hatchery management actions. Instead, in Section 9.7.2.4.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.4.4 Additional Necessary Survival Changes

Table 9.7-9 shows that the RPA is not expected to increase the population survival rate; a negative median annual population growth rate is expected to continue for the UWR chinook

spawning aggregation in the McKenzie River above Leaburg Dam. An additional survival improvement of from 9% to 65% (1.09 to 1.65 times the average base period survival rate) is needed to meet the extinction indicator criteria.

Table 9.7-9. Upper Willamette River chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

							Additional Change In Survival Needed to Achieve:			
	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
Spawning Aggregation	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
McKenzie River above Leaburg Dam	0.90	0.99	1.00	1.00	0.90	0.99	1.09	1.65	1.05	1.59

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

9.7.2.4.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations noted that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the RPA would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, UWR chinook salmon. In fact, this analysis contains assumptions that may make the results overly pessimistic. For example, NMFS assumes that all supplementation programs cease immediately, and that the background survival rate will continue as it has since 1980. These points are addressed in Section 6.3.1.5.

9.7.2.4.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the RPA on survival below Bonneville Dam, or changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-9 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for UWR chinook salmon. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above Willamette Falls). The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. Further, the RPA provides mechanisms for pursuing additional, more intensive actions within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.5 Lower Columbia River Chinook Salmon

Evaluation of the species-level effects of the RPA requires placing the action-area effects of the RPA in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of LCR chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include the impacts of timber harvest (altered riparian vegetation, unstable streambanks, and decreased habitat complexity), agricultural practices (channelization and loss of riparian vegetation), road construction, and urban and industrial development; dams on the Cowlitz, Lewis, (Big) White Salmon, Clackamas, Sandy, and Hood rivers, which block fish passage to historical spawning areas; residual effects of mudflows from the Mt. St. Helens eruption (1980), which significantly disrupted and degraded habitat in the South Fork Toutle and Green rivers – as did post-eruption dredging, diking, and bank protection works in the Cowlitz River (below its confluence with the Toutle River); hatchery programs, beginning in the 1870s, which released billions of fish, homogenizing stocks between subbasins and introducing others from outside the ESU such that most of the fall-run chinook salmon spawning today in the Lower Columbia River ESU are first-generation hatchery strays; and an average total exploitation rate on fall-run stocks from this ESU of 65% for the base period brood years (approximately 45% in the ocean and 20% in freshwater).

In this section, NMFS quantitatively evaluates the action-area effects associated with the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions could increase annual population growth rates such that survival and recovery are likely.

9.7.2.5.1 Populations Evaluated

NMFS quantitatively evaluated 20 spawning aggregations below Bonneville Dam. Adequate information was not available for similar analyses for spawning aggregations above Bonneville Dam. NMFS has not yet determined which, if any, of the LCR chinook salmon spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the 20 aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

9.7.2.5.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria for the 20 spawning aggregations of LCR chinook salmon. NMFS also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the recovery indicator criterion of lambda ≥1.0 for each aggregation. Details of these estimates are provided in Appendix A.

9.7.2.5.3 Expected Survival Change

NMFS' calculation of the needed survival change (improvement in population growth rate) for the 20 spawning aggregations of LCR chinook salmon referenced above assumes that the life-stage survival rates that influenced the base period adult returns will continue indefinitely. Although structural and operational modifications have been made to Bonneville Dam since 1980, none of the spawning aggregations for which NMFS could perform quantitative analyses passes this project. NMFS was also unable to quantify potential changes in egg-to-smolt or estuary survival that may have resulted from recent or ongoing habitat and hatchery management actions. Instead, in Section 9.7.2.5.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.5.4 Additional Necessary Survival Changes

Table 9.7-10 shows that the RPA is not expected to increase the survival rate of these 20 LCR chinook salmon spawning aggregations, all located below Bonneville Dam; negative median annual population growth rates are expected to continue. Survival improvements needed to meet the survival and recovery indicator criteria range from 3% to 732% (1.03 to 8.32 times the average base period survival rates). For the Lewis and Clark spawning aggregation, improvements of 934% to 1,493% (10.34 to 15.93 times the average base period survival rates) are needed.

Table 9.7-10. Lower Columbia River chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
Aggregations Above Bonneville Dam:										
(insufficient information for analysis)										
Aggregations Below Bonneville Dam:										
Bear Creek	0.73	0.82	1.00	1.00	0.73	0.82	2.14	3.13	1.89	2.83
Big Creek	0.84	0.93	1.00	1.00	0.84	0.93	1.10	1.62	1.31	1.97
Clatskanie	0.80	0.89	1.00	1.00	0.80	0.89	2.93	4.12	1.55	2.32
Cowlitz Tule	0.82	0.92	1.00	1.00	0.82	0.92			1.33	1.99
Elochoman	0.88	0.99	1.00	1.00	0.88	0.99			1.04	1.56
Germany	0.83	0.93	1.00	1.00	0.83	0.93			1.30	1.95
Gnat	0.84	0.94	1.00	1.00	0.84	0.94	2.07	2.95	1.27	1.91
Grays Tule	0.76	0.85	1.00	1.00	0.76	0.85			1.76	2.64
Kalama Spring	0.76	0.85	1.00	1.00	0.76	0.85			1.87	2.80
Kalama	0.89	0.99	1.00	1.00	0.89	0.99			1.06	1.58
Klaskanine	0.80	0.89	1.00	1.00	0.80	0.89	2.30	3.27	1.54	2.30
Lewis R Bright	0.97	0.99	1.00	1.00	0.97	0.99			1.05	1.11
Lewis Spring	0.81	0.91	1.00	1.00	0.81	0.91			1.46	2.20
Lewis, E Fk Tule	0.99	0.99	1.00	1.00	0.99	0.99			1.03	1.03
Lewis and Clark	0.49	0.54	1.00	1.00	0.49	0.54			10.34	15.93
Mill Fall	0.72	0.81	1.00	1.00	0.72	0.81	2.44	3.58	2.19	3.29
Plympton	0.86	0.95	1.00	1.00	0.86	0.95	1.18	1.74	1.21	1.82
Sandy Late	0.98	0.98	1.00	1.00	0.98	0.98	1.00	1.00	1.07	1.09
Skamokawa	0.74	0.82	1.00	1.00	0.74	0.82			2.05	3.08
Youngs	0.84	0.94	1.00	1.00	0.84	0.94	6.73	8.32	1.25	1.88

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

9.7.2.5.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the RPA would meet the survival and recovery indicator criteria. However,

these comments were not specific to, or relevant to, LCR chinook salmon. In fact, this analysis contains assumptions that may make the results overly pessimistic. For example, NMFS assumes that all supplementation programs cease immediately, and that the background survival rate will continue as it has since 1980. These points are addressed in Section 6.3.1.5.

9.7.2.5.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the RPA on survival below Bonneville Dam or changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-10 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for LCR chinook salmon. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival and estuary survival. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. Further, the RPA provides mechanisms for pursuing additional, more intensive actions within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.6 Snake River Steelhead

Evaluation of species-level effects of the RPA requires placing the action-area effects in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of SR steelhead in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. Hydrosystem projects create substantial habitat blockages for this ESU. The major ones are the Hells Canyon Complex on the mainstem Snake River and Dworshak Dam on the North Fork of the Clearwater River. Minor blockages are common throughout the region. Steelhead spawning areas have been degraded by overgrazing, as well as by historical gold dredging and sedimentation due to poor land management. Hatchery fish are widespread and stray to spawn naturally throughout the region. In the 1990s, an average of 86% of adult steelhead passing Lower Granite Dam were of hatchery origin. However, hatchery contribution

to naturally spawning populations varies across the region. Some stocks are dominated by hatchery fish, whereas others are composed of all wild fish.

In this section, NMFS quantitatively evaluates the action-area effects associated with the hydrosystem component of the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

9.7.2.6.1 Populations Evaluated

NMFS evaluated A-run and B-run aggregate groups of SR steelhead (McClure et al. 2000b,c). These analyses are based on Lower Granite Dam counts, with the two groups distinguished by date and/or size. Once past Lower Granite Dam, SR steelhead spawn in tributaries throughout the lower Snake River basin, and it is likely that there are multiple populations within these aggregates. However, populations have not yet been defined according to criteria in McElhany et al. (2000) and spawner data from tributaries are not available. The Idaho Department of Fish and Game, in comments on the July 27, 2000, Draft Biological Opinion, suggested that NMFS should assign lower abundance levels to each aggregate group, to simulate the greater risk of extinction faced by smaller populations that probably exist in the basin. In response, NMFS evaluated the sensitivity of necessary survival changes to steelhead pseudopopulations, defined as 10% of the abundance of the A-run aggregate and 33% of the B-run aggregate abundance (McClure et al. 2000b; Appendix A). These approximations were based on information on spawning distribution contained in Busby et al. (1996) and the 1990 NWPPC subbasin plans (Tucannon River, Salmon River, Grande Ronde River, and Clearwater River plans). Those documents identify the major summer steelhead spawning areas with respect to each ESU. B-run steelhead are believed to return mainly to three general areas (Middle Fork Salmon River, Upper Salmon River, and South Fork Salmon River). Summer steelhead returns classified as A-run appear to be distributed among a wider array of spawning areas throughout the Snake River region.

9.7.2.6.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. NMFS also estimated the change from base period lambda necessary to achieve $\geq$50% likelihood of meeting the lambda $\geq$1.0 (Appendix A) recovery indicator criterion. Details of these estimates are included in Appendix A.

9.7.2.6.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns in the base period will continue

indefinitely. However, in Section 6.3.6.3, NMFS estimates that current survival of the A-run aggregate represents a 33%-to-42% improvement over the average survival rate influencing base period adult returns. NMFS estimated that B-run survival has improved 44% to 54%. These estimates represent a combination of reduced harvest rates, which differ for the two aggregates, and an expectation that juvenile passage survival has changed proportionate to that of SR spring/summer chinook salmon for both stocks. Rationale and methods are described in Section 6.3.6.3 and Appendix A.

Implementing the hydrosystem component of the RPA will proportionally increase adult survival beyond the current level by an additional 3.9%, based on information in Table 9.7-5. The hydrosystem component of the RPA will also increase juvenile survival to below Bonneville Dam, including differential post-Bonneville survival of transported fish (D) of 52% to 58%, by 4.4% (Table 9.7-5). The product of the proportional survival improvements associated with the current conditions, including harvest reductions, and the hydrosystem RPA actions results in an expected survival improvement of 44% to 54% (1.44 to 1.54 times the average base period survival rate) for A-run SR steelhead and 56% to 67% (1.56 to 1.67 times the average base period survival rate) for B-run SR steelhead, as described in Appendix A.

No other quantifiable survival rates changed significantly between the average base period condition and the current condition. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival, estuary survival, and adult survival above Lower Granite Dam that may have resulted from habitat and hatchery management actions, so no change in these survival rates is included in this quantitative analysis. In Section 9.7.2.6.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.6.4 Additional Necessary Survival Changes

Table 9.7-11 shows the effect of the 44% to 54% A-run survival rate increase and the 56% to 67% B-run survival increase expected from the hydrosystem component of the RPA on the future median annual population growth rates. The survival improvement is not sufficient to reduce the declining population trend for SR steelhead. Additional survival improvement ranging from 44% to 333%, depending on assumptions and aggregate run, would be necessary to achieve the recovery indicator criterion of lambda greater than or equal to 1.0.

The effect of the proposed action on the ability to meet the recovery indicator criterion was not affected by the pseudopopulation sensitivity analysis because the pseudopopulations were assumed to have the same abundance trends as the A-run and B-run aggregates. The use of pseudopopulations did increase the risk of extinction, compared with that of the aggregates, but not significantly. For example, the highest estimate of the survival improvement necessary to meet the survival indicator criteria was 152% for the B-run aggregate and 165% for the B-run pseudopopulation (Table 9.7-11). In all cases, it was more difficult to meet the recovery

Table 9.7-11. Snake River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

							Additional Change In Survival Needed to Achieve:			
	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
Spawning Aggregation	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	0.72	0.83	1.50	1.61	0.78	0.91	0.93	1.94	1.58	3.60
A-Run Aggregate	0.74	0.85	1.44	1.54	0.80	0.93	0.85	1.74	1.44	3.14
A-Run Pseudopopulation[9]	0.74	0.85	1.44	1.54	0.80	0.93	0.96	1.93	1.44	3.14
B-Run Aggregate	0.74	0.84	1.56	1.67	0.80	0.90	1.18	2.52	1.92	4.33
B-Run Pseudopopulation[10]	0.74	0.84	1.56	1.67	0.80	0.90	1.25	2.65	1.92	4.33

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low represents SR spring/summer chinook low estimate.
[4] High represents SR spring/summer chinook high estimate.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.
[9] Pseudopopulation is 10% of A-run aggregate abundance
[10] Pseudopopulation is 33% of B-run aggregate abundance

indicator criteria than the survival indicator criteria, so the overall needed survival change was not affected by the use of pseudopopulations.

9.7.2.6.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the RPA's ability to achieve survival and recovery indicator criteria. Substantial comments primarily questioned 1) the estimates of hydrosystem survival associated with the RPA (addressed in Section 6.2), 2) the method of estimating the expected proportional change in the juvenile survival rate from the average associated with base period returns (addressed in Section 6.3.6.3 with one new and one modified method of estimating the expected change for SR spring/summer chinook; the application of that survival change to steelhead was not questioned), 3) the assumption that the effectiveness of hatchery-origin spawners may have been as low as 20% that of wild-origin spawners (addressed in Section 6.3.2.3), and 4) the analytical assumption that all survival changes are achieved instantaneously. This last point is addressed below.

The simple analytical approach used in this biological opinion does assume that all survival changes are instantaneous (McClure et al. 2000c). To the extent that improvements are implemented gradually, the analysis underestimates the survival change that will ultimately be required. The magnitude of the additional change for SR steelhead is unknown. The potential effect of delay on SR steelhead may be inferred from analyses of three chinook salmon ESUs. NMFS evaluated a 10-year delay in implementing the hydrosystem component of the RPA and in achieving any survival improvements in other life stages (Appendix A) for SR spring/summer chinook (Section 9.7.2.1.5), SR fall chinook (Section 9.7.2.2.5), and UCR spring chinook (Section 9.7.2.3.5). These analyses also assumed that there has been no change from average 1980-to-most-recent-year survival as a result of current hydrosystem operations (including those of the PUD projects for UCR spring chinook) and harvest reductions (SR fall chinook), which are already implemented. The results indicated that these pessimistic assumptions would result in a substantially greater necessary survival improvement at the end of 10 years for UCR spring chinook (highest necessary change [178%] increased to 368%). They also indicated that a much smaller effect would occur for SR fall chinook (highest necessary change [44%] increased to 69%). Results for the SR spring/summer chinook index stocks were intermediate. NMFS qualitatively considers possible inferences from these chinook ESUs to SR steelhead in making a jeopardy determination.

This analysis also contains assumptions that may make the results overly pessimistic. Three of these are the analytical assumptions that all spawning aggregates behave as independent populations, that all supplementation programs cease immediately, and that background survival will continue as it has from 1980 to the present. These assumptions are discussed in Section 6.3.6.5.

9.7.2.6.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-11 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for SR steelhead. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival, estuary survival, and prespawning adult survival above Lower Granite Dam. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for

ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. The RPA also provides mechanisms for pursuing additional, more intensive, actions, including possible dam breaching, within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.7 Upper Columbia River Steelhead

Evaluation of species-level effects of the RPA requires placing the action-area effects in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of UCR spring chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. Specifically, Chief Joseph and Grand Coulee dams block substantial portions of the historical spawning range. Habitat problems are largely related to irrigation diversions and hydroelectric dams, as well as degraded riparian and instream habitat from urbanization and livestock grazing. Hatchery fish are widespread and escape to spawn naturally throughout the region. The relative contribution of these hatchery spawners to natural production rates is unknown.

In this section, NMFS quantitatively evaluates the action-area effects associated with the hydrosystem component of the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

9.7.2.7.1 Populations Evaluated

Ford et al. (1999) identified at least three populations comprising this ESU: the Wenatchee River population, the Methow River population, and the Entiat River population. Ford et al. (1999) identified interim recovery goals for each population and included the criterion that all three must meet these goals for delisting. Steelhead spawner estimates are available only from dam counts, so Cooney (2000) evaluated the Methow River population based on Wells Dam counts and evaluated the combined Wenatchee River and Entiat River populations based on differences between Rock Island and Wells Dam counts. McClure et al. (2000b,c) analyzed the aggregate ESU based on Rock Island Dam counts.

9.7.2.7.2 Necessary Survival Change

McClure et al. (2000b,c) and Cooney (2000) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. Cooney (2000) also estimated the change from base period lambda necessary to achieve $\geq$50%

likelihood of meeting the Methow and combined Wenatchee/Entiat population interim recovery abundance levels (Ford et al. 1999) in 48 and 100 years. NMFS (Appendix A) estimated the survival change necessary to meet the alternative recovery indicator criterion of lambda $\geq$ 1.0 for the aggregate run, using lambda estimates from McClure et al. (2000b) and methods described in Appendix A. The CRI analytical approach (McClure et al. 2000c) and the QAR analytical approach (Cooney 2000) produce different estimates of necessary survival changes for these populations. NMFS considers both approaches to have advantages and disadvantages and uses results from both to define a range of necessary survival change.

9.7.2.7.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from base period will continue indefinitely. However, the Basinwide Recovery Strategy identifies implementation of the Mid-Columbia HCP at five PUD projects as a probable element of recovery planning that is, therefore, included in the analysis, consistent with step 4 of the jeopardy analysis framework described in Section 1.3. The Basinwide Recovery Strategy estimates that this action will be implemented within 2 to 5 years. Cooney (2000, Table 20) estimates that implementation of the HCP will improve survival 23% for the Wenatchee population, 33% for the Entiat population, and 38% for the Methow population.

In addition, in Section 6.3.7.3, NMFS estimates that current FCRPS hydrosystem survival, combined with implementation of the Mid-Columbia HCP and harvest reductions, represents a 12%-to-43% improvement over the average survival rate influencing base period adult returns. The range represents different effects of the HCP on each population and a range of estimates of the historical differential post-Bonneville survival (D = 0.8 to D = 1.0) in years when fish were transported from McNary Dam. Implementing the hydrosystem component of the RPA will proportionally increase adult survival through the FCRPS projects beyond the current level by an additional 1.6%, based on information in Table 9.7-5. The hydrosystem component of the RPA is also expected to proportionally increase juvenile survival to below Bonneville Dam by 15.2% (Table 9.7-5; Appendix A). The product of the proportional survival improvements associated with the current conditions, implementation of the HCP, and implementation of the hydrosystem RPA results in an expected survival improvement of 31% to 68% (1.31 to 1.68 times the average base period survival rate), as described in Appendix A.

No other quantifiable survival rates changed significantly between the average base period and the current condition. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival (other than those associated with the HCP; Cooney 2000), estuary survival, and adult survival above the upper dam that may have resulted from habitat and hatchery management actions, so no change in these survival rates is included in this quantitative analysis. In Section 9.7.2.7.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.7.4 Additional Necessary Survival Changes

Table 9.7-12 shows the effect of the 31%-to-68% survival rate increase expected from the hydrosystem component of the RPA on the future median annual population growth rates for the Methow and Wenatchee/Entiat populations and the aggregate ESU. Because different methods were used to estimate the population requirements and the aggregate ESU requirements, differences may be a result of either the analytical method or the scale of the analysis. Low estimates of the population growth rate indicate that it will continue to be negative after HCP implementation and continuation of the proposed action. High estimates indicate, however, that the Methow River and Wenatchee/Entiat River population growth rate will be positive. No additional survival improvements are necessary for Methow and Wenatchee/Entiat populations under the most optimistic estimates. For all other cases, however, additional survival improvements ranging from 26% to 193% (1.26 to 2.93 times the average base period survival rate) will be necessary to meet the recovery indicator criteria.

Table 9.7-12. Upper Columbia River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

							Additional Change In Survival Needed to Achieve:			
	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
Spawning Aggregation	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
UCR Steelhead Aggregate - CRI	0.69	0.83	1.39	1.59	0.75	0.94	1.02	2.36	1.26	2.93
Methow - QAR	0.81	0.97	1.48	1.68	0.90	1.11	0.69	1.46	0.92	2.10
Wenatchee/Entiat - QAR[9]	0.85	0.94	1.31	1.49	0.91	1.04	0.75	1.27	1.00	1.67

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low represents an estimate of juvenile survival improvement based on assumption of historical D=0.8 from McNary Dam .
[4] High represents an estimate of juvenile survival improvement based on assumption of historical D=1.0 from McNary Dam.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.
[9] Expected survival change is based on the Wenatchee estimate of HCP survival increase (Cooney 2000 Table 20). Entiat estimate from same source is higher.

9.7.2.7.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate

of the proposed action's ability to achieve survival and recovery indicator criteria. Most comments were not specific to, or in some cases relevant to, UCR steelhead. However, three comments of particular relevance were that NMFS should not assume that the Mid-Columbia HCP will be implemented and achieve its survival goals within the time described in the Basinwide Recovery Strategy; that the analysis is overly optimistic because it assumes that all survival changes are achieved instantaneously; and that the analysis is overly optimistic because NMFS rejected the assumption of 80% effectiveness of hatchery-origin natural spawners. As described in Section 6.3.6.5, NMFS considers the full range of hatchery spawner effectiveness in this biological opinion.

The first comment applies to implementation of the proposed Mid-Columbia HCP. CRITFC believes that anticipated HCP survival rates will not be achieved at all five PUD dams for at least 10 years because long-term gas-abatement projects are needed to achieve the necessary spill levels. NMFS agrees that there is some uncertainty about the exact schedule for achieving all survival improvements anticipated in the HCP, but the proposed HCP for the Chelan and Douglas PUDs and the draft EIS anticipate that the survival improvements will be achieved by the end of Phase I (2003). If this does not occur, it is reasonable to anticipate additional changes under the terms of the proposed HCP.

Regardless of the exact implementation schedule, the analysis described above does assume that HCP and hydrosystem RPA survival improvements are achieved immediately. NMFS conducted a sensitivity analysis on the effect of a 10-year delay in implementing *any* survival improvements over the base period average survival rate for UCR spring chinook (Section 6.3.3.5; Appendix C). Under this worst-case scenario, the CRI estimate of necessary survival change for the Wenatchee population increased significantly from the estimate that assumed immediate implementation. This extreme scenario is unlikely, since some improvements associated with the HCP have already been achieved, but NMFS considers the implications of delayed implementation qualitatively in reaching jeopardy conclusions for this ESU.

This analysis contains assumptions that may make the results overly pessimistic. Two such assumptions are that all supplementation programs cease immediately and that background survival will continue as it has since 1980. These assumptions are discussed in Section 6.3.7.5.

9.7.2.7.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management, other than effects anticipated in the HCP. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-12 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for Upper Columbia River steelhead. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival, estuary survival, and prespawning adult survival above the upper-most dam for each population. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. Further, the RPA provides mechanisms for pursuing additional, more intensive, actions, including possible dam breaching, within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.8 Middle Columbia River Steelhead

Evaluation of species-level effects of the RPA requires placing the action-area effects in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of SR spring/summer chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include timber harvest (altered riparian vegetation, unstable streambanks, and decreased habitat complexity), agricultural practices (channelization and loss of riparian vegetation), road construction, and urban and industrial development. Pelton Dam on the Deschutes River blocks access to historical spawning areas, and there are numerous minor blockages from smaller dams and impassable culverts throughout the region. In addition, the genetic integrity of the ESU is threatened by past and present hatchery practices. Hatchery fish are widespread and escape to spawn naturally throughout the region, so that adults of hatchery origin make up a substantial portion of the spawning population in several basins (e.g., the Umatilla and Deschutes rivers).

In this section, NMFS evaluates the action-area effects associated with the hydrosystem component of the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

9.7.2.8.1 Populations Evaluated

NMFS evaluated four spawning aggregations of MCR steelhead. The Yakima River aggregation passes through four FCRPS projects, the Umatilla River aggregation passes through three

FCRPS projects, and the Deschutes River and Warm Springs aggregations pass through two FCRPS projects. NMFS has not yet determined which, if any, of these spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the four aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

9.7.2.8.2 Necessary Survival Change

McClure et al. (2000b) described changes from the 1980-to-1994 (Yakima and Warm Springs) or 1980-to-1986 (Deschutes and Umatilla) median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. NMFS also estimated the change from the 1980-to-1994/1996 lambda necessary to meet the recovery indicator criterion of lambda $\geq$1.0. Details of these estimates are found in Appendix A.

9.7.2.8.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns in the base period will continue indefinitely. However, in Section 6.3.8.3, NMFS estimates that current survival of the Yakima River spawning aggregation represents a -9% to +4% improvement from the average survival rate influencing 1980-to-1994 adult returns. NMFS estimated a 14% increase for the Umatilla spawning aggregation and a 7% increase for the Deschutes and Warm Springs spawning aggregations. These estimates represent a combination of reduced harvest rates, which NMFS assumes equal to the SR A-run steelhead harvest reductions, and increased juvenile passage survival. Rationale and methods are described in Section 6.3.8.3 and Appendix A.

Implementing the hydrosystem component of the RPA will proportionally increase adult survival beyond the current level by an additional 1.7% to 3.%%, depending on the number of FCRPS dams each spawning aggregate passes (Table 9.7-5). The hydrosystem component of the RPA will also increase juvenile survival to below Bonneville Dam by 11.7% to 15.2%, depending on the number of dams passed (Table 9.7-5). The product of the proportional survival improvements associated with the current conditions, including harvest reductions, and the hydrosystem RPA actions results in an expected survival improvement of 9% to 24% (1.09 to 1.24 times the average 1980-to-1994 survival rate) for the Yakima stock; 33% (1.33 times the average 1980-to-1996 survival rate) for the Umatilla stock; and 22% (1.22 times the average base period survival rate) for the Deschutes and Warm Springs stocks, as described in Appendix A.

No other quantifiable survival rates changed significantly between the average base period and the current condition. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival, estuary survival, and adult survival above the upper dam that may have resulted from habitat and hatchery management actions, so no change in these survival rates is included in this quantitative analysis. In Section 9.7.2.8.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.8.4 Additional Necessary Survival Changes

Table 9.7-13 shows the effect of the 9% to 33% survival rate change expected from the hydrosystem component of the RPA on the future median annual population growth rates for the four MCR steelhead spawning aggregations in this analysis. Population growth rates are expected to be negative for all aggregations except the Yakima River aggregation (lambda is 1.03 to 1.08). Additional survival changes of 31% to 226% (1.31 to 3.26 times the base period average survival rates) are necessary to meet recovery indicator criteria for the Deschutes, Warm Springs, and Umatilla spawning aggregations. No additional improvement is needed for the Yakima River aggregation to meet the survival and recovery indicator criteria.

Table 9.7-13. Mid-Columbia River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

							Additional Change In Survival Needed to Achieve:			
	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
Spawning Aggregation	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	0.77	0.84	1.21	1.25	0.80	0.88	N/A	N/A	1.92	3.18
Deschutes R Sum	0.77	0.84	1.22	1.22	0.80	0.87	1.28	2.06	2.02	3.26
Warm Springs NFH Sum	0.91	0.91	1.22	1.22	0.94	0.94	1.16	1.19	1.36	1.36
Umatilla R Sum	0.90	0.90	1.33	1.33	0.95	0.95	0.88	0.86	1.31	1.27
Yakima R Sum	1.01	1.04	1.09	1.24	1.03	1.08	0.81	0.92	0.67	0.85

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low for Yakima R. represents an estimate of juvenile survival improvement based on assumption of historical D=0.8 from McNary Dam.
[4] High for Yakima R. represents an estimate of juvenile survival improvement based on assumption of historical D=1.0 from McNary Dam.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

9.7.2.8.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. Most comments were not specific to, or in some cases relevant to, MCR steelhead. However, two comments of particular relevance were that the analysis is overly optimistic because it assumes that all survival changes are achieved instantaneously, and that the analysis is overly optimistic because NMFS rejected the assumption of 80% effectiveness of hatchery-origin natural

spawners. As described in Section 6.3.8.5, NMFS considers the full range of hatchery spawner effectiveness in this biological opinion.

The simple analytical approach used in this biological opinion assumes that all survival changes are instantaneous (McClure et al. 2000c). To the extent that improvements are implemented gradually, the analysis underestimates the survival change that will ultimately be required. The magnitude of the additional change for MCR steelhead is unknown. The potential effect of delay on MCR steelhead may be inferred from analyses of three chinook salmon ESUs. NMFS evaluated a 10-year delay in implementing the hydrosystem component of the RPA and in achieving any survival improvements in other life stages (Appendix A) for SR spring/summer chinook (Section 9.7.2.1.5), SR fall chinook (Section 9.7.2.2.5), and UCR spring chinook (Section 9.7.2.3.5). The analyses also assumed that there has been no change from average-1980 to most-recent-year survival as a result of current hydrosystem operations (including those of the PUD projects for UCR spring chinook) and harvest reductions (SR fall chinook), which are already implemented. The results indicated that these pessimistic assumptions would result in a substantially greater necessary survival improvement at the end of 10 years for UCR spring chinook (highest necessary change [178%] increases to 368%). They also indicated that a much smaller effect would occur for SR fall chinook (highest necessary change [44%] increased to 69%). Results for the SR spring/summer chinook index stocks were intermediate. NMFS qualitatively considers possible inferences from these chinook ESUs to MCR steelhead in making a jeopardy determination.

This analysis also contains assumptions that may make the results overly pessimistic. Three of these are the analytical assumptions that all spawning aggregates behave as independent populations; that all supplementation programs cease immediately; and that background survival will continue as it has from 1980 to the present. These assumptions are discussed in Section 6.3.8.5.

9.7.2.8.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-13 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for MCR steelhead. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival, estuary

survival, and prespawning adult survival above the upper dam passed by each stock. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with those expected of other Federal and non-Federal entities will achieve necessary survival improvements. Further, the RPA provides mechanisms for pursuing additional, more intensive, actions, including possible dam breaching, within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.9 Upper Willamette River Steelhead

Evaluation of the species-level effects of the RPA requires placing the action-area effects of the RPA in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of UWR steelhead in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include the loss of habitat due to inundation or blockages resulting from the construction of numerous tributary hydroelectric and irrigation facilities; and habitat degradation due to timber harvest, development (agricultural, municipal, and industrial), dam development, and river channelization and dredging. Many of these activities result in poor water quality, high sediment loads, altered thermal regimes, and a large reduction in available spawning and rearing habitat. Overharvest and hatchery production have also contributed to the decline of this ESU.

In this section, NMFS quantitatively evaluates the action-area effects associated with the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions could increase annual population growth rates such that survival and recovery are likely.

9.7.2.9.1 Populations Evaluated

NMFS quantitatively evaluated four spawning aggregations: the Molalla, North Santiam, South Santiam, and Calapooia river populations. NMFS has not yet determined which, if any, of the UWR steelhead spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the four aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

9.7.2.9.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria for the four spawning aggregations. NMFS also estimated the change from base period lambda necessary to achieve

≥50% likelihood of meeting the recovery indicator criterion of lambda ≥1.0 for each aggregation. Details of these estimates are provided in Appendix A.

9.7.2.9.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for UWR steelhead, referenced above, assumes that the life-stage survival rates that influenced the base period adult returns will continue indefinitely. NMFS cannot identify any significant changes in survival rates under the RPA compared to those that influenced the base period adult returns because survival changes due to implementing the RPA can be quantified only for species that migrate past mainstem dams (which excludes UWR steelhead). NMFS was also unable to quantify potential changes in egg-to-smolt survival, estuary survival, or adult survival that may have resulted from recent or ongoing habitat and hatchery management actions. Instead, in Section 9.7.2.9.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.9.4 Additional Necessary Survival Changes

Table 9.7-14 shows that the RPA is not expected to increase the population survival rate; negative median annual population growth rates are expected to continue for each of the four UWR steelhead spawning aggregations. Survival improvements needed to meet the recovery indicator criteria range from 30% to 108% (1.30 to 2.08 times the average base period survival rates).

9.7.2.9.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the RPA would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, UWR steelhead. In fact, this analysis contains assumptions that may make the results overly pessimistic. For example, NMFS assumes that all supplementation programs cease immediately and that the background survival rate will continue as it has since 1980. These points are addressed in Section 6.3.1.5.

9.7.2.9.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the RPA on survival below Bonneville Dam, or changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-14 are likely to be achieved through recent or anticipated future actions that affect other life stages.

Table 9.7-14. Upper Willamette River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

							Additional Change In Survival Needed to Achieve:			
	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
Spawning Aggregation	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	0.88	0.92	1.00	1.00	0.88	0.92	1.13	1.39	1.37	1.69
Molalla	0.84	0.91	1.00	1.00	0.84	0.91	1.34	1.96	1.45	2.08
N Santiam R	0.89	0.92	1.00	1.00	0.89	0.92	1.20	1.34	1.42	1.58
S Santiam	0.87	0.94	1.00	1.00	0.87	0.94	1.06	1.50	1.30	1.78
Calapooia	0.93	0.93	1.00	1.00	0.93	0.93	1.53	1.53	1.36	1.36

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for UWR steelhead. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above Willamette Falls). Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.10 Lower Columbia River Steelhead

Evaluation of the species-level effects of the RPA requires placing the action-area effects of the RPA in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of LCR steelhead in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include timber harvest (altered riparian vegetation, unstable streambanks, and decreased habitat complexity), agricultural practices (channelization

and loss of riparian vegetation), road construction, and urban and industrial development. Upstream passage is blocked by dams on the Lewis, Clackamas, Sandy, and Hood rivers, and there are minor blockages (such as impassable culverts) throughout the region. Mudflows from the eruption of Mt. St. Helens (1980) significantly disrupted and degraded habitat in the South Fork Toutle and Green rivers, as did post-eruption dredging, diking, and bank protection works in the Cowlitz River below its confluence with the Toutle River. In addition, the genetic integrity of the ESU is threatened by past and present hatchery practices. Each year, hatcheries release approximately 3 million steelhead smolts in basins occupied by the ESU (Busby et al. 1996). In many basins, hatchery strays compose most of the spawning population.

In this section, NMFS quantitatively evaluates the action-area effects associated with the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions could increase annual population growth rates such that survival and recovery are likely.

9.7.2.10.1 Populations Evaluated

NMFS quantitatively evaluated seven spawning aggregations below Bonneville Dam. Adequate information was not available for similar analyses for spawning aggregations above Bonneville Dam. NMFS has not yet determined which, if any, of the LCR steelhead spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the seven aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

9.7.2.10.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rates (lambda) that are necessary to meet the survival indicator criteria for the seven subbasin spawning aggregations. NMFS also estimated the change from the base period lambda necessary to achieve $\geq$50% likelihood of meeting the recovery indicator criterion of lambda $\geq$1.0 for each aggregation. Details of these estimates are provided in Appendix A.

9.7.2.10.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for the seven spawning aggregations of LCR steelhead, referenced above, assumes that the life-stage survival rates that influenced the base period adult returns for winter steelhead in the Clackamas, Green, Kalama, Sandy, and Toutle rivers will continue indefinitely. Adult harvest rates for summer steelhead in the Clackamas and Kalama subbasins have changed, however. NMFS assumes that the size of the change from the average rate over the base period is similar to that estimated for other summer-run steelhead in the Columbia basin. The A-run harvest rate reduction resulted in a survival increase of 7.2% for SR steelhead (Section 6.3.6.3).

Although structural and operational modifications have been made to Bonneville Dam since 1980, none of the spawning aggregations for which NMFS could perform quantitative analyses pass this project. NMFS was also unable to quantify potential changes in egg-to-smolt or estuary survival that may have resulted from recent or ongoing habitat and hatchery management actions. Instead, in Section 9.7.2.10.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.10.4 Additional Necessary Survival Changes

Table 9.7-15 shows that the RPA is expected to increase the survival rate of two of the LCR steelhead spawning aggregations because of harvest rate reductions. Negative median annual population growth rates are expected to continue for all seven aggregations, however. Survival improvements needed to meet the survival and recovery indicator criteria range from 13% to 376% (1.13 to 4.76 times the average base period survival rates).

Table 9.7-15. Lower Columbia River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

							Additional Change In Survival Needed to Achieve:			
	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
Spawning Aggregation	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	0.80	0.91	1.00	1.00	0.80	0.91	N/A	N/A	1.53	2.71
Aggregations Above Bonneville Dam:										
(insufficient information for analysis)										
Aggregations Below Bonneville Dam:										
Clackamas Sum	0.73	0.83	1.07	1.07	0.74	0.84	1.75	3.34	2.44	4.76
Clackamas Win	0.76	0.88	1.00	1.00	0.76	0.88	1.35	2.57	1.75	3.43
Green River Win	0.90	0.90	1.00	1.00	0.90	0.90	1.80	1.80	1.58	1.58
Kalama Sum	0.77	0.91	1.07	1.07	0.78	0.92	1.09	2.50	1.51	3.67
Kalama River Win	0.90	0.97	1.00	1.00	0.90	0.97	1.00	1.14	1.13	1.58
Sandy Win	0.85	0.91	1.00	1.00	0.85	0.91	1.19	1.63	1.49	2.08
Toutle Win	0.88	0.88	1.00	1.00	0.88	0.88	1.30	1.30	1.81	1.81

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

9.7.2.10.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the RPA would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, LCR steelhead. In fact, this analysis contains assumptions that may make the results overly pessimistic. For example, NMFS assumes that all supplementation programs cease immediately, and that the background survival rate will continue as it has since 1980. These points are addressed in Section 6.3.1.5.

9.7.2.10.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the RPA on survival below Bonneville Dam or changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-15 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for LCR steelhead. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival and estuary survival. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.11 Columbia River Chum Salmon

Evaluation of the species-level effects of the RPA requires placing the action-area effects of the RPA in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of CR chum salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include water withdrawals, conveyance, storage, and flood control, resulting in insufficient flows, stranding, juvenile entrainment, and instream temperature increases; logging and agriculture (loss of large woody debris, sedimentation, loss of riparian vegetation, and habitat simplification); mining (especially gravel removal, dredging, and pollution); urbanization (stream channelization, increased runoff, pollution, and habitat simplification); development of many small hydropower facilities in lower river areas; passage

mortality at Bonneville Dam; and substantial habitat loss in the Columbia River estuary and associated areas.

In this section, NMFS quantitatively evaluates the action-area effects associated with the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions could increase annual population growth rates such that survival and recovery are likely.

9.7.2.11.1 Populations Evaluated

NMFS quantitatively evaluated six spawning aggregations below Bonneville Dam. NMFS has not yet determined which, if any, of the CR chum salmon spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the six aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

9.7.2.11.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria for the six spawning aggregations. NMFS also estimated the change from base period lambda necessary to achieve $\geq$50% likelihood of meeting the recovery indicator criterion of lambda $\geq$1.0 for each aggregation. Details of these estimates are provided in Appendix A.

9.7.2.11.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for CR chum salmon, referenced above, assumes that the life-stage survival rates that influenced the base period adult returns will continue indefinitely. Although structural and operational modifications have been made to Bonneville Dam since 1980, none of the spawning aggregations for which NMFS could perform quantitative analyses passes this project. NMFS was also unable to quantify potential changes in egg-to-smolt or estuary survival that may have resulted from recent or ongoing habitat management actions. Instead, in Section 9.7.2.11.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.11.4 Additional Necessary Survival Changes

Table 9.7-16 shows that the RPA is not expected to increase spawning aggregation survival rates. Negative median annual population growth rates are expected to continue for two of the CR chum salmon spawning aggregations (mainstem Grays River and Hamilton Creek). An additional survival improvement of from 18% to 36% (1.18 to 1.36 times the average base period survival rates) is needed to meet the recovery indicator criteria for these two spawning aggregations.

Table 9.7-16. Columbia River chum salmon estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	1.04	1.04	1.00	1.00	1.04	1.04	N/A	N/A	0.88	0.88
Aggregations Above Bonneville Dam:										
(insufficient information for analysis)										
Aggregations Below Bonneville Dam:										
Grays R west fork	1.23	1.23	1.00	1.00	1.23	1.23	N/A	N/A	0.47	0.47
Grays R mouth to head	0.96	0.96	1.00	1.00	0.96	0.96	N/A	N/A	1.18	1.18
Hardy Creek	1.05	1.05	1.00	1.00	1.05	1.05	N/A	N/A	0.85	0.85
Crazy Johnson	1.16	1.16	1.00	1.00	1.16	1.16	N/A	N/A	0.59	0.59
Hamilton	0.92	0.92	1.00	1.00	0.92	0.92	N/A	N/A	1.36	1.36
Hamilton Springs	1.11	1.11	1.00	1.00	1.11	1.11	N/A	N/A	0.68	0.68

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

9.7.2.11.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations comments that NMFS' analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the RPA would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, CR chum salmon. In fact, this analysis contains an assumption that may make the results overly pessimistic. For example, NMFS assumes that the background survival rate will continue as it has since 1980. This point was addressed in Section 6.3.1.5.

9.7.2.11.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the RPA on survival below Bonneville Dam or changes in survival in other life stages that result from habitat management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-16 are likely to

be achieved through recent or anticipated future actions that affect other life stages. NMFS was also unable to quantify potential changes in egg-to-smolt or estuary survival that may have resulted from recent or ongoing habitat management actions. Instead, in Section 9.7.2.11.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for CR chum salmon. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival and estuary survival. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. Further, the RPA provides mechanisms for pursuing additional, more intensive actions within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.12 Snake River Sockeye Salmon

Evaluation of the species-level effects of the RPA requires placing the action-area effects of the RPA in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of SR sockeye salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include tributary hydropower and irrigation storage projects that block or restrict fish passage, water withdrawals that dewater streams, and unscreened diversions.

Because the abundance of SR sockeye salmon is extremely low, the risk of extinction cannot be calculated using the methods that NMFS employs in this biological opinion. However, the risk is undoubtedly very high. Other factors that affect elements of critical habitat also contribute to this ESU's high risk of extinction (summarized in Section 4.1 and Appendix C), but the FCRPS is a significant factor. The high risk of extinction is partially mitigated by a captive breeding program, funded by the Action Agencies, which provides some assurance that SR sockeye salmon will not go extinct in the immediate future. However, long-term survival and recovery in the wild require substantial increases in survival throughout the life cycle.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for SR sockeye salmon. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. Further, the RPA calls for mechanisms for pursuing additional, more intensive actions, including possible dam breaching, within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.13 Summary—Effects of RPA on Biological Requirements Over Full Life Cycle

The ESU-specific analyses in Sections 9.7.2.1 through 9.7.2.12 include both quantitative and qualitative assessments.[1] The quantitative analyses show that recent survival changes continued into the future, plus additional survival changes expected to result from implementation of the RPA, will increase the likelihood of meeting the survival and recovery indicator criteria for stocks that pass through one or more FCRPS projects. Summer steelhead stocks throughout the basin, including two of the spawning aggregations in the LCR steelhead ESU, will also benefit from the recent harvest reduction for A-run steelhead in the Snake River basin. However, for all ESUs, many stocks will need additional survival improvements beyond those expected from the RPA. For most ESUs, the additional improvements range from a few percentage points to two orders of magnitude (Table 9.7-17).[2] For LCR chinook salmon spawning in the Lewis and Clark River, a survival improvement of over 1,000 times is needed.

NMFS' qualitative assessment considers the extent to which the RPA affects the capacity of critical habitat to provide biological requirements for listed fish. As described in Sections 4, 5, and 6, a number of factors affect current population trends of Columbia River basin salmonids. The hydro actions in the RPA address mortality in the action area. Actions in habitat, harvest, and hatcheries address human-caused factors that limit survival and recovery elsewhere in the life cycle. For example, habitat actions include protecting productive habitat, restoring tributary flows, screening and combining water diversions, reducing passage obstructions, and improving or restoring degraded habitat (Table 9.7-18). The Federal agencies will focus these near-term actions on priority subbasins for each ESU. Hatchery reforms expected to reduce adverse interactions with wild fish include developing new, local broodstocks (and eliminating inappropriate broodstocks) and managing the number of hatchery fish allowed to spawn

[1] Quantitative assessments are not possible for SR sockeye salmon.

[2] Critical assumptions that influence results for each ESU are discussed in the preceding sections.

Table 9.7-17. Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA. Low and High estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change			
Spawning Aggregation	**Low**	**High**		
Snake River Spring/Summer Chinook				
Aggregate ESU	46	89		
Index Stocks				
Bear Valley/Elk Creeks	0	0		
Imnaha River	26	66		
Johnson Creek	0	0		
Marsh Creek	0	12		
Minam River	0	28		
Poverty Flats	0	0		
Sulphur Creek	0	5		
Additional Spawning Aggregations				
Alturas Lake Ck	168	186	*	Based only on Lambda ≥ 1.0
American R	11	19	*	Based only on Lambda ≥ 1.0
Big Sheep Ck	29	58	*	Based only on Lambda ≥ 1.0
Beaver Cr	0	0	*	Based only on Lambda ≥ 1.0
Bushy Fork	0	0	*	Based only on Lambda ≥ 1.0
Camas Cr	4	11	*	Based only on Lambda ≥ 1.0
Cape Horn Cr	0	0	*	Based only on Lambda ≥ 1.0
Catherine Ck	50	131	*	Based only on Lambda ≥ 1.0
Catherine Ck N Fk	4	12	*	Based only on Lambda ≥ 1.0
Catherine Ck S Fk	101	114	*	Based only on Lambda ≥ 1.0
Crooked Fork	0	0	*	Based only on Lambda ≥ 1.0
Grande Ronde R	58	142	*	Based only on Lambda ≥ 1.0
Knapp Cr	22	30	*	Based only on Lambda ≥ 1.0
Lake Cr	0	0	*	Based only on Lambda ≥ 1.0
Lemhi R	0	0	*	Based only on Lambda ≥ 1.0
Lookingglass Ck	102	225	*	Based only on Lambda ≥ 1.1
Loon Ck	0	0	*	Based only on Lambda ≥ 1.0
Lostine Ck	15	44	*	Based only on Lambda ≥ 1.0
Lower Salmon R	7	14	*	Based only on Lambda ≥ 1.0
Lower Valley Ck	3	10	*	Based only on Lambda ≥ 1.0
Moose Ck	0	0	*	Based only on Lambda ≥ 1.0
Newsome Ck	0	0	*	Based only on Lambda ≥ 1.0

Table 9.7-17 (Continued). Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA. Low and High estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change			
Spawning Aggregation	Low	High		
Red R	10	18	*	Based only on Lambda ≥ 1.0
Salmon R E Fk	0	2	*	Based only on Lambda ≥ 1.0
Salmon R S Fk	0	0	*	Based only on Lambda ≥ 1.0
Secesh R	0	0	*	Based only on Lambda ≥ 1.0
Selway R	8	15	*	Based only on Lambda ≥ 1.0
Sheep Cr	97	110	*	Based only on Lambda ≥ 1.0
Upper Big Ck	0	0	*	Based only on Lambda ≥ 1.0
Upper Salmon R	13	21	*	Based only on Lambda ≥ 1.0
Upper Valley Ck	0	0	*	Based only on Lambda ≥ 1.0
Wallowa Ck	42	51	*	Based only on Lambda ≥ 1.0
Wenaha R	14	66	*	Based only on Lambda ≥ 1.0
Whitecap Ck	14	22	*	Based only on Lambda ≥ 1.0
Yankee Fork	26	35	*	Based only on Lambda ≥ 1.0
Yankee West Fk	0	0	*	Based only on Lambda ≥ 1.0
Snake River Fall Chinook				
Aggregate	0	44		
Upper Columbia River Spring Chinook				
ESU Aggregate - CRI	32	58		
Methow River-QAR	24	41		
Entiat River-QAR	36	55		
Wenatchee R.-QAR	51	116		
Methow River-CRI	32	90		
Entiat River-CRI	32	119		
Wenatchee R.-CRI	84	178		
Upper Willamette River Chinook				
McKenzie River above Leaburg Dam	9	65		

Table 9.7-17 (Continued). Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA. Low and High estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change		
Spawning Aggregation	**Low**	**High**	
Lower Columbia River Chinook			
Aggregations Above Bonneville Dam:			
(Insufficient information for analysis)			
Aggregations Below Bonneville Dam:			
Bear Creek	114	213	
Big Creek	31	97	
Clatskanie	193	312	
Cowlitz Tule	33	99	* Based only on recovery metric.
Elochoman	4	56	* Based only on recovery metric.
Germany	30	95	* Based only on recovery metric.
Gnat	107	195	
Grays Tule	76	164	* Based only on recovery metric.
Kalama Spring	87	180	* Based only on recovery metric.
Kalama	6	58	* Based only on recovery metric.
Klaskanine	130	227	
Lewis R Bright	5	11	* Based only on recovery metric.
Lewis Spring	46	120	* Based only on recovery metric.
Lewis, E Fk Tule	3	3	* Based only on recovery metric.
Lewis and Clark	934	1,493	
Mill Fall	144	258	
Plympton	21	82	
Sandy Late	7	9	
Skamokawa	105	208	* Based only on recovery metric.
Youngs	573	732	
Snake River Steelhead			
ESU Aggregate	58	260	
A-Run Aggregate	44	214	
A-Run Pseudopopulation	44	214	
B-Run Aggregate	92	333	
B-Run Pseudopopulation	92	333	

Table 9.7-17 (Continued). Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA. Low and High estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change		
Spawning Aggregation	**Low**	**High**	
Upper Columbia River Steelhead			
ESU Aggregate - CRI	26	193	
Methow - QAR	0	110	
Wenatchee/Entiat - QAR	0	67	
Mid-Columbia River Steelhead			
ESU Aggregate	92	218	* Based only on recovery metric.
Deschutes R Sum	102	226	
Warm Springs NFH Sum	36	36	
Umatilla R Sum	31	27	
Yakima R Sum	0	0	
Upper Willamette River Steelhead			
ESU Aggregate	37	69	
Molalla	45	108	
N Santiam R	42	58	
S Santiam	30	78	
Calapooia	53	53	
Lower Columbia River Steelhead			
ESU Aggregate	53	171	* Based only on recovery metric.
Aggregations Above Bonneville Dam:			
(Insufficient information for analysis)			
Aggregations Below Bonneville Dam:			
Clackamas Sum	144	376	
Clackamas Win	75	243	
Green River Win	80	80	
Kalama Sum	51	267	
Kalama River Win	13	58	

Table 9.7-17 (Continued). Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA. Low and High estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change		
Spawning Aggregation	**Low**	**High**	
Sandy Win	49	108	
Toutle Win	81	81	
Columbia River Chum Salmon			
ESU Aggregate	0	0	* Based only on recovery metric.
Aggregations Above Bonneville Dam:			
(Insufficient information for analysis)			
Aggregations Below Bonneville Dam:			
Grays R west fork	0	0	
Grays R mouth to head	18	18	
Hardy Creek	0	0	
Crazy Johnson	0	0	
Hamilton	36	36	
Hamilton Springs	0	0	

naturally. The harvest actions will cap harvest rates at current levels, allowing time for other recovery measures to take effect.

Each set of actions is expected to benefit Columbia basin salmonids, although measures that address hydrosystem passage will clearly benefit the upper river chinook salmon and steelhead ESUs, SR sockeye salmon, and MCR steelhead more than the lower river ESUs. In the short term, benefits to the lower river ESUs will result primarily from the habitat, harvest, and hatchery actions. In the long term, ongoing studies may link the effects of FCRPS flow management to elements of critical habitat in the estuary and plume. These studies may lead to additional hydro actions (i.e., through comprehensive 5- and 8-year check-ins [Sections 9.1.5 and 9.5]) that provide high survival benefits to all 12 ESUs.

Table 9.7-18. Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
SR spring/summer chinook	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**Inriver migrants:** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~9% due to passage improvements at 8 FCRPS projects** **- Expected 10% reduction in reservoir mortality due to predator control actions and reduced delay** **- Potential for reduced delayed mortality due to FCRPS passage** **Transported fish:** **- Potential for reduced delayed mortality** *- Hatchery reforms may reduce adverse interactions with wild fish*	**- Potential habitat degradation in the plume** *- Hatchery reforms may reduce adverse interactions with wild fish* *- Potential reduction in incidental take to reduce ocean harvest*	**- Expected 6% increase in survival during passage through 8 FCRPS projects** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Potential indirect improvement in spawning rate success** *- Potential reduction in incidental take to reduce mainstem harvest*	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*

Table 9.7-18 (Continued). Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
SR fall chinook	**<u>Inriver</u> migrants:** **- Flows and water quality (temperature) improve during summer and early fall in the Snake River due to additional cold water releases from Dworshak Reservoir** **- Inriver survival increases by ~5% due to passage improvements at 8 FCRPS projects** **- Expected 10% reduction in reservoir mortality due to predator control actions and increased summer flows** **- Potential for reduced delayed mortality due to FCRPS passage** **<u>Transported</u> fish:** **-Improved transportation due to extended barging** **-Potential for reduced delayed mortality** *- Hatchery reforms may reduce adverse interactions with wild fish*		*- Acquire, protect, and restore high quality estuarine habitat* *- Hatchery reforms may reduce adverse interactions with wild fish* *- Potential reduction in incidental take to reduce ocean harvest*	**-Expected 11% increase in survival during passage through 8 FCRPS projects** **- Water quality (temperature) improves during summer and early fall in the Snake River due to additional cold water releases from Dworshak Reservoir** **- Potential indirect improvement in spawning rate success** *- Potential reduction in incidental take to reduce mainstem harvest*	**- Unknown effects of flow management on use of spawning habitat below Lower Granite, Little Goose, and Ice Harbor dams** *In the lower Snake mainstem:* *- Protect productive habitat* *- Address flow and passage problems* *- Improve/restore degraded habitat* *- Hatchery reforms may reduce adverse interactions with wild fish*

Table 9.7-18 (Continued). Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
UCR spring chinook	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~9% due to passage improvements at 4 FCRPS projects** **- Expected 10% reduction in reservoir mortality due to predator control actions and reduced delay** **- Potential for reduced delayed mortality due to FCRPS passage** - Mortality due to passage past up to 5 PUD projects *- Hatchery reforms may reduce adverse interactions with wild fish*	**- Potential habitat degradation in the plume** *- Hatchery reforms may reduce adverse interactions with wild fish*	**- Expected 3% increase in survival during passage through 4 FCRPS projects** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Potential indirect improvement in spawning rate success** - Mortality due to passage past up to 5 PUD projects *- Potential reduction in incidental take to reduce mainstem harvest*	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*
UWR chinook	*In the McKenzie subbasin:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill**	*- Acquire, protect, and restore high quality estuarine habitat* *- Hatchery reforms may reduce adverse interactions with wild fish* *- Potential reduction in incidental take to reduce ocean harvest*	*In the McKenzie subbasin:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	*In the McKenzie subbasin:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*

Table 9.7-18 (Continued). Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
LCR chinook	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~5% due to passage past Bonneville Dam for a limited number of subbasin populations**	*- Acquire, protect, and restore high quality estuarine habitat* *- Hatchery reforms may reduce adverse interactions with wild fish*	**- Expected 1-2% increase in survival during passage past Bonneville Dam for a limited number of subbasin populations** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill**	**- Access to and quantity and quality of habitat at Ives Island restricted by FCRPS flows** *In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*

Table 9.7-18 (Continued). Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offisite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Development	Adult Migration Corridor	Spawning Habitat
SR steelhead	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**Inriver migrants:** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~9% due to passage improvements at 8 FCRPS projects** **- Expected 10% reduction in reservoir mortality due to predator control actions and reduced delay** **- Potential for reduced delayed mortality due to FCRPS passage** **Transported fish:** **- Potential for reduced delayed mortality** *- Hatchery reforms may reduce adverse interactions with wild fish*	**- Potential habitat degradation in the plume**	**- Expected 5-6% increase in survival during passage through 8 FCRPS projects** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Potential indirect improvement in spawning rate success** *- Potential reduction in incidental take to reduce mainstem harvest*	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*

Table 9.7-18 (Continued). Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
UCR steelhead	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~9% due to passage improvements at 4 FCRPS projects** **- Expected 10% reduction in reservoir mortality due to predator control actions and reduced delay** **- Potential for reduced delayed mortality due to FCRPS passage** - Mortality due to passage past up to 5 PUD projects *- Hatchery reforms may reduce adverse interactions with wild fish*	**- Potential habitat degradation in the plume**	**- Expected 3% increase in survival during passage through 4 FCRPS projects** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Potential indirect improvement in spawning rate success** - Mortality due to passage past up to 5 PUD projects *- Potential reduction in incidental take to reduce mainstem harvest*	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*

Table 9.7-18 (Continued). Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
MCR steelhead	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~9% due to passage improvements at 4 FCRPS projects** **- Expected 10% reduction in reservoir mortality due to predator control actions and reduced delay** **- Potential for reduced delayed mortality due to FCRPS passage**	**- Potential habitat degradation in the plume**	**- Expected 3% increase in survival during passage through 4 FCRPS projects** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Potential indirect improvement in spawning rate success** *- Potential reduction in incidental take to reduce mainstem harvest*	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*
UWR steelhead	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** *- Hatchery reforms may reduce adverse interactions with wild fish*	*- Acquire, protect, and restore high quality estuarine habitat* *- Hatchery reforms may reduce adverse interactions with wild fish*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** *- Potential reduction in incidental take to reduce mainstem harvest*	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*

Table 9.7-18 (Continued). Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
LCR steelhead	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~4% due to passage improvements at Bonneville Dam for a limited number of subbasin populations**	**- Potential habitat degradation in the plume** *- Hatchery reforms may reduce adverse interactions with wild fish*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Expected 1% increase in survival during passage past Bonneville Dam for a limited number of subbasin populations** *- Potential reduction in incidental take to reduce mainstem harvest*	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*
CR chum	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~5% due to passage past Bonneville Dam for a limited number of subbasin populations**	*- Acquire, protect, and restore high quality estuarine habitat*	**- Expected 1-2% increase in survival during passage past Bonneville Dam for a limited number of subbasin populations** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** *- Potential reduction in incidental take to reduce mainstem harvest*	**- Access to Hamilton Creek and Spring Channel improved by FCRPS flows** **- Access to, quantity of, and quality of habitat at Ives Island restricted by FCRPS flows** *In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*

Table 9.7-18 (Continued). Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
SR sockeye	N/A	**Inriver migrants:** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Survival increase due to passage improvements at 8 FCRPS projects** **- Expected 10% reduction in reservoir mortality due to predator control actions** **- Potential for reduced delayed mortality due to FCRPS passage** **Transported fish:** **- Potential for reduced delayed mortality**	**- Potential habitat degradation in the plume**	**- Expected ~1% increase in survival during passage through 8 FCRPS projects** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** *- Potential reduction in incidental take to reduce mainstem harvest*	N/A

9.7.3 Evaluation of Snake River Four-Dam Breach in Comparison to the RPA

Sections 9.7.1 and 9.7.2 reviewed the action-area and species-level effects of the hydrosystem components of the RPA, given concurrent expectations of survival in other life stages resulting from a continuation of current harvest rates and implementation of the Mid-Columbia HCP. For several ESUs, significant additional changes in survival are necessary, beyond those expected from implementation of the hydrosystem components of the RPA. Effects of expected improvements in other parts of the life cycle that were not captured in Section 9.7.1 are described in the Basinwide Recovery Strategy and are summarized in Section 9.7.2. The qualitative results of these sections suggest that a significant portion of the needed additional survival changes is likely to be achieved through ongoing federal activities and implementation of the off-site mitigation component of the RPA.

Regional debate in recent years has focused on the advisability of breaching four Snake River dams as an alternative to hydrosystem operations similar to those described in the RPA. This section provides an analysis of the effects of this action, to place the effects of the RPA in the context of the primary alternative option that has been discussed within the region.

This analysis is presented, in part, to demonstrate the effects of critical uncertainties on the estimated survival changes associated with breaching four Snake River dams. It is presented to support the possible future need to implement dam breaching following 5- and 10-year reviews (Section 9.5) of species' status, effectiveness of RPA measures, and new research results that may resolve some of the key uncertainties associated with effectiveness of breaching. This analysis supports the elements of the RPA that may require continued engineering and other preparations for possible future breaching.

9.7.3.1 Effects of Snake River Four-Dam Breach on Action Area Biological Requirements

In its report "Return to the River," the Independent Scientific Group (ISG 1996) calls for the reestablishment of "normative" ecosystem features of the Columbia and Snake rivers and tributaries that are essential to salmon restoration. The term "normative" describes a condition that provides "essential ecological conditions and processes needed to maintain diverse and productive salmonid populations." The ISG characterizes the normative river as a continuum of conditions ranging from slightly better than current at one end of the spectrum to nearly pristine on the other. The ISG asserts that only by approaching more normative ecosystem conditions would recovery goals for salmonids be attained. Moreover, sustained productivity will require a network of complex and interconnected habitats that are created, altered, and maintained by natural physical processes in freshwater, the estuary, and the ocean (ISG 1996).

Natural river drawdown of the four Federal hydroprojects on the lower Snake River could reestablish a continuum of riverine habitat. Drawdown to natural river level of the four lower Snake River reservoirs is expected to improve conditions for both juveniles and adults of some

salmonid species by exposing more of the shoreline and allowing the river to redistribute gravel and nutrients, thereby restoring spawning, rearing, and feeding habitat. It is also expected to increase the connectivity of channel, groundwater, floodplain, and upland components of the catchment ecosystem and create more diverse, high-quality habitat, which is crucial for salmonid spawning, rearing, migration, maintenance of food webs, and predator avoidance (ISG 1996).

9.7.3.1.1 Dam Passage Survival During Removal and Transition Periods. The Corps has developed a tentative schedule for breaching the four lower Snake River dams (Corps 1999c [feasibility report/EIS and Appendix D]). After receiving congressional authorization, the Corps estimates that the project would be completed in 8 or 9 years, with drawdown of Lower Granite and Little Goose reservoirs in year 5 or year 6, and drawdown of Lower Monumental and Ice Harbor reservoirs in the following year. During this 2-year removal period, each of the four reservoirs would be drawn down to natural river level during the months of August through December. The Corps predicts a 3- to 8-year transition period after drawdown is complete, during which major changes in the riverine environment — such as sediment scour and redeposition and the redistribution of predators — would stabilize. During the transition period, mortality rates of juvenile and adult salmon and steelhead may be affected by these factors, as well as deviation from normal operations at the dams. For example, normal operations would not be possible during transition from full pool to riverine conditions (August to December). Turbines would operate at less than maximum efficiency, spill conditions would be altered, and transportation of fish would not be possible. All of these conditions could increase mortality of fall chinook and sockeye outmigrating during the 2-year removal period.

Under the Corps' drawdown plan in the draft feasibility report/EIS, turbines would be modified before the 2-year removal period so that they could be operated under the unusual low-head conditions for primary discharge while the reservoirs are lowered. As a result, up to 3 units per project would not be available during part of the preceding spring spill season, and the reduced powerhouse capacity could result in increased spill and potentially undesirable TDG levels in the river downstream. NMFS expects that these effects, if they occur, would be transitory and would most likely occur during May (Table 9.7-19).[3] Effects of elevated TDG could be severe if flows are unusually high while the powerhouse is running under reduced capacity.

[3] The analysis shown in Table 9.7-19 suggests that the Corps should schedule turbine retrofits such that work is completed by April 1 of each year, to minimize potential TDG problems.

Table 9.7-19. Estimated safe discharge[1] and probability of involuntary occurrence of flows exceeding this level under existing project capacities and under project capacities estimated to exist while the three low-capacity turbines are being replaced at each lower Snake River project.

	Current Conditions				Replacement-year Conditions			
	Total Safe Discharge	Probability of Exceedence (%)			Total Safe Discharge	Probability of Exceedence (%)		
Project	(kcfs)	April	May	June	(kcfs)	April	May	June
Lower Granite	178.8	0	2	2	126	8	25	27
Little Goose	162.3	4	6	8	110.4	22	41	33
Lower Monumental	162.7	4	6	8	105.1	29	45	21
Ice Harbor	198.9	0	0	2	161.4	4	8	8

[1] Safe discharge is the discharge that would result in 120% TDG downstream from each project assuming maximum powerhouse capacity and known project TDG characteristics.

Removal and Transition Period Effects on Juvenile Salmon. During the removal period, conditions at the dams (i.e., at juvenile bypass systems) would be outside the criteria of systems designed to improve the passage survival of migrating juvenile salmon and steelhead. By scheduling the dam breaching process between August and December, when relatively few juveniles are passing the projects, the Corps would minimize potential adverse effects on most Snake River ESUs. Some juvenile fall chinook salmon, those rearing or overwintering in the reservoirs, could become stranded in pools when the reservoir elevations are reduced. These potential short-term and transitory adverse effects are difficult to quantify but could affect two year-classes.

Removal and Transition Period Effects on Adult Salmon. Three factors could influence the success of adult salmon and steelhead migration during the removal period and early in the transition period: suspended sediment concentrations, passage around breach and shoreline protection structures, and access into tributaries.

Suspended sediment concentrations would be elevated during drawdown (August through December work period) and then, with decreasing intensity, during subsequent spring freshets (April through June) for several years (the transition period). During removal operations, high concentrations of suspended sediment may cause increased delays and straying of fall migrants (fall chinook salmon and steelhead). Also, spring and summer chinook salmon could be delayed or could be caused to stray by turbidity events during subsequent spring freshets.

Upstream passage facilities at the dams would be inoperable during the fall/winter periods when dams are breached. This period encompasses most of the fall chinook and steelhead migrations. Specific actions would be implemented to ensure that adult fish move upstream. Under the current two-tiered, two-dam removal plan, the Corps recommends that adult fish be transported by truck around the construction reaches. Adults would probably be collected at Ice Harbor and Little Goose dams, respectively, during the two removal periods. Separating Lyons Ferry or

Tucannon River adults from adults destined for tributaries above Lower Granite would be of concern to NMFS during this trap and haul operation.

Adult movement past the former dam sites would probably not be impeded during the transition period or thereafter. Under current conditions in the lower Snake River, adults typically stop migrating when flows reach 170,000 cfs. Flows of this magnitude are expected to occur only for a brief period once every 5 years on average (Corps 1999c). The Corps would develop the breach areas around each dam such that river velocities up to the 170,000 cfs flow level would not impede adult passage. The following Corps' criteria for adult passage through the new channels are based on published information about fish behavior and modeled velocity conditions in the breach area (Corps 1999c [Appendix D]):

- Channel velocities below 1.5 meters per second (m/s) (5 feet per second [ft/s]) require no supplemental fish passage features.

- Higher channel velocities require features in the river that provide rest areas.

- As velocities increase above 1.5 m/s, the density of required rest areas increases.

The Corps will use model studies to determine the extent of appropriate rest structure layout during the next stage of the design process (Corps 1999c [Appendix D]).

In summary, NMFS finds that the greatest potential risk of reduced survival of juvenile and adult salmon and steelhead would occur during and immediately after the 2-year dam removal period. Risk would decrease each subsequent year as environmental conditions stabilize. The SR fall chinook salmon ESU appears to be most vulnerable to drawdown effects because at least part of both the juvenile and adult migration periods coincides with the August to December drawdown period. The risk to adults would be reduced by the Corps' planned trap-and-haul operation, but subsequent indirect effects of this operation are unknown. NMFS concludes that there is not sufficient information currently available to quantify these risks. If the Corps obtains congressional authorization to breach the lower Snake River dams, NMFS would recommend that the Corps develop detailed operations and demolition plans for the projects and consult with NMFS and USFWS on those plans.

9.7.3.1.2 Effects of Breaching on Sedimentation and Fluvial Geomorphology. Over time, breaching the four lower Snake River dams would restore riverine conditions to what is currently a series of impounded reservoirs. Rivers exist in dynamic equilibrium with the environmental forces that form them, including the hydrologic regime, underlying geology, and sediment supply. Whereas other multipurpose developments (e.g., flood control and irrigation) upstream from Lower Granite Dam have somewhat changed the hydrologic regime in the lower Snake River, sediment yields and channel-forming flows appear to be little changed (Corps 1999c

[Appendix H]).[4] These observations, combined with the fact that the lower Snake River is confined within a basalt gorge, lead NMFS to conclude that, following dam removal, a river greatly resembling the pre-dam Snake River would emerge. The rate at which this likely outcome would occur would depend on sediment transport and thus on river discharge and channel form, properties that are difficult to forecast with precision. The Corps predicts that the bulk of the morphological changes would occur during the first decade after dam removal, as sediment deltas in the reservoirs erode (Corps 1999c [Appendix H]).

Estimates of the amount of sediment stored in reservoirs upstream from Ice Harbor Dam range from 100 to 150 million cubic yards (Corps 1999c [Appendix H]), with the majority stored in Lower Granite Reservoir (72 to 96 million cubic yards). About half this stored sediment would be transported out of the Snake River basin within the first few years following breaching (Corps 1999c [Appendix H]). Much of the accumulated sediment that would remain currently covers areas that would become uplands after dam removal, where the erosive forces of the river would become slight to nonexistent. These deposits would be recolonized and stabilized by vegetation and could become relatively permanent features on the landscape. Sediments stored in the active channel would mobilize and be redeposited in accordance with their size relative to the erosive energy of the stream. Sand and finer particles would be readily mobilized and either move as a bedload or become suspended in the water column and move as part of the river's suspended sediment load. These small particles would be deposited in relatively quiescent areas, primarily along the river's shoreline, or would be transported through the Snake River to the Columbia River confluence and beyond. Gravel and larger particles would move primarily as bedload and be sorted and deposited in accordance with local conditions (shear stress). Large particles are the most difficult to move and would tend to dominate the fastest water as smaller particles were washed away. Bedload transport would virtually stop at Lake Wallula (Columbia River confluence), and a substantial sediment deposit would form along the shoreline downstream from the Snake River confluence and other quiescent and backwater areas between the confluence and McNary Dam (Corps 1999c, Appendix H). These deposits are expected to be 3 feet deep or less.

Erosion of the sediment body presently located in Lower Granite Reservoir would be severe near the face of the existing sediment delta (between RM 110 and RM 122). A single channel would rapidly emerge as the particles at its base were transported away and the channel rapidly cut upstream. This downcutting would leave portions of the sediment body perched above the active channel, forming steep banks. Subsequent high flows that fill the channel would flatten the banks. These effects would probably occur within 1 or 2 years of dam removal, assuming near-normal streamflow conditions. Due to the large sediment supply, the channel in and immediately downstream from this sediment body would be subject to the greatest changes in bedform, including tendencies to form islands and large bars.

After dam breaching, the annual sediment yield upstream from Lower Granite Dam would pass unimpeded through the lower river, replenishing gravels and adding to turbidity events. This

[4] Channel bedform changes almost continually over a wide range of discharges. However, as the product of the probability of occurrence and the channel-forming forces exerted, bank full discharge (or the 1.5- to 2-year return period flood) is generally accepted to represent the dominant channel-forming flow.

would add about 3 to 4 million cubic yards to the river's sediment load (Corps 1999c [Appendix H]). These effects would be permanent.

Suspended sediment concentrations in the lower Snake and Columbia rivers would also increase after breaching, as demonstrated during the 1992 partial drawdown test in Lower Granite Reservoir. Suspended sediment concentrations increased from a background level of 9.5 parts per million (ppm) to a high reading of 1,928 ppm. However, the highest concentrations occurred soon after drawdown and declined rapidly; most measurements were lower than 510 ppm (USFWS 1999). The Corps estimates that concentrations as high as 9,000 mg/l might occur immediately following breaching at Ice Harbor Dam (Corps 1999c).

Suspended sediment concentrations would be highest during the first few years following dam breaching and the exposure of the sediment body to the erosive force of the river. Annual peaks would occur immediately after breaching and drawdown operations (August to December) and then again during the spring freshet (April through June). This seasonal flushing would continue several years after removal, but with decreasing intensity (Corps 1999c).

Suspended sediment concentrations would increase permanently as upstream suspended sediment loads pass through the river. It is anticipated that within a decade after dam breaching operations were complete, suspended sediment loads in the affected reach would approximate incoming loads from the upper basin (Corps 1999c, Appendix H).

Effects of Sedimentation and Changes in Fluvial Geomorphology on Juvenile Survival. The expected increase in suspended sediment concentrations following dam breaching (between 2,000 and 9,000 milligrams per liter (mg/l) during part of the spring freshet), in each of several years after breaching could affect juvenile salmonid survival. Salmon and steelhead smolts are known to survive suspended sediment concentrations as high as 20,000 mg/l (Sigler et al. 1984). However, some researchers have observed juvenile salmon mortalities at suspended sediment concentrations as low as 500 mg/l (Waters 1995). Thus, some direct mortality of migrating juveniles is likely during peak suspended sediment events (corresponding with the rising limb of the spring freshet hydrograph). However, such effects would be transitory (a few weeks) and would only affect a fraction of several subsequent juvenile migrations. While the Corps has analyzed the chemical characteristics of some sediment cores, NMFS expects that a much more thorough sampling effort would be carried out before drawdown to ensure that resuspended sediments are not toxic or deleterious to aquatic life.

Given that increasing turbidity reduces the capture efficiencies of visually-oriented predators like smallmouth bass, northern pikeminnows, gulls, and terns (NMFS 2000f), predation rates would probably be reduced by post-drawdown increases in suspended sediment concentrations. However, this effect could be offset somewhat by an increased predator density (at least temporarily) following dam removal, as the assemblage of fishes now occupying the reservoirs vies to occupy smaller volumes of suitable habitat (Corps 1999c).

Effects of Sedimentation and Changes in Fluvial Geomorphology on Spawning Habitat. Two potential biological effects of the morphological changes likely to occur following breaching are increased spawning habitat in the mainstem Snake River, and passage barriers at tributary mouths.

In the short term, breaching activities would disrupt tailrace spawning habitat for fall chinook that currently occurs below Lower Granite and Little Goose dams. At the same time, new spawning habitat would emerge.

In the rapid erosion zone (RM 110 to RM 122) there is some risk that established redds would be subsequently scoured, buried, or dewatered as the channel form changes in the first few years following dam removal. Because few fish are expected to use this habitat during the breaching and transition period, such potential adverse effects are expected to be minor and short-term.

Mainstem spawning habitat would reemerge between RM 10 (the current site of Ice Harbor) to RM 140 (upper end of Lower Granite Reservoir) and would probably be enhanced by a plentiful sediment supply for decades following dam breaching. The Corps (1999c [Appendix H]) estimated that suitable fall chinook spawning habitat in the lower Snake River could increase from 226 acres under current conditions to 3,521 acres following breaching, an almost 16-fold increase. Although this would be a substantial increase in fall chinook spawning habitat, at the current depressed numbers of spawning adults, available spawning habitat is not limiting the population.

Currently accessible tributary habitat may become inaccessible due to the exposure of large sediment fans at the tributary mouths. During 30-plus years of impoundment, sediment has accumulated and formed deltas where tributaries enter the lower Snake River reservoirs. Following drawdown, these deltas would impede upstream fish passage until the streams move sediment back into the original riverbed or the sediment is moved by mechanical means. Schuck (1992) observed a large deposit of sediment at the mouth of Alpowa Creek during the 1992 Lower Granite Reservoir drawdown test and noted a vertical bedform at the mouth of this stream that would have been impassable to steelhead. Tributary sediment deltas are expected to erode rapidly, but human intervention may be necessary to ensure access to all suitable spawning habitat.

9.7.3.1.3 Estimated Juvenile Survival Following Transition Period. After a natural channel configuration has developed in the 210-km reach and riparian vegetation has become established, NMFS expects that juvenile survival rates will approximate the rates observed in free-flowing reaches above the head of Lower Granite pool. Estimates of survival from the Salmon River trap at Whitebird to Lower Granite Dam are available for wild spring chinook salmon during 1966 through 1968 (Raymond 1979) and for wild spring/chinook salmon and steelhead during 1993 through 1998 (Smith et al. 1998; Hockersmith et al. 1999; Smith et al. 2000). The estimates for both periods include survival through Lower Granite Reservoir. Those for the recent period also include survival past Lower Granite Dam. Using the methods described in Appendix A to factor

out the reservoir and dam mortality, NMFS calculates an average per-km survival rate through the free-flowing stretch of 0.999689614 per km for spring chinook and 0.999656 per km for steelhead. Interannual variation was high (Appendix A). The average estimates can be expanded to survival through the entire 210-km reach, resulting in a mean reach survival of 92.2% for SR spring/summer chinook salmon and 93.0% for steelhead (Table 9.7-19). These estimates compare to a range of 85% to 95% estimated by the PATH team (Marmorek et al. 1998). The PATH estimates ranged from historical Whitebird trap estimates (95%) to combined Whitebird and Imnaha trap estimates for the period 1993 through 1996 (85%).

NMFS did not incorporate the Imnaha trap or other Salmon River traps into the estimates. Traps in the Salmon River above Whitebird were not used in estimates for the following reasons:

- The estimates are already captured in the Whitebird to Lower Granite estimate, because it includes fish from all of the tributaries caught at the upstream traps.

- The Whitebird estimate is through a river reach that is more similar to the reach below Lower Granite Dam (in terms of river width and depth and flow characteristics) than are the reaches further up in the tributaries. The Imnaha trap is in a tributary habitat that is more dissimilar to the reach below Lower Granite Dam than is the Whitebird trap.

- The upstream traps are closer to spawning areas, so survival rates from those traps probably represent a culling process that would be greater than that included in the survival rate below Whitebird. To elaborate, culling may result from size, degree of smoltification, or river stretches through which the smolts migrated. These stretches are likely to be more dissimilar among Lower Granite and tributary smolts than among Lower Granite and Whitebird smolts. Imnaha trap estimates were not used because the trap is closer to the spawning grounds than is the Whitebird trap.

To test the hypothesis that survival is lower in reaches closer to spawning grounds than in reaches farther downstream, survival of Whitebird and Imnaha releases was compared in the reach between each trap and Lower Granite Dam and in two reaches below Lower Granite Dam (Appendix A). Survival between the Imnaha trap and Lower Granite Dam, expressed as a per-km rate, was much lower than between the Whitebird trap and Lower Granite Dam, whereas survival estimates for the two traps were nearly identical when compared between Lower Granite Dam and Little Goose Dam, and between Little Goose Dam and Lower Monumental Dam. This suggests that after initial losses of fish occur, there are no inherent differences in smolt survival between stocks released at Imnaha and Whitebird. Thus, the Whitebird trap provides the best estimates of expected survival in downstream stretches of natural river.

The estimates of survival through the breached section of the Snake River can be combined with estimates of survival through the four lower Columbia River projects to derive an estimate of system survival after the drawdown transition period has passed. Estimates of SR spring/summer chinook survival through the four lower Columbia River projects are shown in

Table 9.7-1.[5] Inriver survival from McNary to Bonneville dams would average 66.4%. When survival through the free-flowing reach in the lower Snake River is combined with survival through the impounded reach in the lower Columbia River, system survival of SR spring/summer chinook salmon is expected to average 61.2% (Table 9.7-20). Using a similar method (and data shown in Table 9.7-1) for steelhead, system survival for juveniles from this ESU is expected to average 63% (Table 9.7-20).

Table 9.7-20. Estimates of juvenile survival for three Snake River ESUs following a transition period after breaching four Snake River dams.

ESU	Avg Survival/Km Through Free-Flowing Reach	Survival Through 210-km Reach After 4-Dam Breach	Lower River (MCN to BON) Survival	Total System Survival After 4-Dam Breach
SR spr/sum chinook salmon	99.9614%	92.2%	66.4%	61.2%
SR fall chinook				
Method A	99.78%	63.0%	37.7%	23.8%
Method B	99.95%	90.0%	37.7%	34.0%
SR Steelhead	99.9656%	93.0%	67.7%	63.0%

Empirical estimates of free-flowing reach survival for juvenile SR fall chinook salmon is more limited and difficult to interpret. The PATH participants used two methods to group and extrapolate recent PIT-tag survival estimates (Peters et al. 1999). The first (hereafter called Method A) results in a free-flowing survival rate of 0.9978 per km, and the second (Method B) in a rate of 0.9995 per km. NMFS finds that both methods are credible and that there is no basis for concluding that one better represents the best available scientific information than the other. Therefore, NMFS uses both methods and establishes a range of likely survival estimates. When expanded to the 210-km reach, Method A estimates an average survival of 63.0% versus 90.0% for Method B (Table 9.7-20). Using a method similar to that applied to SR spring/summer chinook salmon, and the data shown in Table 9.7-1 for the survival of fall chinook salmon through the lower Columbia reach, the system survival of juvenile Snake River fall chinook is expected to average 23.8% with Method A and 34% with Method B (Table 9.7-20).

NMFS has not estimated the survival of juvenile Snake River sockeye salmon through free-flowing river reaches or through the four lower Columbia River projects under the RPA. Based on the similar size and migration timing of juvenile sockeye salmon, yearling chinook salmon, and steelhead, it is likely that a four-dam breach will result in Snake River sockeye survival that is similar to that estimated for the other two spring migrating ESUs (approximately 60%, on

[5] NMFS assumes that juvenile fish would not be transported from McNary Dam if the Snake River dams are breached.

average). Breaching four dams in the Snake River will not change the estimates of juvenile survival for ESUs spawning outside of the Snake River basin, so NMFS applies the juvenile survival rates associated with the RPA.

9.7.3.1.4 Estimated Adult Survival Following Transition Period. After a natural channel configuration has developed in the 210-km reach and riparian vegetation has become established, NMFS expects that adult survival rates through the lower Snake River will approximate the rates observed in free-flowing reaches above the head of Lower Granite pool.

The PATH participants estimated free-flowing survival of wild SR spring/summer chinook salmon by applying the absolute difference in Bjornn's (1989) mean dam-count to redd-count ratios at Ice Harbor Dam for two periods, 1962 through 1968 and 1975 through 1988 (Marmorek et al. 1998). Ice Harbor was the furthest upstream hydroproject during the first period. The difference between the mean ratios for each period estimates the effect of the three dams that were constructed above Ice Harbor during the latter period (1975 through 1988). Extrapolating Bjornn's result over all four dams, the estimate of survival of adult spring/summer chinook salmon traversing the post-drawdown reach between the current location of the tailrace of Ice Harbor Dam and the head of Lower Granite pool would be 97% (i.e., 99% per-project). This method assumes that survival from the current location of the head of Lower Granite pool to the various spawning areas did not change between the two periods. In applying this method, NMFS assumes that survival through the four-dam lower Snake reach, as currently configured and operated, is equivalent to survival through that reach during the 1975 through 1988 period. In fact, recent reach survival studies indicate survival rates have improved with changes in FCRPS configuration and operations (NMFS 2000e), suggesting that this method may overestimate survival through a free-flowing lower Snake River reach if the dams were removed.

An alternative method is to evaluate the survival of radio-tagged adults through free-flowing reaches above Lower Granite Dam, in a manner similar to that used to estimate juvenile survival. Bjornn et al. (1995) estimated adult loss of spring chinook salmon from Ice Harbor Dam to reference points in tributaries to the Snake River above Lower Granite Dam. NMFS estimated survival from Ice Harbor to Lower Granite and adjusted total survival rates to derive estimates of survival through the free-flowing reach, using methods documented in Table 6.1-1. The resulting survival rate was 0.994 per km, equal to 88.2% (97% per-project) survival through the 210-km reach that would be affected by breaching four lower Snake River dams. In using this approach, NMFS made numerous assumptions to adjust the original empirical estimates of adult loss. NMFS also assumed that any delayed effects of passing eight dams before entering the free-flowing reach above Lower Granite Dam would be equivalent to the delayed effects of passing only four dams following breaching.

This second method may underestimate survival of adults through free-flowing river sections. In addition to consideration of the assumptions described above, comparison of the estimate of survival generated by the second method with estimates of survival under current conditions (Table 6.1-7) indicates that this method predicts lower adult survival under free-flowing

conditions (88.2%) than under impounded conditions (0.976^4 = 90.8%). Although adults travel through impounded sections of the Snake River at approximately the same speed as they travel through free-flowing reaches (e.g., Bjornn et al. 1998, NMFS 2000e), it is not clear that survival rates through impounded and unimpounded reaches are equivalent.

NMFS considers the best estimate of adult spring/summer chinook survival following breaching to be intermediate to estimates derived from the two methods described above. The survival rate expected to result from the RPA represents survival through an impounded reach with all possible improvements short of breaching. The estimate of adult survival, when the RPA is fully implemented, is 98% per project, intermediate to the survival rate estimated by the first and second methods (97% and 99% per project, respectively). Using the preferred method, expected survival of adult SR spring/summer chinook through the FCRPS, without breaching, is 85.5% (Table 9.7-2).

One advantage of the method used for estimating the survival of SR spring/summer chinook salmon is that it is directly applicable to other ESUs, whereas the other two methods are not. Therefore, estimates of adult survival for all ESUs are as described in Table 9.7-2. The expected survival rates are 74% for SR fall chinook salmon, 80.3% for steelhead, and 88.7% for SR sockeye salmon.

9.7.3.2 Analysis of Effects of Snake River Four-Dam Breach on Biological Requirements Over Full Life Cycle

Quantitative analyses were possible for three of the four Snake River ESUs that would be affected by breaching Snake River dams. Details of the analyses used to evaluate the effects of the proposed action on biological requirements over the full life cycle are described in Appendix A. Specifics of the analyses for each ESU are nearly identical to those described in Section 6.2.1. Results are summarized for the three Snake River ESUs in the following sections.

9.7.3.2.1 Snake River Spring/Summer Chinook Salmon

NMFS evaluated the same populations and used the same general approach as that described in Section 9.7.2.1. The necessary improvements in survival from average base period conditions were also as described in Section 9.7.2.1.

A key uncertainty associated with dam breaching is the effect that it will have on survival below Bonneville Dam (e.g., Marmorek and Peters 1998, Peters et al. 1999, Kareiva et al. 2000). Although it is likely that some actions called for by the RPA will improve fish conditions and survival below Bonneville Dam, NMFS conservatively assumed that there would be no effect of the proposed action (Section 6.3.1) or of the RPA (Section 9.7.2.1) on post-Bonneville survival, compared to average post-Bonneville survival during 1980 to 1999. That is, NMFS considered both the differential survival of transported fish (compared to nontransported fish; D) and the

post-Bonneville delayed mortality of nontransported fish (EM hereafter) to be unchanged from the base period to the future under the proposed action and RPA.

In contrast, NMFS considered three alternatives for future post-Bonneville survival after breaching four Snake River dams. In each alternative, the differential post-Bonneville survival of transported fish is eliminated following breaching because NMFS assumes that transportation would cease. The alternatives apply different assumptions regarding the change in delayed mortality of nontransported fish following breaching.

In one alternative, NMFS assumed that delayed mortality of nontransported fish does not change after four Snake River dams are breached. With this alternative, the current estimate of EM is not important, since the calculated change in survival resulting from breaching will be the same whether EM is believed to be 0% or 74%. This alternative corresponds to two of the three PATH extra mortality hypotheses, which ascribe this mortality to causes other than the hydrosystem (Section 6.2.3.3).

In the second alternative, NMFS assumes that average 1980 to 1999 EM is between 71% (when coupled with D = 0.73) and 74% (when coupled with D = 0.63). This represents the PATH estimate of hydrosystem-caused, post-Bonneville mortality, when all extra mortality is believed to be caused by the hydrosystem. The estimate of 71% to 74% delayed mortality of nontransported fish represents the upper end of the range NMFS considered in this analysis (Section 6.2.3.3). This second alternative assumes that approximately half of this mortality is eliminated when four of the eight Snake River dams are breached, which corresponds to PATH's Hydro Hypothesis (Marmorek and Peters 1998; Wilson 2000).

The third alternative is identical to the second, except that it assumes that 100% of the delayed mortality of nontransported fish is eliminated. This assumption was included in the July 27, 2000, Draft Biological Opinion and incorrectly ascribed to the PATH Hydro Hypothesis (Wilson 2000). NMFS retains it because several agencies and organizations that commented on the July 27, 2000, Draft Biological Opinion expressed their opinion that this is the most likely assumption. Because all of these assumptions are essentially beliefs, based on little or no direct evidence, inclusion of the full range of opinions demonstrates the range of possible outcomes after breaching.

Details of the methods and results for each approach are included in Appendix A. A summary follows.

<u>No Change in Delayed Mortality of Nontransported Juveniles After Breaching</u>

NMFS estimated mean juvenile passage survival to Bonneville Dam during the base period, including differential post-Bonneville survival of transported fish (D=0.63 to D=0.73), using the two methods described in Section 6.3.1.3 and applied in Section 9.7.2.1. Although this first approach is not sensitive to assumptions regarding delayed mortality of nontransported fish, the

assumption of 70% to 74% EM was applied to facilitate comparison with the other approaches. This resulted in a range of 11% to 13% juvenile survival. Juvenile survival to Bonneville following breaching was estimated at 61.2%, as described in Section 9.7.3.1.3 (Table 9.7-20). When the 70% to 74% delayed mortality assumption is applied to the survival to Bonneville, 16.8% juvenile survival is expected after breaching. The result is a 33% to 39% proportional juvenile survival improvement following breaching.

Adult passage survival during the 1980 to 1999 period was 82.5% (Table 9.7-2). Expected survival following breaching is 85.5% (Section 9.7.3.1.4). The result is a 3.7% proportional adult survival improvement following breaching. When the juvenile and adult survival improvements are combined, the overall effect of breaching four Snake River dams is a 38% to 44% proportional improvement (1.38 to 1.44 times average 1980 to 1999 survival).

This expected improvement is sufficient to result in a positive population growth rate under all assumptions considered in this analysis for six of the seven index stocks (Table 9.7-21). The Imnaha River index stock would continue to decline under the lowest estimate of lambda and would be stable under the highest estimate. Additional survival improvements are not required for any of the index stocks under the most optimistic assumptions. Additional improvements ranging from 5% to 56% would be required with the higher estimate of necessary changes.

Delayed Mortality of Nontransported Juveniles is Reduced by Half After Breaching

All aspects of this approach were identical to the first, except for the level of delayed mortality applied to juvenile survival following breaching. Only half of the delayed mortality estimate was applied in this approach, resulting in 39% juvenile survival following breaching. A 220% to 236% proportional survival improvement is associated with breaching under this alternative. Under this assumption, population growth would be positive for all index stocks, and no additional survival changes would be required (Table 9.7-22).

Delayed Mortality of Nontransported Juveniles is Eliminated After Breaching

All aspects of this approach were identical to the first, except for the level of delayed mortality applied to juvenile survival following breaching. No delayed mortality was applied in this approach, resulting in 61.2% juvenile survival following breaching. A 403% to 427% proportional survival improvement is associated with breaching under this approach. Under this assumption, population growth would be positive for all index stocks, and no additional survival changes would be required (Table 9.7-23).

Comparison to PATH

These results are similar to those of PATH (Marmorek et al. 1998, Peters and Marmorek 2000), with respect to the higher likelihood of meeting approximations of the survival and recovery

Table 9.7-21. Snake River spring/summer chinook estimates of current and expected median annual population growth rate (lambda), expected survival change after breaching four dams, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after breaching four dams. This analysis assumes no change in delayed mortality of nontransported fish after breaching four of eight dams.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	0.82	0.91	1.38	1.44	0.88	0.99	1.40	1.46	1.07	1.78
Index Stocks:										
Bear Valley/Elk Creeks	1.02	1.03	1.38	1.44	1.09	1.11	0.48	0.73	0.53	0.84
Imnaha River	0.88	0.92	1.38	1.44	0.95	1.00	0.56	1.09	0.84	1.56
Johnson Creek	1.01	1.03	1.38	1.44	1.09	1.12	0.48	0.73	0.47	0.78
Marsh Creek	0.99	1.00	1.38	1.44	1.06	1.08	0.49	0.83	0.65	1.05
Minam River	0.93	1.02	1.38	1.44	1.01	1.11	0.48	1.06	0.56	1.20
Poverty Flats	0.99	1.02	1.38	1.44	1.07	1.12	0.48	0.73	0.49	0.84
Sulphur Creek	1.04	1.05	1.38	1.44	1.11	1.14	0.56	0.99	0.52	0.82
Additional Aggregations:										
Alturas Lake Ck	0.75	0.75	1.38	1.44	0.80	0.81	N/A	N/A	2.57	2.69
American R	0.91	0.91	1.38	1.44	0.98	0.99	N/A	N/A	1.07	1.12
Big Sheep Ck	0.85	0.88	1.38	1.44	0.92	0.93	N/A	N/A	1.24	1.48
Beaver Cr	0.95	0.95	1.38	1.44	1.02	1.03	N/A	N/A	0.86	0.90
Bushy Fork	0.98	0.98	1.38	1.44	1.05	1.06	N/A	N/A	0.76	0.79
Camas Cr	0.92	0.92	1.38	1.44	0.99	1.00	N/A	N/A	1.00	1.04
Cape Horn Cr	1.05	1.05	1.38	1.44	1.13	1.14	N/A	N/A	0.55	0.58
Catherine Ck	0.78	0.85	1.38	1.44	0.84	0.85	N/A	N/A	1.44	2.17
Catherine Ck N Fk	0.92	0.92	1.38	1.44	0.99	1.00	N/A	N/A	1.00	1.05
Catherine Ck S Fk	0.80	0.80	1.38	1.44	0.85	0.86	N/A	N/A	1.92	2.01
Crooked Fork	1.00	1.00	1.38	1.44	1.07	1.08	N/A	N/A	0.70	0.73
Grande Ronde R	0.77	0.84	1.38	1.44	0.83	0.84	N/A	N/A	1.52	2.28
Knapp Cr	0.89	0.89	1.38	1.44	0.96	0.97	N/A	N/A	1.17	1.22
Lake Cr	1.06	1.06	1.38	1.44	1.14	1.15	N/A	N/A	0.54	0.56
Lemhi R	0.98	0.98	1.38	1.44	1.05	1.06	N/A	N/A	0.77	0.81
Lookingglass Ck	0.72	0.79	1.38	1.44	0.78	0.79	N/A	N/A	1.93	3.05
Loon Ck	1.00	1.00	1.38	1.44	1.08	1.09	N/A	N/A	0.68	0.71
Lostine Ck	0.87	0.90	1.38	1.44	0.94	0.94	N/A	N/A	1.10	1.35
Lower Salmon R	0.92	0.92	1.38	1.44	0.98	1.00	N/A	N/A	1.02	1.07
Lower Valley Ck	0.92	0.92	1.38	1.44	0.99	1.00	N/A	N/A	0.99	1.03
Moose Ck	0.94	0.94	1.38	1.44	1.01	1.02	N/A	N/A	0.90	0.94
Newsome Ck	1.03	1.03	1.38	1.44	1.10	1.12	N/A	N/A	0.61	0.64
Red R	0.91	0.91	1.38	1.44	0.98	0.99	N/A	N/A	1.06	1.11
Salmon R E Fk	0.94	0.94	1.38	1.44	1.01	1.02	N/A	N/A	0.92	0.96
Salmon R S Fk	1.06	1.06	1.38	1.44	1.14	1.15	N/A	N/A	0.54	0.56
Secesh R	0.98	0.98	1.38	1.44	1.05	1.06	N/A	N/A	0.77	0.81
Selway R	0.91	0.91	1.38	1.44	0.98	0.99	N/A	N/A	1.04	1.09
Sheep Cr	0.80	0.80	1.38	1.44	0.86	0.87	N/A	N/A	1.89	1.97
Upper Big Ck	0.97	0.97	1.38	1.44	1.04	1.05	N/A	N/A	0.80	0.84
Upper Salmon R	0.90	0.90	1.38	1.44	0.97	0.98	N/A	N/A	1.09	1.14
Upper Valley Ck	1.03	1.03	1.38	1.44	1.11	1.12	N/A	N/A	0.60	0.63
Wallowa Ck	0.86	0.86	1.38	1.44	0.92	0.93	N/A	N/A	1.36	1.42
Wenaha R	0.84	0.90	1.38	1.44	0.90	0.91	N/A	N/A	1.09	1.56
Whitecap Ck	0.90	0.90	1.38	1.44	0.97	0.98	N/A	N/A	1.09	1.14
Yankee Fork	0.88	0.88	1.38	1.44	0.95	0.96	N/A	N/A	1.21	1.27
Yankee West Fk	0.99	0.99	1.38	1.44	1.06	1.07	N/A	N/A	0.73	0.76

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically, except for the Imnaha (50% as effective). For index stocks, it also includes preliminary 2000 and projected 2001 returns in time series used to estimate lambda.
[3] Low represents estimation of juvenile survival improvement based on a comparison of PATH retrospective and prospective (A2) results.
[4] High represents estimation of juvenile survival improvement based on a combination of PATH and SIMPAS results.
[5] Low represents the low 1980-to-1999 lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-1999 lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A, including preliminary 2000 and projected 2001 returns for index stocks) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A, including only final returns through 1999) divided by the low estimate.

Table 9.7-22. Snake River spring/summer chinook estimates of current and expected median annual population growth rate (lambda), expected survival change after breaching four dams, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after breaching four dams. This analysis assumes high delayed mortality of nontransported fish in the base period, with half of it removed after breaching four of eight dams.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	0.82	0.91	3.20	3.36	1.05	1.18	0.60	0.63	0.46	0.77
Index Stocks:										
Bear Valley/Elk Creeks	1.02	1.03	3.20	3.36	1.30	1.33	0.09	0.31	0.10	0.36
Imnaha River	0.88	0.92	3.20	3.36	1.14	1.21	0.10	0.47	0.15	0.67
Johnson Creek	1.01	1.03	3.20	3.36	1.32	1.37	0.09	0.31	0.09	0.34
Marsh Creek	0.99	1.00	3.20	3.36	1.27	1.30	0.09	0.36	0.12	0.45
Minam River	0.93	1.02	3.20	3.36	1.23	1.36	0.09	0.46	0.10	0.52
Poverty Flats	0.99	1.02	3.20	3.36	1.31	1.36	0.09	0.31	0.09	0.36
Sulphur Creek	1.04	1.05	3.20	3.36	1.34	1.37	0.10	0.43	0.10	0.35
Additional Aggregations:										
Alturas Lake Ck	0.75	0.75	3.20	3.36	0.97	0.98	N/A	N/A	1.11	1.16
American R	0.91	0.91	3.20	3.36	1.18	1.19	N/A	N/A	0.46	0.48
Big Sheep Ck	0.85	0.88	3.20	3.36	1.11	1.12	N/A	N/A	0.53	0.64
Beaver Cr	0.95	0.95	3.20	3.36	1.24	1.25	N/A	N/A	0.37	0.39
Bushy Fork	0.98	0.98	3.20	3.36	1.27	1.29	N/A	N/A	0.33	0.34
Camas Cr	0.92	0.92	3.20	3.36	1.20	1.21	N/A	N/A	0.43	0.45
Cape Horn Cr	1.05	1.05	3.20	3.36	1.37	1.38	N/A	N/A	0.24	0.25
Catherine Ck	0.78	0.85	3.20	3.36	1.02	1.03	N/A	N/A	0.62	0.93
Catherine Ck N Fk	0.92	0.92	3.20	3.36	1.20	1.21	N/A	N/A	0.43	0.45
Catherine Ck S Fk	0.80	0.80	3.20	3.36	1.03	1.04	N/A	N/A	0.83	0.87
Crooked Fork	1.00	1.00	3.20	3.36	1.30	1.31	N/A	N/A	0.30	0.31
Grande Ronde R	0.77	0.84	3.20	3.36	1.00	1.01	N/A	N/A	0.65	0.98
Knapp Cr	0.89	0.89	3.20	3.36	1.16	1.17	N/A	N/A	0.50	0.53
Lake Cr	1.06	1.06	3.20	3.36	1.37	1.39	N/A	N/A	0.23	0.24
Lemhi R	0.98	0.98	3.20	3.36	1.27	1.28	N/A	N/A	0.33	0.35
Lookingglass Ck	0.72	0.79	3.20	3.36	0.94	0.95	N/A	N/A	0.83	1.31
Loon Ck	1.00	1.00	3.20	3.36	1.30	1.32	N/A	N/A	0.29	0.31
Lostine Ck	0.87	0.90	3.20	3.36	1.13	1.14	N/A	N/A	0.47	0.58
Lower Salmon R	0.92	0.92	3.20	3.36	1.19	1.20	N/A	N/A	0.44	0.46
Lower Valley Ck	0.92	0.92	3.20	3.36	1.20	1.21	N/A	N/A	0.42	0.44
Moose Ck	0.94	0.94	3.20	3.36	1.23	1.24	N/A	N/A	0.39	0.40
Newsome Ck	1.03	1.03	3.20	3.36	1.33	1.35	N/A	N/A	0.26	0.28
Red R	0.91	0.91	3.20	3.36	1.18	1.19	N/A	N/A	0.46	0.48
Salmon R E Fk	0.94	0.94	3.20	3.36	1.22	1.23	N/A	N/A	0.39	0.41
Salmon R S Fk	1.06	1.06	3.20	3.36	1.37	1.39	N/A	N/A	0.23	0.24
Secesh R	0.98	0.98	3.20	3.36	1.27	1.28	N/A	N/A	0.33	0.35
Selway R	0.91	0.91	3.20	3.36	1.19	1.20	N/A	N/A	0.45	0.47
Sheep Cr	0.80	0.80	3.20	3.36	1.04	1.05	N/A	N/A	0.81	0.85
Upper Big Ck	0.97	0.97	3.20	3.36	1.26	1.27	N/A	N/A	0.34	0.36
Upper Salmon R	0.90	0.90	3.20	3.36	1.17	1.19	N/A	N/A	0.47	0.49
Upper Valley Ck	1.03	1.03	3.20	3.36	1.34	1.35	N/A	N/A	0.26	0.27
Wallowa Ck	0.86	0.86	3.20	3.36	1.12	1.13	N/A	N/A	0.58	0.61
Wenaha R	0.84	0.90	3.20	3.36	1.09	1.10	N/A	N/A	0.47	0.67
Whitecap Ck	0.90	0.90	3.20	3.36	1.17	1.18	N/A	N/A	0.47	0.49
Yankee Fork	0.88	0.88	3.20	3.36	1.15	1.16	N/A	N/A	0.52	0.54
Yankee West Fk	0.99	0.99	3.20	3.36	1.28	1.30	N/A	N/A	0.31	0.33

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically, except for the Imnaha (50% as effective). For index stocks, it also includes preliminary 2000 and projected 2001 returns in time series used to estimate lambda.
[3] Low represents estimation of juvenile survival improvement based on a comparison of PATH retrospective and prospective (A2) results.
[4] High represents estimation of juvenile survival improvement based on a combination of PATH and SIMPAS results.
[5] Low represents the low 1980-to-1999 lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-1999 lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A, including preliminary 2000 and projected 2001 returns for index stocks) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A, including only final returns through 1999) divided by the low estimate of the expected survival improvement.

Table 9.7-23. Snake River spring/summer chinook estimates of current and expected median annual population growth rate (lambda), expected survival change after breaching four dams, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after breaching four dams. This analysis assumes high delayed mortality of nontransported fish in the base period, with all of it removed after breaching four of eight dams.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	0.82	0.91	5.03	5.27	1.15	1.30	0.38	0.40	0.29	0.49
Index Stocks:										
Bear Valley/Elk Creeks	1.02	1.03	5.03	5.27	1.43	1.46	0.04	0.20	0.04	0.23
Imnaha River	0.88	0.92	5.03	5.27	1.26	1.34	0.04	0.30	0.06	0.43
Johnson Creek	1.01	1.03	5.03	5.27	1.46	1.51	0.04	0.20	0.03	0.21
Marsh Creek	0.99	1.00	5.03	5.27	1.39	1.43	0.04	0.23	0.05	0.29
Minam River	0.93	1.02	5.03	5.27	1.37	1.51	0.04	0.29	0.04	0.33
Poverty Flats	0.99	1.02	5.03	5.27	1.45	1.52	0.04	0.20	0.04	0.23
Sulphur Creek	1.04	1.05	5.03	5.27	1.48	1.51	0.04	0.27	0.04	0.23
Additional Aggregations:										
Alturas Lake Ck	0.75	0.75	5.03	5.27	1.07	1.08	N/A	N/A	0.70	0.74
American R	0.91	0.91	5.03	5.27	1.30	1.32	N/A	N/A	0.29	0.31
Big Sheep Ck	0.85	0.88	5.03	5.27	1.22	1.24	N/A	N/A	0.34	0.41
Beaver Cr	0.95	0.95	5.03	5.27	1.37	1.38	N/A	N/A	0.24	0.25
Bushy Fork	0.98	0.98	5.03	5.27	1.41	1.42	N/A	N/A	0.21	0.22
Camas Cr	0.92	0.92	5.03	5.27	1.32	1.34	N/A	N/A	0.27	0.29
Cape Horn Cr	1.05	1.05	5.03	5.27	1.51	1.53	N/A	N/A	0.15	0.16
Catherine Ck	0.78	0.85	5.03	5.27	1.12	1.14	N/A	N/A	0.40	0.60
Catherine Ck N Fk	0.92	0.92	5.03	5.27	1.32	1.34	N/A	N/A	0.27	0.29
Catherine Ck S Fk	0.80	0.80	5.03	5.27	1.14	1.15	N/A	N/A	0.53	0.55
Crooked Fork	1.00	1.00	5.03	5.27	1.43	1.45	N/A	N/A	0.19	0.20
Grande Ronde R	0.77	0.84	5.03	5.27	1.11	1.12	N/A	N/A	0.42	0.62
Knapp Cr	0.89	0.89	5.03	5.27	1.28	1.29	N/A	N/A	0.32	0.33
Lake Cr	1.06	1.06	5.03	5.27	1.52	1.54	N/A	N/A	0.15	0.15
Lemhi R	0.98	0.98	5.03	5.27	1.40	1.42	N/A	N/A	0.21	0.22
Lookingglass Ck	0.72	0.79	5.03	5.27	1.04	1.05	N/A	N/A	0.53	0.84
Loon Ck	1.00	1.00	5.03	5.27	1.44	1.46	N/A	N/A	0.19	0.20
Lostine Ck	0.87	0.90	5.03	5.27	1.25	1.26	N/A	N/A	0.30	0.37
Lower Salmon R	0.92	0.92	5.03	5.27	1.32	1.33	N/A	N/A	0.28	0.29
Lower Valley Ck	0.92	0.92	5.03	5.27	1.33	1.34	N/A	N/A	0.27	0.28
Moose Ck	0.94	0.94	5.03	5.27	1.36	1.37	N/A	N/A	0.25	0.26
Newsome Ck	1.03	1.03	5.03	5.27	1.47	1.49	N/A	N/A	0.17	0.18
Red R	0.91	0.91	5.03	5.27	1.31	1.32	N/A	N/A	0.29	0.30
Salmon R E Fk	0.94	0.94	5.03	5.27	1.35	1.36	N/A	N/A	0.25	0.26
Salmon R S Fk	1.06	1.06	5.03	5.27	1.52	1.54	N/A	N/A	0.15	0.15
Secesh R	0.98	0.98	5.03	5.27	1.40	1.42	N/A	N/A	0.21	0.22
Selway R	0.91	0.91	5.03	5.27	1.31	1.33	N/A	N/A	0.28	0.30
Sheep Cr	0.80	0.80	5.03	5.27	1.15	1.16	N/A	N/A	0.52	0.54
Upper Big Ck	0.97	0.97	5.03	5.27	1.39	1.40	N/A	N/A	0.22	0.23
Upper Salmon R	0.90	0.90	5.03	5.27	1.30	1.31	N/A	N/A	0.30	0.31
Upper Valley Ck	1.03	1.03	5.03	5.27	1.48	1.50	N/A	N/A	0.16	0.17
Wallowa Ck	0.86	0.86	5.03	5.27	1.23	1.25	N/A	N/A	0.37	0.39
Wenaha R	0.84	0.90	5.03	5.27	1.21	1.22	N/A	N/A	0.30	0.43
Whitecap Ck	0.90	0.90	5.03	5.27	1.30	1.31	N/A	N/A	0.30	0.31
Yankee Fork	0.88	0.88	5.03	5.27	1.27	1.28	N/A	N/A	0.33	0.35
Yankee West Fk	0.99	0.99	5.03	5.27	1.42	1.43	N/A	N/A	0.20	0.21

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically, except for the Imnaha (50% as effective). For index stocks, it also includes preliminary 2000 and projected 2001 returns in time series used to estimate lambda.
[3] Low represents estimation of juvenile survival improvement based on a comparison of PATH retrospective and prospective (A2) results.
[4] High represents estimation of juvenile survival improvement based on a combination of PATH and SIMPAS results.
[5] Low represents the low 1980-to-1999 lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-1999 lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A, including preliminary 2000 and projected 2001 returns for index stocks) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A, including only final returns through 1999) divided by the low estimate of the expected survival improvement.

indicator metrics with breaching than with a modeling scenario approximating the RPA. PATH results also indicated that the degree of difference between the actions depends largely on assumptions regarding delayed mortality of both transported and nontransported fish. PATH analyses differed from the analysis described above in at least one significant way. PATH considered a wide range of differential delayed mortality estimates, rather than the D = 0.63 to D = 0.73 range included in the analyses described above. Half of the PATH analyses included estimates of D that were considerably lower (approximately D = 0.35), which means that for these PATH analyses survival following breaching would increase substantially more than the amount estimated above, simply as a result of eliminating transportation. As described in Section 6.2.3.3, NMFS finds that available empirical information does not support such low estimates of differential post-Bonneville survival. As a result of this and other factors, PATH concluded that the average results for all assumptions considered by PATH indicated that breaching four Snake River dams would easily meet survival and recovery indicator metrics. NMFS results indicate that the ability to meet survival and recovery indicator metrics depends largely on assumptions regarding the degree to which delayed mortality of nontransported fish is reduced—assumptions that cannot be validated with available information.

9.7.3.2.2 Snake River Fall Chinook Salmon

NMFS evaluated the same aggregate population and used the same general approach as that described in Section 9.7.2.2. The necessary improvements in survival from average base period conditions were also as described in Section 9.7.2.2.

A key uncertainty associated with dam breaching is the effect that it will have on survival below Bonneville Dam. NMFS evaluated the same three assumptions described in Section 9.7.3.2.1 regarding the effect of breaching on delayed mortality of nontransported smolts. Although the rationale and conflicting opinions on potential effects have mainly been developed for SR spring/summer chinook salmon, most can also be applied to SR fall chinook salmon.

In one alternative, NMFS assumed that delayed mortality of nontransported fish does not change after four Snake River dams are breached. With this alternative, the current estimate of EM is not important, since the calculated change in survival resulting from breaching will be the same whether EM is believed to be 0% or 19%. This alternative corresponds to two of the three PATH extra mortality hypotheses for SR spring/summer chinook salmon, which ascribe this mortality to causes other than the hydrosystem (Section 6.2.3.3).

In the second alternative, NMFS assumes that average base period EM is 19% (Section 6.2.3.3). This represents the mean PATH estimate of hydrosystem-caused, post-Bonneville mortality, when D=0.24, and all extra mortality is believed to be caused by the hydrosystem. The estimate of 19% delayed mortality of nontransported fish represents the upper end of the range NMFS considered in this analysis (Section 6.2.3.3). This second alternative assumes that approximately half of this mortality is eliminated when four of the eight Snake River dams are breached, which

corresponds to PATH's SR spring/summer chinook Hydro Hypothesis (Marmorek and Peters 1998, Wilson 2000).

The third alternative is identical to the second, except that it assumes that 100% of the delayed mortality of nontransported fish is eliminated. This assumption was included in the July 27, 2000, Draft Biological Opinion and incorrectly ascribed to the PATH Hydro Hypothesis (Wilson 2000). NMFS retains it because several agencies and organizations that commented on the July 27, 2000, Draft Biological Opinion expressed their opinion that this is the most likely assumption. Because all of these assumptions are essentially beliefs, based on little or no direct evidence, inclusion of the full range of opinions demonstrates the range of possible outcomes after breaching.

Details of the methods and results for each approach are included in Appendix A. A summary follows.

No Change in Delayed Mortality of Nontransported Juveniles After Breaching

NMFS estimated mean juvenile passage survival to Bonneville Dam during the base period, including differential post-Bonneville survival of transported fish (D = 0.24), using the method described in Section 6.3.2.3 and applied in Section 9.7.2.3. NMFS has not estimated differential post-Bonneville survival of SR fall chinook and the estimate of 0.24 represents one of the alternative PATH estimates that NMFS considers most consistent with the limited empirical information (Section 6.2.3.3). It is used in the absence of an alternative empirically based estimate. Although this first approach is not sensitive to assumptions regarding delayed mortality of nontransported fish, the assumption of 19% EM was applied to facilitate comparison with the other approaches. This resulted in 14% juvenile survival. Juvenile survival to Bonneville following dam breaching was estimated at 23.8% to 34.0%, as described in Section 9.7.3.1.3 (Table 9.7-20). When the 19% delayed mortality assumption is applied to the survival to Bonneville, 19% to 28% juvenile survival is expected after breaching. The result is a 36% to 95% proportional juvenile survival improvement following breaching.

Adult passage survival during the base period was 71% (Table 9.7-2). Expected survival following breaching is 74% (Section 9.7.3.1.4). The result is a 4.2% proportional adult survival improvement following breaching. When the juvenile and adult survival improvements are combined, the overall effect of breaching four Snake River dams is a 64% to 185% proportional improvement (1.64 to 2.85 times average base period survival).

This expected improvement is sufficient to result in a positive population growth rate under the most optimistic assumptions, but the population would continue to decline under the lowest estimate of lambda (Table 9.7-24). No additional survival improvements are required under the most optimistic assumptions. An additional 32% improvement (1.32 times average 1980 to 1996 survival) would be required with the higher estimate of necessary changes.

Table 9.7-24. Snake River fall chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from breaching four dams, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after breaching four dams.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
No Change In Nontransport Delayed Mortality:										
Aggregate SR Fall Chinook	0.87	0.92	1.63	2.87	0.98	1.18	0.43	0.86	0.60	1.32
Nontransport Delayed Mortality Reduced By Half:										
Aggregate SR Fall Chinook	0.87	0.92	1.82	3.20	1.01	1.22	0.38	0.77	0.54	1.18
Nontransport Delayed Mortality Completely Eliminated:										
Aggregate SR Fall Chinook	0.87	0.92	2.01	3.54	1.03	1.25	0.35	0.70	0.49	1.07

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low represents estimation of juvenile survival improvement based on PATH retrospective and prospective (A2) results and change in harvest rate based on PATH.
[4] High represents estimation of juvenile survival improvement based on a combination of PATH and SIMPAS and harvest rate change based on PSC.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

Delayed Mortality of Nontransported Juveniles Is Reduced by Half After Breaching

All aspects of this approach were identical to the first, except for the level of delayed mortality applied to juvenile survival following breaching. Only half of the delayed mortality estimate was applied in this approach, resulting in 21.5% to 30.8% juvenile survival following breaching. A 282% to 420% proportional survival improvement is associated with breaching under this alternative. Under this assumption, population growth would be positive, and no additional survival changes would be required under the most optimistic assumptions. However, an additional 18% survival improvement (1.18 times average 1980 to 1996 survival) would be necessary under the high estimate of necessary survival changes.

Delayed Mortality of Nontransported Juveniles Is Eliminated After Breaching

All aspects of this approach were identical to the first, except for the level of delayed mortality applied to juvenile survival following breaching. No delayed mortality was applied in this

approach, resulting in 23.8% to 34% juvenile survival following breaching. A 301% to 454% proportional survival improvement is associated with breaching under this approach. Under this assumption, population growth would be positive for all index stocks, and no additional survival changes would be required under the most optimistic assumptions. However, an additional 7% survival improvement (1.07 times average 1980 to 1996 survival) would be necessary under the high estimate of necessary survival changes.

Comparison to PATH

These results are similar to those of PATH (Peters et al. 1999), with respect to the higher likelihood of meeting approximations of the survival and recovery indicator metrics with breaching than with a modeling scenario approximating the RPA, when similar D assumptions are applied. PATH results also indicated that the degree of difference between the actions depends largely on assumptions regarding delayed mortality of both transported and nontransported fish. Under PATH's average assumptions, however, breaching met approximations of the 1995 FCRPS Biological Opinion's jeopardy standards, without the need for any additional survival improvements. NMFS' results indicate that this is likely to happen only if delayed mortality of nontransported fish is currently high and if breaching four dams significantly reduces that delayed mortality.

Both PATH and NMFS' analysis may be somewhat pessimistic regarding the effects of breaching, since the potential additional spawning areas created by breaching had little analytical effect in PATH's analysis and were not analytically considered in this analysis. PATH assumed that most of the newly created habitat would be inferior to that currently available, so did not model a change in carrying capacity until estimated capacity of the currently available habitat was exceeded. This meant that additional spawning habitat did not improve survival until the population was near the recovery level. One organization (Save Our Wild Salmon) commented that NMFS needed to consider the benefits of additional spawning areas in the analysis. This is considered qualitatively in Section 9.7.3.1.2.

9.7.3.2.3 Snake River Steelhead

NMFS evaluated the same spawning aggregations and used the same general approach as that described in Section 9.7.2.6. The necessary improvements in survival from average base period conditions were also as described in Section 9.7.2.6.

A key uncertainty associated with dam breaching is the effect that it will have on survival below Bonneville Dam. NMFS evaluated the same three assumptions described in Section 9.7.3.2.1 regarding the effect of breaching on delayed mortality of nontransported smolts. Although the rationale and conflicting opinions on potential effects have mainly been developed for SR spring/summer chinook salmon, most can also be applied to SR steelhead.

In one alternative, NMFS assumed that delayed mortality of nontransported fish does not change after four Snake River dams are breached. With this alternative, the current estimate of EM is not important, since the calculated change in survival resulting from breaching will be the same whether EM is believed to be 0% or 74%. This alternative corresponds to two of the three PATH extra mortality hypotheses for SR spring/summer chinook salmon, which ascribe this mortality to causes other than the hydrosystem (Section 6.2.3.3).

In the second alternative, NMFS assumes that average base period EM is equivalent to that described for SR spring/summer chinook in Section 9.7.3.2.1. This second alternative assumes that approximately half of this mortality is eliminated when four of the eight Snake River dams are breached, which corresponds to PATH's SR spring/summer chinook Hydro Hypothesis (Marmorek and Peters 1998, Wilson 2000).

The third alternative is identical to the second, except that it assumes that 100% of the delayed mortality of nontransported fish is eliminated. This assumption was included in the July 27, 2000, Draft Biological Opinion and incorrectly ascribed to the PATH Hydro Hypothesis (Wilson 2000). NMFS retains it because several agencies and organizations that commented on the July 27, 2000, Draft Biological Opinion expressed their opinion that this is the most likely assumption. Because all of these assumptions are essentially beliefs, based on little or no direct evidence, inclusion of the full range of opinions demonstrates the range of possible outcomes after breaching.

Details of the methods and results for each approach are included in Appendix A. A summary follows.

<u>No Change in Delayed Mortality of Nontransported Juveniles After Breaching</u>

NMFS assumed that the change from juvenile passage survival to Bonneville Dam during the base period, including differential post-Bonneville survival of transported fish (D=0.52 to D = 0.58), to juvenile survival associated with current operations was the same as that which was estimated for SR spring/summer chinook (Section 6.3.6). NMFS estimated this change as a 24% to 32% proportional improvement. NMFS also estimated changes in harvest rates (Section 6.3.6).

In addition, breaching represents a further survival change from current conditions. Although this first approach is not sensitive to assumptions regarding delayed mortality of nontransported fish, the average SR spring/summer chinook assumption of 73% EM was applied to the estimate of current juvenile survival to facilitate comparison with the other approaches. This resulted in 14% current juvenile survival. Juvenile survival to Bonneville following dam breaching was estimated at 63%, as described in Section 9.7.3.1.3 (Table 9.7-20). When the 73% delayed mortality assumption is applied to the survival to Bonneville, 17.3% juvenile survival is expected after breaching. The result is a 24.5% proportional juvenile survival improvement from current conditions following breaching.

Adult passage survival during the base period was 77.3% (Table 9.7-2). Expected survival following breaching is 80.3% (Section 9.7.3.1.4). The result is a 3.9% proportional adult survival improvement following breaching. When the change from average base period juvenile survival to current juvenile survival, the change from current juvenile survival to juvenile survival after breaching, harvest reductions, and the adult survival improvement are combined, the overall effect of breaching four Snake River dams is a 65% to 77% proportional improvement for A-run steelhead and a 79% to 92% improvement for B-run steelhead.

This expected improvement is not sufficient to produce a positive population growth rate, and additional survival improvements ranging from 25% to 278% (1.25 to 3.78 times average base period survival) would still be necessary to meet survival and recovery indicator criteria (Table 9.7-25).

Delayed Mortality of Nontransported Juveniles Is Reduced by Half After Breaching

All aspects of this approach were identical to the first, except for the level of delayed mortality applied to juvenile survival following breaching. Only half of the delayed mortality estimate was applied in this approach, resulting in 40.1% juvenile survival following breaching. A 285% to 311% proportional survival improvement is associated with breaching under this alternative. Under this assumption, the highest estimates of population growth would be positive, and the lowest would remain negative (Table 9.7-25). No additional survival changes would be required under the most optimistic assumptions. However, an additional 18% to 63% survival improvement (1.18 to 1.63 times average base period survival) would be necessary under the high estimate of necessary survival changes.

Delayed Mortality of Nontransported Juveniles Is Eliminated After Breaching

All aspects of this approach were identical to the first, except for the level of delayed mortality applied to juvenile survival following breaching. No delayed mortality was applied in this approach, resulting in 63% juvenile survival following breaching. A 503% to 544% proportional survival improvement is associated with breaching under this approach. Under this assumption, population growth would be positive except under the low assumptions for B-run steelhead. No additional survival changes would be required for A-run steelhead under all assumptions or for B-run steelhead under the most optimistic assumptions (Table 9.7-25). However, an additional 4% survival improvement (1.04 times average base period survival) would be necessary for B-run steelhead under the high estimate of necessary survival changes.

9.7.3.2.4 Snake River Sockeye Salmon

Because the abundance of SR sockeye salmon is extremely low, the risk of extinction cannot be calculated using the methods that NMFS employs in this biological opinion. However, current risk is undoubtedly very high.

Table 9.7-25. Snake River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from breaching four dams and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after breaching four Snake River dams.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
No Change In Nontransport Delayed Mortality:										
ESU Aggregate	0.72	0.83	1.72	1.84	0.80	0.94	0.81	1.69	1.38	3.14
A-Run Aggregate	0.74	0.85	1.65	1.77	0.82	0.96	0.74	1.52	1.25	2.74
A-Run Pseudopopulation[9]	0.74	0.85	1.65	1.77	0.82	0.96	0.83	1.68	1.25	2.74
B-Run Aggregate	0.74	0.84	1.79	1.92	0.81	0.92	1.03	2.19	1.68	3.78
B-Run Pseudopopulation[10]	0.74	0.84	1.79	1.92	0.81	0.92	1.09	2.31	1.68	3.78
Nontransport Delayed Mortality Reduced By Half:										
ESU Aggregate	0.72	0.83	4.01	4.28	0.94	1.11	0.35	0.73	0.59	1.35
A-Run Aggregate	0.74	0.85	3.84	4.11	0.97	1.13	0.32	0.65	0.54	1.18
A-Run Pseudopopulation[9]	0.74	0.85	3.84	4.11	0.97	1.13	0.36	0.72	0.54	1.18
B-Run Aggregate	0.74	0.84	4.17	4.46	0.93	1.05	0.44	0.94	0.72	1.63
B-Run Pseudopopulation[10]	0.74	0.84	4.17	4.46	0.93	1.05	0.47	0.99	0.72	1.63
Nontransport Delayed Mortality Completely Eliminated:										
ESU Aggregate	0.72	0.83	6.29	6.72	1.03	1.21	0.22	0.46	0.38	0.86
A-Run Aggregate	0.74	0.85	6.03	6.44	1.06	1.24	0.20	0.42	0.34	0.75
A-Run Pseudopopulation[9]	0.74	0.85	6.03	6.44	1.06	1.24	0.23	0.46	0.34	0.75
B-Run Aggregate	0.74	0.84	6.55	6.99	0.99	1.13	0.28	0.60	0.46	1.04
B-Run Pseudopopulation[10]	0.74	0.84	6.55	6.99	0.99	1.13	0.30	0.63	0.46	1.04

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low represents SR spring/summer chinook Low estimate.
[4] High represents SR spring/summer chinook High estimate.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.
[9] Pseudopopulation is 10% of A-run aggregate abundance.
[10] Pseudopopulation is 33% of B-run aggregate abundance.

Due to the extreme low abundance of SR sockeye salmon in recent years, this ESU has not been used in passage survival studies. Therefore, NMFS has not estimated natural system survival or total system survival associated with breaching four Snake River dams for this ESU. Assuming that juvenile mortality in the action area is similar to that of other yearling migrants, dam breaching has the potential to increase action-area survival substantially if delayed mortality is currently high and if it is largely eliminated by breaching four of the eight FCRPS dams that sockeye must pass. Because the extinction risk for SR sockeye is most likely greater than that for SR steelhead and SR spring/summer chinook, additional survival improvements may also be needed for SR sockeye. If, on the other hand, delayed mortality is currently low or if there is no change in delayed mortality following breaching, dam breaching will result in action-area survival similar to the RPA. In this case, substantial survival improvements in addition to breaching would also be needed.

Because a quantitative analysis was not possible for this species, it is difficult to place the effects of the hydrosystem following a four-dam breach in the context of other factors influencing this ESU's survival and recovery. Other factors also affect elements of critical habitat and thus contribute to this ESU's high risk of extinction (summarized in Section 4.1 and Appendix A) and have been discussed in previous sections.

9.7.3.2.5 Eight Other ESUs

Because eight of the ESUs addressed in this biological opinion are distributed downstream of the Snake River dams, the effect of dam breaching would be identical to that of the RPA for UCR spring chinook, LCR chinook, UWR chinook, UCR steelhead, MCR steelhead, LCR steelhead, UWR steelhead, and CR chum salmon. One possible exception may be possible water quality changes, which could affect downstream stocks in an unquantifiable manner.

9.7.3.2.6 Summary—Effects of Snake River Four-Dam Breach on Biological Requirements Over Full Life Cycle

Breaching four Snake River dams is expected to have little or no effect on eight of the ESUs considered in this biological opinion because they do not pass through the lower Snake River. For these ESUs, the effect of dam breaching is identical, or nearly so, to that of the RPA. For the four Snake River ESUs that would be affected by dam breaching, the effect of this action, relative to the RPA, is determined almost entirely by delayed mortality assumptions, as described in previous sections.

The primary biological issue regarding breaching is the extent to which breaching four Snake River dams is likely to modify post-Bonneville survival of Snake River ESUs. If post-Bonneville survival improves significantly after breaching, this option is biologically superior to the RPA and has the potential to recover the four Snake River ESUs, even without additional offsite mitigation (Table 9.7-26). However, if the principal effect is constrained to the area that would be modified above Bonneville Dam, breaching represents only a marginal improvement

Table 9.7-26. Estimated percentage of additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after breaching four Snake River dams. Low and High estimates are based on a range of assumptions, as described in the text. Three assumptions regarding the effect of breaching on delayed mortality of nontransported fish are shown to demonstrate the influence of this assumption on results. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the RPA, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

Spawning Aggregation	Needed Survival Change After Implementing Hydrosystem Component of RPA (From Table 9.7-17)		Needed Survival Change if no Change in Non-Transport Delayed Mortality After Breaching (Whether Current Level is High or Low)		Needed Survival Change if Non-Transport Delayed Mortality is Currently High and is Reduced by Half After Breaching		Needed Survival Change if Non-Transport Delayed Mortality is Currently High and is Completely Eliminated After Breaching	
	Low	High	Low	High	Low	High	Low	High
Snake River Spring/Summer Chinook								
Aggregate ESU	46	89	40	78	0	0	0	0
Bear Valley/Elk Creeks	0	0	0	0	0	0	0	0
Imnaha River	26	66	0	56	0	0	0	0
Johnson Creek	0	0	0	0	0	0	0	0
Marsh Creek	0	12	0	5	0	0	0	0
Minam River	0	28	0	20	0	0	0	0
Poverty Flats	0	0	0	0	0	0	0	0
Sulphur Creek	0	5	0	0	0	0	0	0
Alturas Lake Ck	168	186	157	169	11	16	0	0
American R	11	19	7	12	0	0	0	0
Big Sheep Ck	29	58	24	48	0	0	0	0
Beaver Cr	0	0	0	0	0	0	0	0
Bushy Fork	0	0	0	0	0	0	0	0
Camas Cr	4	11	0	4	0	0	0	0
Cape Horn Cr	0	0	0	0	0	0	0	0
Catherine Ck	50	131	44	117	0	0	0	0
Catherine Ck N Fk	4	12	0	5	0	0	0	0
Catherine Ck S Fk	101	114	92	101	0	0	0	0
Crooked Fork	0	0	0	0	0	0	0	0
Grande Ronde R	58	142	52	128	0	0	0	0
Knapp Cr	22	30	17	22	0	0	0	0
Lake Cr	0	0	0	0	0	0	0	0
Lemhi R	0	0	0	0	0	0	0	0
Lookingglass Ck	102	225	93	205	0	31	0	0
Loon Ck	0	0	0	0	0	0	0	0
Lostine Ck	15	44	10	35	0	0	0	0
Lower Salmon R	7	14	2	7	0	0	0	0
Lower Valley Ck	3	10	0	3	0	0	0	0
Moose Ck	0	0	0	0	0	0	0	0
Newsome Ck	0	0	0	0	0	0	0	0

Table 9.7-26 (Continued). Estimated percentage of additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after breaching four Snake River dams. Low and High estimates are based on a range of assumptions, as described in the text. Three assumptions regarding the effect of breaching on delayed mortality of nontransported fish are shown to demonstrate the influence of this assumption on results. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the RPA, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

Spawning Aggregation	Needed Survival Change After Implementing Hydrosystem Component of RPA (From Table 9.7-17)		Needed Survival Change if no Change in Non-Transport Delayed Mortality After Breaching (Whether Current Level is High or Low)		Needed Survival Change if Non-Transport Delayed Mortality is Currently High and is Reduced by Half After Breaching		Needed Survival Change if Non-Transport Delayed Mortality is Currently High and is Completely Eliminated After Breaching	
	Low	High	Low	High	Low	High	Low	High
Red R	10	18	6	11	0	0	0	0
Salmon R E Fk	0	2	0	0	0	0	0	0
Salmon R S Fk	0	0	0	0	0	0	0	0
Secesh R	0	0	0	0	0	0	0	0
Selway R	8	15	3	9	0	0	0	0
Sheep Cr	97	110	89	97	0	0	0	0
Upper Big Ck	0	0	0	0	0	0	0	0
Upper Salmon R	13	21	9	14	0	0	0	0
Upper Valley Ck	0	0	0	0	0	0	0	0
Wallowa Ck	42	51	36	42	0	0	0	0
Wenaha R	14	66	9	56	0	0	0	0
Whitecap Ck	14	22	9	14	0	0	0	0
Yankee Fork	26	35	21	27	0	0	0	0
Yankee West Fk	0	0	0	0	0	0	0	0
Snake River Fall Chinook								
Aggregate	0	44	0	32	0	18	0	7
Snake River Steelhead								
ESU Aggregate	58	260	38	214	0	35	0	0
A-Run Aggregate	44	214	25	174	0	18	0	0
A-Run Pseudopopulation	44	214	25	174	0	18	0	0
B-Run Aggregate	92	333	68	278	0	63	0	4
B-Run Pseudopopulation	92	333	68	278	0	63	0	4

over the RPA, and additional improvements through off-site mitigation would still be required. As described in previous sections, NMFS considers empirical information bearing on the question of delayed mortality of nontransported fish to be lacking and information related to differential delayed mortality of transported fish to be very limited. The RPA includes a substantial research effort to help resolve the issue and built-in check points to evaluate new research results with respect to possible future modification of the RPA.

9.7.4 RPA Conclusions

The analysis in the preceding sections of this biological opinion forms the basis for NMFS' conclusions as to whether this RPA for operation of the FCRPS and BOR projects satisfies the standards of the ESA, Section 7(a)(2). To do so, the Action Agencies must ensure that the RPA does not jeopardize the continued existence of any listed species or destroy or adversely modify their designated critical habitat. Section 4 of this opinion defines the biological requirements and the current status of each of the 12 listed salmonid species; Section 5 evaluates the relevance of the environmental baseline to each species' current status; Section 9 details the likely effects of the RPA, both on individuals of the species in the action area and on the listed population as a whole across its range and life-cycle; and Section 7 considers cumulative effects of reasonably certain non-Federal actions within the action area. Based on this background information and analysis, NMFS draws its conclusions about the effects of the operation of the FCRPS and BOR projects, as described in this RPA, on the survival and recovery of 12 listed salmonid ESUs.

As discussed in Section 1.3 of this biological opinion, NMFS must now determine whether the species can be expected to survive with an adequate potential for recovery under the effects of the RPA, the environmental baseline and any cumulative effects, and considering measures for survival and recovery specific to other life stages. A relatively large amount of information, with a substantial amount of quantitative data (i.e., based on empirical observations) is available for ESUs such as SR spring/summer chinook salmon. For other ESUs, such as SR sockeye salmon, primarily qualitative information is available, based on the best professional judgment of knowledgeable scientists. Despite an increasing trend toward a more quantitative understanding of the status of each stock and ESU, critical uncertainties limit NMFS' ability to project future conditions and effects. As a result, there are currently no hard and fast numerical indices available for any of these stocks on which NMFS can base its determination about jeopardy or adverse modification of critical habitat, the Section 7(a)(2) standards. Ultimately, for all 12 ESUs, NMFS must make qualitative judgements based upon the best available quantitative and qualitative information for each species.

9.7.4.1 General RPA Conclusions For All ESUs

In Section 8 of this biological opinion, NMFS concludes that four ESUs will not be jeopardized by the proposed action (UWR and LCR chinook salmon and UWR and LCR steelhead). The RPA will have no adverse effects beyond those described in the proposed action, so NMFS concludes that these ESUs will not be jeopardized by the RPA. In Section 8, however, NMFS

also concludes that eight ESUs will be jeopardized by the proposed action. Juvenile and adult mortality in the action area will be substantial, and critical habitat elements, such as water quality and (in the case of CR chum salmon) spawning habitat, will be adversely modified. NMFS concluded that the proposed action was not specific enough regarding measures to improve survival and avoid adverse modification of critical habitat in the action area and that performance standards for guiding improvements were not specific enough and were not tied to biological requirements throughout the life cycle.

Section 8 also indicated that the effects of the proposed action, when combined with anticipated survival improvements in other life stages, were not sufficient to ensure survival and recovery of these eight ESUs. Some additional survival improvements, beyond those considered in analyses of effects, were considered likely to occur as a result of Federal conservation measures related to habitat improvements and hatchery reforms described generally in the Basinwide Recovery Strategy. NMFS concluded, however, that the degree to which these measures will sufficiently augment survival improvements from implementing the proposed action and will ensure a high likelihood of survival and moderate-to-high likelihood of recovery of each ESU is uncertain. In order to conclude that the strategy of progress on non-Federal actions described in the Basinwide Recovery Strategy would provide survival improvements needed to avoid jeopardy, NMFS required a more reliable expectation of progress.

The RPA remedies these two primary shortcomings of the proposed action:

- Measures to improve survival in the action area, specified in detail in Section 9.6.1, are expected to result in higher survival in the action area than would be expected under the proposed action (Section 9.7.1). These measures are guided by explicit action-area performance standards and are integrated with life-cycle performance standards (Section 9.2). Measures also provide specific remedies for adverse modification of critical habitat, such as a gas-abatement program to reduce adverse modification of water quality.

- Section 9.2 of the RPA specifies that the Action Agencies will ensure implementation of enough offsite mitigation to achieve NMFS' estimate of the needed additional survival improvement. Specifics for implementing elements of the Basinwide Recovery Strategy as the Action Agencies' offsite mitigation program are included in Sections 9.6.2 through 9.6.4. In addition, the certainty that the RPA will achieve the survival improvements is increased by the RPA's rigorous evaluation process, by which RPA actions and ESU performance are assessed throughout the RPA's implementation (see Sections 9.4 and 9.5). The RPA thereby greatly increases NMFS' ability to rely on implementation of the non-Federal conservation measures described in the Basinwide Recovery Strategy.

The increased reliability of implementing the Basinwide Recovery Strategy measures, together with other ongoing Federal measures for survival and recovery specific to other life stages and the improved survival that will result from the hydropower measures of this RPA, ensure that

each of the eight ESUs will have a high likelihood of survival and a moderate-to-high likelihood of recovery. NMFS' conclusions for all 12 listed ESUs are specified in the following sections.

9.7.4.2 Specific RPA Conclusions

9.7.4.2.1 Snake River Spring/Summer Chinook Salmon

After reviewing the current status of SR spring/summer chinook salmon and the factors for its decline, the environmental baseline in the action area, the effects of the RPA (particularly as described in Sections 9.7.1 and 9.7.2), and cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of SR spring/summer chinook salmon or to destroy or adversely modify its designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described above. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of enough offsite mitigation that will be targeted to meet the biological requirements of SR spring/summer chinook salmon when combined with other elements of the RPA and the conservation measures anticipated in other life stages described in the Basinwide Recovery Strategy.

9.7.4.2.2 Snake River Fall Chinook Salmon

After reviewing the current status of SR fall chinook salmon and the factors for its decline, the environmental baseline in the action area, the effects of the RPA (particularly as described in Sections 9.7.1 and 9.7.2), and cumulative effects, NMFS concludes that the RPA is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described above. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of enough offsite mitigation that will be targeted to meet the biological requirements of SR fall chinook salmon when combined with other elements of the RPA and the conservation measures anticipated in other life stages described in the Basinwide Recovery Strategy.

9.7.4.2.3 Upper Columbia River Spring Chinook Salmon

After reviewing the current status of UCR spring chinook salmon and its factors for decline, the environmental baseline in the action area, the effects of the RPA (particularly as described in Sections 9.7.1 and 9.7.2), and cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat. This conclusion is based on elements of the RPA that remedy

shortcomings of the proposed action, as described above. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of enough offsite mitigation that will be targeted to meet the biological requirements of UCR spring chinook salmon when combined with other elements of the RPA and the conservation measures anticipated in other life stages described in the Basinwide Recovery Strategy.

9.7.4.2.4 Upper Willamette River Chinook Salmon

Salmonids in the UWR chinook salmon ESU spawn and rear in tributaries that enter the Columbia River downstream from all FCRPS dams. The only effects of operation of the FCRPS on this ESU are potential habitat degradation in the estuary and plume. The magnitude of these effects is uncertain compared to other factors influencing the status of this species. Tables 6.3-13 and 9.7-18 indicate that factors other than the FCRPS limit this ESU's potential for survival and recovery. Therefore, after reviewing the current status of UWR chinook salmon and the factors for its decline, the environmental baseline in the action area, the effects of the RPA, and cumulative effects, NMFS concludes that the RPA, like the proposed action (see Section 8), is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat.

9.7.4.2.5 Lower Columbia River Chinook Salmon

As noted in Section 6.2, this ESU is distributed primarily in spawning and rearing areas below Bonneville Dam. The key effects on this species within the action area, summarized in Sections 6.2.9 and 9.7.1, include passage mortality of juveniles and adults from a limited number of spawning aggregations through one dam and reservoir (Bonneville Dam). For the portion of the ESU that was observed to spawn once in the Ives Island area, access to, and the quantity and quality of, that spawning habitat will be affected by FCRPS flow regulation. Tables 6.3-13 and 9.7-18 indicate, however, that factors other than the FCRPS limit this ESU's potential for survival and recovery. Therefore, after reviewing the current status of LCR chinook salmon and the factors for its decline, the environmental baseline in the action area, the effects of the RPA, and cumulative effects, NMFS concludes that the RPA, like the proposed action, is not likely to jeopardize the continued existence of LCR chinook salmon or to destroy or adversely modify its designated critical habitat.

9.7.4.2.6 Snake River Steelhead

After reviewing the current status of SR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the RPA (particularly as described in Sections 9.7.1 and 9.7.2), and cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its

designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described above. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of enough offsite mitigation that will be targeted to meet the biological requirements of SR steelhead when combined with other elements of the RPA and the conservation measures anticipated in other life stages described in the Basinwide Recovery Strategy.

9.7.4.2.7 Upper Columbia River Steelhead

After reviewing the current status of UCR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the RPA (particularly as described in Sections 9.7.1 and 9.7.2), and cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described above. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of enough offsite mitigation that will be targeted to meet the biological requirements of UCR steelhead when combined with other elements of the RPA and the conservation measures anticipated in other life stages described in the Basinwide Recovery Strategy.

9.7.4.2.8 Middle Columbia River Steelhead

After reviewing the current status of MCR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the RPA (particularly as described in Sections 9.7.1 and 9.7.2), and cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described above. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of enough offsite mitigation that will be targeted to meet the biological requirements of MCR steelhead when combined with other elements of the RPA and the conservation measures anticipated in other life stages described in the Basinwide Recovery Strategy.

9.7.4.2.9 Upper Willamette River Steelhead

Salmonids in the UWR steelhead ESU spawn and rear in tributaries that enter the Columbia River downstream from all FCRPS dams. The only effects of operation of the FCRPS on this ESU are potential habitat degradation in the estuary and plume. The magnitude of these effects is uncertain compared to other factors influencing the status of this species. Tables 6.3-13 and 9.7-18 indicate that factors other than the FCRPS limit this ESU's potential for survival and recovery. Therefore, after reviewing the current status of UWR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the RPA, and cumulative effects, NMFS concludes that the RPA, like the proposed action, is not likely to jeopardize the continued existence of LCR chinook salmon or to destroy or adversely modify its designated critical habitat.

9.7.4.2.10 Lower Columbia River Steelhead

As discussed in Section 6.2, this ESU is distributed primarily in spawning and rearing areas below Bonneville Dam. The key effects on this species within the action area, summarized in Sections 6.2.9 and 9.7.1, include passage mortality of juveniles and adults from a limited number of spawning aggregations through one dam and reservoir (Bonneville Dam). Tables 6.3-13 and 9.7-18 indicate that factors other than the FCRPS limit this ESU's potential for survival and recovery. Therefore, after reviewing the current status of LCR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the RPA, and cumulative effects, NMFS concludes that the RPA, like the proposed action, is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat.

9.7.4.2.11 Columbia River Chum Salmon

After reviewing the current status of CR chum salmon and the factors for its decline, the environmental baseline in the action area, the effects of the RPA (particularly as described in Sections 9.7.1 and 9.7.2), and cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described above. Specifically, for the component of this ESU that migrates above Bonneville Dam, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of enough offsite mitigation that will be targeted to meet the biological requirements (particularly those affecting critical spawning habitat) of CR chum salmon when combined with other elements of the RPA and the conservation measures anticipated in other life stages described in the Basinwide Recovery Strategy.

9.7.4.2.12 Snake River Sockeye Salmon

After reviewing the current status of SR sockeye salmon and the factors for its decline, the environmental baseline in the action area, the effects of the RPA (particularly as described in Sections 9.7.1 and 9.7.2), and cumulative effects, NMFS concludes that the RPA is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described above. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of enough offsite mitigation that will be targeted to meet the biological requirements of SR sockeye salmon when combined with other elements of the RPA and the conservation measures anticipated in other life stages described in the Basinwide Recovery Strategy.

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10.0 INCIDENTAL TAKE STATEMENT

10.1 INTRODUCTION

Section 9 of the ESA and Federal regulations pursuant to Section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct." Incidental take is defined as "take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity." Under the terms of Section 7(b)(4) and Section 7(a)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA, provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described in this section are nondiscretionary and must be undertaken by the Corps, BPA, and BOR. The Action Agencies have a continuing duty to regulate the activities covered by this incidental take statement. If the Action Agencies fail to assume and implement the terms and conditions of this incidental take statement, the protective coverage of Section 7(a)(2) may lapse. To monitor the effect of incidental take, the Action Agencies must report the progress of the action and its effect on each listed species to NMFS, as specified in this incidental take statement [50 CFR Section 402.14(i)(3)].

NMFS has developed the following incidental take statement based on the premise that the RPA described in Section 9 of the biological opinion will be implemented.

10.2 AMOUNT OR EXTENT OF ANTICIPATED TAKE

10.2.1 Incidental Take Associated with Operation of FCRPS

The level of incidental take expected to occur as a result of the RPA will vary annually as the RPA measures are implemented. Initially, the expected take will be approximately equal to the juvenile and adult mortality rates associated with the proposed action, as estimated in Sections 6.2 and 6.3. Once the RPA measures are completely implemented, no later than 2010, the expected take will be reduced to a level that is approximately equal to the juvenile and adult mortality rates associated with the RPA, as estimated in Section 9.7. During the intervening period, the incidental take is expected to decrease on a schedule that cannot be precisely determined at this time. The estimate of incidental take will, therefore, be updated before March 1 of each year. This update will be based on the preceding year's annual report, which will describe those elements of the RPA that were completed in the preceding year, those anticipated to be implemented during the upcoming year, and research to further characterize the effects of implementing those elements on survival of listed ESUs.

Tables 10.1-1 and 10.1-2 identify the expected incidental take resulting from the RPA during 2001 and 2010 for juvenile and adult salmonids, respectively. The take estimates include mortality expected to occur as a result of passage through the mainstem FCRPS projects only. The juvenile take represents means of a range of annual estimates and, for some ESUs, a range of differential delayed mortality estimates. Averages included 1994 through 1999 for spring chinook and steelhead and 1995 through 1999 for SR fall chinook. The SR spring/summer chinook D (delayed mortality) estimate ranged from 0.63 to 0.73, the SR fall chinook D estimate was 0.24, and the SR steelhead D estimate ranged from 0.52 to 0.56.

Quantitative estimates of take are not possible for the spawning and incubation stages of SR fall chinook, LCR chinook salmon, and CR chum salmon. The incidental take of these species during the spawning and incubation life stages will be considered authorized if flow operations are implemented as described in Section 9.6.1.2. Take of juvenile sockeye salmon will be considered authorized as long as the allowable take of juvenile SR spring/summer chinook and SR steelhead is not exceeded, due to the similarity in timing and similar size of each ESU.

10.2.2 Incidental Take Associated with Offsite Mitigation

This biological opinion does not authorize incidental take associated with any projects related to offsite mitigation. It is anticipated that the Action Agencies will seek authorization for any take associated with offsite mitigation projects through separate consultations with NMFS, once details of the proposed actions are determined.

Table 10.1-1 Estimates of incidental take of juvenile salmonids resulting from the RPA during 2001 and 2010.

ESU	Estimated Total System Juvenile Mortality (%)	
	2001	2010
Chinook		
SR spring/summer[1]	43	42
SR fall[2]	88	87
UCR spring [3]	43	34
LCR spring[4]	13	9
LCR fall[4]	28	22
UWR	N/A	N/A
Steelhead		
SR[5]	52	49
UCR[6]	41	32
MCR[7]	41	32
LCR[8]	13	9
UWR	N/A	N/A
Sockeye		
SR[9]	N/A	N/A
Chum		
CR[10]	28	22

Note: Estimates of mean incidental take resulting from RPA in 2001 and 2010. Estimates of take during intervening years will be updated annually. N/A = not applicable (for ESUs that do not pass through the hydrosystem). Estimates for ESUs with populations that pass variable numbers of dams are for maximum number of dams passed.

[1] Represents survival of transported and nontransported smolts, including NMFS' (2000e) estimate of differential delayed mortality. Take of inriver migrants is estimated as 59% in 2001 and 50% in 2010. For comparison, estimate of natural mortality is 15% (Appendix A).

[2] Represents survival of transported and non-transported smolts, including PATH 24% estimated of differential delayed mortality. Take of inriver migrants is estimated as 90% in 2001 and 86% in 2010. For comparison, estimate of natural mortality is 32% to 77% (Appendix A).

[3] For comparison, estimate of natural mortality is 9% (Appendix A).

[4] For comparison, estimate of natural mortality is 2% (Appendix A).

[5] Represents survival of transported and nontransported smolts including NMFS' (2000e) estimates of differential delayed mortality. Take of inriver migrants is estimated as 59% in 2001 and 49% in 2010. For comparison, estimate of natural mortality is 16% (Appendix A).

[6] For comparison, estimate of natural mortality is 9% (Appendix A).

[7] For comparison, estimate of natural mortality is 9% (Appendix A).

[8] For comparison, estimate of natural mortality is 1% (Appendix A).

[9] A quantitative estimate is not available for this ESU. SR sockeye take is authorized as long as allowable take of SR spring/summer chinook and SR steelhead is not exceeded.

[10] Based on LCR fall chinook survival estimates. No estimate of natural survival rate is available for comparison.

Table 10.1-2. Estimates of incidental take of adult salmonids expected to result from RPA during 2001 and 2010. Estimates of adult take will be updated annually during the intervening years. N/A = not applicable (i.e., for ESUs that do not pass FCRPS projects). Estimates for ESUs with subbasin populations that pass different numbers of dams are for the maximum number of dams passed.

ESU	Estimated Adult Mortality (%)	
	2001	2010
Chinook		
SR spring/ summer	18	15
SR fall	29	26
UCR spring	9	8
LCR spring	3	2
LCR fall	4	4
UWR	N/A	N/A
Steelhead		
SR	23	20
UCR	12	11
MCR	12	11
LCR	3	3
UWR	N/A	N/A
Sockeye		
SR	14	11
Chum		
CR	4	4

10.3 EFFECT OF THE TAKE

In the biological opinion, NMFS determined that this level of anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

The overall incidental take of ESA-listed juvenile and adult anadromous fish species under the proposed action is described in Tables 9.7.1 and 9.7.2, respectively. The take of listed species resulting from the research and monitoring activities described in Tables 9.7.1.1 and 9.7.1.2 is incorporated into the earlier tables and is not in addition to those estimates. A proportion of the overall authorized take is partitioned among the specifically numbered research projects described in Section 9.6.5.5.

10.4 REASONABLE AND PRUDENT MEASURES

10.4.1 Monitor Incidental Take

The Action Agencies will monitor the level of incidental take associated with the RPA and report the results to NMFS in a timely manner.

10.4.2 Reduce Incidental Take by Improving Juvenile and Adult Passage Survival

The Action Agencies will reduce the level of incidental take by implementing measures to further improve survival of juveniles and adults, in addition to measures required by the RPA. NMFS has determined that the additional measures specified in Section 10.5 constitute only minor changes to the RPA.

10.5 TERMS AND CONDITIONS

10.5.1 Terms and Conditions Related to Monitoring Take

10.5.1.1 Evaluate Reach Survivals

The Action Agencies will estimate dam passage and inriver survival of both juvenile and adult migrating salmonids. Using PIT-tags, radio tags, sonic tags, or other developing technology, the Action Agencies will measure the survival of juvenile fish migrating through the FCRPS. Using radio and PIT tags and additional techniques, they will also measure the survival and reproductive success (arrival on the spawning grounds, successful spawning behavior, and successful gamete production) of adult salmonids migrating through the FCRPS. The primary focus of the current PIT-tag monitoring program is on juvenile inriver survival and return rates. However, as adult PIT-tag detection facilities are developed and installed, they will be used to measure adult passage survival on a per-project basis for fish with known origins and passage histories. Until then, a portion of the adult salmonid population will be radio-tagged, and their migration behavior and survival will be monitored as they migrate upstream through the FCRPS.

The Action Agencies, in coordination with NMFS through the annual planning process, will continue to provide funding for monitoring wild juvenile fall chinook survival, growth, and other early life attributes. Knowledge of wild fish early life attributes is critical as a baseline comparison for studies involving juvenile hatchery fall chinook used as surrogates for wild fish. Also, supplementation of juvenile fall chinook above Lower Granite Dam is resulting in increased parr densities. At some point, decreased growth may occur, affecting the survival of wild fish.

The Action Agencies will continue to provide funding for required monitoring of juvenile fish passage at all dams with bypass systems. Facilities with PIT-tag detection capability at selected FCRPS projects will be provided for this purpose. In addition, BPA is responsible for funding the smolt monitoring program coordinated and implemented by the Fish Passage Center, and the Corps is responsible for funding sampling relative to the juvenile fish transportation program and facility operations. To reduce juvenile fish handling and staffing requirements, multiple data sets are collected from sampled fish by onsite fishery agency personnel. For example, the Corps requires collection of fish condition information (injury, descaling, length, weight, etc.) to detect juvenile fish passage facility problems that can descale, injure, or kill fish. The Corps also needs information regarding the numbers and weights of fish collected and the species composition for holding and loading purposes at the collector dams. This sampling effort also meets the requirements of approved monitoring programs (smolt monitoring, GBT sampling) and research (AFEP, NWPPC's Fish and Wildlife Program), as well as new research required by this biological opinion). Given the multiple tasks accomplished under the program, the Action Agencies involved should share the cost of the program. Sampled juvenile fish handling at the projects should remain the responsibility of fishery agency personnel.

10.5.1.2 Monitor Smolt-to-Adult Returns

The Corps and BPA, in coordination with NMFS through the annual planning process, will evaluate transport-to-inriver return ratios for wild SR yearling chinook salmon and steelhead. In addition, the Corps and BPA will also evaluate effects of transportation of summer-migrating, subyearling SR chinook salmon.

Currently, the only way to conduct this research on spring-migrating fish is to mark and release wild fish at Lower Granite Dam, collect some for transport at Little Goose Dam, and allow others to continue their migration inriver. This design should continue until wild SR anadromous salmonids are abundant enough to conduct studies by PIT-tagging wild fish in natal areas above the lower Snake River dams. If the decision for the long-term operation of FCRPS projects on the lower Snake River includes continued reliance on transportation, the Corps and BPA will continue transport survival studies for spring and summer migrants passing Lower Granite Dam in future years.

Future research to evaluate the smolt-to-adult survival of subyearling fall chinook transported from Lower Granite versus the survival of marked study fish left to migrate in river will require adequate numbers of representative test fish (e.g., Lyons Ferry hatchery stock) and also may require special spill operations at one or more of the four collector dams.

10.5.1.3 Monitor Post-transport and Post-bypass Delayed Mortality

The Corps and BPA, in coordination with NMFS through the annual planning process, will include an evaluation of D of transported fish relative to inriver migrating juvenile anadromous salmonids during all transport evaluations.

Considerable uncertainty exists concerning the levels of differential post-Bonneville Dam mortality of transported and nontransported fish. Evaluations of post-transport and post-bypass delayed mortality should receive high priority. Determining how much transportation mitigates for the loss of juvenile anadromous salmonids during passage through the hydrosystem will be given the highest priority.

10.5.1.4 Monitor Juvenile Fish Passage at Dams

The Action Agencies will continue to provide funding for required monitoring of juvenile fish passage at all dams with bypass systems. Facilities with PIT-tag detection capability at selected FCRPS projects will be provided for this purpose. In addition, BPA is responsible for funding the smolt monitoring program coordinated and implemented by the Fish Passage Center, and the Corps is responsible for funding sampling relative to the juvenile fish transportation program and facility operations. To reduce juvenile fish handling and staffing requirements, multiple data sets are collected from sampled fish by onsite fishery agency personnel. For example, the Corps requires collection of fish condition information (i.e., injury, descaling, length, weight, etc.) to

detect juvenile fish passage facility problems that can descale, injure, or kill fish. The Corps also needs information regarding the numbers and weights of fish collected and the species composition for holding and loading purposes at the collector dams. This sampling effort also meets the requirements of approved monitoring programs (i.e., smolt monitoring, GBT sampling) and research (AFEP, the NWPPC's Fish and Wildlife Program), as well as new research required by this biological opinion. Given the multiple tasks accomplished under the program, the Action Agencies involved should implement cost sharing of the program. Sampled juvenile fish handling at the projects should remain the responsibility of fishery agency personnel.

10.5.1.5 Monitor Effects of Dissolved Gas Supersaturation

The Action Agencies will monitor the effects of TDG. This annual program will include physical and biological monitoring and will be developed and implemented in consultation with the Water Quality Team and the Mid-Columbia PUDs' monitoring programs.

At a minimum, the physical monitoring components of this plan will include placement of physical TDG monitors in the tailraces and forebays of all lower Snake and lower Columbia river dams and daily recording of TDG data in the Columbia River Operational Hydromet Management System (CROHMS) database. This program will also include a QA/QC component, with redundant and backup monitors at as many locations as determined necessary by the Water Quality Team; calibration of monitoring equipment at least every 2 weeks; enough funding for spot-checking monitoring equipment during the fish passage season (with the number determined in the preseason by the Water Quality Team); an error-checking, correcting, and recording function for CROHMS data; and daily data reporting. The QA/QC components will be reviewed annually and modified as improved information and techniques become available. The Action Agencies will conduct the annual review in coordination with the Water Quality Team. At a minimum, the biological monitoring components will include smolt monitoring at selected smolt monitoring locations, adult monitoring at Bonneville and Lower Granite dams, and daily data collection and reporting.

10.5.1.6 Install Adult PIT-tag Detectors to Facilitate Monitoring

BPA and the Corps will install adult PIT-tag detectors at appropriate FCRPS projects before the expected return of any adult salmon from the 2002 juvenile outmigration. If technical problems preclude installation of these detectors in this time frame, the evaluation of spring migrant transportation from McNary should be delayed until the systems are installed.

10.5.1.7 Monitor Adult Survival

The Action Agencies will conduct a comprehensive evaluation to assess survival of adult salmonids migrating upstream and factors contributing to unaccounted losses. Broad objectives for such studies may include the following:

- Evaluate survival rates between dams and through the system.
- Partition interdam losses by factor.
- Assess causal mechanisms associated with losses.
- Assess reproductive success, including causal mechanisms associated with reduced reproductive success, if any.
- Identify measures, as appropriate, to address factors affecting passage, survival, and reproductive success.

More specific investigations may include the following:

- Fallback (operational-related versus other factors)
- Passage delay (in relation to project and reservoir operations, including turbines, spill, and peaking)
- Injury (resulting from passage, marine mammals)
- Headburns
- Homing/straying
- Mainstem spawning
- Tributary turnoff and spawning
- Effect of TDG
- Effect of temperature (including use of cool water microhabitat)
- Energy expenditure
- Susceptibility to disease
- Unaccounted incidental mortality associated with harvest
- Cumulative effects (synergism)

10.5.1.8 Monitor Turbine Efficiency

BPA and the Corps will prepare an annual summary report detailing compliance with the 1% peak efficiency turbine operation guidelines for the FCRPS projects. The report should be provided to the Fish Facility Operation and Maintenance Coordination Team and NMFS by February 1 of each year.

A summary report will allow review of seasonal operation of turbine units which may reveal methods to improve operations for safe fish passage.

10.5.1.9 Report Project Operations in Timely Manner

The Corps will work through the FPOM to make hourly individual turbine unit and spill bay operation data available on its website, real time, during the juvenile migration season. These data are necessary to monitor compliance with operating criteria in the annual Fish Passage Plan (e.g., unit operating priorities and spill patterns), as well as agreed-on special project operations for research or maintenance. These data were available for some projects while information was collected for the gas-abatement program, but they have since been discontinued.

10.5.1.10 Report Progress in Implementing Fish Passage Plan in Timely Manner

The Action Agencies, in coordination with the annual planning process, will continue to provide weekly and annual reports regarding implementation of the fish passage plan to FPOM.

The current practice of providing 7-day Corps project adult/juvenile facility reports and 7-day fish transportation summarys to NMFS via electronic mail once a week has worked well and should continue. Additionally, hard copies of these reports have been formally submitted monthly. Since NMFS staff already have the desired information up to several weeks earlier, it is no longer necessary to provide formal hard copies monthly. Rather, the Corps should provide these reports to NMFS once a year (at the February FPOM meeting) in electronic format on a compact disk for archiving. Specific details should be developed in coordination with FPOM.

10.5.2 Terms and Conditions Related to Improving Juvenile and Adult Passage Survival

10.5.2.1 Develop a TDG Model to Inform Spill and TDG Management Decisions

The Action Agencies will complete development of, and continue to refine, a TDG model to be used as a river operations management tool. Once the model is developed, applications and results will be coordinated through the Water Quality Team. The Action Agencies will coordinate the systemwide management applications of gas abatement model studies with the annual planning process, the Transboundary Gas Group, the Mid-Columbia PUDs, and other interested parties.

TDG supersaturation, caused by water spilling over dams, can result in the injury or mortality of juvenile salmonids. Since the 1960s, increased hydraulic capacity at powerhouses of mainstem projects, increased water storage, and structural modification to spillways have substantially reduced this problem. High levels of TDG have, however, been measured under some river conditions even in recent years, e.g., during periods of involuntary spill.

10.5.2.2 Model Water Temperature to Inform Operational Decisions

By June 30, 2001, the Action Agencies will develop and submit for NMFS' and EPA's approval a plan to model the water temperature effects of alternative Snake River operations.

The modeling plan should focus on water temperatures in the Snake River from Hells Canyon Dam on the Snake River and from Dworshak Dam on the Clearwater River to Bonneville Dam on the Columbia River, with predictive nodes located at the near-dam forebays and tailraces of each project. Both one-dimensional and multidimensional models (due to reservoir stratification) may be needed to fully define expected temperature conditions within the reach. The models should be developed to function both as a preseason planning tool and to provide predicted outcomes of immediate operations in real time.

10.5.2.3 Develop Temperature Data Collection System to Inform Operational Decisions

The Action Agencies will develop, in consultation with EPA, NMFS, and state and Tribal water quality agencies, a temperature data collection strategy. Such a strategy is necessary for developing and operating the models and documenting the effects of project operation.

Existing water temperature and meteorological data are inadequate for this purpose. Existing data and statistical tools will be used to identify locations where additional or improved data collection, in terms of precision, accuracy, and frequency, would be most beneficial.

10.5.2.4 Assess Use of Safer PIT-tag Detection Methods

The Corps and BPA will assess less-intrusive, PIT-tag interrogation methods at FCRPS juvenile bypass systems with interrogation sites, including McNary, John Day, and Bonneville dams. The Corps and BPA shall also assess providing similar detection capability for the Ice Harbor juvenile bypass system.

The Corps and BPA should assess the use of full bypass flow PIT-tag detection, without the need to dewater and route fish through separators and sample flumes, with the possible benefit of reducing adverse survival effects of passage through multiple bypasses.

10.5.2.5 Improve Panel Design of Extended Submerged Intake Screens

The Corps will complete the extended submerged intake screen systemwide letter report and implement recommended improvements.

The Corps will complete investigation of fish performance and engineering issues pertaining to the need for improved porosity-control panel and panel connection design and install improved panels in all extended, submerged-intake screens. In particular, the Corps will develop improved vertical barrier screen (VBS) gatewell cleaning and inspection measures for McNary and John Day dams and implement them, as warranted. The Corps will also develop improved debris handling measures in the forebays and screen/bypass systems to limit juvenile injury and mortality.

10.5.2.6 Implement Studies to Reduce Bird Predation at FCRPS Projects

The Action Agencies will recover PIT-tag information from predacious bird colonies and evaluate trends, including hatchery-to-hatchery and hatchery-to-wild depredation ratios.

Evaluation of this information, when combined with bird and fish behavioral information, will help managers develop a better understanding of issues such as prey selection, stock-specific vulnerability, and potential long-term predation effects on specific listed stocks, including the effectiveness of management actions to reduce predation by birds.

10.5.2.7 Reduce Incidental Take Associated with Annual Fish Passage Plans

The Action Agencies, in coordination with the FPOM, will implement or reconcile, in writing, comments received from NMFS regarding ways of reducing incidental take in the current and future Corps' Fish Passage Plans before release of the plan each year.

Review of the final 2000 plan indicated that only about 40% of NMFS' comments (NMFS letter to William Branch, dated January 21, 2000) on the Portland District projects were addressed by the text in the plan. The Corps has to incorporate NMFS' recommendations for reducing delayed mortality or explain in writing why the recommendations were not implemented.

10.5.2.8 Reduce Mortality Associated with Special Facility Operations

All planned special facility operation activities that cause any facility to be out of compliance with the operations and criteria in the main text of the Fish Passage Plan (and expected to result in the take of listed salmon stocks) must be coordinated with NMFS through the Regional Forum process at least 1 month before the anticipated action date.

Identifying special project operations in the Fish Passage Plan does not necessarily mean that the action has undergone the requirements of ESA Section 7 consultation. Generally, this section of

the plan is not ready for review with the rest of the draft plan, and insufficient consultation occurs before release of the plan. Essential information to be provided includes a brief summary of the action, location, anticipated date and time, analysis of potential impact to listed salmon stocks, and potential alternative actions.

10.5.2.9 Develop Action Plan for Reducing Steelhead Holding in John Day Fish Ladders

The Corps will use information from previous and ongoing investigations regarding the problem of adult steelhead holding and jumping in the fish ladders at John Day Dam, develop a proposed course of action, and implement as warranted.

This problem has been investigated in a fragmented manner for years. A more detailed collation of cumulative work to date is required, combined with an assessment of alternatives.

10.5.2.10 Evaluate Kelt Passage and Potential Improvements

The Corps will initiate an adult steelhead downstream migrant (kelt) assessment program to determine the magnitude of passage, their contribution to population diversity and growth, and potential actions to provide safe passage.

Evaluations should be conducted to review available literature and develop pilot testing regarding reconditioning of kelts. The Corps will assess and conduct a short-term holding evaluation at a project site where kelt are more abundant and initiate a kelt transportation pilot study as a possible means of reducing dam passage mortality. The Corps will evaluate kelt passage associated with the RSW at Lower Granite (described in Section 9.2.2.4), which will be prototype-tested in 2001 in the context of juvenile fish passage. The Corps will synthesize these work elements and report the magnitude of kelt passage to the NMFS Regional Forum, the effects of passage on their survival, and potential actions to improve their survival, if deemed appropriate, by 2003.

10.5.3 Terms and Conditions Related to FCRPS Research Projects Described in Section 9.6.5.3

The specific terms described below are addressed to "the researcher" because NMFS expects that the Action Agencies will conduct the research or contract it with other entities. These terms and conditions apply to the Action Agencies or their contractors who will conduct the research. The terms and conditions also refer to the researcher's designated take authorization in this incidental take statement, i.e., take associated with each numbered research activity, not to an unidentified researcher. The specific terms and conditions are described below:

10.5.3.1 Special Conditions

- ESA-listed fish must be handled with extreme care and kept in water to the maximum extent possible during sampling and processing. Adequate circulation and replenishment of water in holding units is required. When using gear that captures a mix of species, ESA-listed fish must be processed first to minimize the duration of handling stress. ESA-listed fish must be transferred using a sanctuary net (which holds water during transfer) whenever necessary to prevent the added stress of being out of water. Should NMFS determine that a researcher's procedure is no longer acceptable, the researcher must immediately cease such activity until NMFS determines an acceptable substitute procedure.

- Each ESA-listed fish handled out of water must be anesthetized when necessary to prevent injury or mortality. Anesthetized fish must be allowed to recover (e.g., in a recovery tank) before being released. Fish that are simply counted must remain in water, but they do not have to be anesthetized.

- To minimize the lateral transfer of pathogens, a sterilized needle must be used for each individual injection when PIT-tagging ESA-listed fish. Sterilization methods are required for the application of surgically implanted radio transmitters.

- Whenever possible, unintentional or indirect mortalities of ESA-listed juvenile fish that occur during scientific research and monitoring activities shall be used in place of intentional lethal take, if applicable.

- Each researcher must ensure that the ESA-listed species are taken only by the means, in the areas, and for the purposes set forth in the research proposal, as limited by the terms and conditions in this incidental take statement.

- Each researcher, in effecting the take authorized by this incidental take statement, is considered to have accepted the terms and conditions of this incidental take statement and must be prepared to comply with the provisions of this incidental take statement, the applicable NMFS regulations, and the ESA.

- Each researcher is responsible for the actions of any individual operating under the authority of the researcher's designated take authorization within this incidental take statement. Such actions include capturing, handling, releasing, transporting, maintaining, and caring for any ESA-listed species authorized to be taken by this incidental take statement.

- Each researcher, staff member, or designated agent acting on the researcher's behalf must possess a copy of this incidental take statement when conducting the activities

for which a take of ESA-listed species or other exception to ESA prohibitions is authorized herein.

- Researchers may not transfer or assign a take authorization included within this incidental take statement to any other person(s), as person is defined in Section 3(12) of the ESA. The take authorization ceases to be in force or effective if transferred or assigned to any other person without prior authorization from NMFS.

- Each researcher must obtain any other Federal, state, and local permits/authorizations necessary to conduct the activities provided for in this incidental take statement.

- Each researcher must coordinate with other applicable comanagers and/or researchers to ensure that no unnecessary duplication and/or adverse cumulative effects occur as a result of the researcher's activities.

- Each researcher must allow any NMFS employee(s), or any other person(s) designated by NMFS, to accompany field personnel during the activities provided for within this incidental take statement. Each researcher must allow such person(s) to inspect the researcher's records and facilities if such records and facilities pertain to ESA-listed species covered by this incidental take statement or NMFS' responsibilities under the ESA.

- Under the terms of NMFS' regulations, a violation of any of the terms and conditions of this incidental take statement will subject the offending researcher, and/or any individual who is operating under the authority of this incidental take statement, to penalties as provided for in the ESA.

- Each researcher is responsible for biological samples collected from ESA-listed species as long as they are useful for research purposes. The terms and conditions concerning any samples collected remain in effect as long as the researcher maintains authority over and responsibility for the material taken. A researcher may not transfer biological samples to anyone not listed in the research proposal without obtaining prior written approval from NMFS. Any such transfer will be subject to such conditions as NMFS deems appropriate.

- NMFS may amend a take authorization identified in this incidental take statement or adjust specific take levels after reasonable notice to the applicable researcher.

- NMFS may revoke a take authorization identified in this incidental take statement if the activities it provides for are not carried out, if the activities are not carried out in accordance with the conditions of this incidental take statement and the purposes and requirements of the ESA, or if NMFS otherwise determines that the continuation of activities would operate to the disadvantage of ESA-listed species.

10.5.3.2 Annual Reporting and Authorization Requirements

The conduct of scientific research/monitoring activities each year is contingent on submission and approval of a report on each preceding year's research and monitoring activities. Annual reports are due by January 31 of each year. The report must include the following:

- A detailed description of scientific research and monitoring activities, including the total number of fish taken at each location, an estimate of the number of ESA-listed fish taken at each location, the manner of take, and the dates and locations of the take

- Measures taken to minimize disturbances to ESA-listed fish and the effectiveness of these measures, the condition of ESA-listed fish taken and used for research and monitoring, a description of the effects of research and monitoring activities on the subject species, the disposition of ESA-listed fish in the event of mortality, and a brief narrative of the circumstances surrounding fish injuries or mortalities to ESA-listed fish

- Any problems that may arise during research and monitoring activities, and a statement as to whether the activities had any unforeseen effects

- A description of how all take estimates were derived

- Any preliminary analyses of the data

- Steps that have been and will be taken to coordinate research and monitoring activities with those of other researchers

10.5.3.3 Operational Reporting and Notification Requirements

- Researchers must provide plans for future undefined projects and/or changes in sampling locations or research/monitoring protocols and obtain NMFS' approval before implementation.

- Each researcher must alert NMFS whenever the authorized level of take is exceeded, or if circumstances indicate that such an event is imminent. Notification should be made as soon as possible, but no later than 2 days after the authorized level of take is exceeded. The researcher must then submit a detailed written report to NMFS. Pending a review of the circumstances, NMFS may suspend the research and monitoring activities or implement reasonable measures and/or alternatives to allow research and monitoring activities to continue.

- Each researcher must alert NMFS when a take of any ESA-listed species not included in the research proposal is killed, injured, or collected during the course of research and monitoring activities. Notification should be made as soon as possible, but no later than 2 days after the unauthorized take. The researcher must then submit a detailed written report to NMFS. Pending a review of the circumstances, NMFS may suspend research and monitoring activities or implement reasonable measures and/or alternatives to allow research and monitoring activities to continue.

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11.0 CONSERVATION RECOMMENDATIONS

Section 11 discusses NMFS' obligation to develop conservation recommendations under Section 7 (a)(1) of the ESA, which directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and listed species. Conservation recommendations are discretionary measures suggested to minimize or avoid the potential adverse effects of a proposed action on listed species, to minimize or avoid adverse modification of critical habitat, to develop additional information, or to assist the Federal agencies in complying with the obligations under Section 7(a)(1) of the ESA. NMFS believes that the following conservation recommendations are consistent with these obligations and, therefore, supports their implementation by the Action Agencies.

11.1 CREATE SPAWNING HABITAT FOR LCR CHINOOK SALMON IN IVES ISLAND AREA BELOW BONNEVILLE DAM

As described in Section 6, the Action Agencies can augment lower Columbia River flows with upper basin reservoir storage to create spawning habitat for tule chinook salmon in the Ives Island area. Starting the flow augmentation program described in Section 9.6.1.2.1 to benefit CR chum salmon approximately 4 weeks earlier will give LCR fall chinook salmon access to this habitat. However, NMFS is concerned about whether the hydrosystem can sustain this operation during a low or average water year without an adverse effect on the ability to meet flow objectives specified in Section 9.6.1.2.1. NMFS, therefore, recommends that the Action Agencies provide flow augmentation for access to spawning habitat in the Ives Island area as early as the first week in October, if the hydroregulation studies completed by mid-September indicate that the operation will not add significant risk to operations designed to meet spawning and incubation requirements for chum salmon or spring and summer flow objectives for juvenile migrants.

11.2 EVALUATE EFFECTS OF FCRPS OPERATIONS ON INFECTIOUS DISEASE TRANSMISSION

The Corps should evaluate the cumulative effects of delay and temperature on the transmission occurrence and level of infectious diseases. Adult passage delay has been documented at FCRPS hydro projects, but effects of cumulative delay passing the FCRPS hydrosystem (including increased exposure to elevated temperatures) have not been adequately addressed.

11.3 DEVELOP ANESTHETIC THAT WILL MEET FDA REQUIREMENTS

The Corps should identify and develop an anesthetic appropriate for use on salmonids in mainstem trapping facilities and other locations, and should seek Food and Drug Administration (FDA) and any other necessary approvals for its use. The anesthetic must meet a number of criteria, including ease of use (when large numbers of fish must be handled) and low immediate

and delayed handling mortality. In addition, any fish released back into the river must be safe for consumption by fishers who may catch those fish after they are trapped.

Trapping and sampling components of each run of adult salmonids at mainstem locations is a fundamental requirement for monitoring ESU status, run performance, and effectiveness of hydrosystem operations. Trapping facilities are also important for reducing the straying of hatchery fish into natural production areas. Handling large numbers of fish during trapping operations requires using an anesthetic to calm the fish, thereby reducing injuries and mortalities. Anesthetics currently used in the Columbia River basin include MS-222 (tricaine methanesulfonate or ethyl m-aminobenzoate sulphonate), clove oil, and carbon dioxide. Each substance is considered effective for anesthetic use, but each also has drawbacks. For example, carbon dioxide can result in increased injuries due to thrashing of the fish during recovery, particularly as water temperatures increase. MS-222 has not been approved for use in fish that may be consumed within 21 days of use. Therefore, it is critical to evaluate all potential anesthetics and to identify and adopt the most effective substance, based on minimizing injuries and lasting effects on salmonid survival and eliminating health risks to consumers. The anesthetic finally adopted may already be one in use, but with possible modifications to existing methods. It is also possible that different substances may be found effective for different objectives or under different conditions.

11.4 EVALUATE EFFECTS OF SHAD

The Corps should evaluate the effects of large numbers of shad in fish ladders on adult salmon migratory behavior, timing, and passage. Delay and accumulations of shad in fish ladders may contribute to delay of adult salmonids migrating through the FCRPS hydrosystem.

The Corps and BPA should also evaluate the effects large numbers of juvenile shad may have on the food base for juvenile salmon.

For NMFS to be kept informed of actions to minimize or avoid adverse effects or to benefit listed species or their habitats, NMFS requests notification of the implementation of any conservation recommendation.

11.5 EVALUATE MOVING LOWER COLUMBIA RIVER FLOW MEASUREMENT LOCATION

The Action Agencies, in coordination with NMFS, will evaluate the hydrologic effects of moving the lower Columbia River flow measurement location from McNary Dam to Bonneville or The Dalles Dams. To do so, the parties will develop new flow objectives for those sites.

The present flow objectives were developed using available fish survival data at various locations in the basin. McNary Dam was selected as a flow measurement location because 1)

data were available to define a flow objective, 2) it is located downstream of the confluence of the Snake and Columbia rivers, and 3) little active storage is provided by downstream FCRPS projects. Changing the flow objective to The Dalles or Bonneville Dam would include the streamflow depletion effects of BOR's projects located downstream of McNary Dam, as well as other water diversions from the lower Columbia River.

11.6 IMPROVE RUNOFF VOLUME FORECASTING

The Action Agencies will provide funding for improved runoff forecasts in storage reservoir basins. To improve forecasts may involve supporting such measures as improved forecasting methodologies, low elevation snowpack estimation by plane, addition of snow telemetry sites, improved maintenance and reliability of snow telemetry sites, and additional snow monitoring sites.

Accurate runoff forecasts are extremely important in managing Columbia Basin runoff for multipurpose uses such as electrical energy, flood control, and listed and unlisted fish species. Forecasting errors can cause too much water to be drafted for flood control, resulting in shortfalls of water for listed species and reservoir refill failures. The Libby basin is a site where runoff forecasting has to be improved. Water in that basin is needed to protect and enhance three listed species: salmon, bulltrout, and sturgeon. The average April-through-August runoff volume from 1960 to 1989 has been 6.4 Maf; the average forecast error has been 1.5 Maf, or 23.4%. In 2000, forecasts indicated that water would be available for sturgeon, bulltrout, and salmon. Libby Reservoir did not fill enough to provide any salmon augmentation water, however.

11.7 EXPLORE CHANGES IN KOOTENAY LAKE OPERATING RANGE WITH CANADIAN ENTITIES

The Corps, in coordination with USFWS and NMFS, will explore the opportunity to change Kootenay Lake regulation to increase its benefit to listed salmon and sturgeon. Increasing the operating range of Kootenay Lake, particularly the upper limit, would allow additional spring water storage and summer delivery that, by augmenting summer flows, would benefit listed salmon downstream. USFWS has also requested such changes in Kootenay Lake operations to improve sturgeon spawning in the Kootenai River downstream of Libby Dam.

11.8 PARTICIPATE IN DEVELOPING MAINSTEM TMDLS

The Action Agencies will participate in developing the Columbia-Snake River mainstem TMDLs for TDG and water temperature. The Action Agencies will also participate in the collaborative process of developing the implementation plan resulting from the TMDLs.

The Columbia-Snake River mainstem TMDLs are being developed by EPA and the states of Oregon, Washington, and Idaho under court order. The TMDLs will establish load allocations

for TDG and temperature for the mainstem Snake River from RM 188 to its confluence with the Columbia River and for the mainstem Columbia River from the Canadian Border to the Astoria Bridge. The water quality plan (Appendix B) presents a conceptual strategy for the TMDL implementation plan. The plan should enable future decisions on study results from RPAs identified in the biological opinion (Appendix B, Table B-2) and should also help determine future decisions on studies identified as conservation measures (Appendix B, Table B-3).

The TMDL provides a useful tool under the CWA for developing a strategy to move toward attaining water quality standards. Participation by the Action Agencies with the states, EPA, the Tribes, and other Federal agencies and private entities in monitoring, modeling, data analysis, and action-item selection will yield a more coordinated and collaborative plan for moving toward standard attainment. Coordination with tributary TMDL and water quality standard attainment efforts will also benefit mainstem water quality efforts (conservation recommendation 11.11).

11.9 CONDUCT LONG-TERM GAS-ABATEMENT ALTERNATIVE STUDY

The Action Agencies should continue to conduct a long-term gas-abatement alternative selection study for the following FCRPS projects: Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, Bonneville, and Grand Coulee dams. The study would be a follow-up evaluation of long-term structural gas-abatement alternatives based on the results of 1) the Corps' systemwide gas-abatement study due to be completed in spring 2001 and 2) the BOR's recently completed feasibility study of gas abatement alternatives at Grand Coulee Dam.

11.10 SUPPORT FEDERAL HABITAT TEAM

To ensure that Federal support for non-Federal habitat initiatives is effective, clear, regular, and predictable across Federal and non-Federal lands, lines of coordination will be needed among Federal agencies and between Federal and non-Federal entities. In the basinwide strategy, the Federal agencies propose to ensure coordination through a Federal Habitat Team.

The Action Agencies should enter into a memorandum of understanding with other Federal habitat agencies establishing a Federal Habitat Team to coordinate Federal activities across Federal and non-Federal lands. During the team's first year, BPA will provide a coordinator and administrative support. Thereafter, the Action Agencies should develop an agreement with other agencies participating on the team to share funding, staff, and administrative support.

11.11 PROVIDE FUNDING TO DEVELOP TMDLS

BPA should strongly consider providing funds to states, Tribes, and/or approved local planning entities that are prepared to develop TMDLs at the watershed level as part of implementing a completed subbasin plan.

Section 9.6.2 of this document and Section 3 of the basinwide strategy cite the importance of water quality to ensuring properly functioning conditions within tributary spawning and rearing habitat. They also name water quality compliance as a key objective in meeting the biological needs of listed salmonids. While water quality compliance is a delegated state responsibility under the CWA, these processes complement, and in some cases can facilitate, accomplishing ESA goals.

In cases where states, Tribes, and/or local planning entities are prepared to embrace TMDLs as mechanisms for achieving recovery of listed species, and in particular when no other funding sources are available, BPA should consider providing funds to assist in their development. Planning and developing TMDLs are necessary prerequisites to implementing legally sanctioned water quality improvements likely to result in biological benefits for listed species. NMFS can foresee situations in which TMDLs may be the appropriate remedies for addressing the biological needs of salmon and steelhead, but in which resources are insufficient to support participation by the affected parties. In those cases, BPA can play a beneficial role on behalf of the resource.

11.12 PROVIDE ALTERNATIVE FISHING LOCATIONS

Working through regional priority processes and in collaboration with state, Tribal, and Federal fishery managers, the Action Agencies will contribute to the identification, development, and establishment of alternative terminal fishing opportunities.

Fishery opportunities can be recreated, expanded, and/or improved in known-stock terminal areas where abundant fish can be harvested with minimal impacts on listed fish, provided the brood stock is appropriate to the area and/or unwanted straying is minimal. Those areas could potentially reduce fishing pressures in existing mixed stock areas, particularly for Tribal fisheries that are already oriented toward terminal fishing. This strategy will be effective for Tribal fisheries only to the extent that the affected Tribes are fully engaged in the planning process to ensure that usual and accustomed fishing areas, catch distribution, and other considerations receive appropriate respect.

11.13 PROVIDE FISHERY EFFORT REDUCTION PROGRAMS

Working through regional prioritization processes and in collaboration with state, Tribal, and Federal fishery managers, the Action Agencies will help develop and implement effective fishery effort reduction programs. The programs will be designed to add value to the catch in commercial fisheries in the basin by such means as price supports, value-added processing, and other strategies for mitigating the effects of harvest constraints necessitated by the status of natural populations.

Programs and strategies may include, but are not limited to, voluntarily buying out and retiring commercial fishing licenses and permits (particularly when catch reductions in harvest of listed

species are needed), purchasing harvest conservation easements to further reduce impacts on listed fish in commercial fisheries, and identifying economic development strategies designed to enhance fishery values, even in the face of smaller catches. Innovative strategies might include the price supports and value-added measures mentioned above, or other strategies that enhance fishery values.

12.0 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

Public Law 104-267, the Sustainable Fisheries Act of 1996, amended the Magnuson-Stevens Act to establish new requirements for essential fish habitat (EFH) descriptions in Federal fishery management plans and to require Federal agencies to consult with NMFS on activities that may adversely affect EFH. EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (Magnuson-Stevens Act, Section 3)." The Secretary of Commerce has designated EFH for the Federally managed groundfish, coastal pelagics, and Pacific salmon fisheries (PFMC 1998a,b, PFMC 1999) as those waters and substrate necessary to ensure the production needed to support a long-term sustainable fishery. That is, EFH provides the properly functioning habitat conditions necessary for the long-term survival of the species over the full range of environmental variation.

The Magnuson-Stevens Act consultation requirements apply to all actions that may adversely affect EFH, regardless of their location. Any reasonable attempt to encourage the conservation of EFH must take into account actions that occur outside EFH, such as upstream and upslope activities that may have an adverse effect on EFH.

The consultation requirements of Section 305(b) of the Magnuson-Stevens Act [16 USC 1855(b)] provide that:

- Federal agencies must consult with NMFS on all actions, or proposed actions, authorized, funded, or undertaken by the agency, that may adversely affect EFH.

- NMFS shall provide conservation recommendations for any Federal or state activity that may adversely affect EFH.

- Federal agencies shall, within 30 days after receiving conservation recommendations from NMFS, provide NMFS with a detailed response in writing regarding the conservation recommendations. The response shall include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the conservation recommendations of NMFS, the Federal agency shall explain its reasons for not following the recommendations.

12.1 ESSENTIAL FISH HABITAT IN THE COLUMBIA RIVER BASIN

The Columbia River estuary and the Pacific Ocean off the mouth of the Columbia River are designated EFH for groundfish and coastal pelagic species (see Table 12.1-1, PFMC 1998a,b). The marine extent of groundfish and coastal pelagic EFH includes waters from the nearshore and tidal submerged environments within Washington, Oregon, and California state territorial waters out to the exclusive economic zone (370.4 km) offshore between the Canadian border to the north and the Mexican border to the south.

PFMC has recommended to the Secretary of Commerce an EFH designation for the Pacific salmon fishery that includes all streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon in Washington, Oregon, Idaho, and California, except above the impassable barriers identified by PFMC (1999). Chief Joseph Dam, Dworshak Dam, and the Hells Canyon Complex (Hells Canyon, Oxbow, and Browne dams) are among the listed manmade barriers that represent the upstream extent of the Pacific salmon fishery EFH. Salmon EFH excludes areas upstream of longstanding, naturally impassable barriers (e.g., natural waterfalls in existence for several hundred years). In the estuarine and marine areas, the designated salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (370.4 km) offshore of Washington, Oregon, and California north of Point Conception (PFMC 1999).

Table 12.1-1. Species with designated EFH found in waters of proposed FCRPS action area.

Groundfish Species	Blue rockfish (S. mystinus)	Rougheye rockfish (S. aleutianus)	Flathead sole (Hippoglossoides elassodon)
Leopard shark (Triakis semifasciata)	Bocaccio (S. paucispinis)	Sharpchin rockfish (S. zacentrus)	Pacific sanddab (Citharichthys sordidus)
Soupfin shark (Galeorhinus zyopterus)	Brown rockfish (S. auriculatus)	Shortbelly rockfish (S. jordani)	Petrale sole (Eopsetta jordani)
Spiny dogfish (Squalus acanthias)	Canary rockfish (S. pinniger)	Shortraker rockfish (S. borealis)	Rex sole (Glyptocephalus zachirus)
Big skate (Raja binoculata)	Chilipepper (S. goodei)	Silvergray rockfish (S. brevispinus)	Rock sole (Lepidopsetta bilineata)
California skate (R. inornata)	China rockfish (S. nebulosus)	Speckled rockfish (S. ovalis)	Sand sole (Psettichthys melanostictus)
Longnose skate (R. rhina)	Copper rockfish (S. caurinus)	Splitnose rockfish (S. diploproa)	Starry flounder (Platyichthys stellatus)
Ratfish (Hydrolagus colliei)	Darkblotched rockfish (S. crameri)	Stripetail rockfish (S. saxicola)	
Pacific rattail (Coryphaenoides acrolepsis)	Grass rockfish (S. rastrelliger)	Tiger rockfish (S. nigrocinctus)	**Coastal Pelagic Species**
Lingcod (Ophiodon elongatus)	Greenspotted rockfish (S. chlorostictus)	Vermillion rockfish (S. miniatus)	Northern anchovy (Engraulis mordax)
Cabezon (Scorpaenichthys marmoratus)	Greenstriped rockfish (S. elongatus)	Widow Rockfish (S. entomelas)	Pacific sardine (Sardinops sagax)
Kelp greenling (Hexagrammos decagrammus)	Longspine thornyhead (Sebastolobus altivelis)	Yelloweye rockfish (S. ruberrimus)	Pacific mackerel (Scomber japonicus)
Pacific cod (Gadus macrocephalus)	Shortspine thornyhead (Sebastolobus alascanus)	Yellowmouth rockfish (S. reedi)	Jack mackerel (Trachurus symmetricus)
Pacific whiting (Hake) (Merluccius productus)	Pacific Ocean perch (S. alutus)	Yellowtail rockfish (S. flavidus)	Market squid (Loligo opalescens)
Sablefish (Anoplopoma fimbria)	Quillback rockfish (S. maliger)	Arrowtooth flounder (Atheresthes stomias)	
Aurora rockfish (Sebastes aurora)	Redbanded rockfish (S. babcocki)	Butter sole (Isopsetta isolepsis)	**Salmon**
Bank Rockfish (S. rufus)	Redstripe rockfish (S. proriger)	Curlfin sole (Pleuronichthys decurrens)	Coho salmon (O. kisutch)
Black rockfish (S. melanops)	Rosethorn rockfish (S . helvomaculatus)	Dover sole (Microstomus pacificus)	Chinook salmon (O. tshawytscha)
Blackgill rockfish (S. melanostomus)	Rosy rockfish (S. rosaceus)	English sole (Parophrys vetulus)	

Sources: Casillas et al. 1998, Eschmeyer et al. 1983, Miller and Lea 1972, Monaco et al. 1990, Emmett et al. 1991, Turner and Sexsmith 1967, Roedel 1953, Phillips 1957, Roedel 1948, Phillips 1964, Fields 1965, Walford 1931, Gotshall 1977, Hart 1973, Healey 1991, Sandercock 1991, and Dees 1961.

12.2 SUMMARY OF PROPOSED ACTION

Below is a brief description of the proposed action. For a more detailed description, see Section 3.

12.2.1 Operation and Configuration of FCRPS

The FCRPS serves an array of individual project and system purposes. Individual purposes vary widely and may include power generation, flood control, irrigation, recreation, and fish and wildlife benefits. Congress authorized all 30 of BOR's projects in the basin to provide water for irrigated agriculture; all the projects except Hungry Horse Dam and Reservoir currently fulfill the congressional mandate.

12.2.2 Flow Objectives for Salmon and Steelhead

The Action Agencies recommend that mainstem flow operations be based on the 1995 RPA as supplemented by the 1998 FCRPS Biological Opinion. System operators will continue to confer with NMFS and the regional fisheries comanagers to determine how to best manage in-season conditions relative to the seasonal average flow objectives.

For fall chinook and chum salmon spawning below Bonneville Dam, the FCRPS would be operated to use storage to augment natural flows, attempting to provide a flow level of 125 kcfs during early November through early April while maintaining the 1995 RPA requirement for storage projects to be at their upper (flood control) rule curve elevation on April 10 of each year. As natural conditions permit, a conservative stepwise approach would allow higher flows during late fall and early winter.

12.2.2.1 Water Quality

The Action Agencies propose to continue to operate the FCRPS to reduce water temperatures during periods of juvenile and adult fish migration and to minimize the harmful effects of elevated levels of spill-generated TDG on anadromous and resident fish.

12.2.2.2 Specific Project Operations

See Section 3 for a detailed discussion of specific project operations.

12.2.2.3 Spill for Fish Passage

Spill reduces turbine-related mortality of juvenile salmon and steelhead at lower Snake and Columbia River hydroelectric projects. It will be maintained at the levels recommended in the 1998 FCRPS Supplemental Biological Opinion, assuming that variances to exceed 110% TDG state water quality standards are obtained from Oregon and Washington.

12.2.2.4 Juvenile Fish Transportation

Juvenile salmonids would be collected at several dams on the lower Snake and Columbia rivers and transported downstream by truck or barge to release points below Bonneville Dam in an effort to improve survival over that experienced by inriver migrants.

12.2.2.5 Minimum Operating Pool (MOP)

Some mainstem run-of-river FCRPS reservoirs on the lower Snake River and John Day Reservoir on the Columbia River would be lowered during the spring and summer migration periods to increase water velocity (intended to increase the migration rate and survival of salmon).

12.2.2.6 Peak Turbine Efficiency Operation

The Action Agencies would operate turbines at the eight FCRPS mainstem Snake and Columbia river projects at high efficiency (within 1% of peak operating efficiency) to reduce the mortality of fish passing through the turbines.

12.2.2.7 Fish Passage Facilities

Turbine intakes with bypass/collection facilities at Lower Granite, Little Goose, Ice Harbor, Lower Monumental, McNary, John Day, and Bonneville dams would be screened. An ice and trash sluiceway passage would be provided at The Dalles Dam. Water would be spilled through the spillway to enhance fish passage.

12.2.2.8 Predator Control Program

The Northern Pikeminnow Management Program would continue. Efforts to relocate Caspian terns from Rice Island would continue.

12.2.2.9 Adaptive Management Framework Through Adoption of Performance Measures

Use of adaptive management would avoid jeopardy and facilitate the future recovery of listed stocks. Applying the "Construct for Achieving Survival Improvements" (BPA et al. 1999) would establish measurable biological performance standards for the hydrosystem, prioritize actions, and estimate the likely outcome of future actions. Ongoing studies would aid in evaluating the feasibility of lower Snake River actions, such as dam breaching, and the John Day phase 1 report (Corps 2000b) that addresses juvenile fish passage alternatives. Measures would be undertaken to improve TDG and temperature conditions for the benefit of anadromous and resident species. Changes in storage project operations and configurations in the Snake and

lower Columbia rivers would benefit anadromous species. The Action Agencies' Construct would establish an overall recovery goal.

The Action Agencies recommend that interim performance standards be developed during consultation to enhance decision-making and to provide a model for developing performance standards for the Basinwide Recovery Strategy.

12.2.2.10 NMFS' Issuance of Section 10 Permit for JFT

NMFS extended the Corps' existing Permit 895 under authority of Section 10 of the ESA and the NMFS regulations governing ESA-listed fish and wildlife permits (50 CFR Parts 217 through 227). The permit is valid until December 31, 2000. The Corps has conducted a feasibility study (Corps 1999c) to evaluate several alternatives to juvenile fish transportation. Permit 895 also authorizes the Corps' annual incidental takes of ESA-listed adult fish associated with fallbacks through the juvenile fish bypass systems at the four dams.

12.3 EFFECTS OF PROPOSED ACTION

12.3.1 General Considerations

As described above in Section 5.3, the activities proposed for the configuration and operation of the FCRPS are likely to continue to reduce the function of already impaired EFH and retard the long-term progress of the impaired habitat toward properly functioning conditions. Direct effects of the FCRPS on EFH include blockage of habitat and habitat alteration.

By providing a storage capacity for almost 40% of the average annual runoff of the Columbia River above Bonneville Dam and operating to meet electrical generation, flood control, and irrigation demands, reservoir operations have changed streamflow conditions affecting turbidity and sediment transport, estuary conditions, and the extent and characteristics of the Columbia River plume. Reservoir operations on the mainstem Columbia and Snake rivers have altered the natural runoff pattern in the basin by increasing fall and winter flows, decreasing spring and summer flows, and effectively increasing the cross-sectional area of the river, resulting in downstream migration delays. Reduced flows result in substantial modification of the rivers' thermal regime and water quality by increasing water temperatures and altering water chemistry.

The effects of water regulation and impoundments effectively transform an ecosystem dependent on moving water (lotic habitat) into one dependent on still water (lentic habitat). This results in substantial changes in the distribution, abundance, and diversity of organisms and in the carrying capacity of the habitat, as well as changed predator-prey dynamics. Because reservoirs have low water velocity, changes in water temperature, dissolved oxygen levels, turbidity, water chemistry, and aquatic habitat may result. Thermal and chemical stratification are likely to occur, with potentially significant effects on associated aquatic life in and downstream of the

reservoir. Specific downstream effects are likely to depend on site, water quality, size of impoundment, and facility design.

12.3.2 Estuary and Nearshore Essential Fish Habitat

12.3.2.1 Groundfish EFH

Flow changes in the estuary as a result of changes in the FCRPS have the potential to adversely affect estuarine EFH for groundfish and coastal pelagic species, primarily by altering the distribution of salt water and freshwater. Increased river flow will decrease both the extent and the duration of intrusion by salt water into the estuary, while decreased river flows will do the opposite. Changes in flow can also affect the nearshore ocean environment by altering the size of the freshwater plume, which will alter the availability of habitat in the immediate area offshore of the mouth of the Columbia River. Predicting the precise impact on EFH is not possible until the relationship between the physical parameters of the plume and the biology of fish is better understood.

The estuary is used by juveniles of several groundfish species as a rearing area. The dominant species in the Columbia River are starry flounder and English sole. They occur in the estuary primarily as different-age juveniles that use the channel as a migratory corridor to rearing areas in the bays and intertidal areas. These areas have large concentrations of food organisms such as the amphipod *Corophium salmonis* and are important rearing habitat. The less-than-1-year-old juveniles occur throughout the estuary, but are more concentrated in the freshwater and low-salinity areas. They are generally not as abundant in the estuary as the older age classes. One- to 2-year-old juveniles occur throughout the estuary, but are abundant year-round in the side channels and bays and also in the main navigation channel. Two-year-old juveniles are less widespread and occur mostly in the higher-salinity parts of the lower estuary.

Altering the flow patterns has the potential to affect the value of these habitats for rearing juvenile flounders if the change occurs in the summer when they are in the estuary. The dominant flatfish species is the starry flounder, which is euryhaline and extremely tolerant of wide ranges of salinity. Starry flounder, for example, have been captured as far upstream as Portland in totally freshwater systems. Consequently, unless the change from altering flow patterns is extremely large, it is unlikely that it will have an effect beyond that to which this species can adjust. Altering salinity patterns may also affect prey items for groundfish species, which could conceivably affect rearing success. These species are generalist feeders and would probably find other prey items if one group was negatively affected by a change in flow patterns.

12.3.2.2 Coastal Pelagics EFH

Only the northern anchovy of the coastal pelagic group uses the Columbia River estuary to any extent. Individuals that occur in the estuary are an extension of the coastal population and occur primarily in the lower estuary, where salinity is high. Though anchovies spawn in the ocean, all

life stages can occur in the estuary. Eggs and larvae can apparently be swept into the estuary by flood tides. Individuals less than 1 year old, however, are not abundant in the estuary, whereas anchovies 1 year or older actively move into the estuary and can be abundant, particularly during periods of low river flow, when salinity is high. Anchovies are pelagic feeders, feeding primarily on copepods.

Changes in flow regulation are not expected to adversely affect anchovy EFH in the Columbia River, because all areas except the lower estuary are used irregularly. High river flows may reduce the extent of this upstream, marginally important, habitat for anchovies.

12.3.2.3 Salmon EFH

Flow changes in the estuary as a result of changes in the FCRPS have the potential to adversely affect estuarine EFH for chinook and coho salmon, primarily by altering the distribution of salt water and freshwater. Increased river flow will decrease both the extent and the duration of intrusion by salt water into the estuary, while decreased river flows will do the opposite. Changes in flow can also affect the nearshore ocean environment by altering the size of the freshwater plume, which will change the availability of habitat in the immediate area offshore of the mouth of the Columbia River. Predicting the precise impact on EFH is not possible until the relationship between the physical parameters of the plume and the biology of salmon is better understood.

Water developments in the Columbia River have reduced average flow, altered the seasonality of Columbia River flows and sediment discharge, and changed the estuarine ecosystem (NRC 1996; Sherwood et al. 1990; Simenstad et al. 1990, 1992; Weitkamp 1994). Annual spring freshet flows (May and June) through the Columbia River estuary are about 70% of predevelopment levels, and total sediment discharge is about one-third of 19th-century levels.

Decreased spring flows and sediment discharges have also reduced the extent, speed of movement, thickness, and turbidity of the plume that extended far out and south into the Pacific Ocean during the spring and summer (Barnes et al. 1972, Cudaback and Jay 1996; Hickey et al. 1998). Pearcy (1992) suggested that low river discharge is unfavorable for juvenile salmonid survival, despite some availability of nutrients from upwelling, because of reduced turbidity in the plume (increasing foraging efficiency of birds and fish predators, increased residence time of the fish in the estuary and near the coast where predation is high, decreased incidence of fronts with concentrated food resources for juvenile salmonids, and reduced overall total secondary productivity based on upwelled and fluvial nutrients). Reduced secondary productivity not only affects salmonid food sources, but also focuses predation by other fishes and birds on the juvenile salmonids.

Because of decreased river flows and development of the hydrosystem, juvenile migrant salmon probably arrive in the estuary later than under conditions in which they evolved. Efforts to make conditions in the Columbia River plume similar to those that existed before development of the

hydrosystem would likely benefit salmonids (NRC 1996). Although the effects of reduced or altered flow timing from individual tributaries (e.g., the Snake River) in the estuary and nearshore ocean are minimal, collectively they are not.

Small changes in salinity distribution may have significant effects on the ecology of fishes, including salmonids. Salinity distribution, as affected by tidal flow and river discharge, is a primary factor explaining seasonal species distributions and the structure of entire assemblages of fish and epibenthic and benthic invertebrate prey species throughout the Columbia River estuary (Haertel et al. 1969; Bottom and Jones 1990; Jones et al. 1990). By altering the distribution of preferred habitats within particular salinity ranges and the particular suite of species that salmon encounter at different locations during their estuarine residence, small changes in salinity structure may have consequences for estuarine food webs and fish production in the estuary. In particular, small changes in the distribution and gradient of oligohaline salinities could change the type of habitats available when juvenile salmon must make the critical physiological transition from riverine to brackish salinities. Assessments of the ecological effects of salinity change on estuarine fishes, rearing conditions at specific places, and times that support at-risk populations are needed to assess the impacts of altered flow regimes in the estuary.

12.3.2.4 Mainstem Essential Fish Habitat

Mainstem EFH provides the migratory corridor for juvenile salmonids and returning adults. In the Columbia River basin, dams built to provide hydropower and reservoirs built for water storage and flood control may adversely affect salmon EFH. Potential adverse effects include impaired fish passage (including blockages and diversions); altered water temperature, water quality, water quantity, and flow patterns; interrupted transport of the nutrients, large woody debris, and sediment that affect river, wetland, riparian, and estuarine systems; increased competition with non-native species; and increased predation and disease.

Hydrologic effects of dams include water-level fluctuations, altered seasonal and daily flow regimes, reduced water velocities, and reduced discharge volume. These altered flow regimes can affect the migratory behavior of juvenile salmonids. Water-level fluctuations associated with hydropower peak operations may reduce habitat availability, inhibit the establishment of aquatic macrophytes that provide cover for fish, and sometimes strand fish or allow desiccation of spawning redds. Drawdowns reduce available habitat area and concentrate organisms, potentially increasing predation and transmission of disease (Spence et al. 1996). Drawdown in the fall for flood control produces high flows during spawning. The high flows allow fish to spawn in areas that may not have water during the winter and spring, resulting in loss of the redds.

12.4 CONCLUSION

NMFS believes that the proposed action may adversely affect designated EFH for groundfish and coastal pelagics listed in Table 12.1-1 and designated EFH for chinook and coho salmon.

12.5 EFH CONSERVATION RECOMMENDATIONS

Conservation measures are discretionary measures suggested to avoid, minimize, or otherwise offset adverse modification of EFH, or to develop additional information. The RPA detailed in Section 9, along with the reasonable and prudent measures and the terms and conditions that implement them (listed in Sections 10.4 and 10.5), are applicable to designated groundfish and coastal pelagics EFH and designated Pacific salmon EFH.

Because listed fish in the Columbia River are in such precarious condition, the habitat strategy is intended to accelerate efforts to help fish in priority areas in the short term, while laying a foundation for long-term strategies through subbasin and watershed assessment and planning.

In the short term, in the Basinwide Recovery Strategy, Federal agencies commit to focus immediate attention on priority subbasins, i.e., those with potential for significant improvement in anadromous fish productive capacity as a result of habitat restoration. The Basinwide Recovery Strategy identifies short-term actions, timelines, and responsible Federal agencies. This biological opinion identifies the Action Agencies' contribution to the Basinwide Recovery Strategy.

Over the long term, the habitat strategy has three overarching objectives: 1) protect existing high-quality habitat, 2) restore degraded habitats on a priority basis and connect them to other functioning habitats, and 3) prevent further degradation of tributary and estuarine habitats and water quality. Estuarine protection and restoration must play a vital role in rebuilding the productivity of listed salmon and steelhead throughout the Columbia River basin. The states of Oregon and Washington, with congressional authorization under the CWA, have developed a Comprehensive Conservation and Management Plan through LCREP. The Federal agencies strongly support the actions of this plan that contribute to salmon recovery and seek to expand on them.

The following action items call on the Action Agencies, primarily the Corps and BPA, to play an important role in estuary restoration efforts. The Corps is meant to play a lead role, with BPA primarily providing cost-share funding. Corps and BPA actions are not meant to hinge on LCREP approval, but they are meant to be fully coordinated with LCREP.

***Action 158*:** During 2001, the Corps and BPA shall seek funding and develop an action plan to rapidly inventory estuarine habitat, model physical and biological features of the historical lower river and estuary, identify limiting biological and physical factors in the estuary, identify impacts of the FCRPS on habitat and listed salmon in the

estuary relative to other factors, and develop criteria for estuarine habitat restoration.

A good deal is unknown about the ecology of the Columbia River estuary insofar as it affects listed species. It is important to develop a better understanding of historical salmon rearing patterns in the estuary; historical changes in the distribution, amounts, and classes of estuarine and floodplain habitat available to juvenile salmonids; variability in salinity, temperature, water depth, velocity, dissolved oxygen, and turbidity; habitat-salmon associations; sedimentation rates; salmon and habitat conditions in the transition zone; long-term variability and trends in the size, timing, and abundance of hatchery and wild out-migrants from the Columbia River; and the relative effects of inflow from upriver, changes in bathymetry due to the navigation channel, and changes in habitat due to other forms of development. Under this action item, the Corps and BPA are expected to develop programs to build an understanding of these matters and, in the relatively short term, to develop criteria for estuarine habitat restoration on the basis of the best available information.

***Action 159*:** BPA and the Corps, working with LCREP and NMFS, shall develop a plan addressing the habitat needs of salmon and steelhead in the estuary.

BPA and the Corps, working with LCREP and NMFS, will develop specific plans for salmon and steelhead habitat protection and enhancement. These plans should contain clear goals for listed salmon conservation in the estuary, identify habitats with the characteristics and diversity to support salmon productivity, identify potential performance measures, identify flow requirements to support estuarine habitat requirements for salmon, and develop a program of research, monitoring, and evaluation. The plans should be completed by 2003.

Action 160: The Corps and BPA, working with LCREP, shall develop and implement an estuary restoration program with a goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats over 10 years, beginning in 2001, to rebuild productivity for listed populations in the lower 46 river miles of the Columbia River. The Corps shall seek funds for the Federal share of the program, and BPA shall provide funding for the non-Federal share. The Action Agencies shall provide planning and engineering expertise to implement the non-Federal share of on-the-ground habitat improvement efforts identified in LCREP, Action 2.

Much of the complexity of the estuary's historical shallow-water habitat and much of the estuary's saltwater wetlands have been lost due to the effects of local, navigational, and hydropower development. LCREP proposes a 10-year program to protect and enhance high-quality habitat on both sides of the river to support salmon rebuilding. A high priority should be put on tidal wetlands and other key habitats to rebuild productivity in the lower 46 river miles. Federal agencies will provide technical and financial support for this program, and for implementing on-the-ground activities identified in planning.

As more information is gained from inventory and analytical work, the 10,000-acre goal may be modified to ensure that habitats that are determined to be important to the survival and recovery of anadromous fish are addressed. Examples of acceptable estuarine habitat improvement work include the following:

- Acquiring rights to diked lands
- Breaching levees
- Improving wetlands and aquatic plant communities
- Enhancing moist soil and wooded wetland by better management of river flows
- Reestablishing flow patterns that have been altered by causeways
- Supplementing the nutrient base by importing nutrient-rich sediments and large woody debris into the estuary
- Modifying the abundance and distribution of predators by altering their habitat
- Creating wetland habitats in sand flats between the north and south channels
- Creating shallow channels in intertidal areas
- Enhancing connections between lakes, sloughs, side channels, and the main channel

The Corps and BPA will put high priority on improving access to and the quality of chum habitat, especially in the Grays River. The work outlined in this action is in addition to any mitigation/restoration work that may be connected to the Corps' channel deepening project.

***Action 161*:** Between 2001 and 2010, the Corps and BPA shall fund a monitoring and research program acceptable to NMFS and closely coordinated with the Conservation Reserve Enhancement Program monitoring and research efforts (Management Plan Action 28) to address the estuary objectives of this biological opinion.

***Action 162*:** During 2000, BPA, working with NMFS, shall continue to develop a conceptual model of the relationship between estuarine conditions and salmon population structure and resilience. The model will highlight the relationship among hydropower, water management, estuarine conditions, and fish response. The work will enable the agencies to identify information gaps that have to be addressed to develop recommendations for FCRPS management and operations.

***Action 163*:** The Action Agencies and NMFS, in conjunction with the Habitat Coordination Team, will develop a compliance monitoring program for inclusion in the first 1- and 5-year plans.

Compliance monitoring is necessary to determine how well management actions are implemented. From a regulatory perspective, compliance monitoring is necessary to ensure that agencies and individuals responsible for mitigation or restoration activities complete their responsibilities. From a biological perspective, NMFS must know how well a management action is implemented. If salmon do not respond, NMFS will be able to distinguish between management that did not work and management that was not implemented.

Some compliance monitoring will be conducted during the monitoring and evaluation program outlined in Section 9.6.5. However, not all sites will be checked at the appropriate intervals during this program. Therefore, the agency or party conducting each action will be responsible for keeping a log book of implementation, which is entered monthly into a web-based data archive. NMFS will randomly send out field staff to check on the log books and validate their entries.

12.6 STATUTORY REQUIREMENTS

The Magnuson-Stevens Act and Federal regulations (50 CFR Section 600.920) to implement the EFH provisions require Federal Action Agencies to provide a written response to EFH conservation recommendations within 30 days of receipt. Because the EFH designation for the Pacific salmon fishery has yet to be approved, this regulation does not apply for the salmon species involved in this consultation until the Secretary of Commerce approves it, at which time the 30-day period will begin. The final response must include a detailed description of measures proposed to avoid, mitigate, or offset the adverse impacts of the activity. If the response is inconsistent with the EFH conservation recommendations, an explanation of the reasons for not implementing them must be included.

12.7 CONSULTATION RENEWAL

The Action Agencies must reinitiate EFH consultation with NMFS if the action is substantially revised in a manner that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations (50 CFR Section 600.920 [k]).

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13.0 REINITIATION OF CONSULTATION

Consultation must be reinitiated if the amount or extent of taking specified in the incidental take statement is exceeded, or is expected to be exceeded; if new information reveals effects of the action may affect listed species in a way not previously considered; if the action is modified in a way that causes an effect on listed species that was not previously considered; or if a new species is listed or critical habitat is designated that may be affected by the action (50 CFR Section 402.16).

Except as specifically provided in the RPA, these general conditions apply as well to prospective agreements, plans, and contracts that the Action Agencies use to plan for operation of or to actually operate the FCRPS and BOR projects and to coordinate operations with Canada and regional utilities. Examples include implementation of the Columbia River Treaty between the United States and Canada, such as by the adoption of assured operating plans and detailed operating plans; arrangements with Canada for non-Treaty storage; and renewing and revising the Pacific Northwest Coordination Agreement.

To the extent that the prospective agreements are used to achieve operations that are in accordance with this biological opinion, including its RPA, reasonable and prudent measures, and terms and conditions, the effects of those prospective agreements on listed fish have been considered in this biological opinion. To the extent that proposed agreements have effects on FCRPS or BOR operations that affect listed fish in ways not considered in this biological opinion, or have provisions that go beyond implementing the operations specified in the opinion, those proposed actions may require separate consultation or reinitiation of this consultation.

In addition to the general conditions described above, the RPA in this biological opinion provides specific performance standards that, if not met, would result in a reinitiation of this consultation. These performance measures are described in Section 9.2, and the conditions governing reinitiation on the basis of performance are described in Section 9.5. NMFS will issue an RPA failure report if it determines that the performance standards have not been met; this will be the basis for a reinitiation of consultation.

The RPA recommended in this biological opinion also anticipates specific projects to provide offsite mitigation. Details of those projects will be provided in the annual plans required by Section 9.4. When the details are available, formal or informal supplemental consultation may be necessary to consider the effects of those projects and, if appropriate, authorize any incidental take. NMFS' finding letters that evaluate the annual plans will determine the necessity of additional consultation.

Similarly, the RPA requires BOR to provide supplemental biological assessments concerning certain of its irrigation projects that may have local effects on listed species. NMFS' consideration of this additional information may necessitate formal or informal supplemental consultation.

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APPENDIX A
ANALYSIS OF EFFECTS OF PROPOSED ACTION AND REASONABLE AND PRUDENT ALTERNATIVE ON SPECIES-LEVEL BIOLOGICAL REQUIREMENTS OF LISTED SPECIES

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Annex 1. Estimate of Hydrosystem Survival Under Natural Conditions

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ACRONYMS

BON	Bonneville Dam
CRI	cumulative risk initiative
CWT	coded wire tag
EM	delayed mortality of nontransported fish
ESU	evolutionarily significant units
FCRPS	Federal Columbia River Power System
HCP	Habitat Conservation Plan
LGR	Lower Granite Dam
MCR	Middle Columbia River
NMFS	National Marine Fisheries Service
PATH	Plan for Analyzing and Testing Hypotheses
PUD	public utility district
PSC	Pacific Salmon Commission
QAR	Quantitative Analytical Report
R/Sp	recruits-per-spawner
RPA	reasonable and prudent alternative
S	egg-to-adult survival, or survival during any component life stage
SAR	smolt-to-adult returns
SIMPAS	Simple Passage (model)
SR	Snake River
UCR	Upper Columbia River

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A.1 PURPOSE

This appendix documents the analysis the National Marine Fisheries Service (NMFS) used to estimate effects of a proposed action on the species-level biological requirements of listed Columbia River basin evolutionarily significant units (ESUs). Quantitative analytical results are one of several sources of information used to determine whether a proposed action jeopardizes listed species. Section 6.1.2 of the December 20, 2000, Federal Columbia River Power System (FCRPS) biological opinion (hereafter, Biological opinion) includes an overview of analytical methods, and Sections 6.3, 9.7.2, and 9.7.3.2 of the biological opinion contain summaries of the analytical results. The biological opinion references this appendix as a source for additional details regarding those sections.

A.2 INDICATOR CRITERIA

Section 1.3.1.1 of the biological opinion describes the general analytical approach that NMFS uses to apply the jeopardy standard in the implementing regulations (Section 402.02 - definition of "jeopardize the continued existence"). This general analytical approach states that, for an action to avoid jeopardy, the mortality of listed salmonids within the different ESUs attributable to the action must be low enough to meet the following condition:

> When combined with mortality occurring in other life stages, there is a high likelihood of population survival and a moderate to high likelihood of population recovery.

Most of the Columbia basin ESUs rely on a combined quantitative and qualitative approach to this determination. For most of the ESUs it is possible to quantify key aspects of the population dynamics and expected effects of the proposed action. These quantifications are imperfect, but NMFS considers them useful for organizing facts and hypotheses to support the general analysis. NMFS also considers qualitative factors affecting other life-stage survivals that could not be estimated quantitatively. For SR sockeye salmon, the entire analysis is qualitative.

In Section 1.3.1.2, NMFS identified "survival and recovery indicator criteria" that are useful for evaluating the general analytical approach described in Section 1.3.1.1. Table A-1 describes the four criteria.

NMFS considered all four criteria qualitatively, but, quantitatively, the 100-year extinction risk criterion is always harder to meet than the 24-year criterion, and the 48-year recovery criterion is always harder to meet than the 100-year criterion. For this reason, only the 100-year survival indicator criterion and the 48-year recovery indicator criterion are displayed in the biological opinion. This Appendix also estimates survival improvements necessary to meet the other criteria for comparison.

Table A-1. Summary of survival and recovery indicator criteria.

	24-Year Survival	100-Year Survival	48-Year Recovery	100-Year Recovery
Applies to:	All actions, including operation of the FCRPS, in combination	All actions, including operation of the FCRPS, in combination	All actions, including operation of the FCRPS, in combination	All actions, including operation of the FCRPS, in combination
Metric:	1 - the probability of absolute extinction in 24 years	1 - the probability of absolute extinction in 100 years	the probability that 8-year geometric mean abundance will be ≥ recovery abundance level in 100 years	the probability that 8-year geometric mean abundance will be ≥ recovery abundance level in 100 years
Acceptable Risk:	High probability (approximated as 5% or less risk of extinction)	High probability (approximated as 5% or less risk of extinction)	Moderate to high probability (approximated as 50% or greater likelihood of meeting the recovery abundance level in the specified time period)	Moderate to high probability (approximated as 50% or greater likelihood of meeting the recovery abundance level in the specified time period)

A.3 GENERAL APPROACH

Briefly, the analysis includes the steps illustrated in Figure A-1. The general approach is discussed in the five steps presented below and in Section 6.1.2 of the biological opinion.

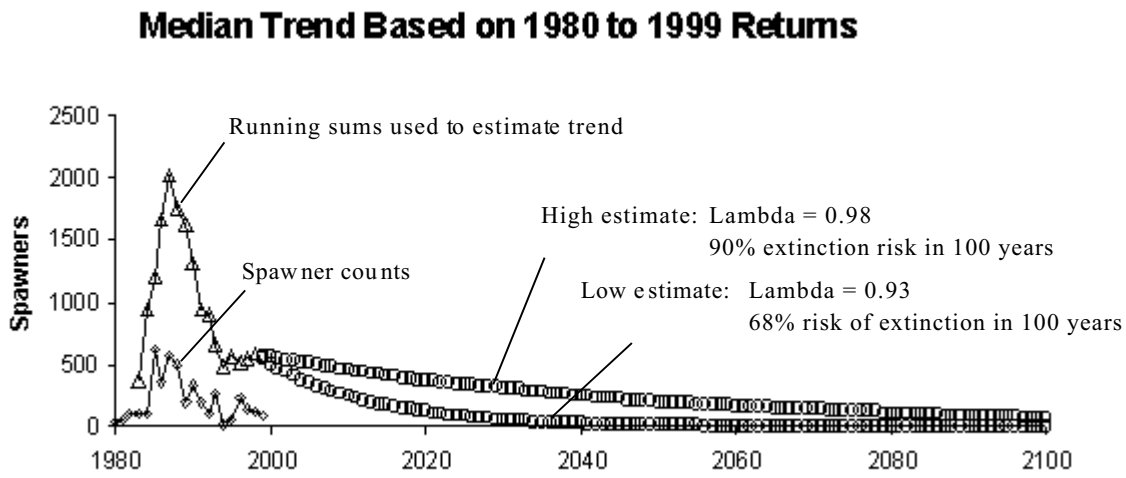
1) Define the recent population trend, based on adult returns from 1980 through the most recent year available.

The starting point is the NMFS cumulative risk initiative (CRI) analysis for 11 ESUs (McClure et al. 2000a,b,c) and the NMFS Quantitative Analytical Report (QAR) for the two Upper Columbia River ESUs (Cooney 2000). These reports assess population trends, based on adult returns during recent years. The trend is defined as the median annual population growth rate (lambda, λ). In the CRI analysis, this is estimated by methods described in McClure et al. (2000c) and Holmes (in review). Simply put, the analysis fits a stochastic exponential decline curve to running sums of total living current or future spawners. Cooney (2000) estimates population growth rate using a stochastic simulation model fit to adult spawner-to-spawner data.

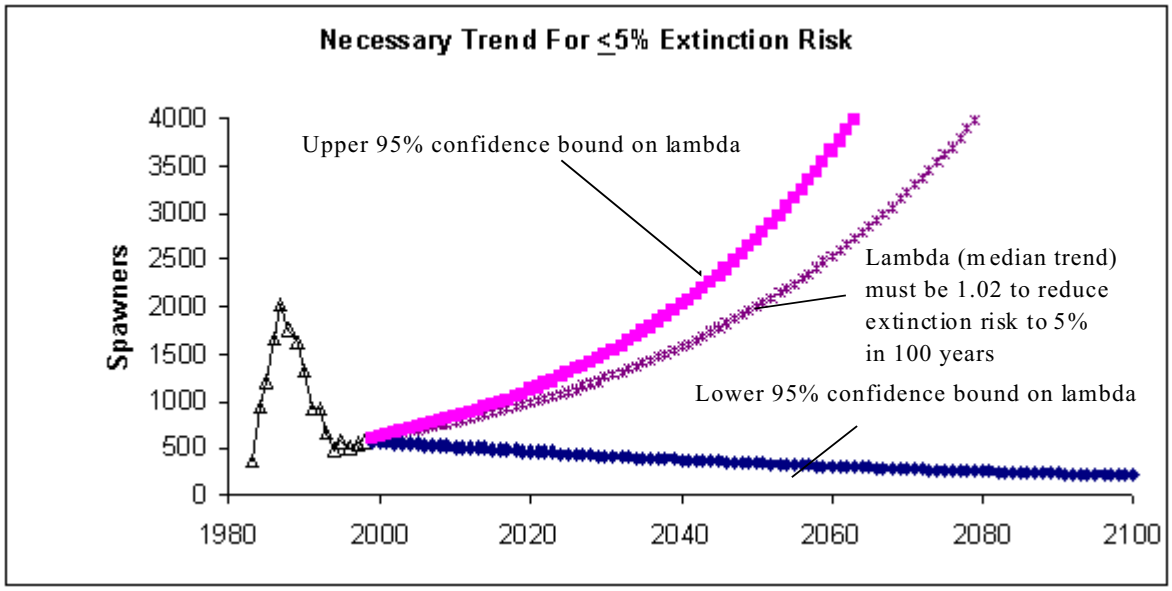
Since the primary purpose of the analysis is to determine the status of stocks and the risks they face under current conditions, NMFS restricted it to the years since 1980. Several agencies and organizations commented on the July 27, 2000, Draft Biological Opinion that NMFS should have included earlier starting years in its estimation of population trends. Changes to the hydrosystem were a main component of the choice of 1980 as the starting year, since before then, the hydrosystem on the Columbia River was in a state of flux. The final dam on the mainstem

Figure A-1. Primary steps in the analysis of effects of the action on species-level biological requirements for a hypothetical salmon population. Lambda is the median annual population growth rate.

Define the recent population trend, based on adult returns from 1980 through the most recent year available.



Define the change in trend that is necessary to meet the survival and recovery indicator criteria described in Section 1.3.1.

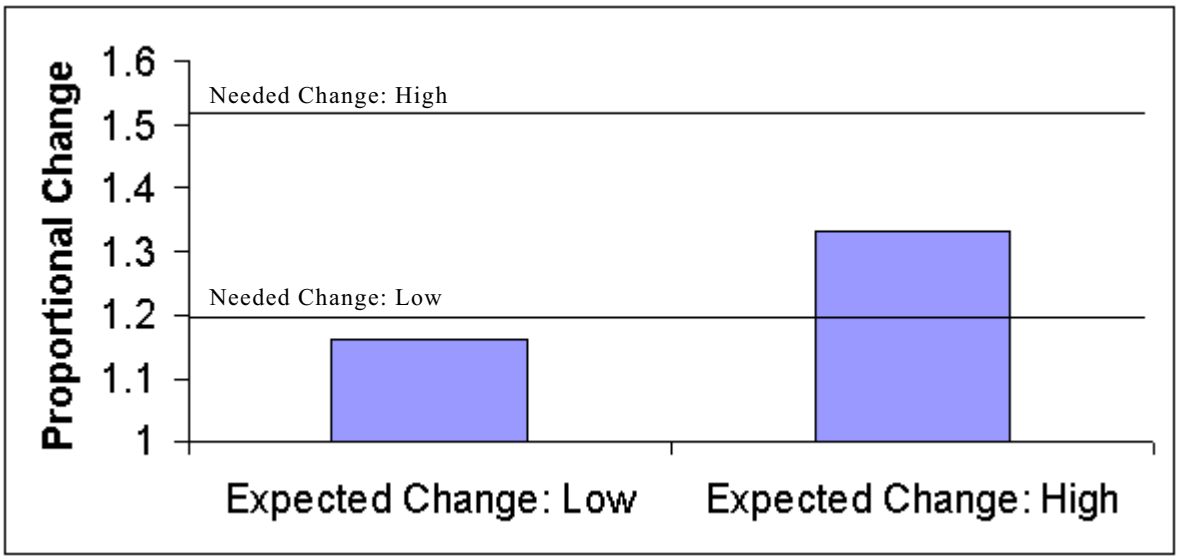


$$\text{Low Needed Survival Change} = \left(\frac{\text{Needed Lambda} = 1.02}{\text{Current Lambda} = 0.98}\right)^{\text{Mean Generation Time [4.5]}} = 1.20$$

$$\text{High Needed Survival Change} = \left(\frac{\text{Needed Lambda} = 1.02}{\text{Current Lambda} = 0.93}\right)^{\text{Mean Generation Time [4.5]}} = 1.52$$

Figure A-1 (Continued). Primary steps in the analysis of effects of the action on species-level biological requirements for a hypothetical salmon population. "Lambda" refers to the median annual population growth rate.

Estimate the change in survival rates associated with the proposed action and with expected changes in other life stages and update the estimate of population growth rate.



Compare the change in survival resulting from the proposed action with the necessary change defined in step 2.

In the example, the highest estimate of the expected survival change achieves the lowest estimate of the goal but the lowest estimate does not. In the worst case, an additional 31% (1.31 times "Low" expected survival rate) survival improvement is still necessary to meet the highest estimate of the goal.

Qualitatively evaluate the likelihood that survival through life stages that could not be quantified is likely to sufficiently reduce the additional necessary survival change.

Relies on information in Basinwide Recovery Strategy

Columbia was completed in 1971, the last of the four lower Snake River dams was completed in 1975, and the full complement of turbines was installed by 1979. The reservoir storage capacity in the Columbia was nearly doubled in 1975, when Libby and Mica dams were completed. Including data from before 1980 would, therefore, confound the evaluation of the current status by implicitly incorporating conditions that no longer exist. The evaluation would also be confounded for other reasons, such as the oceanic regime shift that occurred in the late 1970s (Mantua et al. 1997).

Agencies and organizations commented on the choice of median annual population growth rate as the measure of current trends in the July 27, 2000, Draft Biological Opinion and the anadromous fish appendix. Commenters expressed computational concerns and confusion because NMFS' methods for estimating lambda changed. Many of the suggestions are reflected in the current analysis. The exact methods are now available in McClure et al. (2000c) and Holmes (in review). Some agencies and organizations suggested using alternative indicators of population trend, such as recruits-per-spawner (R/Sp) and smolt-to-adult returns (SARs). Use of median annual population growth rate yields results nearly identical to R/Sp if recruits are defined as adults reaching the spawning grounds. Use of R/Sp with recruits expressed at other life stages, such as adults to the Columbia River mouth, and use of SARs yield estimates of trend for only part of the life cycle. Unless survival is assumed constant in the other life stages, these measures are not useful for assessing population trends.

NMFS also received comments that the annual population growth rate, as determined in McClure et al. (2000), is very sensitive to start- and end-points of the time period selected for the analysis and to data points considered outliers. NMFS applies running sums to the abundances, which reduces the influence of individual years. However, NMFS agrees in general with the comment. In response, NMFS developed an alternative method of estimating the mean instantaneous rate of population change (μ, which, in turn, is used to estimate lambda; McClure et al. 2000c) that is less sensitive to these factors. The alternative estimate and the estimates of annual population growth rate used in this biological opinion vary, but for 80% of all spawning aggregations, the two estimates differ by an absolute value of less than 0.05 (McClure 2000). Whereas this method reduces the sensitivity to time period (or outliers), the implications for estimates of extinction risk, which are sensitive to data distribution, are not well understood. Additional research is needed to determine whether this method, or an alternative, best addresses the sensitivity of NMFS' analytical method to start- and end-points and extreme values. NMFS has not used this new method in this biological opinion, therefore, but considers this characteristic of the analysis qualitatively when drawing conclusions.

2) Define the change in the trend that is necessary to meet the survival and recovery indicator criteria described in Section 1.3.1 of the biological opinion.

Both McClure et al. (2000b,c) and Cooney (2000) estimated the proportional change in population growth rate necessary to reduce extinction risk to 5% in 24 and 100 years. That change in population growth rate can be translated into a needed change in survival if the mean generation time is known:

(1) $$\Delta S = \Delta\lambda^{\text{mean generation time}}$$

where $\Delta\lambda$ is the multiplicative change in median annual population growth rate (based on 1980 to most recent available year), and ΔS is the multiplicative change in average egg-to-adult survival, or survival during any component life stage, that corresponds to the return years used to estimate $\Delta\lambda$.

McClure et al. (2000b,c) used diffusion approximation methods (Dennis et al. 1991; Holmes in review) to project future population trajectories and estimate extinction risk for the survival indicator criterion. Cooney (2000) used a cohort replacement model (Botsford and Brittinacher 1998) to do the same. Neither approach includes density dependence at the low population levels evaluated in the estimation of extinction risk. A few agencies and organizations that commented on the July 27, 2000, Draft Biological Opinion suggested including density dependence at low population levels, and the Idaho Department of Fish and Game suggested including depensation at low population levels. NMFS' assumption of density independence at low population levels is more conservative (i.e., results in higher risk of extinction) than models based on density dependence, such as those based on Ricker functions. A model based on depensation may yield more conservative results, but parameterization of such a model for the populations under consideration must be based almost exclusively on guesswork.

NMFS evaluated the recovery indicator criteria for stocks with interim recovery abundance levels using either simulations with the cohort replacement model for UCR stocks (Cooney 2000), or with an estimate of the minimum change in survival that would be necessary to grow from the current abundance level to the recovery abundance level in either 48 or 100 years (Schiewe 2000). The first method includes assumptions regarding density dependence as populations approach the recovery abundance level; the second method assumes continued exponential growth near recovery abundance levels. Several agencies and organizations, when commenting on the July 27, 2000, Draft Biological Opinion, criticized the absence of density dependance at high abundence levels using this second approach. NMFS agrees that density dependence probably occurs at some high abundance level. The difficulty is in defining the capacity of the system and the rate at which productivity declines as that capacity is approached. NMFS has been unable to detect density dependence since 1980 for Columbia River basin stocks (McClure et al. 2000c) and questions the data quality and conclusions from analyses that have been based on longer time-series (Schaller et al. 1999; Zabel and Williams 2000; Schaller et al. 2000). With the exception of the QAR analysis for UCR spring chinook and UCR steelhead, therefore, analyses of the survival changes necessary to meet recovery indicator criteria do not include density dependence. NMFS qualitatively considers the likelihood that these are, however, minimum estimates in its jeopardy determination.

NMFS applies a simple method of estimating the minimum survival change necessary to meet the recovery indicator criteria for stocks lacking an interim recovery abundance level. As described in Section 1.3.1, the recovery abundance level may be unknown, but it is certainly higher than the current abundance level. At a minimum, therefore, the median annual population

growth rate must be > 1.0. The necessary change in lambda is determined by simply dividing 1.0 by the estimate of lambda from the first step of the analysis.

3) Estimate the change in survival rates associated with the proposed action and with expected changes in other life stages, and update the estimate of population growth rate.

The necessary survival changes identified in the second step of the analysis are based on the assumption that life-stage survival rates influencing adult returns in 1980 through the most recent available year will continue indefinitely. The survival rate associated with the proposed action may, however, represent an improvement over the average survival rate influencing the 1980-through-the-most-recent adult returns. Current survival in other life stages may also differ from the 1980-through-the-most-recent-year average. If these current or expected survival rates are expected to continue, they will change the population growth rate.

NMFS estimates FCRPS juvenile and adult survival resulting from the proposed action using the methods defined in Section 6.1.1 of the biological opinion. The change for each species is addressed separately for each ESU. In some cases, retrospective modeling analyses are available for comparison (e.g., Plan for Analyzing and Testing Hypotheses [PATH] juvenile passage survival estimates for SR spring/summer and fall chinook). In other cases, inferences must be drawn from other species or geographic areas. NMFS also estimates expected survival associated with current and future harvest rates, based on actions defined in the Basinwide Recovery Strategy, and compares that with average historical harvest rates. The combined change in survival is the product of the survival change expected from the proposed action and that expected from current harvest rates. For example, if the average smolt survival through the hydrosystem averaged 50% for the migration years corresponding to the risk assessment and is expected to be 55% as a result of the proposed action, a 10% survival improvement is expected (0.55/0.50 = 1.10). If current and future harvest management results in a 5% survival improvement, the combined change is 15.5% (1.10 x 1.05 = 1.155).

NMFS was not able to quantify expected changes in survival resulting from habitat and hatchery management actions in this analysis. Those effects are evaluated qualitatively relative to the remaining survival change needed after implementing the proposed action (see Step 5 below).

The analysis of survival changes used in this biological opinion is identical to that used for SR steelhead in the July 27, 2000, Draft Biological Opinion and for the evaluation of alternative harvest strategies in McClure et al. (2000c), but is simpler than the Leslie matrix approach that was applied to other ESUs in the draft (Leslie 1945,1948). The primary reason for the change is that applying the Leslie matrix requires an estimate of survival through all life stages, while the method used here requires only estimates of survival changes for life stages that are affected by the proposed action, or that have been affected by changes in other management actions. The matrix approach is useful (Kareiva et al. 2000; Cooney 2000), but it is unnecessarily complex for the analysis required in the biological opinion. Technical discussions with other agencies and organizations on the July 27, 2000, draft sometimes focused on estimating survival rates that were not critical to the results and generated debates regarding differences between estimates of

population growth rate from the deterministic Leslie matrix and the stochastic modified Dennis model approach. The current method simply updates the original estimate of median annual population growth rate (λ) according to a generalized form of Equation 11 in McClure et al. (2000c):

(2) $\lambda_{NEW} = \lambda_{OLD}$ * (new life-stage survival rate/old life-stage survival rate)$^{1/\text{mean generation time}}$

4) Compare the change in survival resulting from the proposed action with the necessary change defined in step 2.

NMFS constructed ratios that indicate the degree to which the proposed action meets the survival and recovery indicator criteria. Ratios less than, or equal to, 1.0 indicate that the jeopardy standard indicator criteria are met, given the effects of the proposed action and other expected activities. Values over 1.0 indicate that additional improvements in survival are necessary to meet the criterion. Those values represent the multiplier by which survival, after the proposed action and other expected actions are implemented, must be additionally increased.

5) Qualitatively evaluate the likelihood that survival through life stages that could not be quantified is likely to reduce the additional necessary survival change.

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. NMFS must use a combination of qualitative methods and professional judgment to determine the extent to which changes in other life stages might account for the necessary survival improvements. Survival changes can be expected if there have been changes from the average 1980-to-1999 egg-to-smolt survival, estuary survival, and/or prespawning adult (above the uppermost dam) survival rates. Also, because the quantitative analysis does not include the effects of FCRPS operations on some life stages in some ESUs (e.g., spawning and rearing requirements of LCR chinook salmon and CR chum salmon), the effects must also be evaluated qualitatively. For SR sockeye salmon, this is the only type of analysis NMFS can perform, because the information available is not suitable for calculating an estimate of current demographic risks, let alone expected survival improvements under the proposed action.

For these reasons, this qualitative evaluation is a key factor in the jeopardy determination for each ESU. Among the factors that NMFS considers at this step are the effects of the proposed action on critical habitat in the action area in the overall context of all the effects on biological requirements throughout the life cycle. The evaluation draws on a review of the existing literature, including the information summarized in Section 4.1 and Appendix C of the biological opinion. Adverse effects on individuals of a species or constituent elements or segments of critical habitat generally do not result in jeopardy or determination of adverse modifications unless those losses, when added to the environmental baseline, are likely to result in significant adverse affects throughout the species' range, or appreciably diminish the value of the critical habitat for both the survival and the recovery of the listed species (50 CFR Section 402.02). Therefore, NMFS considers the range of critical habitat types affected by the proposed action,

the geographic scope of the effects, and the degree to which the effects are likely to limit the productivity of each ESU.

A.4 ESTIMATES OF NEEDED IMPROVEMENT FROM BASE PERIOD SURVIVAL

In the first two steps of the analysis, NMFS must estimate the current trend and the survival change that are necessary to meet survival and recovery indicator criteria. The following two subsections discuss the estimates of the necessary survival improvements and the key assumptions influencing those estimates.

A.4.1 SURVIVAL AND RECOVERY INDICATOR CRITERIA

Tables A-2 through A-6 display estimates of the improvement from base period survival needed to meet the four survival and recovery indicator criteria. All results are expressed as multipliers to either median annual population growth rate (λ) or per-generation (egg-to-adult spawner) survival (S).

CRI Estimates. CRI estimates are available for 12 of the 13 ESUs in the Columbia River basin. McClure et al. (2000b) is the source of CRI estimates of the current median annual population growth rate (lambda), based on returning spawners from 1980 through the most recently available year. McClure et al. (2000b) is also the source of estimates of the change in lambda that is needed to meet the 24- and 100-year survival indicator criteria. Methods are described in McClure et al. (2000c).

NMFS generated estimates of the change necessary to meet recovery indicator criteria from McClure et al.'s (2000b) lambda estimates. NMFS used two alternative methods, depending upon whether or not interim recovery abundance levels were defined for an ESU. Interim recovery abundance levels have been defined only for SR spring/summer chinook index stocks, SR fall chinook, SR sockeye salmon, UCR spring chinook, and UCR steelhead (Appendix C). For each of these ESUs except SR sockeye salmon, which was not evaluated in this analysis, NMFS used the method of estimating recovery indicator criteria described in Schiewe (2000). Because that document is not easily accessible, the method is briefly described here. Needed changes in annual population growth rate were calculated using Equation 3:

(3) $$\lambda_{needed} = (\boldsymbol{n}_{goal} \div \boldsymbol{n}_{current})^{(1/\mathbf{t})}$$

Where:

λ_{needed} is the geometric mean annual population growth rate that would yield the interim recovery abundance level in the desired time, $\boldsymbol{n}_{\text{goal}}$ is the interim recovery abundance level (Appendix C, expressed as the 8-year geometric mean of spawner numbers), $\boldsymbol{n}_{current}$ is the current number of spawners (expressed as the geometric mean of the most recent 8 years), and $\boldsymbol{t}$ is the time period over which recovery goals are to be achieved (44 or 96 years, corresponding to midpoints of 8-year geometric means in 48 and 100 years). The most recent 8-year geometric mean spawner

Table A-2. Needed incremental change from base period survival to achieve 5% risk of extinction in 24 years. A "Necessary % Change in Lambda" of, for example, 15.00 means that the median annual population growth rate ("Estimated Lambda") must be multiplied by 1.15 to meet the recovery criterion. A "Necessary % Change in Survival" of, for example, 81.12 means that the average 1980-to-most-recent-year egg-to-adult survival rate rate, or any component life-stage survival rate, must be multiplied by 1.8112 to meet the recovery criterion.

		Lambda Calculated From 1980 to Most Recent Completed Year								Lambda Calculated From 1980 through 2001 (From Jack Returns)							
		20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners				20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners			
	Mean Gen. Time	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival
Snake River Spring/Summer Chinook																	
Aggregate ESU	4.73	0.91	0.91	0.00	0.00	0.82	0.82	0.00	0.00								
Bear Valley/Elk Creeks	4.729	1.02	1.02	0.00	0.00	1.02	1.02	0.00	0.00	1.03	1.03	0.00	0.00	1.03	1.03	0.00	0.00
Imnaha River[1]	4.486	0.89	0.89	0.00	0.00	0.88	0.88	0.00	0.00	0.92	0.92	0.00	0.00	0.91	0.91	0.00	0.00
Johnson Creek	4.351	1.01	1.01	0.00	0.00	1.01	1.01	0.00	0.00	1.03	1.03	0.00	0.00	1.03	1.03	0.00	0.00
Marsh Creek	4.684	0.99	0.99	0.00	0.00	0.99	0.99	0.00	0.00	1.00	1.00	0.00	0.00	1.00	1.00	0.00	0.00
Minam River	4.178	0.98	0.98	0.00	0.00	0.93	0.93	0.00	0.00	1.02	1.02	0.00	0.00	0.97	0.97	0.00	0.00
Poverty Flats	4.221	1.00	1.00	0.00	0.00	0.99	0.99	0.00	0.00	1.02	1.02	0.00	0.00	1.02	1.02	0.00	0.00
Sulphur Creek	4.610	1.04	1.04	0.00	0.00	1.04	1.04	0.00	0.00	1.05	1.05	0.00	0.00	1.05	1.05	0.00	0.00
1 50%, rather than 20%, effectiveness of hatchery-origin natural spawners was applied to the Imnaha index stock.																	
Alturas Lake Creek	4.465	0.75				0.75											
American River	4.465	0.91				0.91											
Big Sheep Creek	4.465	0.88				0.85											
Beaver Creek	4.465	0.95				0.95											
Bushy Fork	4.465	0.98				0.98											
Camas Creek	4.465	0.92				0.92											
Cape Horn Creek	4.465	1.05				1.05											
Catherine Creek	4.465	0.85				0.78											
Catherine Creek N Fk	4.465	0.92				0.92											
Catherine Creek S Fk	4.465	0.80				0.80											
Crooked Fork	4.465	1.00				1.00											
Grande Ronde River	4.465	0.84				0.77											
Knapp Creek	4.465	0.89				0.89											
Lake Creek	4.465	1.06				1.06											
Lemhi River	4.465	0.98				0.98											
Lookingglass Creek	4.465	0.79				0.72											
Loon Creek	4.465	1.00				1.00											
Lostine Creek	4.465	0.90				0.87											
Lower Salmon River	4.465	0.92				0.92											

Table A-2 (continued). Needed incremental change from base period survival to achieve 5% risk of extinction in 24 years. A "Necessary % Change in Lambda" of, for example, 15.00 means that the median annual population growth rate ("Estimated Lambda") must be multiplied by 1.15 to meet the recovery criterion. A "Necessary % Change in Survival" of, for example, 81.12 means that the average 1980-to-most-recent-year egg-to-adult survival rate rate, or any component life-stage survival rate, must be multiplied by 1.8112 to meet the recovery criterion.

		Lambda Calculated From 1980 to Most Recent Completed Year								Lambda Calculated From 1980 through 2001 (From Jack Returns)							
		20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners				20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners			
	Mean Gen. Time	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival
Lower Valley Creek	4.465	0.92				0.92											
Moose Creek	4.465	0.94				0.94											
Newsome Creek	4.465	1.03				1.03											
Red River	4.465	0.91				0.91											
Salmon River E. Fork	4.465	0.94				0.94											
Salmon River S. Fork	4.465	1.06				1.06											
Secesh River	4.465	0.98				0.98											
Selway River	4.465	0.91				0.91											
Sheep Creek	4.465	0.80				0.80											
Upper Big Creek	4.465	0.97				0.97											
Upper Salmon River	4.465	0.90				0.90											
Upper Valley Creek	4.465	1.03				1.03											
Wallowa Creek	4.465	0.86				0.86											
Wenaha River	4.465	0.90				0.84											
Whitecap Creek	4.465	0.90				0.90											
Yankee Fork	4.465	0.88				0.88											
Yankee West Fork	4.465	0.99				0.99											
Snake River Fall Chinook																	
Aggregate	4.137	0.92	0.92	0.00	0.00	0.87	0.87	0.00	0.00								
Upper Columbia River Spring Chinook																	
ESU Aggregate - CRI	4.25	0.85	0.85	0.00	0.00	0.84	0.96	15.00	81.12								
Methow River - QAR	4.400	0.90	0.92	2.61	12.00	0.90	0.91	0.95	12.00								
Entiat River - QAR	4.320	0.89	0.89	0.00	0.00	0.89	0.89	0.00	0.00								
Wenatchee R. - QAR	4.370	0.88	0.89	1.56	7.00	0.88	0.89	0.97	7.00								
Methow River - CRI	4.250	0.86	0.95	10.50	52.86	0.85	0.94	10.50	52.86	0.89	0.97	8.5	1.41	0.870	0.95	9.5	1.47
Entiat River - CRI	4.210	0.85	0.86	1.00	4.28	0.81	0.87	6.50	30.36	0.89	0.89	0.0	1.00	0.852	0.86	1.5	1.06
Wenatchee River - CRI	4.336	0.80	0.80	0.00	0.00	0.80	0.80	0.50	2.19	0.85	0.85	0.0	1.00	0.841	0.84	0.0	1.00

Table A-2 (continued). Needed incremental change from base period survival to achieve 5% risk of extinction in 24 years. A "Necessary % Change in Lambda" of, for example, 15.00 means that the median annual population growth rate ("Estimated Lambda") must be multiplied by 1.15 to meet the recovery criterion. A "Necessary % Change in Survival" of, for example, 81.12 means that the average 1980-to-most-recent-year egg-to-adult survival rate rate, or any component life-stage survival rate, must be multiplied by 1.8112 to meet the recovery criterion.

		Lambda Calculated From 1980 to Most Recent Completed Year								Lambda Calculated From 1980 through 2001 (From Jack Returns)							
		20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners				20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners			
	Mean Gen. Time	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival
Upper Willamette River Chinook																	
McKenzie River above Leaburg	4.430	0.99	0.99	0.00	0.00	0.90	0.90	0.00	0.00								
Lower Columbia River Chinook																	
Aggregations Above Bonneville Dam: (Insufficient Information For Analysis)																	
Aggregations Below Bonneville Dam:																	
Bear Creek	3.29	0.82	0.94	13.50	51.68	0.73	0.92	26.00	113.90								
Big Creek	3.96	0.93	0.93	0.00	0.00	0.84	0.84	0.00	0.00								
Clatskanie	3.68	0.89	1.16	31.00	169.76	0.80	1.13	42.00	262.79								
Cowlitz Tule	3.56	0.92															
Elochoman	3.50	0.99															
Germany	3.68	0.93															
Gnat	3.74	0.94	1.08	15.50	71.42	0.84	1.06	26.00	137.35								
Grays Tule	3.53	0.85															
Kalama Spring	3.77	0.85															
Kalama	3.77	0.99															
Klaskanine	3.68	0.89	1.08	21.00	101.48	0.80	1.06	32.50	181.28								
Lewis R Bright	3.84	0.99															
Lewis Spring	3.84	0.91															
Lewis, E Fk Tule	3.84	0.99															
Lewis and Clark	3.84	0.54															
Mill Fall	3.68	0.81	0.92	14.00	61.85	0.72	0.90	24.50	123.74								
Plympton	3.83	0.95	0.95	0.00	0.00	0.86	0.86	0.00	0.00								
Sandy Late	3.68	0.98	0.98	0.00	0.00	0.98	0.98	0.00	0.00								
Skamokawa	3.68	0.82															
Youngs	3.68	0.94	1.58	67.50	565.66	0.84	1.49	76.50	706.84								

Table A-2 (continued). Needed incremental change from base period survival to achieve 5% risk of extinction in 24 years. A "Necessary % Change in Lambda" of, for example, 15.00 means that the median annual population growth rate ("Estimated Lambda") must be multiplied by 1.15 to meet the recovery criterion. A "Necessary % Change in Survival" of, for example, 81.12 means that the average 1980-to-most-recent-year egg-to-adult survival rate rate, or any component life-stage survival rate, must be multiplied by 1.8112 to meet the recovery criterion.

		Lambda Calculated From 1980 to Most Recent Completed Year								Lambda Calculated From 1980 through 2001 (From Jack Returns)							
		20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners				20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners			
	Mean Gen. Time	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival
Snake River Steelhead																	
ESU Aggregate	5.168	0.83	0.83	0.00	0.00	0.72	0.72	0.00	0.00								
A-Run Aggregate	5.040	0.85	0.85	0.00	0.00	0.74	0.74	0.00	0.00								
A-Run Pseudopopulation	5.040	0.85	0.85	0.00	0.00	0.74	0.74	0.00	0.00								
B-Run Aggregate	6.490	0.84	0.84	0.00	0.00	0.74	0.74	0.00	0.00								
B-Run Pseudopopulation	6.490	0.84	0.84	0.00	0.00	0.74	0.74	0.00	0.00								
Upper Columbia River Steelhead																	
ESU Aggregate - CRI	3.784	0.83	0.83	0.00	0.00	0.69	0.74	7.00	29.18								
Methow - QAR	3.800	0.97	0.97	0.00	0.00	0.81	0.81	0.00	0.00								
Wenatchee/Entiat - QAR	3.800	0.94	0.94	0.00	0.00	0.85	0.85	0.00	0.00								
Mid-Columbia River Steelhead																	
ESU Aggregate	5.17	0.84				0.77											
Deschutes River Sum	5.169	0.84	0.84	0.00	0.00	0.77	0.77	0.00	0.00								
Warm Springs NFH Sum	5.169	0.91	0.91	0.00	0.00	0.91	0.91	0.00	0.00								
Umatilla River Sum	5.169	0.90	0.90	0.00	0.00	0.90	0.90	0.00	0.00								
Yakima River Sum	5.169	1.04	1.04	0.00	0.00	1.01	1.01	0.00	0.00								
Upper Willamette River Steelhead																	
ESU Aggregate	4.08	0.92	0.92	0.00	0.00	0.88	0.88	0.00	0.00								
Mollala	4.080	0.91	0.91	0.00	0.00	0.84	0.84	0.00	0.00								
N Santiam River	4.080	0.92	0.92	0.00	0.00	0.89	0.89	0.00	0.00								
S Santiam	4.080	0.94	0.94	0.00	0.00	0.87	0.87	0.00	0.00								
Calapooia	4.080	0.93	0.93	0.00	0.00	0.93	0.93	0.00	0.00								

Table A-2 (continued). Needed incremental change from base period survival to achieve 5% risk of extinction in 24 years. A "Necessary % Change in Lambda" of, for example, 15.00 means that the median annual population growth rate ("Estimated Lambda") must be multiplied by 1.15 to meet the recovery criterion. A "Necessary % Change in Survival" of, for example, 81.12 means that the average 1980-to-most-recent-year egg-to-adult survival rate rate, or any component life-stage survival rate, must be multiplied by 1.8112 to meet the recovery criterion.

		Lambda Calculated From 1980 to Most Recent Completed Year								Lambda Calculated From 1980 through 2001 (From Jack Returns)							
		20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners				20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners			
	Mean Gen. Time	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival
Lower Columbia River Steelhead																	
ESU Aggregate	4.47	0.91				0.80											
Aggregations Above Bonneville Dam:																	
(Insufficient Information For Analysis)																	
Aggregations Below Bonneville Dam:																	
Clackamas summer	5.17	0.83	0.83	0.00	0.00	0.73	0.73	0.00	0.00								
Clackamas winter	4.47	0.88	0.88	0.00	0.00	0.76	0.76	0.00	0.00								
Green River winter	4.47	0.90	0.91	0.50	2.25	0.90	0.91	0.50	2.25								
Kalama summer	5.17	0.91	0.91	0.00	0.00	0.77	0.77	0.00	0.00								
Kalama River winter	4.47	0.97	0.97	0.00	0.00	0.90	0.90	0.00	0.00								
Sandy winter	4.47	0.91	0.91	0.00	0.00	0.85	0.85	0.00	0.00								
Toutle winter	4.47	0.88	0.88	0.00	0.00	0.88	0.88	0.00	0.00								
Columbia River Chum Salmon																	
ESU Aggregate	3.61	1.04				1.04											
Aggregations Above Bonneville Dam:																	
(Insufficient Information For Analysis)																	
Aggregations Below Bonneville Dam:																	
Grays River west fork	3.61	1.23				1.23											
Grays River mouth to head	3.61	0.96				0.96											
Hardy Creek	3.61	1.05				1.05											
Crazy Johnson	3.61	1.16				1.16											
Hamilton	3.61	0.92				0.92											
Hamilton Springs	3.61	1.11				1.11											

Table A-3. Needed incremental change from base period survival to achieve 5% risk of extinction in 100 years. A "Necessary % Change in Lambda" of, for example, 1.50 means that the median annual population growth rate ("Estimated Lambda") must be multiplied by 1.015 to meet the recovery criterion. A "Necessary % Change in Survival" of, for example, 7.30 means that the average 1980-to-most-recent-year egg-to-adult survival rate rate, or any component life-stage survival rate, must be multiplied by 1.073 to meet the recovery criterion.

		Lambda Calculated From 1980 to Most Recent Completed Year								Lambda Calculated From 1980 through 2001 (From Jack Returns)							
		20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners				20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners			
	Mean Gen. Time	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival
Snake River Spring/Summer Chinook																	
Aggregate ESU	4.73	0.91	0.93	1.50	7.30	0.82	0.93	14.00	85.83								
Bear Valley/Elk Creeks	4.729	1.02	1.02	0.00	0.00	1.02	1.02	0.00	0.00	1.03	1.03	0.000	0.00	1.03	1.03	0.000	0.00
Imnaha River[1]	4.486	0.89	0.96	7.50	38.32	0.88	0.96	9.50	50.24	0.92	0.95	3.500	16.69	0.91	0.96	5.500	27.15
Johnson Creek	4.351	1.01	1.01	0.00	0.00	1.01	1.01	0.00	0.00	1.03	1.03	0.000	0.00	1.03	1.03	0.000	0.00
Marsh Creek	4.684	0.99	1.02	3.00	14.85	0.99	1.02	3.00	14.85	1.00	1.01	0.500	2.36	1.00	1.01	0.500	2.36
Minam River	4.178	0.98	1.02	4.50	20.19	0.93	1.02	9.50	46.11	1.02	1.02	0.000	0.00	0.97	1.02	5.000	22.61
Poverty Flats	4.221	1.00	1.00	0.00	0.00	0.99	0.99	0.00	0.00	1.02	1.02	0.000	0.00	1.02	1.02	0.000	0.00
Sulphur Creek	4.610	1.04	1.11	7.00	36.60	1.04	1.11	7.00	36.60	1.05	1.09	3.500	17.19	1.05	1.09	3.500	17.19
1 50%, rather than 20%, effectiveness of hatchery-origin natural spawners was applied to the Imnaha index stock.																	
Alturas Lake Creek	4.465	0.75				0.75											
American River	4.465	0.91				0.91											
Big Sheep Creek	4.465	0.88				0.85											
Beaver Creek	4.465	0.95				0.95											
Bushy Fork	4.465	0.98				0.98											
Camas Creek	4.465	0.92				0.92											
Cape Horn Creek	4.465	1.05				1.05											
Catherine Creek	4.465	0.85				0.78											
Catherine Creek N. Fork	4.465	0.92				0.92											
Catherine Creek S. Fork	4.465	0.80				0.80											
Crooked Fork	4.465	1.00				1.00											
Grande Ronde River	4.465	0.84				0.77											
Knapp Creek	4.465	0.89				0.89											
Lake Creek	4.465	1.06				1.06											
Lemhi River	4.465	0.98				0.98											
Lookingglass Creek	4.465	0.79				0.72											
Loon Creek	4.465	1.00				1.00											
Lostine Creek	4.465	0.90				0.87											
Lower Salmon River	4.465	0.92				0.92											
Lower Valley Creek	4.465	0.92				0.92											

Table A-3 (continued). Needed incremental change from base period survival to achieve 5% risk of extinction in 100 years. A "Necessary % Change in Lambda" of, for example, 1.50 means that the median annual population growth rate ("Estimated Lambda") must be multiplied by 1.015 to meet the recovery criterion. A "Necessary % Change in Survival" of, for example, 7.30 means that the average 1980-to-most-recent-year egg-to-adult survival rate rate, or any component life-stage survival rate, must be multiplied by 1.073 to meet the recovery criterion.

		Lambda Calculated From 1980 to Most Recent Completed Year								Lambda Calculated From 1980 through 2001 (From Jack Returns)							
		20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners				20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners			
	Mean Gen. Time	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival
Moose Creek	4.465	0.94				0.94											
Newsome Creek	4.465	1.03				1.03											
Red River	4.465	0.91				0.91											
Salmon River E. Fork	4.465	0.94				0.94											
Salmon River S. Fork	4.465	1.06				1.06											
Secesh River	4.465	0.98				0.98											
Selway River	4.465	0.91				0.91											
Sheep Creek	4.465	0.80				0.80											
Upper Big Creek	4.465	0.97				0.97											
Upper Salmon River	4.465	0.90				0.90											
Upper Valley Creek	4.465	1.03				1.03											
Wallowa Creek	4.465	0.86				0.86											
Wenaha River	4.465	0.90				0.84											
Whitecap Creek	4.465	0.90				0.90											
Yankee Fork	4.465	0.88				0.88											
Yankee West Fork	4.465	0.99				0.99											
Snake River Fall Chinook																	
Aggregate	4.137	0.92	0.96	5.00	22.37	0.87	0.95	8.50	40.15								
Upper Columbia River Spring Chinook																	
ESU Aggregate - CRI	4.25	0.85	0.96	14.00	74.52	0.84	0.96	15.00	81.12								
Methow River - QAR	4.400	0.90	0.96	6.51	32.00	0.90	0.90	0.87	32.00								
Entiat River - QAR	4.320	0.89	0.99	11.01	57.00	0.89	0.90	0.79	57.00								
Wenatchee River - QAR	4.370	0.88	1.00	13.66	75.00	0.88	0.88	0.75	75.00	0.92	1.00	8.00	40.00	0.82	0.88	8.00	40.00
Methow River - CRI	4.250	0.86	1.05	22.00	132.82	0.85	1.04	23.00	141.04	0.89	1.07	19.5	2.13	0.870	1.06	21.5	2.29
Entiat River - CRI	4.210	0.85	0.98	15.00	80.11	0.81	0.99	21.50	127.02	0.89	0.98	10.5	1.52	0.852	0.99	16.0	1.87
Wenatchee River - CRI	4.336	0.80	0.96	20.00	120.46	0.80	0.96	21.00	128.54	0.85	0.97	13.5	1.73	0.841	0.96	14.5	1.80

Table A-3 (continued). Needed incremental change from base period survival to achieve 5% risk of extinction in 100 years. A "Necessary % Change in Lambda" of, for example, 1.50 means that the median annual population growth rate ("Estimated Lambda") must be multiplied by 1.015 to meet the recovery criterion. A "Necessary % Change in Survival" of, for example, 7.30 means that the average 1980-to-most-recent-year egg-to-adult survival rate rate, or any component life-stage survival rate, must be multiplied by 1.073 to meet the recovery criterion.

		Lambda Calculated From 1980 to Most Recent Completed Year								Lambda Calculated From 1980 through 2001 (From Jack Returns)							
		20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners				20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners			
	Mean Gen. Time	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival
Upper Willamette River Chinook																	
McKenzie River above Leaburg	4.430	0.99	1.01	2.00	9.17	0.90	1.01	12.00	65.21								
Lower Columbia River Chinook																	
Aggregations Above Bonneville Dam:																	
Bear Creek	3.29	0.82	1.04	26.00	113.90	0.73	1.03	41.5	213.32								
Big Creek	3.96	0.93	0.96	2.50	10.27	0.84	0.95	13.00	62.25								
Clatskanie	3.68	0.89	1.19	34.00	193.16	0.80	1.17	47.00	311.99								
Cowlitz Tule	3.56	0.92															
Elochoman	3.50	0.99															
Germany	3.68	0.93															
Gnat	3.74	0.94	1.14	21.50	107.16	0.84	1.12	33.50	194.65								
Grays Tule	3.53	0.85															
Kalama Spring	3.77	0.85															
Kalama	3.77	0.99															
Klaskanine	3.68	0.89	1.12	25.50	130.42	0.80	1.10	38.00	226.63								
Lewis River Bright	3.84	0.99															
Lewis Spring	3.84	0.91															
Lewis, E Fk Tule	3.84	0.99															
Lewis and Clark	3.84	0.54															
Mill Fall	3.68	0.81	1.03	27.50	144.20	0.72	1.02	41.50	258.12								
Plympton	3.83	0.95	0.99	4.50	18.36	0.86	0.99	15.50	73.66								
Sandy Late	3.68	0.98	0.98	0.00	0.00	0.98	0.98	0.00	0.00								
Skamokawa	3.68	0.82															
Youngs	3.68	0.94	1.58	68.00	572.99	0.84	1.50	78.00	732.33								
Snake River Steelhead																	
ESU Aggregate	5.168	0.83	0.90	8.00	48.84	0.72	0.89	23.00	191.49								
A-Run Aggregate	5.040	0.85	0.90	5.50	30.98	0.74	0.89	20.00	150.65								
A-Run Pseudopopulation	5.040	0.85	0.92	8.00	47.39	0.74	0.91	22.50	178.10								

Table A-3 (continued). Needed incremental change from base period survival to achieve 5% risk of extinction in 100 years. A "Necessary % Change in Lambda" of, for example, 1.50 means that the median annual population growth rate ("Estimated Lambda") must be multiplied by 1.015 to meet the recovery criterion. A "Necessary % Change in Survival" of, for example, 7.30 means that the average 1980-to-most-recent-year egg-to-adult survival rate rate, or any component life-stage survival rate, must be multiplied by 1.073 to meet the recovery criterion.

		Lambda Calculated From 1980 to Most Recent Completed Year								Lambda Calculated From 1980 through 2001 (From Jack Returns)							
		20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners				20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners			
	Mean Gen. Time	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival
B-Run Aggregate	6.490	0.84	0.93	11.00	96.85	0.74	0.92	23.50	293.48								
B-Run Pseudopopulation	6.490	0.84	0.94	12.00	108.65	0.74	0.93	24.50	314.62								
Upper Columbia River Steelhead																	
ESU Aggregate - CRI	3.784	0.83	0.95	13.50	61.47	0.69	0.94	37.00	229.12								
Methow - QAR	3.800	0.97	1.00	3.75	15.00	0.81	0.85	5.24	115.00								
Wenatchee/Entiat - QAR	3.800	0.94	0.97	3.03	12.00	0.85	0.88	4.37	67.00								
Mid-Columbia River Steelhead																	
ESU Aggregate	5.17	0.84				0.77											
Deschutes River summer	5.169	0.84	0.92	9.00	56.12	0.77	0.92	19.50	151.14								
Warm Springs NFH summer	5.169	0.91	0.97	7.50	45.33	0.91	0.97	7.50	45.33								
Umatilla River summer	5.169	0.90	0.93	3.00	16.51	0.90	0.93	2.50	13.61								
Yakima River summer	5.169	1.04	1.04	0.00	0.00	1.01	1.01	0.00	0.00								
Upper Willamette River Steelhead																	
ESU Aggregate	4.08	0.92	0.95	3.00	12.82	0.88	0.95	8.50	39.49								
Mollala	4.080	0.91	0.98	7.50	34.32	0.84	0.99	18.00	96.46								
N Santiam River	4.080	0.92	0.96	4.50	19.67	0.89	0.96	7.50	34.32								
S Santiam	4.080	0.94	0.95	1.50	6.26	0.87	0.96	10.50	50.29								
Calapooia	4.080	0.93	1.03	11.00	53.08	0.93	1.03	11.00	53.08								
Lower Columbia River Steelhead																	
ESU Aggregate	4.47	0.91				0.80											

Table A-3 (continued). Needed incremental change from base period survival to achieve 5% risk of extinction in 100 years. A "Necessary % Change in Lambda" of, for example, 1.50 means that the median annual population growth rate ("Estimated Lambda") must be multiplied by 1.015 to meet the recovery criterion. A "Necessary % Change in Survival" of, for example, 7.30 means that the average 1980-to-most-recent-year egg-to-adult survival rate rate, or any component life-stage survival rate, must be multiplied by 1.073 to meet the recovery criterion.

		Lambda Calculated From 1980 to Most Recent Completed Year								Lambda Calculated From 1980 through 2001 (From Jack Returns)							
		20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners				20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners			
	Mean Gen. Time	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival
Aggregations Above Bonneville Dam:																	
Clackamas summer	5.17	0.83	0.94	13.00	88.09	0.73	0.93	28.00	258.24								
Clackamas winter	4.47	0.88	0.94	7.00	35.31	0.76	0.94	23.50	156.84								
Green River winter	4.47	0.90	1.03	14.00	79.60	0.90	1.03	14.00	79.60								
Kalama summer	5.17	0.91	0.94	3.00	16.51	0.77	0.93	21.00	167.87								
Kalama River winter	4.47	0.97	0.97	0.00	0.00	0.90	0.93	3.00	14.12								
Sandy winter	4.47	0.91	0.95	4.00	19.16	0.85	0.95	11.50	62.66								
Toutle winter	4.47	0.88	0.93	6.00	29.75	0.88	0.93	6.00	29.75								
Columbia River Chum Salmon																	
ESU Aggregate	3.61	1.04				1.04											
Aggregations Above Bonneville Dam:																	
Grays River west fork	3.61	1.23				1.23											
Grays River mouth to head	3.61	0.96				0.96											
Hardy Creek	3.61	1.05				1.05											
Crazy Johnson	3.61	1.16				1.16											
Hamilton	3.61	0.92				0.92											
Hamilton Springs	3.61	1.11				1.11											

Table A-4. Needed incremental change from base period survival to achieve 50% likelihood of recovery in 48 years. A "Necessary % Change in Lambda" of, for example, 1.99 means that the median annual population growth rate ("Estimated Lambda") must be multiplied by 1.0199 to meet the recovery criterion. A "Necessary % Change in Survival" of, for example, 9.79 means that the average 1980-to-most-recent-year egg-to-adult survival rate rate, or any component life-stage survival rate, must be multiplied by 1.0979 to meet the recovery criterion.

		Lambda Calculated From 1980 to Most Recent Completed Year								Lambda Calculated From 1980 Through 2001 (Based on Jack Returns)							
		20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners				20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners			
	Mean Gen. Time	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival
Snake River Spring/Summer Chinook																	
Bear Valley/Elk Creeks	4.729	1.02	1.05	3.14	15.75	1.02	1.05	3.14	15.75	1.03	1.05	1.99	9.79	1.03	1.05	1.99	9.79
Imnaha River[1]	4.486	0.89	1.04	16.99	102.14	0.88	1.04	18.61	114.99	0.92	1.04	13.15	74.04	0.91	1.04	15.09	87.87
Johnson Creek	4.351	1.01	1.03	1.70	7.61	1.01	1.03	1.70	7.61	1.03	1.03	0.00	0.00	1.03	1.03	0.00	0.00
Marsh Creek	4.684	0.99	1.07	8.29	45.19	0.99	1.07	8.29	45.19	1.00	1.07	6.70	35.48	1.00	1.07	6.70	35.48
Minam River	4.178	0.98	1.05	7.79	36.83	0.93	1.05	12.79	65.36	1.02	1.05	3.61	15.95	0.97	1.05	8.82	42.33
Poverty Flats	4.221	1.00	1.03	2.61	11.51	0.99	1.03	3.67	16.41	1.02	1.03	0.40	1.69	1.02	1.03	1.31	5.65
Sulphur Creek	4.610	1.04	1.07	2.74	13.26	1.04	1.07	2.74	13.26	1.05	1.07	1.63	7.72	1.05	1.07	1.63	7.72
Snake River Fall Chinook																	
Aggregate	4.137	0.92	1.05	14.07	72.42	0.87	1.05	20.21	114.13								
Upper Columbia River Spring Chinook																	
Methow River - QAR	4.400	0.90	1.06	17.72	105.000	0.90	1.06	17.72	105.000								
Entiat River - QAR	4.320	0.89	1.06	19.00	112.000	0.89	1.06	19.00	112.000								
Wenatchee River - QAR	4.370	0.88	1.10	25.52	170.000	0.88	1.10	25.52	170.000	0.92	1.10	19.14	115.00	0.92	1.10	19.14	115.00
Methow River - CRI	4.250	0.86	1.08	24.74	155.86	0.85	1.08	27.03	176.48	0.89	1.08	20.24	118.90	0.87	1.08	23.62	146.23
Entiat River - CRI	4.210	0.85	1.05	23.43	142.58	0.81	1.05	29.74	199.29	0.89	1.05	18.50	104.36	0.85	1.05	23.85	146.09
Wenatchee River - CRI	4.336	0.80	1.06	32.03	233.64	0.80	1.06	33.26	247.34	0.85	1.06	24.76	160.97	0.84	1.06	26.13	173.66
Upper Columbia River Steelhead																	
Methow - QAR	3.800	0.97	1.08	12.22	55.00	0.81	1.08	33.52	200.00								
Wenatchee/Entiat - QAR	3.800	0.94	1.05	11.26	50.00	0.85	1.04	23.06	120.00								

1 50%, rather than 20%, effectiveness of hatchery-origin natural spawners was applied to the Imnaha index stock..

Table A-5. Needed incremental change from base period survival to achieve 50% likelihood of recovery in 100 years. A "Necessary % Change in Lambda" of, for example, 1.99 means that the median annual population growth rate ("Estimated Lambda") must be multiplied by 1.0199 to meet the recovery criterion. A "Necessary % Change in Survival" of, for example, 9.79 means that the average 1980-to-most-recent-year egg-to-adult survival rate rate, or any component life-stage survival rate, must be multiplied by 1.0979 to meet the recovery criterion.

		Lambda Calculated From 1980 to Most Recent Completed Year								Lambda Calculated From 1980 Through 2001 (Based on Jack Returns)							
		20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners				20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners			
	Mean Gen. Time	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival
Snake River Spring/Summer Chinook																	
Bear Valley/Elk Creeks	4.729	1.02	1.02	0.00	0.00	1.02	1.02	0.00	0.00	1.03	1.02	0.00	0.00	1.03	1.02	0.00	0.00
Imnaha River[1]	4.486	0.89	1.02	14.31	82.17	0.88	1.02	15.89	93.75	0.92	1.02	10.55	56.85	0.91	1.02	12.46	69.31
Johnson Creek	4.351	1.01	1.01	0.00	0.00	1.01	1.01	0.00	0.00	1.03	1.01	0.00	0.00	1.03	1.01	0.00	0.00
Marsh Creek	4.684	0.99	1.03	4.45	22.62	0.99	1.03	4.45	22.62	1.00	1.03	2.92	14.43	1.00	1.03	2.92	14.43
Minam River	4.178	0.98	1.02	4.88	22.03	0.93	1.02	9.74	47.48	1.02	1.02	0.81	3.41	0.97	1.02	5.87	26.93
Poverty Flats	4.221	1.00	1.01	1.07	4.61	0.99	1.01	2.11	9.21	1.02	1.01	0.00	0.00	1.02	1.01	0.00	0.00
Sulphur Creek	4.610	1.04	1.03	0.00	0.00	1.04	1.03	0.00	0.00	1.05	1.03	0.00	0.00	1.05	1.03	0.00	0.00
Snake River Fall Chinook																	
Aggregate	4.137	0.92	1.02	11.21	55.23	0.87	1.02	17.19	92.78								
Upper Columbia River Spring																	
Methow River - QAR	4.400	0.90	1.04	16.39	95.00	0.90	1.04	16.39	95.00								
Entiat River - QAR	4.320	0.89	1.04	17.40	100.00	0.89	1.04	17.40	100.00								
Wenatchee River - QAR	4.370	0.88	1.09	23.89	155.00	0.88	1.09	23.89	155.00	0.93	1.09	17.46	102.00	0.93	1.09	17.46	102.00
Methow River - CRI	4.250	0.86	1.03	19.89	116.20	0.85	1.03	22.10	133.63	0.89	1.03	15.57	84.97	0.87	1.03	18.82	108.07
Entiat River - CRI	4.210	0.85	1.02	19.92	114.84	0.81	1.02	26.05	165.06	0.89	1.02	15.13	80.99	0.85	1.02	20.33	117.95
Wenatchee River - CRI	4.336	0.80	1.03	27.88	190.43	0.80	1.03	29.07	202.35	0.85	1.03	20.83	127.18	0.84	1.03	22.16	138.22
Upper Columbia River																	
Methow - QAR	3.800	0.97	1.08	12.22	55.00	0.81	1.08	33.52	200.00								
Wenatchee/Entiat - QAR	3.800	0.94	1.05	11.26	50.00	0.85	1.04	23.06	120.00								

1 50%, rather than 20%, effectiveness of hatchery-origin natural spawners was applied to the Imnaha index stock..

Table A-6. Needed incremental change from base period survival to achieve lambda = 1.0, for stocks that do not have an interim recovery abundance level. A "Necessary % Change in Lambda" of, for example, 9.65 means that the median annual population growth rate ("Estimated Lambda") must be multiplied by 1.0965 to meet the recovery criterion. A "Necessary % Change in Survival" of, for example, 54.58 means that the average 1980-to-most-recent-year egg-to-adult survival rate rate, or any component life-stage survival rate, must be multiplied by 1.5458 to meet the recovery criterion.

		Lambda Calculated From 1980 to Most Recent Completed Year								Lambda Calculated From 1980 Through 2001 (Based on Jack Returns)							
		20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners				20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners			
	Mean Gen. Time	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival
Snake River Spring/Summer Chinook																	
Aggregate ESU	4.73	0.91	1.00	9.65	54.58	0.82	1.00	22.26	158.72								
Alturas Lake Creek	4.465	0.75	1.00	34.14	271.19	0.75	1.00	34.14	271.19								
American River	4.465	0.91	1.00	10.10	53.68	0.91	1.00	10.10	53.68								
Big Sheep Creek	4.465	0.88	1.00	13.90	78.81	0.85	1.00	17.36	104.41								
Beaver Creek	4.465	0.95	1.00	4.94	24.05	0.95	1.00	4.94	24.05								
Bushy Fork	4.465	0.98	1.00	2.01	9.28	0.98	1.00	2.01	9.28								
Camas Creek	4.465	0.92	1.00	8.45	43.64	0.92	1.00	8.45	43.64								
Cape Horn Creek	4.465	1.05	1.00	0.00	0.00	1.05	1.00	0.00	0.00								
Catherine Creek	4.465	0.85	1.00	17.85	108.23	0.78	1.00	27.82	199.26								
Catherine Creek N. Fork	4.465	0.92	1.00	8.60	44.57	0.92	1.00	8.60	44.57								
Catherine Creek S. Fork	4.465	0.80	1.00	25.68	177.51	0.80	1.00	25.68	177.51								
Crooked Fork	4.465	1.00	1.00	0.11	0.51	1.00	1.00	0.11	0.51								
Grande Ronde River	4.465	0.84	1.00	19.23	119.35	0.77	1.00	29.22	214.09								
Knapp Creek	4.465	0.89	1.00	12.37	68.31	0.89	1.00	12.37	68.31								
Lake Creek	4.465	1.06	1.00	0.00	0.00	1.06	1.00	0.00	0.00								
Lemhi River	4.465	0.98	1.00	2.50	11.64	0.98	1.00	2.50	11.64								
Lookingglass Creek	4.465	0.79	1.00	25.83	178.94	0.72	1.00	37.97	320.95								
Loon Creek	4.465	1.00	1.00	0.00	0.00	1.00	1.00	0.00	0.00								
Lostine Creek	4.465	0.90	1.00	10.90	58.72	0.87	1.00	14.91	86.00								
Lower Salmon River	4.465	0.92	1.00	9.08	47.43	0.92	1.00	9.08	47.43								
Lower Valley Creek	4.465	0.92	1.00	8.27	42.57	0.92	1.00	8.27	42.57								
Moose Creek	4.465	0.94	1.00	5.94	29.40	0.94	1.00	5.94	29.40								
Newsome Creek	4.465	1.03	1.00	0.00	0.00	1.03	1.00	0.00	0.00								
Red River	4.465	0.91	1.00	9.97	52.85	0.91	1.00	9.97	52.85								
Salmon River E. Fork	4.465	0.94	1.00	6.46	32.25	0.94	1.00	6.46	32.25								
Salmon River S. Fork	4.465	1.06	1.00	0.00	0.00	1.06	1.00	0.00	0.00								
Secesh River	4.465	0.98	1.00	2.44	11.35	0.98	1.00	2.44	11.35								
Selway River	4.465	0.91	1.00	9.43	49.52	0.91	1.00	9.43	49.52								
Sheep Creek	4.465	0.80	1.00	25.13	172.07	0.80	1.00	25.13	172.07								

Table A-6 (continued). Needed incremental change from base period survival to achieve lambda = 1.0, for stocks that do not have an interim recovery abundance level. A "Necessary % Change in Lambda" of, for example, 9.65 means that the median annual population growth rate ("Estimated Lambda") must be multiplied by 1.0965 to meet the recovery criterion. A "Necessary % Change in Survival" of, for example, 54.58 means that the average 1980-to-most-recent-year egg-to-adult survival rate rate, or any component life-stage survival rate, must be multiplied by 1.5458 to meet the recovery criterion.

		Lambda Calculated From 1980 to Most Recent Completed Year								Lambda Calculated From 1980 Through 2001 (Based on Jack Returns)							
		20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners				20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners			
	Mean Gen. Time	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival
Upper Big Creek	4.465	0.97	1.00	3.33	15.76	0.97	1.00	3.33	15.76								
Upper Salmon River	4.465	0.90	1.00	10.58	56.68	0.90	1.00	10.58	56.68								
Upper Valley Creek	4.465	1.03	1.00	0.00	0.00	1.03	1.00	0.00	0.00								
Wallowa Creek	4.465	0.86	1.00	16.30	96.24	0.86	1.00	16.30	96.24								
Wenaha River	4.465	0.90	1.00	10.73	57.65	0.84	1.00	18.77	115.54								
Whitecap Creek	4.465	0.90	1.00	10.77	57.91	0.90	1.00	10.77	57.91								
Yankee Fork	4.465	0.88	1.00	13.30	74.63	0.88	1.00	13.30	74.63								
Yankee West Fork	4.465	0.99	1.00	1.13	5.16	0.99	1.00	1.13	5.16								
Upper Willamette River Chinook																	
McKenzie River above	4.430	0.99	1.00	1.01	4.55	0.90	1.00	11.11	59.48								
Lower Columbia River																	
Aggregations Above Bonneville Dam:																	
Bear Creek	3.29	0.82	1.00	21.31	88.80	0.73	1.00	37.22	183.20								
Big Creek	3.96	0.93	1.00	7.15	31.46	0.84	1.00	18.70	97.19								
Clatskanie	3.68	0.89	1.00	12.58	54.56	0.80	1.00	25.71	131.85								
Cowlitz Tule	3.56	0.92	1.00	8.24	32.55	0.82	1.00	21.29	98.82								
Elochoman	3.50	0.99	1.00	1.12	3.97	0.88	1.00	13.54	55.96								
Germany	3.68	0.93	1.00	7.36	29.82	0.83	1.00	19.88	94.73								
Gnat	3.74	0.94	1.00	6.66	27.27	0.84	1.00	18.87	90.90								
Grays Tule	3.53	0.85	1.00	17.37	76.00	0.76	1.00	31.65	163.99								
Kalama Spring	3.77	0.85	1.00	18.03	86.80	0.76	1.00	31.43	180.20								
Kalama	3.77	0.99	1.00	1.44	5.53	0.89	1.00	12.96	58.30								
Klaskanine	3.68	0.89	1.00	12.38	53.54	0.80	1.00	25.48	130.31								
Lewis River Bright	3.84	0.99	1.00	1.39	5.42	0.97	1.00	2.71	10.83								
Lewis Spring	3.84	0.91	1.00	10.43	46.36	0.81	1.00	22.73	119.55								
Lewis, E Fork Tule	3.84	0.99	1.00	0.78	3.01	0.99	1.00	0.78	3.01								
Lewis and Clark	3.84	0.54	1.00	83.73	933.74	0.49	1.00	105.63	1493.10								
Mill Fall	3.68	0.81	1.00	23.78	119.05	0.72	1.00	38.22	228.58								

Table A-6 (continued). Needed incremental change from base period survival to achieve lambda = 1.0, for stocks that do not have an interim recovery abundance level. A "Necessary % Change in Lambda" of, for example, 9.65 means that the median annual population growth rate ("Estimated Lambda") must be multiplied by 1.0965 to meet the recovery criterion. A "Necessary % Change in Survival" of, for example, 54.58 means that the average 1980-to-most-recent-year egg-to-adult survival rate rate, or any component life-stage survival rate, must be multiplied by 1.5458 to meet the recovery criterion.

		Lambda Calculated From 1980 to Most Recent Completed Year								Lambda Calculated From 1980 Through 2001 (Based on Jack Returns)							
		20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners				20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners			
	Mean Gen. Time	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival
Plympton	3.83	0.95	1.00	5.11	21.03	0.86	1.00	16.85	81.54								
Sandy Late	3.68	0.98	1.00	1.76	6.63	0.98	1.00	2.27	8.59								
Skamokawa	3.68	0.82	1.00	21.65	105.46	0.74	1.00	35.84	208.19								
Youngs	3.68	0.94	1.00	6.35	25.37	0.84	1.00	18.75	88.06								
Snake River Steelhead																	
ESU Aggregate	5.168	0.83	1.00	19.81	154.46	0.72	1.00	38.66	441.55								
A-Run Aggregate	5.040	0.85	1.00	17.09	121.47	0.74	1.00	34.94	352.83								
A-Run Pseudopopulation	5.040	0.85	1.00	17.09	121.47	0.74	1.00	34.94	352.83								
B-Run Aggregate	6.490	0.84	1.00	19.68	220.96	0.74	1.00	34.28	577.48								
B-Run Pseudopopulation	6.490	0.84	1.00	19.68	220.96	0.74	1.00	34.28	577.48								
Mid-Columbia River Steelhead																	
ESU Aggregate	5.17	0.84	1.00	18.48	140.28	0.77	1.00	29.87	286.15								
Deschutes River summer	5.169	0.84	1.00	19.07	146.47	0.77	1.00	30.55	296.73								
Warm Springs NFH summer	5.169	0.91	1.00	10.27	65.76	0.91	1.00	10.27	65.76								
Umatilla River summer	5.169	0.90	1.00	11.29	73.82	0.90	1.00	10.67	68.91								
Yakima River summer	5.169	1.04	1.00	0.00	0.00	1.01	1.00	0.00	0.00								
Upper Willamette River Steelhead																	
ESU Aggregate	4.08	0.92	1.00	8.11	37.46	0.88	1.00	13.77	69.25								
Mollala	4.080	0.91	1.00	9.60	45.36	0.84	1.00	19.67	108.05								
N Santiam River	4.080	0.92	1.00	8.89	41.55	0.89	1.00	11.91	58.27								
S Santiam	4.080	0.94	1.00	6.63	29.94	0.87	1.00	15.13	77.71								
Calapooia	4.080	0.93	1.00	7.80	35.87	0.93	1.00	7.80	35.87								

Table A-6 (continued). Needed incremental change from base period survival to achieve lambda = 1.0, for stocks that do not have an interim recovery abundance level. A "Necessary % Change in Lambda" of, for example, 9.65 means that the median annual population growth rate ("Estimated Lambda") must be multiplied by 1.0965 to meet the recovery criterion. A "Necessary % Change in Survival" of, for example, 54.58 means that the average 1980-to-most-recent-year egg-to-adult survival rate rate, or any component life-stage survival rate, must be multiplied by 1.5458 to meet the recovery criterion.

		Lambda Calculated From 1980 to Most Recent Completed Year								Lambda Calculated From 1980 Through 2001 (Based on Jack Returns)							
		20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners				20% Historical Effectiveness of Hatchery Spawners				80% Historical Effectiveness of Hatchery Spawners			
	Mean Gen. Time	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival	Estimated Lambda	Lambda Needed to Meet Criterion	Necessary % Change in Lambda	Necessary % Change in Survival
Lower Columbia River Steelhead																	
ESU Aggregate	4.47	0.91	1.00	9.98	52.99	0.80	1.00	24.97	170.82								
Aggregations Above Bonneville Dam:																	
Clackamas summer	5.17	0.83	1.00	20.42	161.32	0.73	1.00	37.09	410.77								
Clackamas winter	4.47	0.88	1.00	13.41	75.46	0.76	1.00	31.75	242.95								
Green River winter	4.47	0.90	1.00	10.73	57.68	0.90	1.00	10.73	57.68								
Kalama summer	5.17	0.91	1.00	9.83	62.34	0.77	1.00	30.37	293.92								
Kalama River winter	4.47	0.97	1.00	2.70	12.65	0.90	1.00	10.71	57.59								
Sandy winter	4.47	0.91	1.00	9.32	48.93	0.85	1.00	17.82	108.07								
Toutle winter	4.47	0.88	1.00	14.25	81.40	0.88	1.00	14.25	81.40								
Columbia River Chum Salmon																	
ESU Aggregate	3.61	1.04	1.00	0.00	0.00	1.04	1.00	0.00	0.00								
Aggregations Above Bonneville Dam:																	
Grays River west fork	3.61	1.23	1.00	0.00	0.00	1.23	1.00	0.00	0.00								
Grays River mouth to head	3.61	0.96	1.00	4.60	17.61	0.96	1.00	4.60	17.61								
Hardy Creek	3.61	1.05	1.00	0.00	0.00	1.05	1.00	0.00	0.00								
Crazy Johnson	3.61	1.16	1.00	0.00	0.00	1.16	1.00	0.00	0.00								
Hamilton	3.61	0.92	1.00	8.81	35.64	0.92	1.00	8.81	35.64								
Hamilton Springs	3.61	1.11	1.00	0.00	0.00	1.11	1.00	0.00	0.00								

numbers were estimated from information in the digital appendices to McClure et al. (2000c). The necessary percent improvement in population growth rate to achieve recovery goals in the allotted time was then calculated using the ratio of the needed growth rate to the current growth rate. This method assumes that population growth is density-independent (see discussion in Section A.3.1).

For the spawning aggregations comprising all other ESUs, as well as for the spawning aggregations that are not defined as index stocks for the SR spring/summer chinook ESU, an alternative recovery indicator criterion was evaluated. Because interim recovery abundance levels have not yet been defined for these stocks, this analysis determines the change in survival necessary to achieve an increasing population growth rate ($\lambda>1.0$) . Equation 4 defines the calculation.

(4) $$\Delta\lambda > 1.0 \div \lambda$$

in which λ refers to the current estimate (1980 through most recent available year).

All CRI-based estimates of the multiplicative change in annual population growth rate ($\Delta\lambda$) were converted to a multiplicative change in per-generation (egg-to-adult spawner) survival rate (ΔS) according to Equation 1 using mean generation times (in years) listed in Tables A2 to A6. For example, if the base λ must be multiplied by 1.05, and the average generation time of the stock is 4.56 years, the 1.05 change must be applied to the annual survival rate for each of those 4.56 years. To determine the necessary change over the lifetime of a salmon, the base period egg-to-spawner survival rate (or any survival rate contributing to this) must be multiplied by $1.05^{4.56}$, which is equal to 1.25.

<u>QAR Estimates</u> The QAR estimates of survival changes necessary to meet survival and recovery criteria are from Cooney (2000) and various personal communications with T. Cooney (NMFS). QAR estimates applied only to UCR steelhead and UCR spring chinook. QAR estimates of the needed change were sometimes reported only as changes in per-generation survival. To generate $\Delta\lambda$ in Tables C2 to C6 for QAR estimates, Equation 1 was rearranged as follows:

(5) $$\Delta\lambda = \Delta S^{(1/\text{Mean Generation Time})}$$

Methods used to generate the QAR estimates are described in Cooney (2000).

A.4.2 Key Assumptions Influencing Estimates of Current Population Trend and Change Necessary to Meet Survival and Recovery Indicator Criteria

NMFS considered three sets of alternative assumptions that influenced the current trend estimate and estimates of the survival change necessary to meet survival and recovery indicator criteria. The first is the historical effectiveness of hatchery-origin natural spawners for populations in which both wild- and hatchery-origin spawners have contributed to production. In these mixed populations, the productivity of the wild-origin spawners is unknown. If the reproductive

success of hatchery-origin spawners has been high during the base period, then the productivity of natural-origin spawners is lower than would be predicted from the mixed stock returns. In this situation, a large improvement in the survival rate of natural-origin fish may be necessary to reduce risk to the levels described in Table A-1. Conversely, if the effectiveness of hatchery-origin spawners has been low during the base period, productivity of natural-origin spawners is higher than in the previous case, and a smaller survival improvement is needed.

The effectiveness of hatchery-origin natural spawners during the base period could have ranged from 0% to 100%. Based on a review of pertinent literature, NMFS considers a range of between 20% to 80% effectiveness to capture a large fraction of realistic scenarios (Waples 2000). While it may be possible to further narrow this range if there is an understanding of the specific characteristics of the hatchery-produced spawners (e.g., locally derived, non-domesticated versus non-native or domesticated hatchery populations), NMFS applied the full range to all but one stock evaluated in the biological opinion. NMFS applied a range of 50% to 80% hatchery-origin spawner effectiveness to the Imnaha River SR spring/summer chinook index stock, based on information reviewed in Section 6.3.1.5 of the biological opinion.

The second assumption that affects this analysis is the selection of the base period. Extinction risk depends on the trend during the base period, variability in the trend, and current population level. Results for some populations can vary drastically, depending on choice of the starting year of the time series (Waples et al. 1991). For this reason, and because of assumptions of the Dennis et al. (1991) extinction risk model regarding time series characteristics (McClure et al. 2000c), the relevant time period must be chosen carefully. NMFS considers the period between 1980 and the present the most appropriate for all ESUs considered in this biological opinion (Schiewe 2000) because it most closely resembles current operation and configuration of the hydrosystem, including upstream storage. This includes the doubling of water storage capacity in the 1970s, which is likely to have affected the freshwater plume and estuarine conditions.

While NMFS did not consider alternative starting years in this analysis, it did consider alternative definitions of "the present" for two ESUs. For all ESUs, the primary analysis used the most recently available return year, which ranged from 1996 for SR fall chinook to 1999 for SR spring/summer chinook (digital appendices, McClure et al. 2000c). For UCR spring chinook and SR spring/summer chinook (moderate projection category; Cooney 2000, McClure et al. 2000b), NMFS also included preliminary 2000 return estimates and projected 2001 returns from 2000 jack counts. Because survival of fish returning in 2000 and projected to return in 2001 is higher than that occurring during most other years of the time series, addition of these return years results in a lower estimate of extinction risk and a lower needed change in survival.

The third factor influencing these results was use of CRI or QAR analysis for UCR steelhead and UCR spring chinook estimates. QAR estimates of needed survival change are consistently lower than those of CRI for the three UCR spring chinook populations. The QAR Methow and Wenatchee/Entiat UCR steelhead estimates are also lower than the CRI estimate for the aggregate UCR steelhead ESU. NMFS does not understand the nature of these discrepancies at present and is working to resolve them. Until this occurs, NMFS includes both analytical approaches to represent a reasonable range of results for the UCR ESUs.

To summarize, the biological opinion included two alternatives for each of three key assumptions influencing the range of trend estimates and the estimate of the survival change needed to meet the survival and recovery indicator criteria. Table A-7 displays each alternative and the ESUs to which it applies.

Table A-7. Alternative assumptions for estimation of the base period trend and survival changes necessary to meet survival and recovery indicator criteria.

Assumption	Alternatives Included	ESUs to Which Alternatives Were Applied
Effectiveness of Hatchery-Origin Natural Spawners During Base Period	1. 20%, relative to wild-origin natural spawners (except for 50% for Imnaha River SR spring/summer chinook index stock) 2. 80%, relative to wild-origin natural spawners	All 12 ESUs included in the quantitative analysis.
Base Period (Years Included in Estimate of Annual Population Growth Rate and Per-Generation Survival Rate)	1. 1980 - most recent return year for which spawner counts are available (no later than 1999) 2. 1980 - projected 2001 spawner counts	First alternative applied to all 12 ESUs. Both alternatives are applied only to UCR spring chinook and SR spring/summer chinook.
Analytical Method	1. CRI 2. QAR	First alternative applied to all 12 ESUs. Both alternatives are applied only to UCR spring chinook and UCR steelhead.

A.5 PROPORTIONAL SURVIVAL CHANGE ASSOCIATED WITH THE PROPOSED ACTION, RPA, AND BREACHING

The third step of the analysis is to estimate the change in survival rates associated with proposed actions and with changes in other life stages anticipated in the Basinwide Recovery Strategy. The necessary improvements in population growth rate described in Section A.4 are based on the assumption that average life-stage survival rates influencing adult returns from 1980 to the most recent year (base period) will continue indefinitely into the future. However, certain life-stage survival rates associated with current conditions and proposed actions represent an improvement from the average survival rate that influenced adult returns during the base period. In this section, NMFS first identifies life stages for which current or expected survival represents a quantifiable change from average survival during the base period. NMFS then estimates average base period survival rates for these life stages and current and future expected survival rates. NMFS then calculates the proportional survival change represented by the actions.

This analysis applies only to life-stages and actions for which enough information exists to quantify survival rates. These life stages are restricted to juvenile and adult mainstem passage survival rates associated with FCRPS actions and survival rate changes associated with changes in harvest rates. In nearly all cases, NMFS is unable to quantitatively estimate survival rates and/or survival rate changes associated with habitat and hatchery management actions. The one exception is the implicit estimate of the effects of habitat and hatchery actions when the Mid-Columbia Habitat Conservation Plan (HCP) is implemented. These other actions and life-stage survival changes are evaluated qualitatively in the biological opinion and are not addressed in this appendix. Additionally, this analysis does not address non-quantifiable effects of the FCRPS, such as effects on spawning success and incubation and rearing survival for mainstem-spawning ESUs.

A.5.1 Snake River Spring/Summer Chinook Salmon

The SR spring/summer chinook salmon population trends estimated in Section A.4 were derived from 1980-to-1999 adult returns. NMFS estimates that the average juvenile FCRPS passage survival rate under current operations and configuration of the hydrosystem represents an improvement from the average juvenile passage survival rate influencing 1980-to-1999 adult returns. That is because many structural and operational modifications to the hydrosystem have been implemented since 1980. A short review of these modifications and their impacts on juvenile passage survival is included in Section 6.3.1.3 of the biological opinion. Additional juvenile passage survival improvements are anticipated under the hydrosystem component of the reasonable and prudent alternative (RPA), and survival rate changes are also expected if four Snake River dams are breached. NMFS concludes that the current adult passage survival rate through the FCRPS has not changed from the average 1980-to-1999 adult survival rate. However, NMFS estimates that the adult survival rate associated with the RPA and with breaching will be an improvement over the 1980-to-1999 adult survival rate. The following sections review the methods and estimates for these juvenile and adult passage survival rate changes. Harvest rate changes have been, and are expected to continue to be, relatively minor for this ESU, so are not included in this analysis. NMFS was unable to quantify survival rate changes for other life stages or actions. Table A-8 provides an overview of the assumptions and life stages addressed in this analysis. The assumptions and life stages are discussed in more detail in the following sections.

A.5.1.1 Survival Rate Change Associated With the Proposed Action

Juvenile Passage Survival NMFS used two methods to estimate the proportional change in juvenile survival from that experienced on average by adults returning from 1980 to 1999 to that associated with the proposed action, which is essentially a continuation of the current juvenile survival rate. The first method compared PATH estimates of juvenile survival during 1980 to 1992 (retrospective scenario in Marmorek et al. 1998) to PATH estimates of 1995 FCRPS Biological Opinion operations applied to the same water conditions (scenario A2 of Marmorek et al. 1998). The purpose was to evaluate historical survival versus an approximation of current juvenile survival under a 13-year range of water conditions. NMFS applied the approach in response to comments by agencies and organizations that the method used in the July 27 Draft

Biological Opinion evaluated the change from historical to current operations under too narrow a range of water years for current operations, which led to overly optimistic results.

Table A-8. Key assumptions affecting the range of Snake River spring/summer chinook salmon survival change (from base period) estimates expected from three actions.

	Proposed Action	RPA	Breach
Direct LGR-BON Juvenile Passage Survival	Method 1: PATH passage models used for both base period and proposed action estimates Method 2: Combination of PATH and SIMPAS for base period; SIMPAS for proposed action	Method 1: PATH passage models used for both base period and RPA estimates Method 2: Combination of PATH and SIMPAS for base period; SIMPAS for RPA	**Base**: Method 1 and Method 2, as described for other actions **Breach**: One estimate, derived from LGR-MCN free-flowing reach survival and MCN-BON from SIMPAS RPA estimate
Differential Post-BON Survival of Transported, Compared to Non-Transported, Fish (D)	Average of D=0.65 and D=0.75, for both base and proposed action, so does not affect estimate	Average of D=0.65 and D=0.75, for both base and RPA, so does not affect estimate	**Base:** Average of D=0.65 and D=0.75 **Breach**: No transportation, so D not relevant. All fish have equivalent post-BON survival, which is functionally equivalent to D=1.0.
Delayed Mortality of Non-Transported Fish (EM)	Assumed constant for base and proposed action, so does not affect estimate, regardless of value (0% to 74%)	Assumed constant for base and RPA, so does not affect estimate, regardless of value (0% to 74%)	**Approach 1**: Assumed constant for base and breach, so does not affect estimate, regardless of value (0% to 74%) **Approach 2:** High in base period (71% to 74%); half that after breaching 4 of 8 dams (36% to 37%) **Approach 3:** High in base period (71% to 74%); 0% after breaching 4 dams
Adult Survival	Constant for base and proposed action, so does not affect estimate. Delayed mortality, if any, identical in base and proposed action, so does not affect estimate.	Improves from base to RPA, as described in Table 9.7-5 of Biological Opinion. Delayed mortality, if any, identical in base and RPA, so does not affect estimate.	Same survival improvement as base to RPA. Delayed mortality, if any, identical in base and breach, so does not affect estimate.
Harvest	Similar in base and current/future, so no change included in calculations.	Similar in base and current/future, so no change included in calculations.	Similar in base and current/future, so no change included in calculations.
Other Life Stages and Actions	Not included in quantitative analysis; qualitative discussion in Biological Opinion	Not included in quantitative analysis; qualitative discussion in Biological Opinion	Not included in quantitative analysis; qualitative discussion in Biological Opinion

The 1980 juvenile passage survival estimate corresponds to the first juvenile migration year that fully contributes to adult returns in the first pair of 5-year running sums used to calculate lambda (McClure et al. 2000c, Holmes in review). The first two running sums represent weighted sums of 1980 through 1984 returns and 1981 through 1985 returns. The 1992 migration year represents the last year for which PATH model estimates are available. The survival rate used in NMFS' comparison included estimates of direct survival to below Bonneville Dam from both of PATH's alternative passage models (FLUSH and CRiSP; Marmorek et al. 1998; data files in allpmrun.zip, obtained from C. Peters June 18, 1999). NMFS used the PATH retrospective results for a set of passage assumptions considered closest to mean PATH results (C. Peters, ESSA, pers. comm., June 1999) and averaged the estimates from the two alternative PATH passage models.

NMFS included differential post-Bonneville survival (D=0.63 to 0.73; Section 6.2.3.3) in addition to the direct survival estimates because, even though NMFS finds no evidence that D changed during the 1980-to-1999 period, the proportion of fish transported has changed over time. Because the proportion of transported fish surviving to Bonneville is multiplied by D, D has a significant impact on survival. On the other hand, delayed mortality of nontransported fish had no effect on the proportional change in survival, so was not relevant to this analysis.

The expected juvenile passage survival change ranged from 27% to 38%, depending on passage model and D assumption, and averaged 32% (1.39 times the average historical survival rate) across all assumptions (Table A-9).

The second method represented a modification of the approach used in the July 27, 2000, Draft Biological Opinion. In this case, NMFS defined average juvenile passage survival during the historical period using PATH passage model estimates for 1980 to 1992, coupled with Simple Passage Model (SIMPAS) estimates for 1994 to 1997. The 1997 migration year was included because it was the last migration year contributing to the 1999 adult returns in NMFS' 1980-to-1999 risk assessment. An estimate for 1993 is not available from either passage modeling system. The average of all 17 years was the estimate corresponding to NMFS' 1980-to-1999 risk assessment. NMFS defined current operations corresponding to effects of the proposed action as the 1994-to-1999 average SIMPAS estimates. Section 6.2 of the biological opinion describes the rationale for equally weighting each year when calculating the average. This second method resulted in expected survival improvements ranging from 12% to 35%, depending upon passage model and D assumption, and averaged 24% (1.24 times the average historical survival rate) across all assumptions (Table A-9).

The July 27, 2000, Draft Biological Opinion included a method similar to this second approach, since it also combined SIMPAS and PATH estimates of juvenile survival to evaluate the change in juvenile survival. Several agencies and organizations criticized that approach, claiming that some intrinsic difference between PATH and SIMPAS passage models overestimates the survival improvement associated with the proposed action. The difference cited most frequently was the treatment of reservoir survival in each passage model. However, both of PATH's passage models provide fairly close fits to NMFS' 1994-to-1996, PIT-tag reach survival

Table A-9. Estimates of proportional change in SR spring/summer chinook survival associated with proposed action (current), RPA, and breaching four Snake River dams. Bold estimates define range considered in subsequent analyses.

	Survival Estimate	Proportional Change
Base to Current		
a. Juvenile Passage Survival		
Base Method 1 = average PATH 1980-1992 migration year retrospective juvenile survival with D=.63 and 0.73.		
CRiSP .63	0.391	
CRiSP .73	0.440	
FLUSH .63	0.440	
FLUSH .73	0.503	
Current Method 1 = average PATH A2 1977-1992 WY juvenile survival with D=.63 and 0.73.		
CRiSP .63	0.532	1.362
CRiSP .73	0.606	1.379
FLUSH .63	0.558	1.269
FLUSH .73	0.646	1.284
average:		**1.323**
Base Method 2 = PATH 1980-92 + SIMPAS 1994-97 with D=0.63,0.73		
CRiSP .63 + SIMPAS	0.423	
CRiSP .73 + SIMPAS	0.460	
FLUSH .63 + SIMPAS	0.460	
FLUSH .73 + SIMPAS	0.509	
Current Method 2 = average SIMPAS 1994-99 juvenile survival with D=0.63,0.73		
SIMPAS	0.571	1.351
		1.241
		1.241
		1.122
average:		**1.239**
Current to RPA		
a. Juvenile Passage Survival		
Current = SIMPAS including D=0.63-0.73	0.571	
RPA = SIMPAS RPA including D=0.63-0.73	0.576	1.009
b. Adult Passage Survival		
Current =	0.825	
RPA =	0.855	
		1.037
c. Combined Juvenile and adult change from RPA		1.046
Combined Base-to-Current and Current-to-RPA Change:		
PATH/PATH Base:Current Hydro		**1.384**
PATH/SIMPAS Base:Current Hydro		**1.296**

Table A-9 (continued). Estimates of proportional change in SR spring/summer chinook survival associated with proposed action (current), RPA, and breaching four Snake River dams. Bold estimates define range considered in subsequent analyses.

	Survival Estimate	Proportional Change
Base to Breach		
a. Juvenile Passage Survival		
Assumption #1: No Change in EM Between Base and Breach		
(Same proportional change, whether EM high or low)		
Base Method 1 = average PATH 1980-1992 retrospective juvenile survival		
with D=.63 and 0.73 and EM = 0.709,.743		
CRiSP .63	0.114	
CRiSP .73	0.113	
FLUSH .63	0.128	
FLUSH .73	0.129	
Base Method 2 = PATH 1980-92 + SIMPAS 1994-97		
(Matches better with 1980-99 adult return in CRI analysis)		
CRiSP .63 + SIMPAS	0.123	
CRiSP .73 + SIMPAS	0.118	
FLUSH .63 + SIMPAS	0.134	
FLUSH .73 + SIMPAS	0.131	
Breach=Natural For Snake*MCN-BON SIMPAS RPA*(1-avg [.709,.743])	0.168	
PATH/PATH:		1.392
PATH/SIMPAS:		1.329
Assumption #2: EM is high in base and 1/2 goes away when 4 dams breached		
Breach=Natural For Snake and (1-(0.5*.726))*MCN-BON SIMPAS RPA	0.390	
PATH/PATH:		3.237
PATH/SIMPAS:		3.090
Assumption #3: EM is high in base and all goes away when 4 dams breached		
Breach=Natural For Snake*MCN-BON SIMPAS RPA	0.612	
PATH/PATH:		5.081
PATH/SIMPAS:		4.851
b. Adult Passage Survival (Breach expected identical to RPA)		
Base/Current =	0.825	
RPA/Breach =	0.855	1.037
c. Combined adult and Juvenile Survival		
Assumption #1: No Change in EM Between Base and Breach		
PATH/PATH:		**1.443**
PATH/SIMPAS:		**1.378**
Assumption #2: EM is high in base and 1/2 goes away when 4 dams breached		
PATH/PATH:		**3.356**
PATH/SIMPAS:		**3.204**
Assumption #3: EM is high in base and all goes away when 4 dams breached		
PATH/PATH:		**5.268**
PATH/SIMPAS:		**5.029**

estimates (Marmorek and Peters 1998), and the SIMPAS model is calibrated directly to those and to the 1997-to-1999 reach survival estimates (Appendix D). Additionally, both the structure and

parameters of the dam passage components of the SIMPAS model are very similar to those used in PATH (Appendix D). The main difference is that some of the parameter estimates used in SIMPAS reflect new information obtained since the PATH models were completed (Appendix D). Ideally, NMFS would compare PATH and SIMPAS estimates for the same years and actions to test the assumption that SIMPAS provides higher estimates of survival than PATH models. While this was possible for SR fall chinook results (see Section A.5.2), there are no years for which both PATH and SIMPAS SR spring/summer chinook estimates exist. However, it is unlikely that significant discrepancies between PATH and SIMPAS exist because of the similar structure, similar fit to PIT-tag reach survival estimates, and because both the PATH-only and combined PATH and SIMPAS methods included in this analysis yield similar results. Also, because the method using both PATH and SIMPAS yields a lower estimate of the survival change than does the exclusive use of PATH estimates, this approach does not produce optimistic results compared with PATH.

A.5.1.2 Survival Rate Change Associated With the RPA

Juvenile and Adult Passage Survival. Implementing the hydrosystem component of the RPA will proportionally increase both juvenile and adult survival beyond the current level associated with the proposed action. NMFS estimates that adult survival will increase from the recent average (82.5%) to 85.5% after implementation of the RPA (Table 9.7-5). This represents a proportional survival increase of 3.7% (Table A-9). NMFS estimates that the hydrosystem component of the RPA will increase juvenile survival to below Bonneville Dam, including differential post-Bonneville survival of transported fish (D=0.63 to 0.73), by approximately 1% (Table 9.7-5; Table A-9). The juvenile survival change is based on a comparison of SIMPAS model results for operations associated with the proposed action and RPA, given 1994 to 1999 water conditions. The product of the proportional survival improvements associated with the current conditions (Section A.5.1.1) and the RPA results in an expected survival improvement of 30% to 38% (1.30 to 1.38 times the average 1980-to-1999 survival rate; Table A-9).

A.5.1.3 Survival Rate Change Associated With Breaching Four Snake River Dams

Overview of Alternative Delayed Mortality Assumptions. A key uncertainty associated with dam breaching is the effect that it will have on survival below Bonneville Dam (e.g., Marmorek and Peters 1998, Peters et al. 1999, Kareiva et al. 2000). Although it is likely that some actions called for by the RPA will improve fish condition and survival below Bonneville Dam, NMFS conservatively assumed that neither the proposed action or RPA would change the post-Bonneville survival of nontransported fish. That is, NMFS considered both the differential survival of transported fish (compared to nontransported fish, D) and the post-Bonneville delayed mortality of nontransported fish (EM) to be unchanged from the 1980 to 1999 period to the future under the proposed action and RPA.

In contrast, NMFS considered three alternatives for future post-Bonneville survival after breaching four Snake River dams. In each alternative, the differential post-Bonneville survival of transported fish is eliminated following breaching because NMFS assumes that transportation

would cease. The alternatives apply different assumptions regarding the potential change in delayed mortality of nontransported fish following breaching.

In one alternative, NMFS assumed that delayed mortality of nontransported fish does not change after four Snake River dams are breached. With this alternative, the current estimate of EM is not important, since the calculated change in survival resulting from breaching will be the same whether EM is believed to be 0% or 74%. This alternative corresponds to two of the three PATH extra mortality hypotheses, which ascribe this mortality to causes other than the hydrosystem (Section 6.2.3.3 of the biological opinion).

In the second alternative, NMFS assumes that average 1980-to-1999 EM is between 71% (when couple with D=0.73) and 74% (when coupled with D=0.63). This represents the PATH estimate of hydrosystem-caused, post-Bonneville mortality, when all extra mortality is believed to be caused by the hydrosystem. The estimate of 71% to 74% delayed mortality of nontransported fish represents the upper end of the range NMFS considered in this analysis (Section 6.2.3.3 of the biological opinion). This second alternative assumes that approximately half of this mortality is eliminated when four of the eight Snake River dams are breached, which corresponds to PATH's hydrosystem hypothesis (Marmorek and Peters 1998; Wilson 2000).

The third alternative is identical to the second, except that it assumes that 100% of the delayed mortality of nontransported fish is eliminated. This assumption was included in the July 27 Draft Biological Opinion and incorrectly ascribed to the PATH hydrosystem hypothesis (Wilson 2000). NMFS retains it because several agencies and organizations that commented on the July 27, 2000, Draft Biological Opinion expressed their belief that this is the most likely assumption. Because all of these assumptions are essentially beliefs, inclusion of the full range of beliefs demonstrates the range of possible outcomes after breaching.

Details of the methods and results for each approach follow.

<u>No Change in Delayed Mortality of Nontransported Juveniles After Breaching</u>

NMFS estimated average juvenile passage survival to Bonneville Dam during the base period using the same two approaches and data sets described in Section A.5.1.1 for the change from base to current survival, with one exception. NMFS included differential post-Bonneville survival of transported fish (D=0.63 to D=0.73), as described above. When EM is assumed not to change from that which may have occurred during the base period to that which may occur following breaching, the results are insensitive to assumptions regarding the magnitude of EM. However, to facilitate comparison with the other two EM change approaches, NMFS evaluated a high level of nontransport, delayed mortality during both the 1980-1999 period and following breaching. NMFS has not estimated EM, but assumes that it could range from near zero to the highest rate estimated by PATH (Marmorek et al. 1998). The highest PATH estimate that corresponds to D=0.63 is EM=0.709, and the highest PATH estimate that corresponds to D=0.73 is EM=0.743. By highest PATH estimate, NMFS means an estimate that assumes that the hydrosystem is responsible for all extra mortality (Marmorek et al. 1998) that cannot be

explained by PATH's productivity functions, estimates of year-to-year changes in productivity common to several stocks, and estimates of direct survival.

PATH did not actually estimate EM that corresponds to NMFS' D estimates. The EM estimates were derived from PATH total mortality estimates according to the following equation:

(6) EM = 1 - {[exp-(PATH "m"- PATH "M")] ÷ [(D * PATH "Pbt") + (1- PATH "Pbt")]}

in which PATH "m" is the absolute value of the natural logarithm of total mortality that cannot be explained by PATH's productivity functions or assessment of common changes in annual productivity. PATH "M" is the absolute value of the natural log of total direct mortality of juveniles through the hydrosystem. PATH "Pbt" is the proportion of juveniles alive below Bonneville Dam that arrived via transportation. NMFS applied PATH's average FLUSH and CRiSP passage model estimates for these terms and solved for EM using NMFS' estimates of D.

NMFS estimated a range of 11% to 13% juvenile survival during the base period (Table A-9) based on the PATH direct survival estimates described above, coupled with D of 63% to 73% and EM of 71% to 74%.

NMFS evaluated expected juvenile survival from breaching following the transitional period described in Sections 9.7.3.1.1 and 9.7.3.1.2. After a natural channel configuration has developed in the 210-km reach and riparian vegetation has become established, NMFS expects that juvenile survival rates will approximate the rates observed in free-flowing reaches above the head of Lower Granite pool. Estimates of survival from the Salmon River trap at Whitebird to Lower Granite Dam are available for wild spring chinook salmon during 1966 through 1968 (Raymond 1979) and for wild spring/chinook salmon and steelhead during 1993 through 1999 (Smith et al. 1998; Hockersmith et al. 1999; Smith et al. 2000a,b). The estimates for both periods include survival through Lower Granite Reservoir. Those for the recent period also include survival past Lower Granite Dam. Using the methods described in Annex 1 of this appendix to factor out the reservoir and dam mortality, NMFS calculated an average per-km survival rate through the free-flowing stretch of 0.999689614 per km for spring chinook. Interannual variation was high (Annex 1). The average per-km survival rate estimate can be expanded to survival through the entire 210-km reach (0.999689614^{210}) , resulting in a mean reach survival of 92.2% for SR spring/summer chinook salmon (Table 9.7-20 of the biological opinion).

The estimates of survival through the breached section of the Snake River were multiplied by estimates of survival through the four lower Columbia River projects under the RPA to derive an estimate of system survival after the drawdown transition period. SIMPAS estimates of SR spring/summer chinook survival through the four lower Columbia River projects are described in Table 9.7-1 of the biological opinion. In-river survival from McNary pool to Bonneville dam averaged 66.4% (Table 9.7-20 of the biological opinion). When survival through the free-flowing reach in the lower Snake River was combined with survival through the impounded reach in the lower Columbia River, system survival of SR spring/summer chinook salmon

averaged 61.2% (Table 9.7-20 of the biological opinion). When the 70% to 74% delayed mortality assumption is applied to the survival at Bonneville, 16.8% juvenile survival is expected after breaching (Table A-9). This represents a 33% to 39% proportional change in juvenile passage survival (Table A-9). Again, an identical proportional change is calculated if NMFS assumes EM = 0 instead of EM = 71% to 74%, because EM was assumed to be constant in both the base period and following breaching.

Adult passage survival during the 1980-to-1999 period was 82.5% (Table 9.7-2 of the biological opinion). Expected survival following breaching is 85.5% (Section 9.7.3.1.4 of the biological opinion). This represents a 3.7% proportional change in adult survival (Table A-9).

When the juvenile and adult survival improvements are combined, the overall effect of breaching four Snake River dams is a 38% to 44% proportional improvement (1.38 to 1.44 times average 1980-to-1999 survival; Table A-9).

Delayed Mortality of Nontransported Juveniles is Reduced by Half After Breaching

All aspects of this approach were identical to the first, except for the level of delayed mortality applied to juvenile survival following breaching. Only half of the delayed mortality estimate was applied in this approach, resulting in 39% juvenile survival following breaching (Table A-9). This represents a 209% to 224% proportional change in juvenile passage survival following breaching. When this juvenile survival change is combined with the adult survival change described above, the result is a 220% to 236% proportional survival improvement (3.20 to 3.36 times average 1980-to-1999 survival) following breaching (Table A-9).

Delayed Mortality of Nontransported Juveniles Is Eliminated After Breaching

All aspects of this approach were identical to the first, except that no delayed mortality was applied to the estimate of juvenile survival following breaching. This resulted in 61% juvenile survival following breaching (Table A-9). A 403% to 427% proportional survival improvement (5.03 to 5.27 times average 1980-to-1999 survival) is associated with breaching under this assumption regarding delayed mortality (Table A-9).

A.5.2 Snake River Fall Chinook Salmon

The SR fall chinook population trends estimated in Section A.4 were derived from 1980-to-1996 adult returns. NMFS estimates that the average juvenile FCRPS passage survival rate under current operations and configuration of the hydrosystem and under the RPA represents an improvement from the average juvenile passage survival rate influencing 1980-to-1996 adult returns. NMFS concludes that the current adult passage survival rate through the FCRPS has not changed from the average 1980-to-1996 adult survival rate. However, NMFS estimates that the adult survival rate associated with the RPA and with breaching will be an improvement from the 1980-to-1996 adult survival rate. Current and expected future harvest rates are lower than the average harvest rates affecting 1980-to-1996 returning adults, which also results in increased survival. The following sections review the methods and estimates for these juvenile and adult

survival rate changes. NMFS was unable to quantify survival rate changes for other life stages or actions. Table A-10 provides an overview of the assumptions and life stages addressed in this analysis, which are discussed in more detail in the following sections.

Table A-10. Key assumptions affecting the range of Snake River fall chinook salmon survival change (from base period) estimates expected from three actions.

	Proposed Action	RPA	Breach
Direct LGR-BON Juvenile Passage Survival	Method 1: PATH passage models used for both base period and proposed action estimates Method 2: Combination of PATH and SIMPAS for base period; SIMPAS for proposed action	Method 1: PATH passage models used for both base period and RPA estimates Method 2: Combination of PATH and SIMPAS for base period; SIMPAS for RPA	**Base**: Method 1 and Method 2, as described for other actions **Breach**: Two alternative estimates for LGR-MCN free-flowing reach survival (Breach Method A and Breach Method B), each coupled with one MCN-BON estimate from SIMPAS (RPA)
Differential Post-BON Survival of Transported, Compared to Non-Transported, Fish (D)	Assumed PATH D=0.24, for both base and proposed action, so does not affect estimate	Assumed PATH D=0.24, for both base and proposed action, so does not affect estimate	**Base:** Assumed PATH D=0.24, for both base and proposed action, so does not affect estimate **Breach**: No transportation, so D not relevant. All fish have equivalent post-BON survival, which is functionally equivalent to D=1.0.
Delayed Mortality of Non-Transported Fish (EM)	Assumed constant for base and proposed action, so does not affect estimate, regardless of value (0% to 19%)	Assumed constant for base and RPA, so does not affect estimate, regardless of value (0% to 19%)	**Approach 1**: Assumed constant for base and breach, so does not affect estimate, regardless of value (0% to 19%) **Approach 2:** High in base period (19%); half that after breaching 4 of 8 dams (10%) **Approach 3:** High in base period (19%); 0% after breaching 4 dams
Adult Survival	Constant for base and proposed action, so does not affect estimate. Delayed mortality, if any, identical in base and proposed action, so does not affect estimate.	Improves from base to RPA, as described in Table 9.7-5 of Biological Opinion. Delayed mortality, if any, identical in base and RPA, so does not affect estimate.	Same survival improvement as base to RPA. Delayed mortality, if any, identical in base and breach, so does not affect estimate.
Harvest	PSC Method: Base ocean and in-river harvest estimated from PSC model. Current is 70% of 88-92 average from same model. PATH Method: Same as above, except used PATH harvest rate estimates	Identical to approaches described for proposed action.	Identical to approaches described for proposed action.
Other Life Stages and Actions	Not included in quantitative analysis; qualitative discussion in Biological Opinion	Not included in quantitative analysis; qualitative discussion in Biological Opinion	Not included in quantitative analysis; qualitative discussion in Biological Opinion

A.5.2.1 Survival Rate Change Associated With the Proposed Action

Juvenile Passage Survival. The juvenile SR fall chinook salmon survival rate associated with the proposed action is an improvement over the average survival rate influencing 1980-to-1996 adult returns. This is because of the many structural and operational modifications to the hydrosystem since 1980 (Section 6.3.1.3). NMFS used two methods to estimate the proportional change in

juvenile survival from that experienced on average by adults returning from 1980 to 1996 to that associated with the proposed action.

The first method compared PATH estimates of juvenile survival for the 1980-to-1992 migration years (retrospective scenario in Marmorek et al. 1998) with PATH estimates of 1995 FCRPS Biological Opinion operations applied to the same water conditions (scenario A2 of Marmorek et al. 1998). The rationale and general method were identical to those defining the first method for SR spring/summer chinook salmon (Section 6.3.1.3). However, NMFS included an estimate of differential delayed mortality specific to SR fall chinook salmon (D = 0.24, Section 6.2.3.3). NMFS has not estimated D for SR fall chinook salmon. As described in Section 6.2.3.3 of the Draft Biological Opinion, there is great uncertainty regarding differential post-Bonneville survival of this ESU. Because this species has not been the subject of formal transportation studies, the scientific justification for any given estimate of D is weaker than for SR spring/summer chinook salmon or steelhead. NMFS (2000) reviewed the range of alternative assumptions Peters et al. (1999) used to estimate D for this species: application of returns of transported and nontransported fish PIT-tagged during the 1995 outmigration, application of transport studies from McNary Dam (i.e., based on Hanford Reach fall chinook) to Snake River fall chinook, and comparisons of different assumptions about D and other values in relation to the best fit of a life-cycle model to the observed recruit-per-spawner data. The estimates of D derived using these alternative methods ranged from approximately 0.05 to more than 1.0. NMFS (2000b) reviewed these methods and noted that each had inherent strengths and weaknesses. For purposes of the July 27, 2000, Draft Biological Opinion, NMFS considered the PATH PIT-tag method more consistent with methods it used to estimate spring/summer chinook and steelhead Ds than with either of the other PATH approaches. Using this method, PATH estimated D=0.24, with very wide statistical confidence limits. NMFS concluded that this represents the best SR fall chinook D-estimate currently available and applied it as a point estimate in the fall chinook analysis.

Direct passage survival terms were averages from PATH (Peters et al.1999; data files in newfall.zip, obtained from C. Peters, October 5, 1999). NMFS used the PATH retrospective results for a set of passage assumptions considered closest to mean PATH results (C. Peters, ESSA, pers. comm., October 1999) and averaged the estimates from the two alternative PATH passage models (FLUSH and CRiSP). The expected survival change using this method ranged from -2% to +31%, depending on the PATH passage model, and averaged 15% (1.15 times the average historical survival rate; Table A-11).

Table A-11. Estimates of proportional change in SR fall chinook survival associated with proposed action (current), RPA, and breaching four Snake River dams. Bold estimates define range considered in subsequent analyses.

			Survival Estimate	Proportional Change
Base to Current				
a. Juvenile Passage Survival				
Base = average PATH 1980-1992 MY retrospective juvenile survival with D=.24. LGR pool mort not included.				
CRiSP =			0.208	
FLUSH =			0.138	
Current Method 1 = average PATH A2 1980-1992 WY juvenile survival with D=0.24. Accounts for 95-99 may just be good water years.				
CRiSP =			0.205	0.983
FLUSH =			0.182	1.314
average=				**1.148**
Current Method 2 = average SIMPAS 1995-99 juvenile survival with D=0.24				
(LGR pool mort removed from SIMPAS to match PATH)			0.193	
Compared to CRiSP =				0.928
Compared to FLUSH =				1.400
average=				**1.164**
b. Change in Harvest Rate				
Method 1 - PSC Col. R. Mouth Adult Equivalent Harvest Rate For Combined Fisheries				
Base = 80-96 Run Year average	Exp. Rate = 0.6447	(1-E.R.) =	0.3553	
Current = 70% of 88-93 Run Year Average	Exp. Rate = 0.5017	(1-E.R.) =	0.4983	1.403
Method 2 - PATH Ocean and In-River Harvest Rates to Estimate Age-1 to River Survival (Table A-10)				
Ocean: Base = 80-96 Run Year average survival Age-1 to return to CR mouth			0.167	
Ocean: Current = 70% of 88-93 Run Year Average survival Age-1 to return to CR mouth			0.177	1.056
In-River: Base = 80-96 Run Year average	Exp. Rate = 0.300	(1-E.R.) =	0.700	
In-River: Current = 70% of 88-93 Run Year Average	Exp. Rate = 0.245	(1-E.R.) =	0.755	1.078
PATH Combined In-River and Ocean Harvest Reduction				1.139

Table A-11 (continued). Estimates of proportional change in SR fall chinook survival associated with proposed action (current), RPA, and breaching four Snake River dams. Bold estimates define range considered in subsequent analyses.

		Survival Estimate	Proportional Change
c. Combined Base:Current passage and harvest survival changes			
PATH/PATH Hydro Change *	PSC Harvest Change		1.611
PATH/PATH Hydro Change *	PATH Harvest Change		**1.308**
PATH/SIMPAS Hydro Change *	PSC Harvest Change		**1.633**
PATH/SIMPAS Hydro Change *	PATH Harvest Change		1.326
Current to RPA			
a. Juvenile Passage Survival			
Current = SIMPAS including LGR pool mort and D=0.24		0.117	
RPA = SIMPAS 'Aggressive' including LGR pool mort and D=0.24		0.127	1.090
b. Adult Passage Survival			
Current =		0.710	
RPA =		0.740	1.042
c. Combined Juvenile and adult change from RPA			1.136
Combined Base-to-Current and Current -to-RPA Change:			
PATH/PATH Hydro Change *	PSC Harvest Change		1.830
PATH/PATH Hydro Change *	PATH Harvest Change		**1.487**
PATH/SIMPAS Hydro Change *	PSC Harvest Change		**1.855**
PATH/SIMPAS Hydro Change *	PATH Harvest Change		1.507
Base to Breach			
a. Juvenile Passage Survival			
Assumption #1: No Change in EM Between Base and Breach			
(Same proportional change, whether EM high or low)			
Base = average PATH 1980- 1992 (BY79-91) retrospective juvenile survival with D=.24. LGR pool mort not included. EM=0.19.			
CRiSP =		0.169	
FLUSH =		0.112	
average =		0.140	
Breach Method A = Low Free-flowing Reach Estimate*SIMPAS 95-99*(1-0.19)		0.193	1.371
Breach Method B = High Free-flowing Reach Estimate*SIMPAS 95-99*(1-0.19)		0.275	1.961
Assumption #2: EM is high in base and 1/2 goes away when 4 dams breached			
Breach Method A = Low Free-flowing Reach Estimate*SIMPAS 95-99*(1-[0.5*0.19])		0.215	1.532
Breach Method B = High Free-flowing Reach Estimate*SIMPAS 95-99*(1-[0.5*0.19])		0.308	2.190

Table A-11 (continued). Estimates of proportional change in SR fall chinook survival associated with proposed action (current), RPA, and breaching four Snake River dams. Bold estimates define range considered in subsequent analyses.

	Survival Estimate	Proportional Change
Assumption #3: EM is high in base and all goes away when 4 dams breached		
Breach Method A = Low Free-flowing Reach Estimate*SIMPAS 95-99	0.238	1.693
Breach Method B = High Free-flowing Reach Estimate*SIMPAS 95-99	0.340	2.420
b. Adult Passage Survival (Breach expected identical to RPA)		
Base/Current =	0.710	
RPA/Breach =	0.740	1.042
c. Base to Current/Future Harvest Rate Change (as described above)		
Method 1 - PSC Col. R. Mouth Adult Equivalent Harvest Rate For Combined Fisheries		1.403
Method 2 - PATH Ocean and In-River Harvest Rates and Maturation Rates, PSC Ocean Survivals		1.139
d. Combined adult (including harvest) and juvenile survival		
Assumption #1: No Change in EM Between Base and Breach		
PSC Harv+ Method A +Adult Pass.		2.005
PSC Harv+ Method B +Adult Pass.		**2.866**
PATH Harv + Method A +Adult Pass.		**1.628**
PATH Harv + Method B +Adult Pass.		2.328
Assumption #2: EM is high in base and 1/2 goes away when 4 dams breached		
PSC Harv+ Method A +Adult Pass.		2.240
PSC Harv+ Method B +Adult Pass.		**3.202**
PATH Harv + Method A +Adult Pass.		**1.819**
PATH Harv + Method B +Adult Pass.		2.601
Assumption #3: EM is high in base and all goes away when 4 dams breached		
PSC Harv+ Method A +Adult Pass.		2.475
PSC Harv+ Method B +Adult Pass.		**3.538**
PATH Harv + Method A +Adult Pass.		**2.010**
PATH Harv + Method B +Adult Pass.		2.874

The second method defined the historical period using PATH passage models, as described above. NMFS did not supplement the historical PATH estimates with SIMPAS passage survival estimates, as in the second method used for SR spring/summer chinook salmon (Section A.5.1.1) because the first available SIMPAS estimate for fall chinook was the 1995 migration year, and those fish would not return as adults until at least 1997. NMFS defined current operations, corresponding to effects of the proposed action, as the 1995-to-1999 average SIMPAS estimates. The second method resulted in expected survival improvements ranging from -7% to +40%, depending on the PATH passage model, and averaged 16% (1.16 times the average historical survival rate) across all assumptions (Table A-11).

The second approach was similar to that included in the July 27, 2000, Draft Biological Opinion, which also compared estimates of current operations, based on SIMPAS, to PATH estimates of historical juvenile survival. Several agencies and organizations criticized that approach, as described for SR spring/summer chinook salmon in Section A.5.1.1. Reservoir survival in PATH's CRiSP passage model is directly calibrated to NMFS' 1995-to-1998, PIT-tag reach survival estimates (Peters et al. 1999), as is SIMPAS (Appendix D). PATH's FLUSH model is not directly calibrated to this data (Peters et al. 1999). However, Figures 4.3.2-4 and 4.3.3-6 of Peters et al. (1999) suggest that the FLUSH model corresponds to the PIT-tag survival estimates, which are highly variable, about as well as the CRiSP model does.

In addition, both the structure and parameterization of the dam passage components of the SIMPAS model are very similar to those used in PATH (Appendix D). The main difference is that some of the parameter estimates used in SIMPAS reflect new information obtained since the PATH models were completed (Appendix D). NMFS compared total juvenile survival (including D = 0.24) estimates generated by the PATH FLUSH model and by SIMPAS for the 1995-through-1998 migration years (Table A-12). In each case, the estimates varied by no more than 3% and averaged 0.5%. CRiSP estimates developed for PATH ended in 1992, so it was not possible to conduct a similar comparison. However, significant discrepancies between PATH and SIMPAS are unlikely, because of the similar structure and similar fit to PIT-tag reach survival estimates, and because both the PATH-only and PATH/SIMPAS methods in this analysis yield similar results.

Table A-12. Comparison of juvenile passage survival estimates from the FLUSH and SIMPAS SR fall chinook salmon passage models.

Migration Year	FLUSH (No LGR pool mort, D=0.24)	SIMPAS (No LGR pool mort, D=0.24)	FLUSH - SIMPAS Difference
1995	0.184	0.208	-0.023
1996	0.198	0.208	-0.010
1997	0.197	0.166	0.032
1998	0.184	0.201	-0.017
Average difference			-0.005

Harvest Rate Reductions. In addition to the change in juvenile passage survival, harvest rates changed significantly during this period. NMFS used two methods to evaluate the reduction in harvest from the 1980-to-1996 return year average. The first method is similar to that used in the July 27, 2000, Draft Biological Opinion, which relies on PATH estimates of age-specific ocean exploitation rates and inriver exploitation rates (Peters et al. 1999; their Table 4.5-2). However, three changes were made in response to comments. First, the Pacific Salmon Commission (PSC) age-specific, ocean natural survival rates (D. Simmons, NMFS, pers. comm 2000) were used in place of the constant natural survival rate assumed in the July 27, 2000, analysis. Second, NMFS applied PSC maturation rates (Simmons 2000) in preference to the CRI propensity to reproduce estimates in the earlier analysis, because of their greater consistency with the methods used by PATH. The modifications produced minor changes in the analysis. The third change (defining the current and future harvest rates as 70% of the 1988-to-1993 ocean and inriver harvest rates), however, reduced the expected survival improvement from that estimated previously. The modified definition of current and future harvest rates is more consistent with the Basinwide Recovery Strategy and with recent NMFS biological opinions on fall chinook harvest than is the previous definition (average 1993-to-1996 harvest rates).

NMFS used the PATH age-specific ocean harvest rates (h2-h6), PSC age-specific, natural ocean survival rates (s2-s6), and PSC maturation rates (b2-b6) to estimate survival from the end of age 1 until adults returned to the mouth of the Columbia River (Table A-13). These cumulative ocean survival rates were then compared using the base and current/future ocean harvest rates to determine the survival improvement resulting from recent harvest rate reductions. The cumulative ocean survival rate was defined according to the following equations.

(7) Survival to Age-3 Returns = $(s2 * (1-h_2) * s3 * (1-h3) * b3)$

(8) Survival to Age-4 Returns = Age-3 Returns * (1/b3) * (1-b3) * s4 * (1-h4) * b4

(9) Survival to Age-5 Returns = Age-4 Returns * (1/b4) * (1-b4) * s5 * (1-h5) * b5

(10) Survival to Age-6 Returns = Age-5 Returns * (1/b5) * (1-b5) * s6 * (1-h6) * b6

(11) Cumulative Survival From End of Age-1 to Columbia River Returns =
Sum of Equations (7) through (10)

Using this approach, NMFS estimates that the reduction in ocean harvest rates has resulted in a 6% survival improvement (Table A-11). PATH's in-river harvest rate estimates indicate that the reduction in inriver harvest has resulted in a 9% survival improvement and that the combination of ocean and in-river harvest reductions has resulted in a 16% survival improvement (Table A-11).

Table A-13. Estimation of fall chinook total survival rate from end of age-1 until return to Columbia River mouth. Ocean exploitation rates are from PATH (Peters et al. 1999, their Table 4.4-3). Natural survival and maturation rates are estimates used by Pacific Salmon Commission (PSC; D. Simmons, pers. Comm 2000) . Base is average 1980-1996 run years (other years not available) and current is 70% of 1988-93 average.

	Age	Base	Current
PATH exploitation rate	2	0.023	0.021
PATH exploitation rate	3	0.089	0.058
PATH exploitation rate	4	0.181	0.164
PATH exploitation rate	5	0.197	0.149
PATH exploitation rate	6	0.208	0.143
PSC natural ocean survival rate	2	0.500	0.500
PSC natural ocean survival rate	3	0.600	0.600
PSC natural ocean survival rate	4	0.700	0.700
PSC natural ocean survival rate	5	0.800	0.800
PSC natural ocean survival rate	6	0.900	0.900
PSC maturation rate	3	0.230	0.230
PSC maturation rate	4	0.720	0.720
PSC maturation rate	5	0.960	0.960
PSC maturation rate	6	1.000	1.000
% Age-1 Fish Surviving to Columbia River mouth	3	0.061	0.064
% Age-1 Fish Surviving to Columbia River mouth	4	0.085	0.090
% Age-1 Fish Surviving to Columbia River mouth	5	0.020	0.023
% Age-1 Fish Surviving to Columbia River mouth	6	0.001	0.001
Total % Return:		**0.167**	**0.177**

NMFS used a second method to estimate the reduction in harvest to address comments by CRITFC and others that the PATH-derived harvest estimates in the July 27, 2000, draft did not match the estimates used by harvest management entities and by NMFS in its harvest biological opinions. Commenters did not question the validity of the PATH estimates, which are based on coded-wire tag (CWT) cohort survival estimates, but suggested that the estimates be reconciled with the PSC and U.S. *v.* Oregon Technical Advisory Committee harvest rate estimates. NMFS was unable to reconcile the estimates, but concluded that there are advantages and disadvantages of both the PATH approach and the harvest modeling approach used by PSC and the Technical Advisory Committee. Therefore, NMFS includes estimates derived from both approaches in this analysis.

The second method relies on results of a PSC model run (Simmons 2000b) that expresses combined ocean and inriver harvest as losses of age-3 to age-5 adult equivalents to the mouth of the Columbia River. NMFS compared average 1980-to-1996 adult equivalent exploitation rates to 70% of average 1988-to-1993 adult equivalent exploitation rates. The estimated survival change using this second method was 40% (Table A-11).

The four combinations of the two alternative harvest change methods and the two alternative juvenile survival change methods result in estimates of total survival change ranging from 31% to 63% (1.31 to 1.63 times the average historical survival rate; Table A-11).

A.5.2.2 Survival Rate Change Associated With the RPA

Juvenile and Adult Passage Survival. Implementing the hydrosystem component of the RPA will proportionally increase both juvenile and adult survival beyond the current level associated with the proposed action. NMFS estimates that adult survival will increase from the recent average (71%) to 74% after implementation of the RPA (Table 9.7-5). This represents a proportional survival increase of 4.2% (Table A-11). NMFS estimates that the hydrosystem component of the RPA will increase juvenile survival to below Bonneville Dam, including differential post-Bonneville survival of transported fish (D=0.24), by approximately 9% (Table 9.7-5; Table A-11). The juvenile survival change is based on a comparison of SIMPAS model results for operations associated with the proposed action and RPA, given 1995 to 1999 water conditions. The product of the proportional survival improvements associated with the current conditions (Section A.5.2.1) and the RPA results in an expected survival improvement of 49% to 86% (1.49 to 1.86 times the average 1980-to-1999 survival rate; Table A-11).

A.5.2.3 Survival Rate Change Associated With Breaching Four Snake River Dams

The approach and rationale for used to evaluate effects of breaching on SR fall chinook salmon were nearly identical to those used for SR spring/summer chinook salmon. The main differences between the two analyses are the fall chinook D assumption (previously described in Section A.5.2.1), the EM estimate for nontransported fall chinook, and the estimate of survival through the free-flowing river section following breaching (Table A-10).

Delayed Mortality of Nontransported Fish. As described in Section 6.2.3.3 of the biological opinion, NMFS did not estimate delayed mortality of nontransported SR fall chinook salmon. NMFS considered a value near 0% to be a reasonable approximation of the low end of the range of EM assumptions. NMFS assumed that the highest reasonable assumption was the highest PATH estimate (Peters et al. 1999). The highest PATH estimate that corresponds to D=0.24 is approximately EM=0.19. PATH did not actually estimate EM that corresponds to this D estimate. The EM estimate was derived from a PATH estimate of the STEP term in the PATH fall chinook model that corresponded to D = 0.20. This is the closest available approximation of D = 0.24. The STEP term corresponds to the absolute value of the natural logarithm of EM estimated by PATH (Peters et al. 1999). For fall chinook, Equation 12 was relevant.

(12) $EM = 1 - \exp(-\text{PATH “STEP”})$

Equation 12 was suggested by C. Peters (pers. comm., June 13, 2000, ESSA Technologies, Ltd.), and he provided the relevant PATH STEP results in a June 13, 2000, spreadsheet “fallsteps.xls.”

Juvenile Passage Survival. Empirical estimates of free-flowing reach survival are more limited and difficult to interpret for juvenile SR fall chinook salmon than for SR spring/summer chinook

salmon. The PATH participants used two methods to group and extrapolate recent PIT-tag survival estimates (Peters et al. 1999). The first (referred to as "Breach Method A" in Tables A-10 and A-11) results in a free-flowing survival rate of 0.9978 per km, and the second ("Breach Method B" in Tables A-10 and A-11) results in a rate of 0.9995 per km (Annex 1). NMFS finds that both methods are credible and that there is no basis for concluding that one better represents the best available scientific information than the other. Therefore, NMFS used both methods to establish a range of likely survival estimates. When expanded to the 210-km reach, Method A estimates an average survival of 63% versus 90% for Method B.

Summary. Final estimates of the survival changes expected from breaching were evaluated for 12 alternative assumption sets, representing two alternative harvest rate change estimates (PSC versus PATH), two alternative estimates of juvenile survival through the free-flowing reach (Breach method A versus Breach Method B), and three assumptions regarding the extent to which delayed mortality of nontransported fish is reduced following breaching (no change, 50% reduction, complete elimination - Section A.5.1.3). Results are presented in Table A-11.

A.5.3 Upper Columbia River Spring Chinook

The UCR spring chinook population trends estimated in Section A.4 were derived from 1980-to-1998 adult returns. NMFS estimates that the average juvenile FCRPS passage survival rate under current operations and configuration of the hydrosystem and under the RPA represents a change from the average juvenile passage survival rate influencing 1980-to-1998 adult returns. NMFS includes an estimate of expected survival changes through projects above McNary Dam, consistent with implementation of the proposed Mid-Columbia HCP, as anticipated in the Basinwide Recovery Strategy. NMFS concludes that the current adult passage survival rate through the FCRPS has not changed from the average 1980-to-1998 adult survival rate. NMFS estimates that the adult survival rate associated with the RPA and with breaching will, however, be an improvement from the 1980-to-1998 adult survival rate. The following sections present the methods and estimates for these juvenile and adult passage survival rate changes. Harvest rate changes have been, and are expected to continue to be, relatively minor for this ESU, so are not included in this analysis. NMFS was unable to quantify survival rate changes for other life stages or actions. Table A-14 provides an overview of the assumptions and life stages addressed in this analysis, which are discussed in more detail in the following sections.

A.5.3.1 Survival Rate Change Associated With the Proposed Action

Juvenile FCRPS (McNary Dam to Bonneville Dam) Passage Survival. NMFS estimates that the juvenile UCR spring chinook salmon survival rate associated with the proposed action is reduced from the average survival rate influencing 1980-to-1996 adult returns. This is because transportation from McNary Dam has been discontinued and because structural and operational modifications to the four lower Columbia River dams have been implemented since 1980

Table A-14. Key assumptions affecting the range of Upper Columbia River spring chinook salmon survival change (from base period) estimates expected from three actions.

	Proposed Action	RPA	Breach
Direct MCN-BON FCRPS Juvenile Passage Survival	**Base:** Single estimate from QAR analysis **Current:** Single estimate from SIMPAS model	**Base:** Single estimate from QAR analysis **RPA:** Single estimate from SIMPAS model	N/A
Survival Above MCN	Assume HCP implementation per All-H Paper. Single estimate of base-to-HCP change, from QAR analysis.	Assume HCP implementation per All-H Paper. Single estimate of base-to-HCP change, from QAR analysis.	N/A
Differential Post-BON Survival of Transported, Compared to Non-Transported, Fish (D)	**Base D=0.8:** QAR low assumption for years in which transportation occurred **Base D=1.0:** QAR high assumption for years in which transportation occurred **Current:** no transportation	**Base D=0.8:** QAR low assumption for years in which transportation occurred **Base D=1.0:** QAR high assumption for years in which transportation occurred **RPA:** no transportation	N/A
Delayed Mortality of Non-Transported Fish (EM)	Assumed constant for base and proposed action, so does not affect estimate, regardless of value	Assumed constant for base and RPA, so does not affect estimate, regardless of value	N/A
Adult Survival	Constant for base and proposed action, so does not affect estimate. Delayed mortality, if any, identical in base and proposed action, so does not affect estimate.	Improves from base to RPA, as described in Table 9.7-5 of Biological Opinion. Delayed mortality, if any, identical in base and RPA, so does not affect estimate.	N/A
Harvest	Similar in base and current/future, so no change included in calculations.	Similar in base and current/future, so no change included in calculations.	N/A
Other Life Stages and Actions	Not included in quantitative analysis; qualitative discussion in Biological Opinion	Not included in quantitative analysis; qualitative discussion in Biological Opinion	N/A

(Section 6.3.1.3 of the biological opinion). The project modifications have improved survival for inriver migrants, but the system survival from McNary Dam to Bonneville Dam has declined from the average rate during the base period (Cooney 2000), when a significant proportion of the smolts were transported. The proposed action specifies that nearly all fish will remain in the river because of very low returns of transported smolts in 1994, after the new McNary bypass system was constructed (Appendix B to 1998 FCRPS Biological Opinion).

The size of the estimated decline in McNary-to-Bonneville-Dam juvenile survival depends on the estimate of historical differential post-Bonneville survival (D) during the years when smolts were transported from McNary Dam. NMFS evaluated D estimates ranging from 0.8 to 1.0, based on results of historical McNary transportation studies (Cooney 2000; reviewed in NMFS 2000). Only a fraction of the run is transported for the proposed action, so estimating D under the proposed action is not necessary for this ESU. Cooney (2000, his Table 23) estimated 1980-to-

1994 juvenile survival from McNary to Bonneville at 60.7% and 69.0% for historical D estimates of 0.8 and 1.0, respectively.

NMFS estimated juvenile survival associated with the proposed action (current survival) using the SIMPAS passage model. SIMPAS estimated McNary-to-Bonneville Dam survival estimates from 1994 to 1999. These averaged 57.5%. The resulting change in lower river survival associated with the proposed action was -5% to -17% (Table A-15).

Juvenile Non-Federal Project Survival. The Basinwide Recovery Strategy identifies implementation of the Mid-Columbia HCP at five public utility district (PUD) projects as a probable element of recovery planning that is, therefore, included in the analysis. The Basinwide Recovery Strategy estimates that this action will be implemented within 2 to 5 years. Cooney (2000, his Table 20) estimates that implementing the HCP will improve survival 28% for the Wenatchee population, 40% for the Entiat population, and 49% for the Methow population (Table A-15).

Summary. Combining changes in survival resulting from implementation of the Mid-Columbia HCP and modifying the four lower Columbia River FCRPS projects result in a 7% to 41% increase in survival, depending on the population under consideration and the historical D estimate (Table A-15).

A.5.3.2 Survival Rate Change Associated With the RPA

Juvenile and Adult Passage Survival. Implementing the hydrosystem component of the RPA will proportionally increase both juvenile and adult survival through the four lower Columbia River projects beyond the current level associated with the proposed action. NMFS estimates that adult survival will increase from the recent average (90.8%) to 92.2% after implementation of the RPA (Table 9.7-5). This represents a proportional survival increase of 1.5% (Table A-15). NMFS estimates that the hydrosystem component of the RPA will increase recent average juvenile survival from McNary Dam to Bonneville Dam (57.5%) by approximately 15.5%, to a new survival rate of 66.4% (Table 9.7-5; Table A-15). The juvenile survival change is based on a comparison of SIMPAS model results for operations associated with the proposed action and RPA, given 1994 to 1999 water conditions. The product of the proportional survival improvements associated with the current conditions (Section A.5.3.1) and the RPA results in an expected survival improvement of 25% to 65% (1.25 to 1.65 times the average 1980-to-1999 survival rate), depending upon the population under consideration and the historical D estimate (Table A-15).

A.5.3.3 Survival Rate Change Associated With Breaching

No quantifiable survival improvements are expected for this ESU after four Snake River dams are breached.

Table A-15. Estimates of proportional change in UCR spring chinook survival associated with proposed action (current), RPA, and breaching four Snake River dams. Bold estimates define range considered in subsequent analyses.

	Survival Estimate	Proportional Change
Base to Current		
a. Survival Above McNary (All Life Stages)		
Base to HCP from Cooney (2000; his Table 20)		
Wenatchee		1.280
Entiat		1.400
Methow/Okanogan		1.490
b. Juvenile Survival McNary-Bonneville		
Base #1 = 1980-94 Survival With D=0.8 (Cooney 2000; his Table 23)	0.607	
Base #2 = 1980-94 Survival With D=1.0 (Cooney 2000; his Table 23)	0.690	
Current = SIMPAS MCN-BON (No Transport) 1994-1999	0.575	0.947
		0.833
c. Combined Base:Current above- and below-McNary survival changes		
Wenatchee		
Hist. D=0.8		**1.212**
Hist. D=1.0		**1.067**
Entiat		
Hist. D=0.8		**1.326**
Hist. D=1.0		**1.167**
Methow/Okanogan		
Hist. D=0.8		**1.411**
Hist. D=1.0		**1.242**
Current to RPA		
a. Juvenile Passage Survival		
Current = SIMPAS MCN-BON (No Transport) 1994-1999	0.575	
RPA = SIMPAS MCN-BON (No Transport) 1994-1999	0.664	1.155
b. Adult Passage Survival		
Current =	0.908	
RPA =	0.922	1.015
c. Combined Juvenile and adult change from RPA		1.172
Combined Base-to-Current and Current -to-RPA Change:		
Wenatchee		
Hist. D=0.8		**1.421**
Hist. D=1.0		**1.250**
Entiat		
Hist. D=0.8		**1.554**
Hist. D=1.0		**1.367**
Methow/Okanogan		
Hist. D=0.8		**1.654**
Hist. D=1.0		**1.455**

A.5.4 Upper Willamette River Chinook

NMFS is unable to quantify any survival changes for this ESU as a result of any of the actions evaluated in the analysis.

A.5.5 Lower Columbia River Chinook

The current population trends and needed survival changes summarized for this ESU in Tables A-2 through A-6 refer only to spawning aggregations below Bonneville Dam. Operation of the FCRPS under the actions considered in this analysis may influence survival or spawning success of these aggregations, but NMFS is unable to quantify those effects.

A.5.6 Snake River Steelhead

The SR steelhead A-Run and B-Run aggregate trends estimated in Section A.4 were derived from 1980-to-1997 adult returns. NMFS estimates that the average juvenile FCRPS passage survival rate under current operations and configuration of the hydrosystem and under the RPA represents an improvement from the average juvenile passage survival rate influencing 1980-to-1997 adult returns. NMFS concludes that the current adult passage survival rate through the FCRPS has not changed from the average 1980-to-1997 adult survival rate. However, NMFS estimates that the adult survival rate associated with the RPA and with breaching will be an improvement from the 1980-to-1996 adult survival rate. Current and expected future harvest rates are lower than the average harvest rates affecting 1980-to-1997 returning adults, which also results in increased survival. The following sections review the methods and estimates for these juvenile and adult survival rate changes. NMFS was unable to quantify survival rate changes for other life stages or actions. Table A-16 provides an overview of the assumptions and life stages addressed in this analysis, which are discussed in more detail in the following sections.

A.5.6.1 Survival Rate Change Associated With the Proposed Action

Proportional Change in Juvenile Passage Survival. No estimates of average juvenile SR steelhead survival during the base period are available. Neither PATH nor NMFS estimated the SR steelhead survival rates, including transported fish and possible indirect effects. Because direct estimates of historical steelhead juvenile passage survival are not available, NMFS assumes that the proportional change in juvenile SR steelhead survival from the base to current (proposed action) condition equals the proportional change estimated for SR spring/summer chinook salmon (24% to 32%, depending on method; Section A.5.1.1; Tables A-17 and A-18). Improvements to the system over that period (e.g., new bypasses, increased spill levels, increased flow rates, and new transportation facilities) probably have affected spring-migrating yearling steelhead and yearling chinook similarly. The 1998 FCRPS Biological Opinion contains details regarding similar effects of the hydrosystem on the two ESUs. The 1998 FCRPS Biological Opinion relied on a comparison of SR spring/summer chinook and SR steelhead to draw conclusions for steelhead. Additional information about effects of the hydrosystem on each ESU is available in NMFS (2000e,h,i).

Table A-16. Key assumptions affecting the range of Snake River steelhead survival change (from base period) estimates expected from three actions.

	Proposed Action	RPA	Breach
Direct LGR-BON Juvenile Passage Survival	Assumed identical to base-to-current survival change estimated for SR spring/summer chinook: Method 1: PATH/PATH SR spring/summer incremental change Method 2: PATH/SIMPAS spring/summer incremental change	Method 1: PATH/PATH SR spring/summer base-to-current incremental change, coupled with SIMPAS SR steelhead current-to-RPA survival change Method 2: PATH/SIMPAS SR spring/summer base-to-current incremental change, coupled with SIMPAS SR steelhead current-to-RPA survival change	**Base**: Method 1 and Method 2, as described for other actions **Breach**: One estimate, derived from LGR-MCN free-flowing reach survival and MCN-BON from SIMPAS RPA estimate
Differential Post-BON Survival of Transported, Compared to Non-Transported, Fish (D)	Average D=0.53 and D=0.58 for both base and proposed action, so does not affect estimate	Average D=0.52 and D=0.58 for both base and proposed action, so does not affect estimate	**Base:** Average D=0.52 and D=0.58 **Breach**: No transportation, so D not relevant. All fish have equivalent post-BON survival, which is functionally equivalent to D=1.0.
Delayed Mortality of Non-Transported Fish (EM)	Assumed constant for base and proposed action, so does not affect estimate, regardless of value(assume range identical to SR spring/summer chinook)	Assumed constant for base and RPA, so does not affect estimate, regardless of value (assume range identical to SR spring/summer chinook)	**Approach 1**: Assumed constant for base and breach, so does not affect estimate, regardless of value **Approach 2:** High in base period (71% to 74% - from SR spring/summer chinook); half that after breaching 4 of 8 dams (36% to 37%) **Approach 3:** High in base period (71% to 74% - from SR spring/summer chinook); 0% after breaching 4 dams
Adult Survival	Constant for base and proposed action, so does not affect estimate. Delayed mortality, if any, identical in base and proposed action, so does not affect estimate.	Improves from base to RPA, as described in Table 9.7-5 of Biological Opinion. Delayed mortality, if any, identical in base and RPA, so does not affect estimate.	Same survival improvement as base to RPA. Delayed mortality, if any, identical in base and breach, so does not affect estimate.
Harvest	One method, based on US *v* Oregon TAC estimates	Identical to approach described for proposed action.	Identical to approach described for proposed action.
Other Life Stages and Actions	Not included in quantitative analysis; qualitative discussion in Biological Opinion	Not included in quantitative analysis; qualitative discussion in Biological Opinion	Not included in quantitative analysis; qualitative discussion in Biological Opinion

Table A-17. Estimates of proportional change in SR A-Run steelhead survival associated with proposed action (current), RPA, and breaching four Snake River dams. Bold estimates define range considered in subsequent analyses.

			Survival Estimate	Proportional Change
Base to Current				
a. Juvenile Passage Survival				
Assume change is equal to proportional change for SR sp/sum				
Method 1 Base:Current Survival Change From Table A-7				1.323
Method 2 Base:Current Survival Change From Table A-7				1.239
b. Change in Harvest Rate				
Base: TAC 1984-98 (84 is first year avail - can't use 80)	0.161	(1-harvest)=	0.839	
Current/Future Harvest (Recent A:B ratio * B cap of 17%)	0.101	(1-harvest)=	0.899	1.072
c. Combined Base:Current passage and harvest survival changes				
SR sp/sum Method 1 Juvenile Change * Harvest Change				**1.418**
SR sp/sum Method 2 Juvenile Change * Harvest Change				**1.327**
Current to RPA				
a. Juvenile Passage Survival				
Current = SIMPAS including D=0.52-0.58			0.486	
RPA = SIMPAS RPA including D=0.52-58			0.507	1.044
b. Adult Passage Survival				
Current =			0.773	
RPA =			0.803	1.039
c. Combined Juvenile and adult change from RPA				1.085
Combined Base-to-Current and Current -to-RPA Change:				
PATH/PATH + TAC Harvest Base:current				**1.540**
PATH/SIMPAS Hydro + TAC Harvest Base:Current				**1.441**
Current to Breach				
a. Juvenile Passage Survival				
Assumption #1: No Change in EM Between Base and Breach (Same proportional change, whether EM high or low)				
Current = SIMPAS including D=0.52-0.58*(1-avg[.709,.743])			0.139	
Breach = Natural For Snake*MCN-BON SIMPAS RPA*(1-avg(.709,.743))			0.173	1.245
Assumption #2: EM is high in base and 1/2 goes away when 4 dams breached				
Breach = Natural For Snake*MCN-BON SIMPAS RPA*(1-[0.5*avg(.709,.743)])			0.401	2.894
Assumption #3: EM is high in base and all goes away when 4 dams breached				
Breach = Natural For Snake*MCN-BON SIMPAS RPA			0.630	4.543

Table A-17 (continued). Estimates of proportional change in SR A-Run steelhead survival associated with proposed action (current), RPA, and breaching four Snake River dams. Bold estimates define range considered in subsequent analyses.

	Survival Estimate	Proportional Change
b. Adult Passage Survival (Breach expected identical to RPA)		
c. Juvenile RPA-to-Breach Changes * Current-to-RPA, as described above		
Assumption #1: No Change in EM Between Base and Breach		
Method 1 base:current		**1.766**
Method 2 base:current		**1.653**
Assumption #2: EM is high in base and 1/2 goes away when 4 dams breached		
Method 1 base:current		**4.105**
Method 2 base:current		**3.842**
Assumption #3: EM is high in base and all goes away when 4 dams breached		
Method 1 base:current		**6.444**
Method 2 base:current		**6.031**

Table A-18. Estimates of proportional change in SR B-Run steelhead survival associated with proposed action (current), RPA, and breaching four Snake River dams. Bold estimates define range considered in subsequent analyses.

			Survival Estimate	Proportional Change
Base to Current				
a. Juvenile Passage Survival				
Assume change is equal to proportional change for SR sp/sum				
Method 1 Base:Current Survival Change From Table A-7				1.323
Method 2 Base:Current Survival Change From Table A-7				1.239
b. Change in Harvest Rate				
Base: TAC 1984-98 (84 is first year avail - can't use 80)	0.286	(1-harvest)=	0.714	
Current/Future Harvest (17%, from All-H Paper and recent biops)	0.170	(1-harvest)=	0.830	1.163
c. Combined Base:Current passage and harvest survival changes				
SR sp/sum Method 1 Juvenile Change * Harvest Change				**1.539**
SR sp/sum Method 2 Juvenile Change * Harvest Change				**1.441**
Current to RPA				
a. Juvenile Passage Survival				
Current = SIMPAS including D=0.52-0.58			0.486	
RPA = SIMPAS RPA including D=0.52-58			0.507	1.044
b. Adult Passage Survival				
Current =			0.773	
RPA =			0.803	1.039
c. Combined Juvenile and adult change from RPA				1.085
Combined Base-to-Current and Current -to-RPA Change:				
PATH/PATH + TAC Harvest Base:current				**1.671**
PATH/SIMPAS Hydro + TAC Harvest Base:Current				**1.564**
Current to Breach				
a. Juvenile Passage Survival				
Assumption #1: No Change in EM Between Base and Breach (Same proportional change, whether EM high or low)				
Current = SIMPAS including D=0.52-0.58*(1-avg[.709,.743])			0.139	
Breach = Natural For Snake*MCN-BON SIMPAS RPA*(1-avg(.709,.743))			0.173	1.245
Assumption #2: EM is high in base and 1/2 goes away when 4 dams breached				
Breach = Natural For Snake*MCN-BON SIMPAS RPA*(1-[0.5*avg(.709,.743)])			0.401	2.894
Assumption #3: EM is high in base and all goes away when 4 dams breached				
Breach = Natural For Snake*MCN-BON SIMPAS RPA			0.630	4.543

Table A-18 (continued). Estimates of proportional change in SR B-Run steelhead survival associated with proposed action (current), RPA, and breaching four Snake River dams. Bold estimates define range considered in subsequent analyses.

	Survival Estimate	Proportional Change
b. Adult Passage Survival (Breach expected identical to RPA)		
c. Juvenile RPA-to-Breach Changes * Current-to-RPA, as described above		
Assumption #1: No Change in EM Between Base and Breach		
Method 1 base:current		**1.916**
Method 2 base:current		**1.793**
Assumption #2: EM is high in base and 1/2 goes away when 4 dams breached		
Method 1 base:current		**4.455**
Method 2 base:current		**4.169**
Assumption #3: EM is high in base and all goes away when 4 dams breached		
Method 1 base:current		**6.993**
Method 2 base:current		**6.545**

Harvest Reductions. In addition to the change in juvenile passage survival, harvest rates changed significantly during this period. The average 1984-through-1997 harvest rates for A-run and B-run steelhead were obtained from the U.S. *v.* Oregon Technical Advisory Committee (ODFW and WDFW 2000; Table A-19). Estimates for 1980-through-1983 returns were not available, except for the run at large. NMFS compared this historical average with the Basinwide Recovery Strategy's 17% B-run harvest cap, which represents the most likely current and future B-run harvest rate. The Basinwide Recovery Strategy does not describe a similar harvest rate for A-run steelhead, so an approximation was obtained by multiplying the B-run harvest cap by the recent ratio of A:B harvest rates (Table A-19). The result was a 10% A-run current and future harvest rate. The reduced harvest rate represents a 7.2% A-run survival increase from the average survival during the 1980-to-1997 period and a 16.3% B-run survival increase.

Summary. The reduced harvest rates and the two alternative methods for estimating the juvenile survival improvement result in estimates of total survival change ranging from 33% to 42% (1.33 to 1.42 times the average historical survival rate) for A-run steelhead and 44% to 54% (1.44 to 1.54 times the average historical survival rate) for B-run steelhead (Tables A-17 and A-18).

A.5.6.2 Survival Rate Change Associated With the RPA

General Approach. Because juvenile survival during the base period is unknown, NMFS was unable to directly estimate the change in survival from the base period to the RPA. Instead, NMFS estimated the change in survival from the proposed action (current conditions) to the RPA, then multiplied that proportional change by the previously estimated proportional change from base-to-current survival (Tables A-17 and A-18).

Table A-19. SR steelhead harvest rates from ODFW and WDFW (2000, their Table 16). A's and B's separated by length (<78 cm and >78 cm).

Run Year	Wild "A" Harvest Rate w/o Nontreaty Fall impacts	Wild "A" Harvest Rate with annual 2% Nontreaty Fall impacts (Dygert 11/30 pers. Comm.)	Wild "B" Harvest Rate w/o Nontreaty Fall impacts	Wild "B" Harvest Rate with annual 2% Nontreaty Fall impacts (Dygert 11/30 pers. Comm.)	Ratio A:B Harvest Rates
1984	0.120	0.140	0.366	0.386	0.363
1985	0.207	0.227	0.310	0.330	0.688
1986	0.138	0.158	0.267	0.287	0.551
1987	0.157	0.177	0.372	0.392	0.452
1988	0.171	0.191	0.234	0.254	0.752
1989	0.159	0.179	0.350	0.370	0.484
1990	0.160	0.180	0.215	0.235	0.766
1991	0.146	0.166	0.300	0.320	0.519
1992	0.162	0.182	0.263	0.283	0.643
1993	0.152	0.172	0.191	0.211	0.815
1994	0.103	0.123	0.186	0.206	0.597
1995	0.104	0.124	0.186	0.206	0.602
1996	0.089	0.109	0.346	0.366	0.298
1997	0.104	0.124	0.143	0.163	0.761
1998	0.088	0.108	0.156	0.176	0.614
1999	0.076	0.096	0.127	0.147	0.653
2000					
84-97 Mean		**0.161**		**0.286**	
Future B Harvest Rate (All-H Paper)				**0.170**	
Recent Ratio A:B (93-98)					**0.592**
Future A Harvest Rate (= recent ratio * Future B)		**0.101**			

Juvenile and Adult Passage Survival. Implementing the hydrosystem component of the RPA will proportionally increase both juvenile and adult survival beyond the current level associated with the proposed action. NMFS estimates that adult survival will increase from the recent average (77.3%) to 80.3% after implementation of the RPA (Table 9.7-5). This represents a proportional survival increase of 3.9% (Tables A-17 and A-18). NMFS estimates that the hydrosystem component of the RPA will increase juvenile survival to below Bonneville Dam, including differential post-Bonneville survival of transported fish (D=0.52 to 0.58), by approximately 4.4% (Table 9.7-5; Tables A-17 and A-18). The juvenile survival change is based on a comparison of SIMPAS model results for operations associated with the proposed action (survival averages 48.6%) and the RPA (survival averages 50.7%), given 1994-to-1999 water conditions.

Summary. The product of the proportional survival improvements associated with the current conditions (Section A.5.1.1) and the RPA results in an expected survival improvement of 44% to 54% (1.44 to 1.54 times the average 1980-to-1999 survival rate; Table A-17) for A-run steelhead and 56% to 67% (1.56 to 1.67 times the average 1980-to-1999 survival rate; Table A-18) for B-run steelhead. The range of estimates reflects the two alternative methods used to estimate the SR spring/summer chinook, base-to-current survival change.

A.5.6.3 Survival Rate Change Associated With Breaching

Juvenile Direct Survival and Delayed Mortality. The approach and rationale for used to evaluate effects of breaching on SR steelhead were nearly identical to those used for SR spring/summer chinook salmon (Table A-16). The main difference was that the same two-step approach used for the RPA was applied. NMFS first estimated the base-to-current survival change, including the two SR spring/summer chinook estimates. Then NMFS estimated the current-to-breach survival change. Direct free-flowing and McNary-to-Bonneville reach survival estimates were specific to SR steelhead, as were D estimates. However, the changes in extra mortality evaluated for breaching relied upon SR spring/summer chinook estimates of EM. As described in Section 6.2.3.3 of the biological opinion, NMFS did not estimate delayed mortality of nontransported SR steelhead. NMFS concluded that it is reasonable to apply the same range of assumptions to SR steelhead as NMFS applied to SR spring/summer chinook. NMFS considered a value near 0% to be a reasonable approximation of the low end of the range of EM assumptions. NMFS assumed that the highest reasonable assumption was the highest PATH estimate for SR spring/summer chinook salmon (71% to 74%; Marmorek et al. 1998). Details of estimates are displayed in Tables A-18 and A-19.

Summary. Final estimates of the survival changes expected from breaching were evaluated for six alternative assumption sets, representing two alternative estimates of base-to-current juvenile survival changes and three assumptions regarding the extent to which EM is reduced following breaching (no change, 50% reduction, complete elimination - Section A.5.1.3). Results are presented in Tables A-18 and A-19.

A.5.7 Upper Columbia River Steelhead

The UCR steelhead trends estimated in Section A.4 were derived from 1980-to-1999 adult returns for the individual populations addressed by the QAR analysis and from 1980-to-1996 adult returns for the aggregate CRI analysis. NMFS estimates that the average juvenile FCRPS passage survival rate under current operations and configuration of the hydrosystem and under the RPA represents a change from the average juvenile passage survival rate influencing 1980-to-1996 or -1999 (base period) adult returns. NMFS includes an estimate of expected survival changes through projects above McNary Dam, consistent with implementation of the proposed Mid-Columbia HCP, as anticipated in the Basinwide Recovery Strategy. NMFS concludes that the current adult passage survival rate through the FCRPS has not changed from the average base period adult survival rate. However, NMFS estimates that the adult survival rate associated with the RPA and with breaching will be an improvement from the base period adult survival rate.

Current and expected future harvest rates are lower than the average harvest rates affecting 1980-to-1997 returning adults, which also results in increased survival. The following sections review the methods and estimates for these juvenile and adult passage survival rate changes. NMFS was unable to quantify survival rate changes for other life stages or actions. Table A-20 provides an overview of the assumptions and life stages addressed in this analysis. These assumptions and life stages are discussed in more detail in the following sections.

Table A-20. Key assumptions affecting the range of Upper Columbia River steelhead survival change (from base period) estimates expected from three actions.

	Proposed Action	RPA	Breach
Direct MCN-BON FCRPS Juvenile Passage Survival	**Base:** Single estimate from QAR analysis **Current:** Single estimate from SIMPAS model	**Base:** Single estimate from QAR analysis **RPA:** Single estimate from SIMPAS model	N/A
Survival Above MCN	Assume HCP implementation per All-H Paper. Single estimate of base-to-HCP change, from QAR analysis.	Assume HCP implementation per All-H Paper. Single estimate of base-to-HCP change, from QAR analysis.	N/A
Differential Post-BON Survival of Transported, Compared to Non-Transported, Fish (D)	**Base D=0.8:** QAR low assumption for years in which transportation occurred **Base D=1.0:** QAR high assumption for years in which transportation occurred **Current:** no transportation	**Base D=0.8:** QAR low assumption for years in which transportation occurred **Base D=1.0:** QAR high assumption for years in which transportation occurred **RPA:** no transportation	N/A
Delayed Mortality of Non-Transported Fish (EM)	Assumed constant for base and proposed action, so does not affect estimate, regardless of value	Assumed constant for base and RPA, so does not affect estimate, regardless of value	N/A
Adult Survival	Constant for base and proposed action, so does not affect estimate. Delayed mortality, if any, identical in base and proposed action, so does not affect estimate.	Improves from base to RPA, as described in Table 9.7-5 of Biological Opinion. Delayed mortality, if any, identical in base and RPA, so does not affect estimate.	N/A
Harvest	One method, based on US *v* Oregon TAC estimates	Identical to approach described for proposed action.	N/A
Other Life Stages and Actions	Not included in quantitative analysis; qualitative discussion in Biological Opinion	Not included in quantitative analysis; qualitative discussion in Biological Opinion	N/A

A.5.7.1 Survival Rate Change Associated With the Proposed Action

Juvenile FCRPS (McNary Dam to Bonneville Dam) Passage Survival. NMFS estimates that the juvenile UCR steelhead survival rate associated with the proposed action is reduced from the average survival rate influencing 1980-to-1996 adult returns. This is because transportation from McNary Dam has been discontinued, and because structural and operational modifications to the four lower Columbia River dams have been implemented since 1980 (Section 6.3.1.3 of the biological opinion). The project modifications have improved survival for inriver migrants, but

the system survival from McNary Dam to Bonneville has declined from the average rate during the base period (Cooney 2000), when a significant proportion of the smolts were transported. The proposed action specifies that nearly all fish will remain in the river because of very low returns of transported smolts in 1994, after the new McNary bypass system was constructed (Appendix B to the 1998 FCRPS Biological Opinion).

NMFS used the base period survival estimate from Cooney (2000, his Table 23), which is identical to the base period estimate for UCR spring chinook (Section A.5.3.1). This estimate varies, based on assumptions regarding historical differential post-Bonneville survival (D) during the years when smolts were transported from McNary Dam. NMFS evaluated D estimates ranging from 0.8 to 1.0, based on results of historical McNary transportation studies (Cooney 2000; reviewed in NMFS 2000). Only a fraction of the run is transported for the proposed action, so estimating D under the proposed action is not necessary for this ESU. Cooney (2000, his Table 23) estimated 1980-to-1994 juvenile survival from McNary to Bonneville at 60.7% and 69.0% for historical D estimates of 0.8 and 1.0, respectively.

NMFS estimated juvenile survival associated with the proposed action (current survival) using the SIMPAS passage model. SIMPAS estimated McNary-to-Bonneville survival estimates from 1994 to 1999. These averaged 58.8%. The resulting change in lower river survival associated with the proposed action was -3% to -15% (Table A-21).

Juvenile Non-Federal Project Survival. The Basinwide Recovery Strategy identifies implementation of the Mid-Columbia HCP at five PUD projects as a probable element of recovery planning that is, therefore, included in the analysis. The Basinwide Recovery Strategy estimates that this action will be implemented within 2 to 5 years. Cooney (2000, his Table 20) estimates that implementing the HCP will improve survival 23% for the Wenatchee population, 33% for the Entiat population, and 38% for the Methow population (Table A-21).

Harvest Reductions. In addition to the change in juvenile passage survival, harvest rates also declined during this period. UCR steelhead are subjected to similar harvest rates as SR A-Run steelhead. Therefore, NMFS applied the change in harvest rate estimated for SR A-run steelhead (Tables A-17 and A-19) to this ESU. This reduced harvest rate results in a 7.2% survival improvement.

Summary. Combining changes in survival resulting from implementation of the Mid-Columbia HCP, reduced harvest rates, and modifications to the four lower Columbia River FCRPS projects results in a 12% to 43% increase in survival, depending on the population under consideration and the historical D estimate (Table A-21).

Table A-21. Estimates of proportional change in UCR steelhead survival associated with proposed action (current), RPA, and breaching four Snake River dams. Bold estimates define range considered in subsequent analyses.

				Survival Estimate	Proportional Change
Base to Current					
a. Survival Above McNary (All Life Stages)					
Base to HCP from Cooney (2000; his Table 20)					
	Wenatchee				1.230
	Entiat				1.330
	Methow/Okanogan				1.380
b. Juvenile Survival McNary-Bonneville					
Base #1 = 1980-94 Survival With D=0.8 (Cooney 2000; his Table 23)				0.607	
Base #2 = 1980-94 Survival With D=1.0 (Cooney 2000; his Table 23)				0.690	
Current = SIMPAS MCN-BON (No Transport) 1994-1999				0.588	0.969
					0.852
c. Harvest Rate - same as SR A-Run Steelhead (Tables A-12, A-14)					
Base: TAC 1984-98 (84 is first year avail - can't use 80)		0.161	(1-harvest)=	0.839	
Current/Future Harvest (Recent A:B ratio * B cap of 17%)		0.101	(1-harvest)=	0.899	1.072
d. Combined Base:Current above- and below-McNary survival changes					
	Wenatchee	Hist. D=0.8			**1.277**
		Hist. D=1.0			**1.123**
	Entiat	Hist. D=0.8			1.381
		Hist. D=1.0			1.215
	Methow/Okanogan	Hist. D=0.8			**1.433**
		Hist. D=1.0			**1.260**
Current to RPA					
a. Juvenile Passage Survival					
Current = SIMPAS MCN-BON (No Transport) 1994-1999				0.588	
RPA = SIMPAS MCN-BON (No Transport) 1994-1999				0.699	1.152
b. Adult Passage Survival					
Current =				0.879	
RPA =				0.893	1.016
c. Combined Juvenile and adult change from RPA					1.170
Combined Base-to-Current and Current -to-RPA Change:					
	Wenatchee	Hist. D=0.8			**1.494**
		Hist. D=1.0			**1.314**
	Entiat	Hist. D=0.8			1.616
		Hist. D=1.0			1.421
	Methow/Okanogan	Hist. D=0.8			**1.676**
		Hist. D=1.0			**1.475**

A.5.7.2 Survival Rate Change Associated With the RPA

Juvenile and Adult Passage Survival. Implementing the hydrosystem component of the RPA will proportionally increase both juvenile and adult survival through the four lower Columbia River projects beyond the current level associated with the proposed action. NMFS estimates that adult survival will increase from the recent average (87.9%) to 89.3% after implementation of the RPA (Table 9.7-5). This represents a proportional survival increase of 1.6% (Table A-21). NMFS estimates that the hydrosystem component of the RPA will increase recent average juvenile survival from McNary Dam to Bonneville Dam (58.8%) by approximately 15.2%, to a new survival rate of 67.7% (Table 9.7-5; Table A-21). The juvenile survival change is based on a comparison of SIMPAS model results for operations associated with the proposed action and RPA, given 1994-to-1999 water conditions. The product of the proportional survival improvements associated with the current conditions (Section A.5.7.1) and the RPA results in an expected survival improvement of 31% to 68% (1.31 to 1.68 times the average base period survival rate), depending upon the population under consideration and the historical D estimate (Table A-21).

A.5.7.3 Survival Rate Change Associated With Breaching

No quantifiable survival improvements are expected for this ESU after four Snake River dams are breached.

A.5.8 Middle Columbia River Steelhead

The MCR steelhead trends estimated in Section A.4 were derived from 1980-to-1994 (Yakima and Warm Springs) or 1980-to-1996 (Deschutes and Umatilla) adult returns. NMFS estimates that the average juvenile FCRPS passage survival rate under current operations and configuration of the hydrosystem and under the RPA represents an improvement from the average juvenile passage survival rate influencing base period adult returns. NMFS concludes that the current adult passage survival rate through the FCRPS has not changed from the average base period adult survival rate. However, NMFS estimates that the adult survival rate associated with the RPA will be an improvement from the base period adult survival rate. Current and expected future harvest rates are lower than the average harvest rates affecting base period returning adults, which also results in increased survival. The following sections review the methods and estimates for these juvenile and adult survival rate changes. NMFS was unable to quantify survival rate changes for other life stages or actions. Table A-22 provides an overview of the assumptions and life stages addressed in this analysis. These assumptions and life stages are discussed in more detail in the following sections.

Table A-22. Key assumptions affecting the range of Middle Columbia River steelhead survival change (from base period) estimates expected from three actions.

	Proposed Action	RPA	Breach
Direct Juvenile Passage Survival	**Base:** Single estimate for each stock from QAR analysis **Current:** Single estimate for each stock from SIMPAS model	**Base:** Single estimate for each stock from QAR analysis **RPA:** Single estimate for each stock from SIMPAS model	N/A
Differential Post-BON Survival of Transported, Compared to Non-Transported, Fish (D) - *Only Applies to Yakima Stock*	**Base D=0.8:** QAR low assumption for years in which transportation occurred **Base D=1.0:** QAR high assumption for years in which transportation occurred **Current:** no transportation	**Base D=0.8:** QAR low assumption for years in which transportation occurred **Base D=1.0:** QAR high assumption for years in which transportation occurred **RPA:** no transportation	N/A
Delayed Mortality of Non-Transported Fish (EM)	Assumed constant for base and proposed action, so does not affect estimate, regardless of value	Assumed constant for base and RPA, so does not affect estimate, regardless of value	N/A
Adult Survival	Constant for base and proposed action, so does not affect estimate. Delayed mortality, if any, identical in base and proposed action, so does not affect estimate.	Improves from base to RPA, as described in Table 9.7-5 of Biological Opinion. Delayed mortality, if any, identical in base and RPA, so does not affect estimate.	N/A
Harvest	One method, based on US *v* Oregon TAC estimates	Identical to approach described for proposed action.	N/A
Other Life Stages and Actions	Not included in quantitative analysis; qualitative discussion in Biological Opinion	Not included in quantitative analysis; qualitative discussion in Biological Opinion	N/A

A.5.8.1 Survival Rate Change Associated With the Proposed Action

Juvenile Passage Survival. The MCR steelhead spawning aggregations evaluated in this analysis pass from two to four FCRPS dams during their juvenile migrations. For each spawning aggregation, an estimate of the base period survival rate is available from the QAR analysis (Cooney 2000), and an estimate of survival under the proposed action (current survival) is available from SIMPAS modeling. The following discussion provides details for each stock.

The Yakima River spawning aggregation passes through the same four FCRPS projects (McNary Dam to Bonneville Dam) as the UCR steelhead ESU and is, therefore, likely to experience the same survival change estimated for that ESU (Tables A-21 and A-23). The FCRPS project modifications have improved survival for inriver migrants, but the system survival from McNary Dam to Bonneville Dam has declined from the average rate during the base period, when a significant proportion of the smolts were transported (Cooney 2000; Table A-23). The proposed action specifies that nearly all fish will remain in the river because of very low returns of transported smolts in 1994, after the new McNary bypass system was constructed (Appendix B to 1998 FCRPS Biological Opinion). The size of the estimated decline in McNary-Bonneville juvenile survival for the Yakima aggregation depends on the estimate of historical differential

post-Bonneville survival (D; see Section 6.2.3.3) during the years when smolts were transported from McNary Dam. NMFS evaluated D estimates ranging from 0.8 to 1.0, based on results of historical McNary transportation studies (Cooney 2000; reviewed in NMFS 2000). Only a fraction of the run is transported for the proposed action, so estimating D under the proposed action is not necessary for this ESU. Cooney (2000, his Table 23) estimated 1980-to-1994 juvenile survival from McNary to Bonneville at 60.7% and 69.0% for historical D estimates of 0.8 and 1.0, respectively.

NMFS estimated Yakima River stock juvenile survival associated with the proposed action (current survival) using the SIMPAS passage model. SIMPAS estimated McNary-to-Bonneville survival estimates from 1994 to 1999. These averaged 58.8%. The resulting change in lower river survival associated with the proposed action was -3% to -15% (Table A-23).

The Umatilla River spawning aggregation passes through three FCRPS projects (John Day Dam to Bonneville Dam). These projects are all below the last transportation site, so no juveniles were transported in either the base or the current period. NMFS compared the estimate in Cooney (2000, his Table 22) of average 1980-to-1994 inriver survival through these projects (61.3%) with the average SIMPAS 1994-to-1999 estimate through the same projects (65.1%). The resulting survival change for the Umatilla spawning aggregate is 6% (Table A-23).

The Deschutes River and Warm Springs spawning aggregations pass through two FCRPS projects (The Dalles Dam and Bonneville Dam). These projects are also below the last transportation site, so no fish were transported in either the base or the current period. NMFS compared the estimate in Cooney (2000, his Table 22) of average 1980-to-1994 inriver survival through these projects (75.7%) with the average SIMPAS 1994-to-1999 estimate through the same projects (75.8%). Based on these estimates, no change in juvenile survival is anticipated for the Deschutes and Warm Springs spawning aggregations (Table A-23).

Harvest Rate Reductions. In addition to the change in juvenile passage survival, harvest rates also declined during this period. MCR steelhead are subjected to similar harvest rates as SR A-Run steelhead. Therefore, NMFS applied the change in harvest rate estimated for SR A-run steelhead (Tables A-17 and A-19) to this ESU. This reduced harvest rate results in a 7.2% survival improvement (Table A-23).

Summary. Combining changes in survival resulting from reduced harvest rates and modifications to the four lower Columbia River FCRPS projects results in a -9% to +14% change in survival, depending on the spawning aggregation under consideration and the historical D estimate (Table A-23).

Table A-23. Estimates of proportional change in MCR steelhead survival associated with proposed action (current), RPA, and breaching four Snake River dams. Bold estimates define range considered in subsequent analyses.

			Survival Estimate	Proportional Change
Base to Current				
a. Juvenile Survival				
Yakima = assume same MCN-BON proportional change as for UCR steelhead				
Base 80-94 with D=0.8			0.607	
Base 80-94 with D=1.0			0.690	
Current SIMPAS MCN-BON			0.588	0.969
				0.852
Umatilla = assume QAR est. (.81*.87*.87) base				
Base 80-94			0.613	
Current SIMPAS JDA-BON			0.651	1.062
Warm Spring and deschutes= assume QAR (.87*.87)				
Base 80-94			0.757	
Current SIMPAS TDA-BON			0.758	1.001
b. Harvest Change - same as SR A-Run Steelhead				
Base: TAC 1984-98 (84 is first year avail - can't use 80)	0.161	(1-harvest)=	0.839	
Current/Future Harvest (Recent A:B ratio * B cap of 17%)	0.101	(1-harvest)=	0.899	1.072
)				
c. Combined Juvenile Passage and Harvest				
Yakima				
Hist. D=0.8				**1.038**
Hist. D=1.0				**0.913**
Umatilla				**1.138**
Warm Springs, Deschutes				**1.073**
Current to RPA				
a. Juvenile Passage Survival				
Yakima: SIMPAS "current" MCN-BON			0.588	
Yakima: SIMPAS "RPA" MCN-BON			0.677	1.152
Umatilla: SIMPAS "current" JDA-BON			0.651	
Umatilla: SIMPAS "RPA" JDA-BON			0.741	1.138
Warm Springs, Deschutes: SIMPAS "current" TDA-BON			0.758	
Warm Springs, Deschutes: SIMPAS "RPA" TDA-BON			0.846	1.117
b. Adult Passage Survival				
Current = 0.972 per project				
Yakima - four projects			0.893	
Umatilla - three projects			0.918	
Warm Springs, Deschutes - two projects			0.945	
RPA = 0.98 per project				
Yakima - four projects			0.922	1.033
Umatilla - three projects			0.941	1.025
Warm Springs, Deschutes - two projects			0.960	1.017

Table A-23 (continued). Estimates of proportional change in MCR steelhead survival associated with proposed action (current), RPA, and breaching four Snake River dams. Bold estimates define range considered in subsequent analyses.

	Survival Estimate	Proportional Change
c. Combined Juvenile and adult change from current to RPA		
Yakima		1.190
Umatilla		1.166
Warm Springs, Deschutes		1.135
Combined Base-to-Current and Current -to-RPA Change:		
Yakima		
Hist. D=0.8		**1.236**
Hist. D=1.0		**1.087**
Umatilla		**1.327**
Warm Springs, Deschutes		**1.218**

A.5.8.2 Survival Rate Change Associated With the RPA

Implementing the hydrosystem component of the RPA will proportionally increase both juvenile and adult survival through the four lower Columbia River projects beyond the current level associated with the proposed action.

Juvenile Passage Survival. NMFS evaluated the expected juvenile survival change based on a comparison of SIMPAS model results for operations associated with the proposed action and the RPA, given 1994-to-1999 water conditions. NMFS estimates that the hydrosystem component of the RPA will increase recent average Yakima River stock juvenile survival from McNary pool to Bonneville Dam (58.8%) by approximately 15.2%, to a new survival rate of 67.7% (Table 9.7-5; Table A-23). NMFS estimates that the hydrosystem component of the RPA will increase recent average Umatilla River stock juvenile survival from the John Day pool to Bonneville Dam (65.1%) by approximately 13.8% to a new survival rate of 74.1% (Table 9.7-5; Table A-23). The RPA is expected to increase the recent average Deschutes and Warm Springs stock juvenile survival from The Dalles pool to Bonneville Dam (75.8%) by approximately 11.7%, to a new survival rate of 84.6% (Table 9.7-5; Table A-23).

Adult Passage Survival. Recent average Middle Columbia River (MCR) steelhead adult survival through two to four projects is 89.3% for the Yakima stock, 91.8% for the Umatilla stock, and 94.5% for the Deschutes and Warm Springs stocks (Table 9.7-5). NMFS estimates that, after implementing the RPA, adult survival will increase from the recent average to 92.2% for the Yakima stock, 94.1% for the Umatilla stock, and 96% for the Warm Springs and Deschutes stocks (Table 9.7-5). These changes represent proportional survival increases ranging from 1.7% to 3.3% (Table A-23).

Summary. The product of the proportional survival improvements associated with the current conditions (Section A.5.8.1) and the RPA results in an expected survival improvement of 9% to 24% (1.09 to 1.24 times the base survival rate) for the Yakima stock, 33% (1.33 times the base

survival rate) for the Umatilla stock, and 22% (1.22 times the base survival rate) for the Deschutes and Warm Springs stocks (Table A-23). The range of survival change estimates for the Yakima stock represents historical D estimates of 0.8 and 1.0 (Table A-21).

A.5.8.3 Survival Rate Change Associated With Breaching

No quantifiable survival improvements are expected for this ESU after four Snake River dams are breached.

A.5.9 Lower Columbia River Steelhead

The current population trends and needed survival changes summarized for this ESU in Tables A-2 through A-6 refer only to spawning aggregations below Bonneville Dam. Operation of the FCRPS under the actions considered in this analysis may influence survival or spawning success of these aggregations, but NMFS is unable to quantify those effects.

A.5.10 Upper Willamette River Steelhead

NMFS is unable to quantify any survival changes for this ESU as a result of any of the actions evaluated in the analysis.

A.5.11 Columbia River Chum Salmon

The current population trends and needed survival changes summarized for this ESU in Tables A-2 through A-6 refer only to spawning aggregations below Bonneville Dam. Operation of the FCRPS under the actions considered in this analysis may influence survival or spawning success of these aggregations, but NMFS is unable to quantify those effects.

A.6 ESTIMATES OF ADDITIONAL NEEDED SURVIVAL IMPROVEMENTS AFTER IMPLEMENTING THE PROPOSED ACTION, RPA, AND BREACHING

NMFS compared the expected survival improvements from each action described in Section A.5 with the survival improvements needed to meet survival and recovery indicator criteria, which were estimated in Section A.4. NMFS estimated the additional needed survival improvement after implementing an action by dividing the needed survival change from Section A.4 by the expected survival change from Section A.5. The results are summarized in tables in Sections 6.3, 9.7.2, and 9.7.3.2 of the biological opinion and are not reproduced in this Appendix. Spreadsheets used to generate the ratios in those tables are available from the NMFS Hydro Program upon request.

A.7 SENSITIVITY ANALYSIS TO 10-YEAR DELAY

The simple analytical approach used in this biological opinion assumes that all survival changes are instantaneous (McClure et al. 2000c). To the extent that improvements are implemented gradually, the analysis underestimates the survival change that ultimately will be required to meet survival and recovery indicator criteria. The magnitude of the additional change depends upon the current trend of the stock under consideration and the length of the delay. To demonstrate the effect of this assumption on the ability to meet the 48-year recovery indicator criterion, NMFS evaluated a 10-year delay in implementing the hydrosystem component of the RPA and in achieving any survival improvements in other life stages. The analysis also assumed that there has been no change from average base period survival as a result of current hydrosystem operations or reduced harvest rates.

NMFS first began with the geometric mean abundance of wild spawners from the eight most recent years used by McClure et al. (2000c) to estimate lambda. The raw spawner counts and proportion wild spawners were from the "Digital Appendices" spreadsheet that accompanies McClure et al. (2000c). The geometric mean cannot be estimated if zero spawners returned in any year. For index stocks with zeros in the most recent eight years, one spawner was added to the spawner count in each year before estimating the geometric mean (Sokal and Rohlf 1969). Table A-24 displays the resulting geometric means for the SR spring/summer chinook index stocks, the SR fall chinook aggregate, and the UCR spring chinook populations.

NMFS then projected the expected 8-year geometric mean population levels in 10 years ($\boldsymbol{n}_{(t+10)}$), given the current population level ($\boldsymbol{n}_{(t)}$) and the range of base period population growth rates (λ) estimated by McClure et al. (2000c):

(13) $$\boldsymbol{n}_{(t+10)} = \boldsymbol{n}_{(t)} * \lambda^{10}$$

The lambda needed to meet the 48-year recovery indicator criterion, after the 10-year delay, was estimated by substituting $\boldsymbol{n}_{(t+10)}$ for $\boldsymbol{n}$ in Equation 3. When applying Equation 3, NMFS used a 44-year period for estimation of the 48-year recovery criterion and a 34-year period for the 10-year delay. These time periods reflect the centering of the 8-year geometric means with respect to the end of the 48-year recovery period. NMFS then estimated the corresponding survival rate change from base period survival according to Equation 1. Finally, NMFS divided the new estimate of the needed survival rate change by the survival rate change expected from the RPA, and compared the additional survival rate change that would be necessary after a 10-year delay with that which would be necessary with immediate achievement of current and RPA hydrosystem survival improvements. Results are displayed in Table A-24.

For SR spring/summer chinook, the Imnaha river index stock required the greatest survival rate change after a 10-year delay in achieving current and RPA survival rates. Given these assumptions, a 57% to 95% survival improvement would be necessary at the end of 10 years to meet the recovery indicator criteria. In contrast, the estimate from the analysis that assumes instantaneous survival changes is a 26% to 66% needed survival improvement (Table 9.7-6 of

Table A-24. Effects of 10-year delay in achieving estimated current survival rates and estimated survival improvements associated with hydrosystem actions in RPA. Effects are evaluated with respect to achieving 48-year recovery indicator criterion, according to methods described in Section A-7.

	1980-Most Recent Year Lambda		Current 8-yr Geomean Wild Spawners	Expected Spawners in 10 Years If No Change		Change In Survival From 1980-99 Lambda Needed to Meet Recovery Criterion After 10-Year Delay		Additional Needed Change In Survival After Implementing RPA in 10 Years		Additional Needed Change In Survival If RPA Is Implemented Immediately (From Section 9.7.2)	
Spawning Aggregation	**Low**	**High**		**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
Snake River Spring/Summer Chinook Salmon											
Bear Valley/Elk creeks	1.02	1.03	110	130.5	146.0	1.15	1.19	***0.83***	***0.92***	0.79	0.89
Imnaha River	0.88	0.92	122	34.0	54.4	2.18	2.53	***1.57***	***1.95***	1.26	1.66
Johnson Creek	1.01	1.03	90	99.1	125.5	0.99	1.07	***0.72***	***0.82***	0.70	0.83
Marsh Creek	0.99	1.00	23	20.0	23.2	1.51	1.59	***1.09***	***1.22***	0.98	1.12
Minam River	0.93	1.02	47	23.6	55.2	1.34	1.73	***0.97***	***1.33***	0.84	1.28
Poverty Flats	0.99	1.02	253	233.8	322.0	1.06	1.17	***0.77***	***0.90***	0.73	0.90
Sulphur Creek	1.04	1.05	15	22.7	25.3	1.12	1.16	***0.81***	***0.89***	0.78	0.87
Aggregate SR Fall Chinook	0.87	0.92	318	80.7	136.2	2.16	2.51	***1.16***	***1.69***	0.93	1.44
Upper Columbia River Spring Chinook											
Methow River - CRI	0.85	0.89	80	15.2	26.3	2.95	3.48	***1.78***	***2.39***	1.32	1.90
Entiat River - CRI	0.81	0.89	48	6.0	15.0	2.82	3.69	***1.82***	***2.70***	1.32	2.19
Wenatchee River - CRI	0.80	0.85	279	28.5	55.1	3.76	4.61	***2.65***	***3.68***	1.84	2.78

the biological opinion). For other SR spring/summer chinook index stocks, the 10-year delay would have a smaller effect on the needed survival changes.

For SR fall chinook salmon, no additional survival changes are needed under the low estimate when instantaneous survival changes are assumed (Table 9.7-7). However, a 10-year delay in achieving current and RPA hydrosystem survival improvements would mean that additional survival improvements would be necessary under both high and low estimates of the necessary change. The low estimate would change from 0% additional change with no delay to a 16% additional change with a 10-year delay. The corresponding high estimates are 44% and 69% for immediate implementation and the 10-year delay, respectively.

The 10-year delay in achieving current and RPA hydrosystem survival improvements would result in greater necessary survival improvements for UCR spring chinook than for SR spring/summer chinook or SR fall chinook. The Wenatchee population's low estimate of additional needed survival changes, given immediate implementation (84%; Table 9.7-8 of the

biological opinion), would increase to 165% if there were a 10-year delay. The corresponding high estimates are 178% and 268% for immediate implementation and the 10-year delay, respectively.

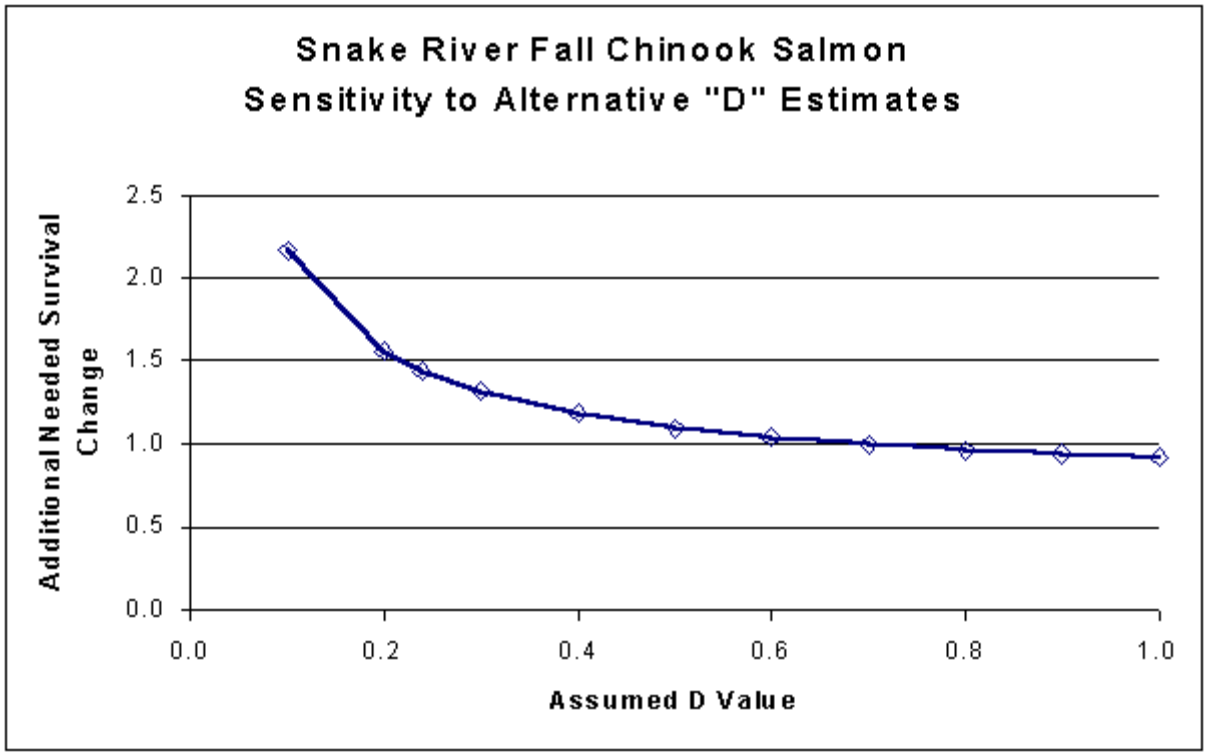
NMFS considered these sensitivity analyses qualitatively when drawing conclusions in the biological opinion.

A.8 SENSITIVITY ANALYSIS TO ALTERNATIVE SR FALL CHINOOK D ESTIMATES

NMFS did not estimate differential post-Bonneville survival (D) of SR fall chinook salmon. PATH generated several alternative estimates ranging from 0.05 to 1.00 and NMFS applied PATH's estimate of 0.24 in these analyses (Section A.5.2). NMFS investigated the sensitivity of fall chinook results to alternative estimates of D for one of the two alternative methods of estimating base-to-current juvenile passage survival changes (Method 1 of Section A.5.2.1, Tables A-10 and A-11), NMFS applied a range of D estimates (0.1 through 1.0, in 0.1 increments). This involved changing the D estimate in the PATH retrospective analysis, the PATH A2 analysis, the SIMPAS current analysis, and the SIMPAS RPA analysis.

Results are summarized in Figure A-2. Using this method, more fish are estimated to be transported under the proposed action and RPA than were transported during the base period. As D increases, RPA survival improves at a faster rate than base period survival improves. The result is that, if D is higher than 0.24, a smaller survival improvement is needed after implementation of the hydrosystem action in the RPA. No additional survival improvement is needed if D is about 0.7 or higher. However, if D is lower than 0.24, considerably higher survival improvements are needed than those estimated in the biological opinion (Table 9.7-7).

Figure A-2. Sensitivity of SR fall chinook salmon results to alternative assumptions regarding differential post-Bonneville survival of transported fish compared with nontransported fish (D). The D estimate used in the biological opinion was 0.24.



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Annex 1

Estimation of Hydrosystem Survival Under Natural Conditions

This annex discusses the methods used by NMFS to estimate survival rates that might occur in the free-flowing reach of the Snake River following dam breaching. The information is used in the body of Appendix A and in the biological opinion to compare the RPA and dam breaching with respect to achieving survival and recovery indicator criteria. Estimates are also generated for the entire reach encompassed by the mainstem FCRPS to compare an approximation of the mortality that might occur under natural conditions with the incidental take estimated for FCRPS operations. This comparison is noted in the incidental take statement.

A1.1 Estimates of Juvenile Passage Survival

NMFS used a two-step method to estimate juvenile survival under free-flowing conditions. First, it determined the average survival rate (expressed as a function of distance) of the species of interest through a river reach that is similar to that expected in the lower Snake and lower Columbia rivers in the absence of the FCRPS. NMFS then expanded these rate estimates to represent the distance each ESU must traverse through the reach proposed for breaching and through the entire FCRPS.

The best available estimates for survival of yearling chinook salmon and steelhead through free-flowing river reaches came from wild PIT-tagged smolts captured and released at the Whitebird trap on the Salmon River and subsequently detected at Lower Granite Dam between 1993 and 1998 (Smith et al. 1998; Hockersmith et al. 1999; Smith et al. 2000a,b; Tables A1-1 and A1-2; and "Natural" worksheets in Draft Biological Opinion spreadsheets). These cumulative survival estimates included passage through the impounded Lower Granite Reservoir and Lower Granite Dam. NMFS estimated survival through Lower Granite Dam and the reservoir from direct estimates made from 1993 through 1995 (chinook), 1994 through 1996 (steelhead), and extrapolations for other years from Williams et al. (in review). NMFS divided the cumulative survival from Whitebird trap to Lower Granite Dam by the estimate of Lower Granite Reservoir and dam survival for each year to obtain an estimate of cumulative survival through the free-flowing reach (Tables A1-1 and A1-2).

The distance between the Whitebird trap and the head of Lower Granite pool is 181 km. Therefore, survival per-km through the free-flowing reach was the 181st root of the cumulative survival rate. For wild yearling chinook, this resulted in a mean estimated free-flowing reach survival rate of 0.99961/km. The corresponding mean survival rate for steelhead was 0.99966/km.

Similar estimates were also available for survival from traps upstream of Whitebird on the Salmon River and from the Imnaha River trap. Estimates of survival per km from these traps

Table A1-1. Summary of NMFS yearling chinook salmon free-flowing reach survival estimates.

	Surv Trap-Lower Granite Dam (LGR)		Surv[a]	Surv Trap-Head Res[b]		Surv per km[b]	
	Imnaha	Salmon	LGR Res	Imnaha	Salmon	Imnaha	Salmon
1993	0.81	0.83	0.90	0.90	0.93	0.99887	0.99960
1994	0.76	0.79	0.92	0.83	0.86	0.99791	0.99919
1995	0.91	0.86	0.92	0.99	0.94	0.99984	0.99963
1996	0.81	0.82	0.90	0.91	0.92	0.99889	0.99951
1997	0.90	NA[c]	0.90	1.00	NA[c]	0.99995	NA[c]
1998	0.85	0.93	0.94	0.91	0.99	0.99897	0.99993
1999	0.88	0.91	0.94	0.94	0.97	0.99926	0.99982
Trap Mean	0.85	0.86		0.92	0.93	0.99910	**0.99961**
Std. Dev.	0.05	0.05		0.06	0.04	0.00069	0.00026

a. Williams et al. (In review).

b. Head of reservoir assumed at Snake River trap; see below for distances.

c. No wild chinook salmon tagged.

Notes: Material used in this table was taken from S. Smith (NMFS) June 12, 2000, trap.xls spreadsheet. "Salmon" refers to releases from Whitebird trap on the Salmon River; "Imnaha" refers to releases from the Imnaha River trap. Bold survival rate was used in all July 27, 2000, Draft Biological Opinion analyses.

	PTAGIS Rkm	km to LGR
Salmon Trap	522.303.103	181
Imnaha Trap	522.308.007	90
Snake Trap	522.23	
Lower Granite	522.17	

Table A1-2. Summary of NMFS yearling steelhead free-flowing reach survival estimates.

	Surv Trap-LGR		Surv[a]	Surv Trap-Head Res[b]		Surv per km[b]	
	Imnaha	Salmon	LGR Res	Imnaha	Salmon	Imnaha	Salmon
1993	0.76	0.83	0.91	0.83	0.91	0.99797	0.99948
1994	0.66	0.77	0.90	0.73	0.85	0.99645	0.99913
1995	0.84	0.89	0.91	0.92	0.98	0.99905	0.99988
1996	0.87	0.96	0.94	0.92	1.01	0.99905	1.00008
1997	0.90	NA[c]	0.92	0.97	NA[c]	0.99971	NA[c]
1998	0.86	0.89	0.90	0.96	0.99	0.99952	0.99997
1999	0.88	0.82	0.91	0.97	0.90	0.99963	0.99939
Trap Mean	0.82	0.86		0.90	0.94	0.99877	**0.99966**
Std. Dev.	0.09	0.07		0.09	0.06	0.00118	0.00037

a. Williams et al. (In review).

b. Head of reservoir assumed at Snake River trap; see below for distances.

c. No wild chinook salmon tagged.

Note: Material used in this table was taken from S. Smith (NMFS) June 12, 2000, trap.xls spreadsheet. "Salmon" refers to releases from Whitebird trap on the Salmon River; "Imnaha" refers to releases from the Imnaha River trap. Bold survival rate was used in all July 27, 2000, Draft Biological Opinion analyses.

	PTAGIS Rkm	km to LGR
Salmon Trap	522.303.103	181
Imnaha Trap	522.308.007	90
Snake Trap	522.225	
Lower Granite	522.171	

were consistently lower than estimates for fish released from the Whitebird trap (Tables A1-1 and A1-2; Paulsen 2000). NMFS did not incorporate the Imnaha trap or other Salmon River traps into the estimates of natural survival. Traps in the Salmon River above Whitebird and the Imnaha trap releases were not used in natural survival estimates for the following reasons:

- The other Salmon River trap estimates were already captured in the Whitebird to Lower Granite estimate, because it included fish from all of the tributaries caught at the upstream traps.

- The Whitebird estimate is through a river reach that is more similar to the reach below Lower Granite Dam (in terms of river width, depth, and flow characteristics) than are the reaches farther up in the tributaries. The Imnaha trap is in a tributary habitat that is also less similar to the reach below Lower Granite Dam than is the Whitebird trap.

- The upstream traps are closer to spawning areas, so survival rates from those traps probably represent a culling process that would be greater than that included in the survival rate below Whitebird. Culling can result from size, degree of smoltification, or river stretches through which the smolts migrated. The river reach from Whitebird to Lower Granite is more similar to the free-flowing lower Snake and lower Columbia than is the reach from Salmon River tributaries to Lower Granite. Imnaha trap estimates were not used because the trap is closer to the spawning grounds than is the Whitebird trap.

To test the hypothesis that survival is lower in reaches closer to spawning grounds than in reaches farther downstream, survival of Whitebird and Imnaha releases was compared in the reach between each trap and Lower Granite Dam and in two reaches below Lower Granite Dam (Tables A1-3 and A1-4). Survival between the Imnaha trap and Lower Granite Dam, expressed as a per-km rate, was much lower than that between the Whitebird trap and Lower Granite Dam (Tables A1-1 and A1-2), whereas survival estimates for the two traps were nearly identical when compared between Lower Granite Dam and Little Goose Dam and between Little Goose Dam and Lower Monumental Dam. This suggests that, after initial losses of fish occur, there are no inherent differences in smolt survival between stocks released at Imnaha and Whitebird. Thus, the Whitebird trap provides the best estimates of expected survival in downstream stretches of natural river.

Table A1-5 shows how the yearling chinook and yearling steelhead survival rates were expanded to approximate the natural survival rates of each chinook and steelhead ESU. NMFS first determined the maximum distance that any population within an ESU travels through the hydrosystem or through the reach affected by Snake River dam breaching. The cumulative natural survival rate for an ESU was then the mean survival rate per km, raised to the power of the number of km traveled through the hydrosystem. For example, UCR spring chinook pass through 287 km of the FCRPS and are assumed to have the same natural survival rate as SR spring/summer chinook. Their expected natural survival through the FCRPS reach is 89.5% ($0.999614283^{286.9}$).

Table A1-3. Survival estimates for Whitebird trap (Salmon R.) spring/summer chinook releases and Imnaha trap spring/summer chinook releases.

	Surv LGR-LGO		Surv LGO-LMN		Surv LGR-LMN	
	Imnaha	Salmon	Imnaha	Salmon	Imnaha	Salmon
1993	0.78	0.87	NA	NA	NA	NA
1994	0.86	0.75	0.82	0.89	0.71	0.67
1995	0.92	0.91	0.97	1.00	0.90	0.91
1996	0.91	0.91	0.86	1.00	0.78	0.90
1997	0.99	NA	0.95	NA	NA	NA
1998	1.02	1.02	0.85	0.81	0.87	0.83
1999	0.98	0.95	0.91	0.93	0.89	0.88
Trap Mean	0.92	0.90	0.89	0.92	0.828	0.837
Std. Dev.	0.09	0.09	0.06	0.08	0.08	0.10

Note: These releases move through river reaches below Lower Granite Dam. Estimates from NMFS PIT-tag studies are described in text. From spreadsheet "trap.xls" prepared by S. Smith (NMFS).

Table A1-4. Survival estimates for Whitebird trap (Salmon R.) steelhead releases and Imnaha trap steelhead releases.

	Surv LGR-LGO		Surv LGO-LMN		Surv LGR-LMN	
	Imnaha	Salmon	Imnaha	Salmon	Imnaha	Salmon
1993	1.02	0.76	NA	NA	NA	NA
1994	0.82	0.81	0.74	0.73	0.60	0.59
1995	0.88	0.96	1.09	0.94	0.96	0.90
1996	0.87	0.87	1.00	1.25	0.87	1.09
1997	1.02	NA	0.83	NA	NA	NA
1998	1.00	0.87	0.82	0.77	0.82	0.67
1999	0.99	1.14	0.88	0.82	0.86	0.93
Trap Mean	0.94	0.90	0.89	0.90	0.823	0.835
Std. Dev.	0.08	0.13	0.13	0.21	0.13	0.20

Note: These releases move through river reaches below Lower Granite Dam. Estimates from NMFS PIT-tag studies are described in text. From spreadsheet "trap.xls" prepared by S. Smith (NMFS).

Table A1-5. Summary of mean per-km juvenile survival rates through free-flowing river reaches and expansions to the reach associated with Snake River dam breaching and with the entire FCRPS.

ESU	Mean Per-Km Survival	Entire FCRPS # Km	Mean Survival	Snake River Breach	Breach Mean Survival
Snake Sp/Sum CH	0.999614283	512	0.821	210	0.922
Snake SH	0.999656110	512	0.838	210	0.930
Snake Fall CH (Method A)	0.997800000	512	0.324	210	0.630
Snake Fall CH (Method B)	0.999500000	512	0.774	210	0.900
UCR Spring CH	0.999614283	287	0.895		
UCR SH	0.999656110	287	0.906		
MCR SH	0.999656110	287	0.906		
LCR CH Yearlings	0.999614283	34.5	0.987		
LCR CH Subs (Method A)	0.997800000	34.5	0.927		
LCR CH Subs (Method B)	0.995000000	34.5	0.841		
LCR SH	0.999656110	24.1	0.992		

Empirical estimates of free-flowing reach survival for juvenile SR fall chinook salmon is more limited and difficult to interpret. The PATH participants used two methods to group and extrapolate recent PIT-tag survival estimates (Peters et al. 1999). The first (designated method A) results in a free-flowing survival rate of 0.9978 per km, and the second (designated method B) in a rate of 0.9995 per km.

Method A was based on the premise that survival from release to Lower Granite for fish released at Pittsburgh Landing encompasses survival through the free-flowing Snake River (the 122 km from release to the head of Lower Granite Reservoir) and a project survival through Lower Granite Reservoir and the dam. After the project survival is divided out of the total survival, the free-flowing survival remains. To estimate Lower Granite project survival, PATH used the mean survival through the two projects below Lower Granite: Little Goose and Lower Monumental.

To obtain the average for all release groups, PATH weighted each survival estimate by the proportion of the total run of wild fish that were sampled in the period that included the release date as its midpoint. In addition, each survival estimate was weighted by the inverse of the relative variance. The relative variance is defined as the variance divided by the estimated survival. This removes some of the bias of lower survivals having lower variance (S. Smith, NMFS, pers. comm. to PATH 1998). For this weighting, the variances were from survival through the entire segment (release to Lower Monumental), since all this information was used in the estimates. Both of these weights were normalized to add to 1.0 so that neither weight would have more influence than the other. Separate estimates of survival through the free-flowing reach were made for each release (19 total) from 1995 to 1998. Each estimate was then

weighted, and the geometric mean of all the estimates was computed. The resulting survival rate estimate was 0.9978 per km.

Peters et al. (1999) state that the method B juvenile survival rate was estimated from NMFS' reported survival rate estimates for PIT tagged fall chinook in 1998, 1997, and 1995 (Muir and Smith 1998, Muir et al. 1998). The value was computed by comparing survival rates from different points of release in the Snake River above the confluence of the Snake and Clearwater Rivers. The ratio of the survival rate estimate for the upstream release site (Pittsburgh Landing – PL) to that of the downstream release site (Billy Creek – BC) was used to derive free-flowing Snake River survival estimates. The ratio was calculated for each release group, then the release group estimates were averaged. The length of the PL-to-BC reach (81 km) was then used to obtain a per-km survival rate, which equaled 0.9995.

NMFS found that both methods were credible and that there was no basis for concluding that one better represented the best available scientific information, NMFS used both methods, therefore, to establish a range of likely natural survival estimates. When expanded to the 512-km reach, method A estimates an average survival of 32.4% versus 77.4% for method B (Table A1-5).

A1.2 Estimates of Adult Passage Survival

NMFS considered three methods for estimating expected survival of adults in the absence of the FCRPS. NMFS concluded that the third method described below was most reasonable, and that method was the only one applied in the Draft Biological Opinion.

A1.2.1 PATH Method

The PATH participants estimated free-flowing survival of wild SR spring/summer chinook salmon as 97% cumulative survival through the Snake River if four dams are breached (equivalent to 99% per project). Although the derivation of this estimate is not explicitly described in Marmorek et al. (1998) or Marmorek and Peters (1998a,b), personal communications indicate that it was obtained by applying the absolute difference in Bjornn's (1989) mean dam-count to redd-count ratios at Ice Harbor Dam for two periods, 1962 through 1968 and 1975 through 1988, to estimates of current adult passage survival through that reach. Ice Harbor was the farthest upstream FCRPS project during the first period. PATH interpreted the 9% difference (3% per project) between the mean ratios for each period as the mortality caused by the three dams that were constructed above Ice Harbor during the latter period (1975 through 1988). Extrapolating Bjornn's (1989) result from three dams to the four dams proposed to be breached, PATH estimated that adult survival would improve 12% if the four lower Snake River dams were breached. PATH estimated the current passage survival at 85%, based on conversion rates in Beamesderfer et al. (1998) and concluded that the survival rate through the four lower Snake River projects would be 97% (85% + 12%) after breaching.

The essential implication of this method is that PATH estimated a 99.24% per-project natural survival rate for adult spring/summer chinook salmon ($0.97^{(1/4)}$). PATH concluded that this same

survival rate applies to SR fall chinook (Peters et al. 1999) without explanation. If NMFS applied this approach to estimates of natural survival through the entire FCRPS, it would conclude that adults of all SR ESUs have a natural survival rate of 94% through eight FCRPS projects, UCR and MCR ESUs have a natural survival rate through up to four FCRPS projects of 97%, and populations of LCR ESUs that spawn above Bonneville Dam have a natural survival rate of 99% through one project.

NMFS has several concerns regarding this approach. The method assumes that survival from the current location of the head of Lower Granite pool to the various spawning areas did not change between the two periods described in Bjornn (1989), and that redd counts represented a constant fraction of total spawners in the Salmon, Grande Ronde, and Imnaha River systems during each period. Neither assumption was discussed or substantiated by PATH, and the assumption's validity is questionable given the variation in more recent estimates, as described below. To apply the 9% change in survival to current survival, one must assume that there has been no change from adult survival during Bjornn's (1989) second period to the present. As described in Appendix C, NMFS believes that adult survival through the FCRPS has been relatively constant since 1980, but it has not drawn the same conclusion for the period beginning in 1975. NMFS also concludes that adult survival is better described by radiotelemetry than by conversion rates. If the 3% per project survival improvement following dam removal was applied to the current SR spring/summer chinook adult survival estimate (0.972; Table 6.1-1 of Draft Biological Opinion), the natural survival rate would be slightly higher than 100%. Finally, a significant drawback of this method is the lack of comparable information for species other than SR spring/summer chinook. PATH assumed that the absolute estimate for spring/summer chinook should be applied to fall chinook (Peters et al. 1999). Given the lower current survival rate of fall chinook (Table 6.1-1 of Draft Biological Opinion), however, equally reasonable alternatives would have been to apply a 3% survival improvement per project to the current fall chinook survival rate or to conclude that the effect of dams on fall chinook cannot be inferred from the effects of dams on spring chinook.

A1.2.2 Direct Estimates of Free-flowing Reach Survival

A second method evaluates the survival of radio-tagged adults through free-flowing reaches above Lower Granite Dam, in a manner similar to that used to estimate juvenile survival. Bjornn et al. (1995) estimated adult loss of spring chinook salmon from Ice Harbor Dam to reference points in tributaries to the Snake River above Lower Granite Dam (Table A1-6). Bjornn et al. (1995) estimated survival from Ice Harbor to Lower Granite (footnotes to Table A1-6), and NMFS adjusted total survival rates to derive estimates of survival through the free-flowing reach above Lower Granite Dam. The resulting survival rate averaged 0.9994 per km, equal to 73.5% survival through the 512-km reach encompassing the entire hydrosystem. This is equivalent to a natural survival rate of 96% per project, for eight projects.

NMFS also has concerns about this second approach, which may underestimate survival of adults through free-flowing river sections. One potential problem is the degree to which radio-tagged adults migrating through free-flowing reaches above Lower Granite Dam represent adults that

would be migrating through a free-flowing reach between Bonneville and Lower Granite. The experience of migrating 512 km past eight dams probably influences the survival upstream of Lower Granite Dam. The method assumes that there is no effect caused by migrating 512 km and no delayed effects due to passing eight dams. The method also assumes that the free-flowing river reaches above Lower Granite are comparable to the reaches between Bonneville and Lower Granite. The end points of the reaches were chosen to avoid inclusion of passage through spawning tributaries that clearly would not represent mainstem passage, but the degree to which the chosen reaches represent conditions below Lower Granite is debatable. One additional concern is that, as with the first method, this approach is not applicable to all species because radiotelemetry estimates are not available.

Table A1-6. Estimates of SR spring/summer chinook survival in free-flowing river sections to spawning stream entrance calculated by radiotelemetry (Bjornn et al. 1995).

Year	Wild/ Hatchery	Survival from Uppermost Dam	Reach	Uppermost Dam Project Survival	Mainly River Survival (1)	KM Mainly River	River Survival/ KM	4-Pool River Survival/ 20 KM	BON-LGR River Survival/ 512 KM	Reference
1991	Run-at-Large Radio-tag	0.54	IHR to Spawning in Upper Salmon River (North Fork)	0.967	0.6187	**685.4**	0.9993	0.8632	0.6987	Bjornn et al. (1995), fish RT at IHR
1992	Run-at-Large Radio-tag	0.63	IHR to Spawning in Upper Salmon River (North Fork)	0.958	0.7482	**685.4**	0.9996	0.9194	0.8148	Bjornn et al. (1995), fish RT at IHR
1993	Run-at-Large Radio-tag	0.77	IHR to Spawning in Upper Salmon River (North Fork)	0.98	0.8370	**685.4**	0.9997	0.9389	0.8576	Bjornn et al. (1995), fish RT at JDA
1991	Run-at-Large Radio-tag	0.54	IHR to Spawning in Middle Fork Salmon River	0.967	0.6187	**624.4**	0.9992	0.8453	0.6638	Bjornn et al. (1995), fish RT at IHR
1992	Run-at-Large Radio-tag	0.63	IHR to Spawning in Middle Fork Salmon River	0.958	0.7482	**624.4**	0.9995	0.9003	0.7741	Bjornn et al. (1995), fish RT at IHR
1993	Run-at-Large Radio-tag	0.77	IHR to Spawning in Middle Fork Salmon River	0.98	0.8370	**624.4**	0.9997	0.9389	0.8576	Bjornn et al. (1995), fish RT at JDA
1991	Run-at-Large Radio-tag	0.54	IHR to Spawning in South Fork Salmon River	0.967	0.6187	**561.4**	0.9991	0.8277	0.6306	Bjornn et al. (1995), fish RT at IHR
1992	Run-at-Large Radio-tag	0.63	IHR to Spawning in South Fork Salmon River	0.958	0.7482	**561.4**	0.9995	0.9003	0.7741	Bjornn et al. (1995), fish RT at IHR
1993	Run-at-Large Radio-tag	0.77	IHR to Spawning in South Fork Salmon River	0.98	0.8370	**561.4**	0.9997	0.9389	0.8576	Bjornn et al. (1995), fish RT at JDA
1991	Run-at-Large Radio-tag	0.54	IHR to Spawning in Imnaha River	0.967	0.6187	**322.4**	0.9985	0.7297	0.4637	Bjornn et al. (1995), fish RT at IHR
1992	Run-at-Large Radio-tag	0.63	IHR to Spawning in Imnaha River	0.958	0.7482	**322.4**	0.9991	0.8277	0.6306	Bjornn et al. (1995), fish RT at IHR
1993	Run-at-Large Radio-tag	0.77	IHR to Spawning in Imnaha River	0.968	0.8370	**322.4**	0.9994	0.8816	0.7354	Bjornn et al. (1995), fish RT at JDA
1991	Run-at-Large Radio-tag	0.54	IHR to Spawning in Grande Ronde River	0.967	0.6187	**277.4**	0.9983	0.6996	0.4185	Bjornn et al. (1995), fish RT at IHR
1992	Run-at-Large Radio-tag	0.63	IHR to Spawning in Grande Ronde River	0.958	0.7482	**277.4**	0.9990	0.8105	0.5991	Bjornn et al. (1995), fish RT at IHR
1993	Run-at-Large Radio-tag	0.77	IHR to Spawning in Grande Ronde River	0.98	0.8370	**277.4**	0.9994	0.8816	0.7354	Bjornn et al. (1995), fish RT at JDA
					Combined Weighted Mean Run-at-Large Estimate		0.9994	0.8816	0.7354	

(1) SURVIVAL FROM UPPERMOST DAM / UPPERMOST DAM PROJECT SURVIVAL = MAINLY RIVER SURVIVAL

Note: This material comes from a spreadsheet and table prepared by C. Pinney (Corps of Engineers) for Federal agency performance standards report.

Bjornn et al. (1995) note: Survival IHR ladder exit to LGR ladder exit = 90% in 1993 and 85% in 1992 (similar to untagged); success of passage IHR tailrace to LGR forebay = 81.3% in 1992 and 87% in 1993; success passage IHR tailrace to upper end LGR pool = 78.7% in 1992 and 75% in 1991; relative distribution of spr/sum chinook into tributaries of SR basin in 1993 = 5% Tuccannon River, 21% Clearwater River, 4% Snake River upstream of Lewiston, 11% Grande Ronde, 8% Imnaha, 51% Salmon rivers (natal tributaries).

A1.2.3 Qualitative Appraisal of Adult Natural Survival Rate

NMFS considers the best estimate of adult SR spring/summer chinook survival following breaching to be intermediate to estimates derived from the two methods described above. The survival rate expected to result from the RPA represents survival through an impounded reach with all possible improvements short of breaching. The estimate of adult survival, when the RPA is fully implemented, is 98% per project. This estimate is intermediate to the survival rate estimated by the first and second methods (96% and 99% per project, respectively).

In addition to the similarity of estimates of survival through impounded and unimpounded reaches, as described above, one of the reasons for concluding that adult survival under the RPA is equal to natural survival is the migration rates through the impounded FCRPS, which are very similar to those through unimpounded reaches. Studies supporting this observation are reviewed in the Basinwide Recovery Strategy (Federal Cascus 2000). Another reason is the description in NMFS (2000) of factors currently causing mortality of adults through the FCRPS and the Draft Biological Opinion's provision to ameliorate these sources of mortality through the RPA. One of the primary factors causing apparent, and to some extent actual, mortality of adults is fallback NMFS (2000) describes studies indicating that this problem is particularly severe for the Bradford Island fish ladder at Bonneville Dam, where fallback rates may be as high as 15%. Structural and operational measures in the RPA are expected to reduce inadvertent fallback and related mortalities (Draft Biological Opinion, Section 9.7.1.2). Another factor described in NMFS (2000) is occasional adult gas bubble disease during conditions of high gas supersaturation. The RPA also calls for a gas abatement program to reduce gas supersaturation. In general, the RPA is expected to reduce the current adult mortality rate, which is already estimated to be relatively low.

One advantage of this method for estimating the survival of SR spring/summer chinook salmon is that it is directly applicable to other ESUs, whereas the other two methods are not. Therefore, estimates of adult survival for all ESUs are as described in Draft Biological Opinion, Table 9.7-2. The expected survival rates are 71% for SR fall chinook salmon, 77.3% for SR steelhead, and 85.7% for SR sockeye salmon.

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APPENDIX B
DEVELOPMENT OF A WATER QUALITY PLAN FOR THE COLUMBIA RIVER MAINSTEM: A FEDERAL AGENCY PROPOSAL

Cover Memorandum for Appendix B

This is a cover memorandum for Appendix B to the Federal Columbia River Power System (FCRPS) Biological Opinion entitled "Development of a Water Quality Plan for the Columbia River Mainstem: A Federal Agency Proposal." The purpose of this memorandum is to describe the relationship of the actions contained in the attached Appendix B to the Reasonable and Prudent Alternative (RPA), Chapter 9 of the FCRPS Biological Opinion.

In developing the biological opinion, the National Marine Fisheries Service (NMFS), in coordination with the Environmental Protection Agency (EPA), U.S. Fish and Wildlife Service (USFWS) and the Federal Action Agencies (U.S. Army Corps of Engineers [Corps]; Bureau of Reclamation [BOR]; and Bonneville Power Administration [BPA]), has considered the respective ecological objectives of the Endangered Species Act (ESA) and the Clean Water Act (CWA). In many instances actions implemented for the conservation of ESA-listed species will also move toward attainment of water quality standards (e.g. reducing total dissolved gas and temperature). The overlap of statutory purpose is extensive, however, there remain additional actions that are appropriate in a water quality plan but which are nonessential for the survival and recovery of the listed species and thus are not required components of the ESA RPA. Further, the water quality plan is likely to require lengthy study and implementation exceeding the duration of this biological opinion.

This appendix charts a course for development of a water quality plan for the mainstem Columbia and Snake rivers to address CWA objectives. The scope of the plan is broader than the FCRPS and would include additional actions to improve mainstem water quality by reducing total dissolved gas and temperature. Some of these actions are expected to be undertaken by entities other than the Federal Action Agencies. Although Appendix B is not itself a water quality plan, it suggests the procedure for development of a plan and identifies actions the plan would likely contain to move toward attainment of water quality standards for the FCRPS.

Appendix B refers to items already called for in the RPA for the FCRPS as a nucleus of actions for the water quality plan. These actions are listed in Table B-2 of the Appendix. These actions are essential for the survival and recovery of the listed species and thus are required components of the RPA.

Appendix B also identifies actions for the FCRPS that further CWA objectives but are not also called for in the ESA RPA. These actions are listed in Table B-3 of the Appendix. These are studies to investigate additional measures to reduced dissolved gas and temperature that may be considered for implementation in the future. These studies are appropriate as ESA conservation measures that will require further ESA consultation when they are developed, analyzed, and proposed for implementation.

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B.1 EXECUTIVE SUMMARY

Fish runs in the Columbia River basin have declined due to a number of factors, including habitat loss across the basin, hatchery production, fish harvest, and hydropower development (Federal Caucus 2000). As a result, 12 stocks of fish in the Columbia River basin that are directly and/or indirectly impacted by the Federal Columbia River Power System (FCRPS) are now listed as threatened or endangered under the Endangered Species Act (ESA). There are also current exceedances of Clean Water Act (CWA) water quality standards (total dissolved gas [TDG] and temperature) that impact fish health and overall beneficial uses in the Columbia River and Snake River mainstem.

The effect of water quality on Federally listed anadromous fish in the basin requires that both issues be addressed in a coordinated manner. Therefore, the Environmental Protection Agency (EPA), the National Marine Fisheries Service (NMFS), the U.S. Fish and Wildlife Service (USFWS), and the Federal Action Agencies (U.S. Army Corps of Engineers [Corps]; Bureau of Reclamation [BOR]; and Bonneville Power Administration [BPA]) are undertaking efforts to conserve listed species under the ESA and create a nexus of water quality improvements consistent with the CWA.

The ESA and the CWA are complementary statutes offering opportunities to conserve listed species and improve overall system water quality. Both laws stress the importance of maintaining ecosystem integrity. Recognizing that system improvements for fish and wildlife can benefit water quality, EPA, NMFS, USFWS, and the Action Agencies intend to integrate their fish and wildlife and water quality efforts in the form of actions to support the objectives and responsibilities of the ESA, CWA, and other fish and wildlife and water quality statutes such as the Northwest Electric Power Planning and Conservation Act.

This appendix describes current activities and planning for improvements in fish survival that can also serve to improve water quality by reducing TDG and temperature. It also describes efforts that EPA, NMFS, USFWS, and the Federal Action Agencies have decided to undertake now and those they believe can benefit the survival and recovery of listed species. Pertinent portions of this appendix are included in the 2000 NMFS Biological Opinion under Sections 9.6.1.7, Water Quality, and 9.6.5, Research, Monitoring, and Evaluation, as part of the discussion of a reasonable and prudent alternative (RPA).

Over the long term, with a focus on water quality, EPA, NMFS, USFWS, and the Federal Action Agencies—the Corps, BPA, and BOR—commit to developing and implementing a water quality plan that supports TDG and temperature water quality improvements to the Columbia River basin, mainly in the portions of the Columbia, Snake, and Clearwater rivers where Federal dams exist. The water quality plan is anticipated to be consistent with the Columbia River and Snake River mainstem total maximum daily load (TMDL) limits that are currently being developed by EPA, the states, and the Tribes. Water quality plan implementation anticipates that EPA, NMFS,

and the Federal Action Agencies will properly integrate implementation of the water quality plan to ongoing TMDL development activities on the mainstem and in the subbasins.

Water quality planning will complement ESA recovery planning efforts by including a development and implementation process consistent with existing planning and review processes, such as the NMFS Regional Forum, scientific peer review, and in some cases, congressional approval.

To successfully implement the water quality plan for the FCRPS, a coalition of Federal, state, Tribal, and other appropriate representatives is necessary to integrate the efforts of all interested stakeholders and provide a connection with ongoing broad-scale coordination efforts in the basin. The water quality plan should include implementation measures to improve water quality. Measures such as ESA and fish and wildlife measures will be coordinated with established processes. These include planning and review processes of the Northwest Power Planning Council (NWPPC), including the Independent Scientific Review Panel, the Columbia Basin Fish and Wildlife Authority, the NMFS Regional Forum, and, if appropriate, the Columbia Basin Forum. Some measures may also require congressional approval. NMFS, EPA, USFWS, and the Federal Action Agencies intend to support implementation of measures that successfully garner approval through these processes. A common approach for selecting water quality, ESA, and fish and wildlife measures to implement will foster coordination among NMFS, EPA, and the Federal Action Agencies, and increase effective use of limited available resources. The outcome of this coordinated approach will be a collection of measures the Action Agencies undertake to serve the agencies' various statutory purposes within budgetary parameters. Recommendations approved via applicable processes could be identified in the water quality plan for implementation.

B.2 WATER QUALITY PLAN

B.2.1 Background

The Federal agencies are committing to development of a water quality plan that is part of the annual planning process (see Section 9.5) for the mainstem Columbia and Snake rivers. At the same time, EPA and the states of Idaho, Oregon, and Washington in coordination with the Columbia River Tribes are embarking on a Columbia River and Snake River mainstem TMDL under court order. EPA will lead development of the portion of the TMDL that addresses the Columbia River mainstem waters from the Canadia border of Lake Roosevelt on the Columbia River, Dworshak Dam on the Clearwater River, and the Brownlee Dam on the Snake River to the Astoria Bridge. The EPA, NMFS, USFWS, and the Federal Action Agencies value consistency of their actions with water quality plans, as well as other plans developed in the Pacific Northwest region. As the Action Agencies make recommendations and decisions, they will take existing water quality plans into account.

The proposed water quality plan anticipates TMDLs consistent with state and Tribal water quality standards and identifies ways that activities can reduce adverse effects on water quality. The Federal Action Agencies intend to participate in the development of the water quality plan to discern further how they can reduce or offset TDG levels and temperature increases associated with their activities. The water quality plan will describe how the listed agencies will participate in this process.

B.2.2 Columbia/Snake River Mainstem System Water Quality Plan

The following outlines how a water quality plan could be developed and implemented. Federal agency representatives developed a water quality plan process to establish a decision process for both operational and structural water quality measures. This process was created to enable decision-making on the biological, cost-effective, and economic implications of water quality measures. Details regarding the process, development, and implementation of a water quality plan may vary, depending on coordination with states, Tribes, and interested persons in the Pacific Northwest.

B.2.3 Project Scope

The water quality plan should consist of a systemwide analysis of the factors that affect temperatures and dissolved gas levels. The analysis will result in development of a suite of recommended actions to improve water quality, using established water quality standards as both the goal and measure of progress for the basin. The Columbia River tributaries and mainstem will be treated as an ecosystem, with the mainstem addressed alongside tributary efforts.

The water quality plan will focus primarily on the physical and operational changes to both Federal and non-Federal dams that may benefit water quality in terms of temperature and

dissolved gas while improving the survival rates of ESA-listed species. Other factors that affect water quality, such as grazing, agriculture, forest practices, point sources, land use, mining, and water withdrawals, are being addressed in other forums, including the states' TMDL processes. Discharges to the mainstem that impact gas and temperature and are not covered in tributary TMDLs may be addressed in this plan.

For the initial phase, the plan will address actions from the international boundary on the Columbia River, Dworshak Dam on the Clearwater River, and Brownlee Dam on the Snake River to the tailrace of Bonneville Dam. Future work may include considerations above the international boundary. While the plan will aim to take into account the role of tributaries in mainstem water quality problems, it will not seek specific remedies in the tributaries. Ongoing CWA TMDL processes and other water quality improvement initiatives are under way in many of the tributaries and should not be delayed in anticipation of the plan.

Mechanisms to implement the water quality plan include the 2000 Biological Opinion for the FCRPS and other agreements as appropriate. For non-Federal dams, CWA, the Federal Energy Regulatory Commission (FERC), and appropriate state and Tribal authorities will be involved in implementation.

It is not the primary goal of the water quality plan to target revision of beneficial uses or standards. The purpose is to identify and test hypotheses, implement reasonable actions to improve water quality, and to consider potential revisions to beneficial uses or standards, based on broader societal, legal, and policy considerations (40 CFR Section 131.10(g)) as appropriate. The goals of the water quality plan are as follows:

- To assist in our understanding of systemwide loading capacity and loading allocation by assessing the existing effects at Federal and non-Federal dams and tributaries.

- To provide an organized, coordinated approach to improving water quality, with the long-term goal of meeting water quality standards that the states and Tribes can integrate into their water quality management programs.

- To provide a framework for identifying, evaluating, and implementing reasonable actions for dam operators to use as they work toward reducing temperature and dissolved gas levels.

- To provide a record of the actions that are and are not feasible for structural and operational improvements aimed at improving water quality conditions and meeting water quality standards. This information may provide a basis for future beneficial use and water quality criteria revisions.

- To bring basinwide information into the decision processes regarding dissolved gas and temperature, and to provide technical assessment of a project's relative value in terms of water quality.

- To integrate dissolved gas and temperature work into one process for both Federal and non-Federal dams on the mainstem Columbia River and Snake River system.

B.2.4 Plan Process

Implementation of the mainstem water quality plan could be accomplished as an additional responsibility of existing teams (and/or other basin forums) or the creation of a new Water Quality Team as discussed in Section B.6.3 of this appendix. The new water quality team would link and attempt to integrate actions by the NMFS Regional Forum and the Columbia River Basin Forum, as appropriate, through input and updates on water quality plan implementation. In implementing the water quality plan, the new water quality team would also link the traditional TMDL development and implementation processes to this new effort to improve water quality on the mainstem Columbia River (see Table B-1). The new team would have specific technical TDG and temperature sub-committees.

B.2.5 Participants

The new Water Quality Team may be composed of key technical staff from Federal agencies (EPA, NMFS, USFWS, Corps, BPA, and BOR), states (Oregon, Washington, and Idaho), Columbia River Tribal governments, and non-Federal entities such as public utility districts (PUDs), municipalities, and Idaho Power Company.

B.2.6 Schedule

The first iteration of the water quality plan (including a detailed workplan and timeline) should be completed by the Action Agencies by March 31, 2001, or as soon thereafter as practical.

Table B-1. Decision-making process to implement the water quality plan.

Water Quality Plan Development Process	Relationship to TMDL Planning Process	Who Leads?	Who Assists (Seek Advice/Kept Informed)?	Item Completion Date
Model development and calibration	Identify applicable water quality criteria/goals	Action Agencies	EPA, state agencies, WQT	To be determined (TBD)
Alt. development	identify source of loadings, including natural background	Action Agencies	WQT/IT, Forum	TBD
Modeling, alt. development, and screening	allocate pollutant loadings	Action Agencies	WQT/IT, Forum, state agencies	TBD
alt. screening, alt. analysis	final development of a water quality implementation plan	Action Agencies, Federal execs, state execs, Tribes/IT, Forum	WQT/IT, Forum, Federal execs, state execs, Tribes/IT, Forum	TBD
Decisions/actions	implement the plan	Action Agencies	EPA, state agencies	TBD
Decisions/actions	monitoring and evaluate plan effectiveness	Action Agencies	WQT/IT, Forum	TBD

Note: WQT = Water Quality Team; IT = Implementation Team.

B.3 TOTAL DISSOLVED GAS

B.3.1 Dissolved Gas Goal

The long-term (10 to 15 years) dissolved gas goal is to reach the state and Tribal TDG standard, which is currently 110% for river discharges up to the 7-day, 10-year flow in all critical habitat in the Columbia River and Snake River basins while taking actions to recover listed species in the basin. For anadromous fish, achieving the goal would mean fish passage survival levels consistent with the performance standards for the mainstem projects.

This goal is intended to guide operating and capital improvement decisions relating to TDG created during periods of spill. A systemwide approach is needed to address gas generated at mainstem projects where fish are present, and at upstream facilities (i.e., outside the current range of listed salmon) in both the U.S. and Canada, the five Public Utility District dams on the Columbia River between the Snake River and Chief Joseph Dam, and the Hells Canyon Complex on the Snake River. There are some exceptions noted in the ability to meet the state and Tribal TDG standard.

Without physical modifications to the dams beyond those that are presently under way, the long-term TDG goal cannot be attained between April and August at and between the eight mainstem FCRPS dams. This is a result of the need to rely on spill to safely pass juvenile salmon around those dams. A similar issue exists with Dworshak Dam, where in some circumstances spill is necessary to contribute to the attainment of spring and summer flow objectives for salmon migration and water temperature standards in the Clearwater and lower Snake rivers. Therefore, in the near term, it will be necessary to conduct spill operations that cause exceedances of the 110% TDG gas standard. The Corps will take the actions necessary to implement the spill operation called for in this biological opinion, including spill in accordance with the special TDG conditions set forth below. NMFS will provide technical assistance, as necessary, to support the Corps' actions.

To ensure progress toward the long-term goal, the Corps, BOR, and BPA will also work with NMFS, USFWS, EPA, the Columbia River Tribes, and the states of Washington, Oregon, Idaho, and Montana. This work will take place through an adaptive management process as a part of the water quality plan to accomplish the following:

- Make operational and capital investment decisions at the Federal projects to reduce levels of gas generated by spill and to reduce the reliance on spill as a primary means of juvenile fish passage.

- Fund, implement, and report on adequate physical and biological TDG monitoring to assess compliance with state and Tribal water quality standards and other special conditions that may apply.

- Fund and implement modeling to better assess and act on TDG water quality issues.

The feasibility of meeting the long-term goal will be revisited annually during the water quality improvement planning process.

B.3.2 Special TDG Conditions for Juvenile Fish Passage

At the eight Columbia River and Snake River mainstem projects, spill will be reduced as necessary when the average TDG concentration of the 12 highest hourly measurements per calendar day exceeds 115% of saturation at the next downstream forebay monitor of any Snake River or lower Columbia River dam or at the Camas/Washougal station below Bonneville Dam. Voluntary spill will also be reduced when the 12-hour average TDG levels exceed 120% of saturation at the tailrace monitor at any Snake River or lower Columbia River dams or Dworshak Dam. Spill will also be reduced when instantaneous TDG levels exceed 125% of saturation for any two hours during the 12 highest hourly measurements per calendar day at any Snake River, Clearwater River, or lower Columbia River monitor.

B.4 UPDATE ON SPILL AND 1995 RISK MANAGEMENT

B.4.1 Background

In 1995, the fishery agencies and the lower Columbia Tribes released a paper called Spill and 1995 Risk Management, which presented the benefits of spill for juvenile fish passage, the risks associated with spill-generated gas, and the survival rates of juveniles passing through other routes.

Since 1995, few dissolved gas research projects have continued within the Columbia River Basin. In addition, extensive physical and biological monitoring has been implemented to track the effects of the spill program. An update of the risk assessment for the spill program described in the 2000 FCRPS Biological Opinion is included as Appendix E. The intent of the risk assessment update is to review the research results, and the results of 5 years of monitoring. The update is intended to provide a basis for evaluating the options being considered in the 2000 FCRPS Biological Opinion.

B.4.2 Summary of Appendix E—Risk Assessment for the NMFS Spill Program[1]

Gas bubble trauma (GBT) research efforts have been reduced, reflecting the opinion of decision-makers that sufficient biological knowledge exists to manage the spill program. The main thrusts of research have addressed gas bubble signs and depth compensation for supersaturated conditions.

Work on GBT has characterized its signs, incidence, severity, progression, and relevance. It has been shown that gas bubble signs correlate to exposure, are progressive, and may be useful in understanding their biological implications. Interpretation of signs must be pursued cautiously, however, due to variations in persistence, inconsistencies involving exposure length and water depth, and extreme variability in gas bubble signs.

Depth compensation research has not been extensive in the U.S. portion of the Columbia River, and the results are incomplete and preliminary. However, it does appear that juveniles may get some protection by migrating at depths ranging from approximately 1.5 to 2.5 meters. Results from adult salmonid studies indicate these fish may be negotiating the Columbia River and Snake River migration corridors at depths compensatory to a surface dissolved gas level of 130%. If one accepts these results as representative, it could mean that the biological opinion targets of 115% to 120% dissolved gas pose little problem to migrants.

[1]The following is a summary of Appendix E spill risk assessment. The reader is referred to Appendix E for additional details and references.

Five years of physical dissolved gas and biological monitoring have accompanied implementation of the spill program. Juvenile and adult salmonids, resident fish species, and aquatic insects have been monitored for the incidence and severity of GBT.

Results of physical monitoring have recorded dissolved gas supersaturation levels in forebays and tailraces of each FCRPS project, as well as the impacts of voluntary and involuntary spill. The physical monitoring program has provided a spill and dissolved gas management tool for compliance with state water quality standards waivers.

NMFS concludes in Appendix E that the risk associated with a managed spill program to the 120% TDG level is warranted by the projected 4% to 6% relative increase in system survival of juvenile salmonids. Recent research and biological monitoring results support the findings of the 1995 report which predicted that TDG in the 120% to 125% range, coupled with vertical distribution fish passage information that indicates most fish migrate at depths providing some gas compensation, would not cause juvenile or adult salmon mortalities that would exceed the expected benefits of spillway passage. We find little evidence that this expected survival improvement would be reduced due to GBT-related mortality. The NMFS also concludes that physical and biological monitoring of GBT signs can continue to be used to reflect dissolved gas exposure in adult and juvenile salmon migrants.

B.5 TEMPERATURE

B.5.1 Water Temperature Goal

The long-term goal for water temperature is standard attainment in all critical habitat in the Columbia River and Snake River basins.

In the mainstem Columbia and Snake rivers, attainment of the temperature standard is very complex, due to a number of interrelated factors that affect water temperatures at certain times of the year and to the limited ability to alter water temperature in the mainstem. In the tributaries, attainment of the temperature standard is also complex, due to many of these same factors and the long time needed to realize the temperature benefits of remedial actions (such as riparian restoration). Therefore, in the near term, working with the state and/or Tribe with relevant regulatory authority, the interim goal is to take actions to move toward attaining the standard. Actions to be taken where TMDLs are not yet in place will be consistent with the annual collaborative process described in the following paragraph. The establishment of TMDLs is expected to significantly assist in making progress toward attainment of the temperature standards.

To ensure progress toward the long-term goal, the Corps, BOR, and BPA will also work with NMFS, USFWS, EPA, the Columbia River Tribes, and the states of Washington, Oregon, Idaho, and Montana through an adaptive management process as a part of the water quality plan to achieve the following:

- Make operational and capital investment decisions at the FCRPS projects to move toward attainment of thermal water quality standards.

- Seek consensus on offsite mitigation measures that would contribute to attainment of water temperature standards.

- Fund, implement, and report on adequate physical and biological temperature monitoring to assess compliance with state and Tribal water quality standards and other special conditions that may apply.

- Cooperate with others to fund implementation and modeling to better assess and act on thermal water quality problems and opportunities.

- Develop emergency measures that may be needed to address immediate and acute water temperature problems affecting listed salmon.

The feasibility of meeting the long-term goal will be revisited annually during the water quality improvement planning process.

B.5.2 Water Quality Standards for Columbia River Temperatures

B.5.2.1 Washington Standards: WAC173-201A-130

Washington has a class-based system for determining appropriate levels of protection. The Columbia River, from its mouth to the Grand Coulee Dam, is designated Class A. It is designated Class AA (the highest class) from the Grand Coulee Dam to the Canadian border.

For that portion of the Columbia River from its mouth to the Washington-Oregon border divergence (river mile [RM] 309.3), special conditions are that temperature shall not exceed 68°F (20°C) due to human activities. When natural conditions exceed 68°F (20°C), no temperature increases will be allowed that raise the receiving water temperature by greater than 32.5°F (0.3°C) due to any single source or 33.9°F (1.1°C) due to all such activities combined.

For that portion of the Columbia River from its divergence from the Washington-Oregon border (RM 309) to Priest Rapids Dam (RM 397), special conditions are that temperatures shall not exceed 68°F (20°C) due to human activities. When natural conditions exceed 68°F (20°C), no temperature increases will be allowed that raise the receiving water temperature by greater than 32.5°F (0.3°C). Nor shall such temperature increases at any time exceed $t = 34 (T + 9)$. There is a special fish passage exemption as described in WAC173-201A-060(4)(b).

The Columbia River from Grand Coulee Dam (RM 596.6) to the Canadian border (RM 745) is Class AA. Temperature criteria for Class AA waters are that temperatures shall not exceed 61°F (16°C), due to human activities. When natural conditions exceed 61°F (16°C), no temperature increases will be allowed that raise the receiving water temperature by greater than 32.5°F (0.3°C).

B.5.2.2 Oregon Standards: ORS 340-041- Basin (b)(A)(ii)

Oregon has a use-based system for designating waters for protection. The Columbia River has been designated for salmonid rearing from the mouth to the Deschutes River basin. The stretches in the John Day and Umatilla basins are designated for salmonid rearing and spawning. However, the Columbia River has its own temperature criteria. Therefore, the spawning and rearing criteria do not apply to the Columbia River, even though it may be designated for rearing and/or spawning. The Snake River is designated for salmonid spawning and rearing, and the respective criteria do apply.

No measurable surface water temperature increase resulting from human activities is allowed in the Columbia River or its associated sloughs and channels from the mouth to RM 309 when the surface water temperature exceeds 68°F (20°C). For those basins that contain portions of the Snake River (Grande Ronde, Powder, Malheur, Owyhee), the temperature criteria are 64°F (18°C) for rearing times, 55°F (13°C) for spawning times.

B.5.2.3 Idaho Standards

There are two use designations that apply to the Snake River, cold water biota and salmonid spawning. Cold water biota standards are 71.6°F (22°C) instantaneously and 66.2°F (19°C) maximum daily average. Salmonid spawning standards are 55.4°F (13°C) instantaneously and 48.2°F (9°C) maximum daily average.

B.5.2.4 Colville Tribe Standards

The use designations and corresponding temperature criteria are as follows:

Class I (Extraordinary)—Fish and shellfish: Salmonid migration, rearing, spawning, and harvesting: Temperature shall not exceed 61°F (16°C) due to human activities. Temperature increases shall not, at any time, exceed $t = 23/(T + 5)$. When natural conditions exceed 61°F (16°C), no temperature increase will be allowed that will raise the receiving water by greater than 32.5°F (0.3°C). For purposes hereof, "t" represents the permissive temperature change across the dilution zone; and "T" represents the highest existing temperature in this water classification outside of any dilution zone. Temperature increase resulting from nonpoint source activities shall not exceed 37°F (2.8°C) and the maximum water temperature shall not exceed 50.5°F (10.3°C).

Class II (Excellent)—Fish and shellfish: Salmonid migration, rearing, spawning, and harvesting: Temperature shall not exceed 64°F (18°C) due to human activities. Temperature increases shall not, at any time, exceed $t = 28/(T + 7)$. For purposes hereof, "t" represents the permissive temperature change across the dilution zone; and "T" represents the highest existing temperature in this water classification outside of any dilution zone. Temperature increase resulting from nonpoint source activities shall not exceed 37°F (2.8°C) and the maximum water temperature shall not exceed 65°(18.3°C).

Class III (Good)—Fish and shellfish: Salmonid migration, rearing, spawning, and harvesting: Temperature shall not exceed 70°F (21°C) due to human activities. Temperature increases shall not, at any time, exceed $t = 34/(T + 9)$. For purposes hereof, "t" represents the permissive temperature change across the dilution zone; and "T" represents the highest existing temperature in this water classification outside of any dilution zone. Temperature increase resulting from nonpoint source activities shall not exceed 37°F (2.8°C) and the maximum water temperature shall not exceed 70.3°F (21.3°C).

Class IV (Fair)—Salmonid migration. Temperature shall not exceed 72°F (22°C) due to human activities; T increases shall not exceed $t = 20/(t + 2)$.

B.5.3 Reservoir Operations

Reservoir existence and operation can have strong effects on water temperatures in the reservoir and in downstream reaches. Water temperature conditions have a complex array of effects on salmonids. Intergravel water temperatures affect the rate of embryonic development, with about 50°F degree-days needed for emergence (Weatherley and Gill 1995). Post-emergence growth rates are directly related to water temperature. Water temperatures experienced by outmigrating juvenile salmon have been shown to affect survival (Connor et al. 1998, Muir et al. 1999). Water temperature also indirectly affects salmon survival. Foraging rates of piscivorous fish are directly related to temperature (Vigg and Burley 1991), and the rates of infertility and mortality of several diseases are known to be directly related to temperature (NMFS 1998).

The presence of hydroelectric dams has modified natural temperature regimes in the mainstem Columbia River. Snake River basin reservoirs are known to affect water temperatures in the river (Yearsley 1999) by extending water residence times and by altering the heat exchange characteristics of affected river reaches. Seasonal temperature fluctuations generally decrease below larger reservoirs that are thermally stratified and have hypolimnetic discharges. Downstream temperatures are cooler in the summer as cold hypolimnetic waters are discharged, but warmer in the fall as energy stored in the epilimnion during the summer is released (Spence et al. 1996). Thermal storage provided by the Snake River reservoirs reduces seasonal variations in stream temperatures in much the same way as it reduces seasonal variations in streamflow. There is a documented upward trend in spring water temperature that is consistent with the introduction of storage in upstream reservoirs (NRC 1996). Thus, operation of storage reservoirs affects both the thermal characteristics of the river and the thermally regulated aspects of salmon survival. For this reason, the thermal effects of reservoir operation are an important consideration in developing system operations aimed at protecting and restoring listed salmonids.

An emerging issue is potential water temperature effects on juvenile outmigration timing (NMFS 2000). The hypothesis is that Snake River juvenile fall chinook outmigration timing is delayed by cooler-than-historical water temperatures during incubation and early rearing life stages. This effect may be exacerbated by delayed spawning due to excessively warm fall temperatures. Because Snake River water temperatures and juvenile salmon mortality rates increase from mid-July through mid-September, delaying outmigration timing reduces juvenile fall chinook survival. Migrating adults can be delayed by excessively warm water temperatures (Karr et al. 1998). In addition, fall chinook spawning is inhibited by temperatures above 61°F (16°C) (McCullough 1999). Delay can reduce not only the adult fishes' ability to survive to spawning but also their vigor and fecundity during spawning.

B.5.4 Summer Operations at Dworshak, Brownlee, and McNary Dams

The EPA, NMFS, USFWS, and the Federal Action Agencies intend to abate or offset temperature impacts associated with FCRPS operations. To assess the feasibility of reducing temperatures in ways beneficial to fish, EPA, NMFS, USFWS, and the Federal Action Agencies

intend to engage in the following modifications to the summer operations of a number of mainstem dams.

B.5.4.1 Dworshak Dam

During the summer and early fall, cool water releases from Dworshak Dam on the North Fork Clearwater River can offset water temperature problems in the lower Snake and lower Columbia rivers. Given the significance of these cool water releases on the Columbia River and Snake River mainstem and the severe limitations of substantive measures to alleviate high water temperatures in the Columbia River and Snake River mainstem, decisions regarding Dworshak releases may be the most critical in the near-term attempt to moderate water temperature problems for migrating juvenile and adult salmon in the lower Snake River. Therefore, the Federal Action Agencies must commit to a scientifically sound approach to ensure the best use of these Dworshak releases into the Columbia River and Snake River mainstem. These decisions will need to be made in the context of existing regional forums and in concert with the Nez Perce Tribe and the State of Idaho.

B.5.4.2 Brownlee Dam

Cool water releases at Brownlee Dam on the Snake River may provide relief for water temperature problems in the lower Snake River. Commitment on these releases will be developed through the ongoing Section 7 consultation process and through the FERC relicensing process for Idaho Power Company's Hells Canyon Hydroelectric Complex.

B.5.4.3 McNary Dam

Because of the configuration of the Snake and Columbia rivers and the location of McNary Dam, high water temperatures in the juvenile fish facilities have caused fish kills over the years. The Action Agencies should investigate operating measures that can be implemented at McNary Dam when water temperatures and fish conditions reach certain thresholds. These operating measures will serve to help improve juvenile fish survival at McNary Dam and through the system to below Bonneville Dam.

B.5.5 Long-term Temperature Modeling

To assess the system's ability to respond to proposed structural and system operational changes to temperature, numerical modeling of the system will be necessary. Three existing models that have potential for use are described below:

- The EPA Region 10 one-dimensional model
- The COLTEMP model of the Corps Reservoir Control Center

- The dissolved gas abatement study (DGAS) Mass 1 and Mass 2 models

It is the intention of the Federal Action Agencies that the modeling work be coordinated. The Federal Action Agencies shall assess each of the listed models, identifying strengths, weaknesses, data, and resolution requirements for achieving the desired goals. The Action Agencies, through the annual water quality planning process, shall recommend the appropriate model(s) for conducting the analysis.

B.5.5.1 EPA Region 10 One-dimensional Model

The EPA one-dimensional thermal energy model characterizes the relative contribution of reservoirs and tributary flows to changes in water temperatures of the Snake and Columbia rivers. The scope of the modelling effort includes the Columbia River from Grand Coulee to Bonneville dams and the Snake River from the confluence of the Grande Ronde River to its confluence with the Columbia River. The model is a one-dimensional mathematical model of the thermal energy budget that simulates daily average water temperature under conditions of gradually varied flow. The model is based on the energy budget method and uses an efficient numerical solution technique that simplifies the characterization of model uncertainty. Models of this type have been used to assess water temperature in the Columbia River system for a number of important environmental analyses. In 1969, the Federal Water Pollution Control Administration (Yearsley 1999) developed and applied a one-dimensional thermal energy budget model to the Columbia River as part of the Columbia River Thermal Effects Study. BPA et al. (1995) used HEC-5Q, a one-dimensional water quality model, to provide the temperature assessment for the System Operation Review, and Normandeau Associates used a one-dimensional model to assess water quality conditions in the lower Snake River for the Corps (1999).

B.5.5.2 COLTEMP Model

The COLTEMP numerical model is a one-dimensional water temperature model that provides conceptual information about water temperature conditions in Columbia River reservoirs. COLTEMP is not an operational model for regulatory real-time reservoir use. Rather, it is a water management tool used to evaluate how reservoir regulation changes could impact the water temperature structure of reservoirs. The potential changes in the water temperature structure of the reservoirs are taken into consideration during water-release scheduling. The COLTEMP model outputs, however, do not forecast water temperatures.

COLTEMP is a simplified version of the Corps' HEC5-Q water quality model. The model uses the concept of mass balance to move water downstream. The fundamental transport mechanisms are advection (the horizontal movement of a mass of water) and diffusion (movement from a region of higher concentration to a region of lower concentration). External sources determining water temperature include point sources and water withdrawals. Point sources include headwater flow, tributary stream flow, and water withdrawals. The major non-point source is solar

radiation. Point sources are represented by daily flow rates multiplied by the corresponding water temperatures. Withdrawals remove mass at the rate of the outflow multiplied by the computed ambient water temperature. As a one-dimensional model, COLTEMP does not consider any degree of thermal stratification within the reservoir. Accuracy of the water temperature output depends on the accuracy of water temperature, weather, and river flow data. In the 1994 interagency Columbia River System Operation Review, the model showed that it adequately represented the one-dimensional thermal dynamics of reservoirs during summer seasons in the Columbia reservoirs.

B.5.5.3 Future Two-dimensional Model

Because reservoir stratification can have effects on salmon survival that cannot be well defined by single-depth monitoring data and one-dimensional models, the Action Agencies, with NMFS and EPA participation, should also develop a two-dimensional model of Columbia River and lower Snake River mainstem water temperature characteristics. Two-dimensional models can provide lateral mixing and temperature information, but they are normally depth averaged and may not be useful for analyzing stratification. In areas suspected or known to have strong stratification, localized three-dimensional modeling may be necessary. To be useful, this model should be capable of estimating bulk average temperatures and providing estimated temperatures on a relatively small two-dimensional scale. This model should also connect the biological aspects of fish presence and specific temperature tolerances to the specific locations of water temperatures to yield a better understanding of water temperature impacts and possible solutions. This model should be fully integrated with the selected one-dimensional input model.

The distribution of flow (velocities) is another important component to understanding and modeling reservoir temperature characteristics. A density current could develop along the bottom of the reservoir, conveying the coldest water through the reservoir with little effect on near-surface water temperature conditions. Further development of the DGAS two-dimensional model (MASS-2) may be appropriate for use in this application and should be further investigated.

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B.6 STRUCTURAL, OPERATIONAL, AND PROCEDURAL MEASURES TO ADDRESS TDG AND TEMPERATURE ISSUES WITHIN THE FCRPS

B.6.1 Structural and Operational Measures

In developing the biological opinion, NMFS, in coordination with EPA, USFWS, and the Federal Action Agencies, has considered the respective ecological objectives of the ESA and the CWA. In many instances actions implemented for the conservation of ESA-listed species will also move toward attainment of water quality standards (e.g. reducing total dissolved gas and temperature). The overlap of statutory purpose is extensive, however, there remain additional actions that are appropriate in a water quality plan but which are nonessential for the survival and recovery of the listed species and thus are not required components of the ESA RPA. Further, the water quality plan is likely to require lengthy study and implementation exceeding the duration of this biological opinion.

Accordingly, action items already in the RPA for the FCRPS, which form a nucleus of actions for the water quality plan, are listed in Table B-2. These actions are essential for the survival and recovery of the listed species and thus are required components of the RPA.

This appendix also identifies actions for the FCRPS that further CWA objectives but are not also called for in the ESA RPA. These actions are listed in Table B-3. These are studies to investigate additional measures to reduce TDG and water temperature that may be considered for implementation in the future. The studies in Table B-3 are appropriate as ESA conservation measures that will require further ESA consultation when they are further developed, analyzed, and proposed for implementation.

B.6.2 Procedural Measures: Decision Process to Implement the Water Quality Plan

There are a number of existing basin forums that address various aspects of salmonid protection and recovery. For example, the NMFS Regional Implementation Forum is principally an ESA-focused intergovernmental forum for regional discussion and decisions on operation and system configuration of the FCRPS. The Columbia River Basin Forum is an entity created by a Memorandum of Agreement among Federal, state, and some Tribal governments that have management responsibilities and treaty rights regarding Columbia River basin fish and wildlife. Although the Columbia River Basin Forum does not have any decision-making authority, it can provide the opportunity for the participants to focus on the most pressing issues to improve effectiveness of regional fish and wildlife recovery efforts. There is also a procedural action in Table B-3 for the Action Agencies to participate in the development of mainstem TMDLs for gas and temperature. In addition, there are ongoing interactions between the EPA, states, municipalities, industry, and Tribes on tributary TMDL development.

Table B-2. List of Clean Water Act and ESA actions in Appendix B that are also called for in 2000 FCRPS Biological Opinion RPA.

FCRPS Project	Description of Action	Action Type	In Biological Opinion Section
	Dissolved Gas Actions		
Systemwide	Development of water quality plan	Plan	9.4.2.4
Lower Granite	Gas fast-track; spillway deflector optimization evaluation	Study	9.6.1.7.2
Little Goose	Gas fast-track; spillway deflector optimization evaluation	Study	9.6.1.7.2
Lower Monumental	Gas fast-track; spillway deflector optimization evaluation; fish passage efficiency and survival	Studies	9.6.1.7.2
Ice Harbor	Post-installation spillway deflector evaluations; fish passage efficiency and survival	Studies	9.6.1.7.2
McNary	Gas fast-track; spillway deflector optimization evaluation; fish passage efficiency and survival	Studies	9.6.1.7.2
John Day	Post-installation spillway deflector evaluations, gas fast-track and fish passage efficiency	Studies	9.6.1.7.2
John Day*	Design and implement spillway end deflector	Design and implementation	9.6.1.7.2
The Dalles	Spill and fish passage survival evaluation; gas fast-track	Studies	9.6.1.7.2
Bonneville	Design/implement gas fast-track and additional spillway deflectors; fish passage efficiency	Implementation and studies	9.6.1.7.2
Systemwide	Complete system gas abatement study	Study	9.6.1.7.2
Chief Joseph	Gas fast-track; spillway deflector design and installation	Implementation	9.6.1.7.2
Grand Coulee	Gas abatement study; evaluate GCL-CHJ gas abatement options	Study	9.6.1.7.2
Libby	Evaluate gas abatement alternatives	Study	9.6.1.7.2
Dworshak	Evaluate gas abatement alternatives	Study	9.6.1.7.2
Systemwide	Total dissolved gas monitoring program	Monitoring	9.6.1.7.2
Systemwide*	Evaluate fixed forebay TDG monitors to determine best location	Study and implementation	9.6.1.7.2
Systemwide	Develop system dissolved gas model	Modeling; study	9.6.1.7.2
Systemwide*	Evaluate gas entrainment divider walls at FCRPS mainstem projects	Study	9.6.1.7.2
Lower Granite	Prototype surface spillway bypass	Construct prototype & study	9.6.1.4.5, 9.67.1.7.2
John Day	Prototype surface spillway bypass	Construct prototype & study	9.6.1.4.5, 9.6.1.7.2

* Action not contained in Appendix B but called for in Sec. 9 of NMFS Biological Opinion.

Table B-2 (continued). List of Clean Water Act and ESA actions in Appendix B that are also called for in the 2000 FCRPS Biological Opinion RPA.

FCRPS Project	Description of Action	Action Type	In Biological Opinion Section
	Water Temperature Actions		
Systemwide	Development of water quality plan	Plan	9.4.2.4
Systemwide	Water temperature data collection/monitoring program	Monitoring	9.6.1.7.2
Systemwide	Develop plan to model system water temperature and operations	Modeling; study	9.6.1.7.2
Systemwide	Evaluate fish ladder water temps.	Study	9.6.1.6.2
Systemwide	Evaluate temp effects on juvenile passage behavior and survival	Study	9.6.1.7.2
Unspecified dam	Conduct comprehensive depth and temp investigation to identify adult passage losses	Study	9.6.1.6.2
Dworshak	DWR NFH water supply improvements to allow temp oper.	Implementation	9.6.1.2.6
Dworshak and L. Snake River dams	Water temp control operations; evaluate effects on adult passage behavior and pre-spawning mortality	Operations and studies	9.6.1.2.6
McNary	Monitor/eval temp in juvenile fish bypass facilities & effects on fish	Monitor and study	9.6.1.7.2
	Tributary Actions		
Systemwide	Coordinate with tributary TMDLs and fund ESA-related TMDL implementation	Study and monitoring; plan implementation	9.6.2.1
Columbia Basin Project	Wasteway water quality monitoring and remediation plan	Study and monitoring; plan implementation	9.6.1.2.7

Table B-3. List of Clean Water Act Actions in Appendix D that are not called for in the 2000 FCRPS Biological Opinion RPA.

FCRPS Project	Description of Action	Action Type	In Biological Opinion Section
Systemwide	Development of Columbia/Snake River TMDLs for dissolved gas and temperature	Study/process	Conservation recommendation 11.8
Grand Coulee	Long-term gas abatement alternative selection study	Study	Conservation recommendation 11.9
Lower Granite	Long-term gas abatement alternative selection study; side channel spillway or raised stilling basin	Study	Conservation recommendation 11.9
Little Goose	Long-term gas abatement alternative selection study; side channel spillway or raised stilling basin	Study	Conservation recommendation 11.9
Lower Monumental	Long-term gas abatement alternative selection study; side channel spillway or raised stilling basin	Study	Conservation recommendation 11.9
Ice Harbor	Long-term gas abatement alternative selection study; side channel spillway or raised stilling basin	Study	Conservation recommendation 11.9
McNary	Long-term gas abatement alternative selection study; side channel spillway or raised stilling basin	Study	Conservation recommendation 11.9
Bonneville	Long-term gas abatement alternative selection study; baffled spillway	Study	Conservation recommendation 11.9
Systemwide	Provide funding to develop tributary TMDLs	Funding	Conservation recommendation 11.11

B.6.3 New Water Quality Team

Perhaps none of the ongoing forums and/or water quality protection activities will provide the desired organizational structure to fully integrate the goals and regulatory requirements of the CWA and ESA in a manner that supports development and implementation of the water quality plan for the mainstem Columbia and Snake rivers. It is also important for EPA, NMFS, USFWS, and the Federal Action Agencies to understand the relationship between the Water Quality Plan and ongoing TMDL planning processes, particularly their relationship with each other and evaluation and implementation of the system improvements and studies. Therefore, final development and implementation of the plan could be accomplished through reformulation of the Water Quality Team, consisting of senior policy analysts and supported by technical staff from Federal agencies (EPA, NMFS, USFWS, Corps, BPA, and BOR); the states of Oregon, Washington, and Idaho; Columbia River Tribal governments; and non-Federal entities such as municipalities and PUDs.

The team would also have specific TDG and temperature technical subcommittees included under the overall umbrella of team actions. The new Water Quality Team could also be a cross-connecting link between the NMFS Regional Implementation Forum and the Columbia River Basin Forum, as appropriate, through input and updates on water quality plan implementation. The new Water Quality Team would review the water quality plan developed by the Action Agencies to help identify key TDG and temperature studies and implementation of structural and operational changes to the FCRPS system, including PUDs. The plan's timeline would provide specific milestones to conclude discussions on technical issues related to structural and operational changes to the FCRPS, consultation with the other basin forums discussed above, and implementation of actions so that they may be considered in conjunction with the 2005 mid-point evaluation under the RPA.

In developing the water quality plan, the new Water Quality Team would incorporate the traditional TMDL development and implementation process with this new effort to improve water quality standards on the mainstem Columbia River (see Table B-1). To accomplish this goal, the new Water Quality Team would seek advice from the NMFS Regional Implementation Forum when necessary. The new Water Quality Team would make funding recommendations for federal projects through the System Configuration Team of the NMFS Regional Implementation Forum, but would also seek other funding for capital structural improvements through traditional agency-focused funding mechanisms. Recommendations by the new Water Quality Team or existing group would undergo the same prioritization and budgeting processes as other actions undertaken or supported by the Action Agencies.

The new Water Quality Team, while having a CWA focus on beneficial uses and on developing and implementing the water quality plan, would interface with ESA compliance by integrating implementation of actions in Tables B-2 and B-3 as appropriate to support water quality improvement in the mainstem, and to complement other related actions and measures that support anadromous fish recovery as well as water quality improvement in the tributaries. As

part of the new Water Quality Team, EPA, NMFS, USFWS, and the Federal Action Agencies would review Table B-2 and Table B-3 annually and revise them as needed, after taking into consideration the best available scientific information.

B.6.4 Project Selection Criteria

The possible actions identified in Table B-2 and Table B-3 are at the heart of implementing the water quality plan. Therefore, it is important that both lists contain all appropriate studies and structural and operational changes necessary to comply with and complement the goals of the ESA and the CWA. To appear on these lists, proposals should go through a well-defined screening, prioritization, funding, allocation, and approval process.

The following criteria are proposed for use by the new Water Quality Team to screen Table B-3 items and any other water quality actions identified in the annual planning process. The new Water Quality Team can then provide advice and recommendations to the System Configuration Team of the NMFS Regional Implementation Forum as they prioritize projects as part of the Corps' Columbia River Fish Mitigation Program.

Proposed criteria for evaluating possible actions are as follows:

- How does the proposal meet the tenets of the 2000 FCRPS Biological Opinion and the water quality plan (i.e., how does the proposal complement the two activities)?
- How does the proposal demonstrate substantial progress toward meeting the 110% TDG and temperature standards by the 2005 check-in point?
- If the proposal is a study, how will it increase the existing knowledge base to meet the temperature and/or dissolved gas standard?
- How does the proposal build on existing science to achieve project goals?
- How does the proposal go beyond mitigation for FCRPS impacts to enhance anadromous fish recovery?
- Is the proposal cost-effective?
- Is there consensus among Federal, state, and Tribal representatives to implement the proposal?

B.6.5 Integration of Water Quality Plan with Other Processes

The water quality plan will include possible measures for implementation to improve water quality. These measures, such as ESA and fish and wildlife measures, will be coordinated with established processes. These include planning and review processes of the NWPPC, including the Independent Scientific Review Panel, the Columbia Basin Fish and Wildlife Authority, the NMFS' Regional Forum, and, if appropriate, the Columbia River Basin Forum. Some measures may also require congressional approval.

NMFS, EPA, USFWS, and the Federal Action Agencies intend to support implementation of those measures that successfully garner approval through these processes. A common approach for selecting water quality, ESA, and fish and wildlife measures to implement should foster coordination among NMFS, EPA, USFWS, and the Federal Action Agencies, and increase effective use of available but finite resources. The outcome of these processes is a collection of measures undertaken by the Action Agencies to serve the agencies' various statutory purposes within budgetary parameters. Recommendations approved by applicable processes could be identified in the water quality plan for implementation.

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B.7 MONITORING AND EVALUATION

As part of implementing the water quality plan, the Federal Action Agencies need to install, maintain and operate a complete water quality monitoring network. That network should include a water temperature and dissolved gas data collection protocol. At a minimum, such a protocol should include descriptions of instrument precision and accuracy, measures to ensure quality control, consistent and reliable recording of time and date, and, for data collected in reservoirs, depth. The protocol should also consider data formatting requirements and should be available for downloading from a website. Such information is useful in evaluating the temperature and dissolved gas-related effects of specific operational strategies and may be useful in devising operations that better protect anadromous fish. At this time, there is a comprehensive dissolved gas monitoring network in the Columbia River and Snake River mainstem. However, there are perceived data gaps in a comprehensive temperature monitoring program that could be used to further both CWA and ESA purposes.

Various entities have collected available water temperature data throughout the basin for an array of purposes (Yearsley 1999). Quality assurance and quality control programs ensure that some of these data are collected with sufficient precision, accuracy, and frequency to serve a variety of purposes. For other data, this is not the case. Much of the data collected are from relatively imprecise instruments and may be subject to inaccuracies. For example, turbine scroll case water temperatures may be collected sporadically, using instruments capable of reading to the nearest 1°F. These dial-type thermometers are subject to parallax inaccuracies beyond those of digital measurements and inaccurate reading by observers.

Furthermore, few researchers perceived the need to correlate temperature conditions with current and historical reservoir operations information. Due to reservoir thermal stratification and the physical layout of hydroelectric projects, temperatures in downstream reaches can be affected by reservoir operations. Water temperatures downstream from stratified reservoirs could vary at a given point in time depending on the relative contribution of spill (which comes from warmer near-surface water) to total discharge. If viewed alone, temperature data from such operational effects could appear to be errors in a one-dimensional model. Therefore, it is important to know current and historical upstream project operations, as well as the distribution of water temperatures in the upstream reservoir when estimating the likely downstream water temperature effects of a given operation.

Several FCRPS reservoirs are known to stratify during the summer. Specifically, Lake Roosevelt (Grand Coulee Dam) on the Columbia River and Lower Granite and Little Goose reservoirs on the lower Snake River stratify (Karr et al. 1998). Due to severe gassing problems at Grand Coulee Dam and the very large turbine discharge capacity of the project, the project is routinely operated to minimize spill. Stratification at Lake Roosevelt has very limited potential to adversely affect listed salmon.

In contrast to the situation at Lake Roosevelt, Lower Granite and Little Goose reservoirs lie within currently occupied salmon habitat and can exhibit temperature conditions that could adversely affect salmon survival. Near-surface temperatures have been shown to be much warmer than temperatures near the bottom of the reservoir. Understanding the thermal characteristics of these reservoirs is important to our efforts to devise long-term management schemes to enhance salmon survival.

In order to adequately address temperature monitoring at mainstem reservoirs, the Federal Action Agencies should develop and maintain a model or series of models capable of estimating water temperatures of the Snake River, from Hells Canyon Dam on the Snake River and from Dworshak Dam on the North Fork of the Clearwater River, to the confluence of the Snake River with the Columbia River downstream from Ice Harbor Dam. The models should be developed to function both as planning tools and to provide predicted outcomes in real time. Both one-dimensional and multiple-dimensional models may be needed to fully define the temperature conditions within the reach (see the modeling discussion in Section B.5 of this appendix).

Until a modeling technique is selected, defining a data collection scheme is somewhat risky. That is, if the data needed to effectively drive the model were perfectly understood, better data could possibly be developed at lower cost. Statistical tests may be available to identify the data needs. However, it is clear that both additional water temperature and meteorological data are needed. It is strongly suggested that the EPA, NMFS, USFWS, and the Federal Action Agencies coordinate this effort with EPA and state and Tribal water quality agencies.

As the Snake and Clearwater rivers are rapid, turbulent rivers, it is reasonable to assume that the free-flowing portions of the rivers are relatively isothermic at any given point and time. Existing tri-level thermograph data (Karr et al. 1998) from the Clearwater River inlet also support this assumption. Thus, a single well-placed temperature probe at each selected station in the free-flowing portions of the study streams may accurately define the water temperature at that point.

The number of additional meteorological stations needed to achieve the desired model accuracy is unknown. Given that the geographic scale of weather variations can be quite small, particularly during the summer (for example, summer convective storms), it is unlikely that all errors associated with extrapolation of site-specific conditions could be eliminated with any reasonable number of new stations. Again, a statistical analysis should be conducted to define the most important locations for new meteorological stations. All additional stations should discretely measure all of the meteorological variables necessary to construct a deterministic model of heat flux. Measured variables should include air temperature, relative humidity, barometric pressure, wind speed and velocity, solar radiation, and evaporation rates.

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APPENDIX C
BIOLOGICAL REQUIREMENTS, CURRENT STATUS, AND TRENDS: TWELVE COLUMBIA RIVER BASIN EVOLUTIONARILY SIGNIFICANT UNITS

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C.1 OVERVIEW OF STATUS OF SPECIES AND CRITICAL HABITAT

Appendix C provides, for each of the 12 Columbia River basin evolutionarily significant units (ESUs), a description of the species, critical habitat designations, a general life history, and a detailed discussion of population dynamics and distribution. Table C-1 provides a summary of each salmon species listed and proposed for listing under the Endangered Species Act (ESA). Table C-2 provides a summary of critical habitat designations under ESA.

Table C-1. Summary of salmon species listed and proposed for listing under the ESA.

Species	Evolutionarily Significant Unit	Present Status	Federal Register Notice	
Chinook Salmon	Sacramento River Winter	Endangered	59 FR 440	1/4/94
(*O. tshawytscha*)	Snake River Fall	Threatened	57 FR 14653	4/22/92
	Snake River Spring/Summer	Threatened	57 FR 14653	4/22/92
	Central Valley Spring	Threatened	64 FR 50393	9/16/99
	California Coastal	Threatened	64 FR 50393	9/16/99
	Puget Sound	Threatened	64 FR 14308	3/24/99
	Lower Columbia River	Threatened	64 FR 14308	3/24/99
	Upper Willamette River	Threatened	64 FR 14308	3/24/99
	Upper Columbia River Spring	Endangered	64 FR 14308	3/24/99
Chum Salmon	Hood Canal Summer-run	Threatened	64 FR 14508	3/25/99
(*O. keta*)	Columbia River	Threatened	64 FR 14508	3/25/99
Coho Salmon	Central California Coastal	Threatened	61 FR 56138	10/31/96
(*O. kisutch*)	S. Oregon/ N. California Coastal	Threatened	62 FR 24588	5/6/97
	Oregon Coastal	Threatened	63 FR 42587	8/10/98
Sockeye Salmon	Snake River	Endangered	56 FR 58619	11/20/91
(*O. nerka*)	Ozette Lake	Threatened	64 FR 14528	3/25/99
Steelhead	Southern California	Endangered	62 FR 43937	8/18/97
(*O. mykiss*)	South-central California	Threatened	62 FR 43937	8/18/97
	Central California Coast	Threatened	62 FR 43937	8/18/97
	Upper Columbia River	Endangered	62 FR 43937	8/18/97
	Snake River Basin	Threatened	62 FR 43937	8/18/97
	Lower Columbia River	Threatened	63 FR 13347	3/19/98
	California Central Valley	Threatened	63 FR 13347	3/19/98
	Upper Willamette River	Threatened	64 FR 14517	3/25/99
	Middle Columbia River	Threatened	64 FR 14517	3/25/99
Cutthroat Trout	Umpqua River	Endangered	61 FR 41514	8/9/96
Sea-run	Southwest Washington/Columbia	Proposed Threatened	64 FR 16397	4/5/99
(*O. clarki clarki*)	River			

Table C- 2. Summary of critical habitat designations under the ESA.

Species	Evolutionarily Significant Unit	Federal Register Notice	
Chinook Salmon	Sacramento River Winter	58 FR 33212	6/16/93
(*O. tshawytscha*)	Snake River Fall	58 FR 68543	12/28/93
	Snake River Spring/Summer	58 FR 68543	12/28/93
	Revised:	64 FR 57399	10/25/99
	Central Valley Spring	65 FR 7764	3/9/98
	California Coastal	65 FR 7764	3/9/98
	Puget Sound	65 FR 7764	2/16/00
	Lower Columbia River	65 FR 7764	2/16/00
	Upper Willamette River	65 FR 7764	2/16/00
	Upper Columbia River Spring	65 FR 7764	2/16/00
Chum Salmon	Hood Canal Summer-run	65 FR 7764	2/16/00
(*O. keta*)	Columbia River	65 FR 7764	2/16/00
Coho Salmon	Central California Coastal	64 FR 24049	5/5/99
(*O. kisutch*)	S. Oregon/ N. California Coastal	64 FR 24049	5/5/99
	Oregon Coastal	65 FR 7764	2/16/00
Sockeye Salmon	Snake River	58 FR 68543	12/28/93
(*O. nerka*)	Ozette Lake	65 FR 7764	2/16/00
Steelhead	Southern California	65 FR 7764	2/16/00
(*O. mykiss*)	South-central California	65 FR 7764	2/16/00
	Central California Coast	65 FR 7764	2/16/00
	Upper Columbia River	65 FR 7764	2/16/00
	Snake River Basin	65 FR 7764	2/16/00
	Lower Columbia River	65 FR 7764	2/16/00
	California Central Valley	65 FR 7764	2/16/00
	Upper Willamette River	65 FR 7764	2/16/00
	Middle Columbia River	65 FR 7764	2/16/00
Cutthroat Trout	Umpqua River	63 FR 1388	1/9/98
Sea-run	Southwest Washington/Columbia River	none proposed	
(*O. clarki clarki*)			

C.2 SPECIES DESCRIPTIONS AND CRITICAL HABITAT DESIGNATIONS

C.2.1 Chinook Salmon

C.2.1.1 Snake River Spring/Summer Chinook Salmon

The Snake River (SR) spring/summer chinook salmon ESU, listed as threatened on April 22, 1992 (67 FR 14653), includes all natural-origin populations in the Tucannon, Grande Ronde, Imnaha, and Salmon rivers. Some or all of the fish returning to several of the hatchery programs are also listed including those returning to the Tucannon River, Imnaha, and Grande Ronde hatcheries, and to the Sawtooth, Pahsimeroi, and McCall hatcheries on the Salmon River. Critical habitat was designated for SR spring/summer chinook salmon on December 28, 1993 (58 FR 68543), and was revised on October 25, 1999 (64 FR 57399).

C.2.1.2 Snake River Fall Chinook Salmon

The SR fall chinook salmon ESU, listed as threatened on April 22, 1992 (67 FR 14653), includes all natural-origin populations of fall chinook in the mainstem Snake River and several tributaries including the Tucannon, Grande Ronde, Salmon, and Clearwater rivers. Fall chinook from the Lyons Ferry Hatchery are included in the ESU but are not listed. Critical habitat was designated for SR fall chinook salmon on December 28, 1993 (58 FR 68543).

C.2.1.3 Upper Columbia River Spring-Run Chinook Salmon

The Upper Columbia River (UCR) spring-run chinook salmon ESU, listed as endangered on March 24, 1999 (64 FR 14308), includes all natural-origin, stream-type chinook salmon from river reaches above Rock Island Dam and downstream of Chief Joseph Dam, including the Wenatchee, Entiat, and Methow River basins. All chinook in the Okanogan River are apparently ocean-type and are considered part of the UCR summer- and fall-run ESU. The spring-run components of the following hatchery stocks are also listed: Chiwawa, Methow, Twisp, Chewuch, and White rivers and Nason Creek. Critical habitat was designated for UCR spring-run chinook salmon on December 28, 1993 (58 FR 68543).

C.2.1.4 Upper Willamette River Chinook Salmon

The Upper Willamette River (UWR) chinook salmon ESU, listed as threatened on March 24, 1999 (64 FR 14308), occupies the Willamette River and tributaries upstream of Willamette Falls, in addition to naturally produced spring-run fish in the Clackamas River. UWR spring chinook salmon is one of the most genetically distinct chinook groups in the Columbia River (CR) basin. Fall chinook salmon spawn in the upper Willamette but are not considered part of the ESU because they are not native. None of the hatchery populations in the Willamette River was listed, although five spring-run hatchery stocks were included in the ESU. Critical habitat was designated for UWR chinook salmon on February 16, 2000 (58 FR 68543).

C.2.1.5 Lower Columbia River Chinook Salmon

The Lower Columbia River (LCR) chinook salmon ESU, listed as threatened on March 24, 1999 (64 FR 14308), includes all natural-origin populations of both spring- and fall-run chinook salmon in tributaries to the Columbia River from a transition point located east of the Hood River, Oregon, and the White Salmon River, Washington, to the mouth of the Columbia River at the Pacific Ocean and in the Willamette River below Willamette Falls, Oregon (excluding spring-run chinook salmon in the Clackamas River). Not included in this ESU are stream-type spring chinook salmon found in the Klickitat River (which are considered part of the Mid-Columbia River spring-run ESU) or the introduced Carson spring chinook salmon strain. Tule fall chinook salmon in the Wind and Little White Salmon rivers are included in this ESU, but not introduced upriver bright fall chinook salmon populations in the Wind, White Salmon, and Klickitat rivers. The Cowlitz, Kalama, Lewis, Washougal, and White Salmon rivers constitute the major systems on the Washington side; the lower Willamette and Sandy rivers are foremost on the Oregon side. Most of this ESU is represented by fall-run fish; there is some question whether any natural-origin spring chinook salmon persist in this ESU. Fourteen hatchery stocks were included in the ESU; one was considered essential for recovery (Cowlitz River spring chinook) but was not listed. Critical habitat was designated for LCR chinook salmon on February 16, 2000 (65 FR 7764).

C.2.2 Steelhead

C.2.2.1 Snake River Steelhead

The SR steelhead ESU, listed as threatened on August 18, 1997 (62 FR 43937), includes all natural-origin populations of steelhead in the Snake River basin of southeast Washington, northeast Oregon, and Idaho. None of the hatchery stocks in the Snake River basin is listed, but several are included in the ESU. Critical habitat was designated for SR steelhead on February 16, 2000 (65 FR 7764).

C.2.2.2 Upper Columbia River Steelhead

The UCR steelhead ESU, listed as endangered on August 18, 1997 (62 FR 43937), includes all natural-origin populations of steelhead in the Columbia River basin upstream from the Yakima River, Washington, to the U.S./Canada border. The Wells Hatchery stock is included among the listed populations. Critical habitat was designated for UCR steelhead on February 16, 2000 (65 FR 7764).

C.2.2.3 Middle Columbia River Steelhead

The Middle Columbia River (MCR) steelhead ESU, listed as threatened on March 25, 1999 (64 FR 14517), includes all natural-origin populations in the Columbia River basin above the Wind River, Washington, and the Hood River, Oregon, including the Yakima River, Washington. This

ESU includes the only populations of winter inland steelhead in the United States (in the Klickitat River, Washington, and Fifteenmile Creek, Oregon). Both the Deschutes River and Umatilla River hatchery stocks are included in the ESU, but are not listed. Critical habitat was designated for MCR steelhead on February 16, 2000 (65 FR 7764).

C.2.2.4 Upper Willamette River Steelhead

The UWR steelhead ESU, listed as threatened on March 25, 1999 (64 FR 14517), consists of all natural-origin populations in the Willamette River and its tributaries upstream of Willamette Falls to the Calapooia River, inclusive. None of the hatchery stocks was included as part of the listed ESU. Critical habitat was designated for UWR steelhead on February 16, 2000 (65 FR 7764).

C.2.2.5 Lower Columbia River Steelhead

The LCR steelhead ESU, listed as threatened on March 19, 1998 (63 FR 13347), consists of all natural-origin populations in tributaries to the Columbia River between the Cowlitz and Wind rivers, Washington, and the Willamette and Hood rivers, Oregon, inclusive. NMFS specifically excluded three river basins: 1) the Willamette River basin above Willamette Falls, 2) the Little White Salmon River, and 3) the Big White Salmon River, Washington (61 FR 41545). Among hatchery stocks, late-spawning Cowlitz River Trout Hatchery and late-spawning Clackamas River ODFW stock No. 122 are part of the ESU, but are not considered essential for recovery. Critical habitat was designated for LCR steelhead on February 16, 2000 (65 FR 7764).

C.2.3 Chum Salmon

C.2.3.1 Columbia River Chum Salmon

The Columbia River (CR) chum salmon ESU, listed as threatened on March 25, 1999 (64 FR 14508), includes all natural-origin chum salmon in the Columbia River and its tributaries in Washington and Oregon. None of the hatchery populations is included as part of the listed ESU. Critical habitat was designated for CR chum salmon on February 16, 2000 (65 FR 7764).

C.2.4 Sockeye Salmon

C.2.4.1 Snake River Sockeye Salmon

The SR sockeye salmon ESU, listed as endangered on November 20, 1991 (56 FR 58619), includes populations of sockeye salmon from the Snake River basin, Idaho (extant populations occur only in the Salmon River subbasin). Under NMFS' interim policy on artificial propagation (58 FR 17573), the progeny of fish from a listed population that are propagated artificially are considered part of the listed species and are protected under ESA. Thus, although not specifically designated in the 1991 listing, SR sockeye salmon produced in the captive

broodstock program are included in the listed ESU. Given the dire status of the wild population under any criteria (16 wild and 264 hatchery-produced adult sockeye returned to the Stanley basin between 1990 and 2000), NMFS considers the captive broodstock and its progeny essential for recovery. Critical habitat was designated for SR sockeye salmon on December 28, 1993 (58 FR 68543).

C.3 GENERAL LIFE HISTORIES

C.3.1 Chinook Salmon

The chinook salmon is the largest of the Pacific salmon. The species' distribution historically ranged from the Ventura River in California to Point Hope, Alaska, in North America, and in northeastern Asia from Hokkaido, Japan, to the Anadyr River in Russia (Healey 1991). Additionally, chinook salmon have been reported in the Mackenzie River area of northern Canada (McPhail and Lindsey 1970). Of the Pacific salmon, chinook salmon exhibit the most diverse and complex life history strategies. Healey (1986) described 16 age categories for chinook salmon, combinations of seven total ages with three possible freshwater ages. This level of complexity is roughly comparable to that seen in sockeye salmon (*O. nerka*), although the latter species has a more extended freshwater residence period and uses different freshwater habitats (Miller and Brannon 1982, Burgner 1991). Gilbert (1912) initially described two generalized freshwater life-history types: "stream-type" chinook salmon, which reside in freshwater for a year or more following emergence, and "ocean-type" chinook salmon, which migrate to the ocean within their first year. Healey (1983, 1991) has promoted the use of broader definitions for ocean-type and stream-type to describe two distinct races of chinook salmon. Healey's approach incorporates life-history traits, geographic distribution, and genetic differentiation and provides a valuable frame of reference for comparisons of chinook salmon populations.

The generalized life history of Pacific salmon involves incubation, hatching, and emergence in freshwater; migration to the ocean; and the subsequent initiation of maturation and return to freshwater for completion of maturation and spawning. The juvenile rearing period in freshwater can be minimal or extended. Additionally, some male chinook salmon mature in freshwater, thereby not emigrating to the ocean. The timing and duration of each of these stages is related to genetic and environmental determinants and their interactions to varying degrees. Although salmon exhibit a high degree of variability in life-history traits, there is considerable debate regarding the degree to which this variability is shaped by local adaptation or results from the general plasticity of the salmonid genome (Ricker 1972, Healey 1991, Taylor 1991). More detailed descriptions of the key features of chinook salmon life history can be found in Myers et al. (1998) and Healey (1991).

C.3.2 Steelhead

Steelhead can be divided into two basic run types based on the level of sexual maturity at the time of river entry and the duration of the spawning migration (Burgner et al. 1992). The stream-maturing type, or summer steelhead, enters freshwater in a sexually immature condition and requires several months in freshwater to mature and spawn. The ocean-maturing type, or winter steelhead, enters freshwater with well-developed gonads and spawns shortly after river entry (Barnhart 1986). Variations in migration timing exist between populations. Some river basins have both summer and winter steelhead, whereas others only have one run type.

In the Pacific Northwest, summer steelhead enter freshwater between May and October (Busby et al. 1996, Nickelson et al. 1992). During summer and fall, before spawning, they hold in cool, deep pools (Nickelson et al. 1992). They migrate inland toward spawning areas, overwinter in the larger rivers, resume migration to natal streams in early spring, and then spawn (Meehan and Bjornn 1991, Nickelson et al. 1992). Winter steelhead enter freshwater between November and April in the Pacific Northwest (Busby et al. 1996, Nickelson et al. 1992), migrate to spawning areas, and then spawn in late winter or spring. Some adults do not, however, enter coastal streams until spring, just before spawning (Meehan and Bjornn 1991). Difficult field conditions (snowmelt and high stream flows) and the remoteness of spawning grounds contribute to the relative lack of specific information on steelhead spawning.

Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death. However, it is rare for steelhead to spawn more than twice before dying, and most that do so are females (Nickelson et al. 1992). Iteroparity is more common among southern steelhead populations than northern populations (Busby et al. 1996). Multiple spawnings for steelhead range from 3% to 20% of runs in Oregon coastal streams.

Steelhead spawn in cool, clear streams with suitable gravel size, depth, and current velocity. Intermittent streams may also be used for spawning (Barnhart 1986, Everest 1973). Steelhead enter streams and arrive at spawning grounds weeks or even months before they spawn and are vulnerable to disturbance and predation. Cover, in the form of overhanging vegetation, undercut banks, submerged vegetation, submerged objects such as logs and rocks, floating debris, deep water, turbulence, and turbidity (Giger 1973), is required to reduce disturbance and predation of spawning steelhead. Summer steelhead usually spawn further upstream than winter steelhead (Withler 1966, Behnke 1992).

Depending on water temperature, steelhead eggs may incubate for 1.5 to 4 months (August 9, 1996, 61 FR 41542) before hatching. Summer rearing takes place primarily in the faster parts of pools, although young-of-the-year are abundant in glides and riffles. Winter rearing occurs more uniformly at lower densities across a wide range of fast and slow habitat types. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small wood. Some older juveniles move downstream to rear in larger tributaries and mainstem rivers (Nickelson et al. 1992).

Juveniles rear in freshwater from 1 to 4 years, then migrate to the ocean as smolts. Winter steelhead populations generally smolt after 2 years in freshwater (Busby et al. 1996). Steelhead typically reside in marine waters for 2 or 3 years before returning to their natal stream to spawn at 4 or 5 years of age. Populations in Oregon and California have higher frequencies of age-1-ocean steelhead than populations to the north, but age-2-ocean steelhead generally remain dominant (Busby et al. 1996). Age structure appears to be similar to other west coast steelhead, dominated by 4-year-old spawners (Busby et al. 1996).

Based on purse seine catches, juvenile steelhead tend to migrate directly offshore during their first summer, rather than migrating along the coastal belt as do salmon. During fall and winter, juveniles move southward and eastward (Hartt and Dell 1986). Oregon steelhead tend to be north-migrating (Nicholas and Hankin 1988, Pearcy et al. 1990, Pearcy 1992).

C.3.3 Chum Salmon

Historically, chum salmon were distributed throughout the coastal regions of western Canada and the United States, as far south as Monterey Bay, California. Presently, major spawning populations are found only as far south as Tillamook Bay on the northern Oregon coast.

Chum salmon (*Oncorhynchus keta*) are semelparous, spawn primarily in freshwater, and, apparently, exhibit obligatory anadromy (there are no recorded landlocked or naturalized freshwater populations) (Randall et al. 1987). Chum salmon spend more of their life history in marine waters than other Pacific salmonids. Like pink salmon, chum salmon usually spawn in the lower reaches of rivers, with redds usually dug in the mainstem or in side channels of rivers from just above tidal influence to nearly 100 km from the sea. Juveniles outmigrate to seawater almost immediately after emerging from the gravel that covers their redds (Salo 1991). This ocean-type migratory behavior contrasts with the stream-type behavior of some other species in the genus *Oncorhynchus* (e.g., coastal cutthroat trout, steelhead, coho salmon, and most types of chinook and sockeye salmon), which usually migrate to sea at a larger size, after months or years of freshwater rearing. This means that survival and growth in juvenile chum salmon depend less on freshwater conditions (unlike stream-type salmonids which depend heavily on freshwater habitats) than on favorable estuarine conditions. Another behavioral difference between chum salmon and species that rear extensively in freshwater is that chum salmon form schools, presumably to reduce predation (Pitcher 1986), especially if their movements are synchronized to swamp predators (Miller and Brannon 1982).

C.3.4 Sockeye Salmon

Snake River sockeye salmon adults enter the Columbia River primarily during June and July. Arrival at Redfish Lake, which now supports the only remaining run of Snake River sockeye salmon, peaks in August, and spawning occurs primarily in October (Bjornn et al. 1968). Eggs hatch in the spring between 80 and 140 days after spawning. Fry remain in the gravel for 3 to 5 weeks, emerge from April through May, and move immediately into the lake. Once there, juveniles feed on plankton for 1 to 3 years before they migrate to the ocean (Bell 1986). Migrants leave Redfish Lake during late April through May (Bjornn et al. 1968) and travel almost 900 miles to the Pacific Ocean. Smolts reaching the ocean remain inshore or within the influence of the Columbia River plume during the early summer months. Later, they migrate through the northeast Pacific Ocean (Hart 1973, Hartt and Dell 1986). Snake River sockeye salmon usually spend 2 to 3 years in the Pacific Ocean and return in their fourth or fifth year of life. For detailed information on the Snake River sockeye salmon, see Waples et al. (1991a).

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C.4 POPULATION DYNAMICS AND DISTRIBUTION

The following sections provide specific information on the distribution and population structure (size, variability, and trends of the stocks or populations) of each listed ESU. Most of this information comes from observations made in terminal, freshwater areas, which may be distinct from the action area. This focus is appropriate because the species status and distribution can only be measured at this level of detail as adults return to spawn.

C.4.1 Chinook Salmon

C.4.1.1 Snake River Spring/Summer Chinook Salmon

The present range of spawning and rearing habitat for naturally spawned SR spring/summer chinook salmon is primarily limited to the Salmon, Grande Ronde, Imnaha, and Tucannon subbasins. Most SR spring/summer chinook salmon enter individual subbasins from May through September. Juvenile SR spring/summer chinook salmon emerge from spawning gravels from February through June (Peery and Bjornn 1991). Typically, after rearing in their nursery streams for about 1 year, smolts begin migrating seaward in April and May (Bugert et al. 1990, Cannamela 1992). After reaching the mouth of the Columbia River, spring/summer chinook salmon probably inhabit nearshore areas before beginning their northeast Pacific Ocean migration, which lasts 2 to 3 years. Because of their timing and ocean distribution, these stocks are subject to very little ocean harvest. For detailed information on the life history and stock status of SR spring/summer chinook salmon, see Matthews and Waples (1991a), NMFS (1991b), and 56 FR 29542 (June 27, 1991).

Bevan et al. (1994) estimated the number of wild adult SR spring/summer chinook salmon in the late 1800s to be more than 1.5 million fish annually. By the 1950s, the population had declined to an estimated 125,000 adults. Escapement estimates indicate that the population continued to decline through the 1970s. Returns varied through the 1980s, but have declined further in recent years. Record low returns were observed in 1994 and 1995. Dam counts were modestly higher from 1996 through 1998, but declined in 1999. For management purposes, the spring and summer chinook salmon in the Columbia River basin, including those returning to the Snake River, have been managed as separate stocks. Historical databases, therefore, provide separate estimates for the spring and summer chinook salmon components. Table C-3 reports the estimated annual return of adult, natural-origin SR spring and summer chinook salmon returning to Lower Granite Dam since 1979.

NMFS set an interim recovery level for SR spring/summer chinook salmon (31,400 adults at Ice Harbor Dam) in its proposed recovery plan (NMFS 1995). The SR spring/summer chinook salmon ESU consists of 39 local spawning populations (subpopulations) spread over a large geographic area (Lichatowich et al. 1993). The number of fish returning to Lower Granite Dam is, therefore, divided among these subpopulations. The relationships between these subpopulations, and particularly the degree to which individuals may intermix, are unknown. It

Table C-3. Estimates of natural-origin SR spring/summer chinook salmon counted at Lower Granite Dam in recent years (CRITFC 1999).

Year	Spring Chinook	Summer Chinook	Total
1979	2,573	2,712	5,285
1980	3,478	2,688	6,166
1981	7,941	3,326	11,267
1982	7,117	3,529	10,646
1983	6,181	3,233	9,414
1984	3,199	4,200	7,399
1985	5,245	3,196	8,441
1986	6,895	3,934	10,829
1987	7,883	2,414	10,297
1988	8,581	2,263	10,844
1989	3,029	2,350	5,379
1990	3,216	3,378	6,594
1991	2,206	2,814	5,020
1992	11,285	1,148	12,433
1993	6,008	3,959	9,967
1994	1,416	305	1,721
1995	745	371	1,116
1996	1,358	2,129	3,487
1997	1,434	6,458	7,892
1998	5,055	3,371	8,426
1999	1,433	1,843	3,276
		Recovery Esc Level	31,440

is unlikely that all 39 are independent populations per the definition in McElhany et al. (2000), which requires that each be isolated such that the exchange of individuals between populations does not substantially affect population dynamics or extinction risk over a 100-year time frame. Nonetheless, monitoring the status of subpopulations provides more detailed information on the status of the species than would an aggregate measure of abundance.

Seven of these subpopulations have been used as index stocks to analyze extinction risk and alternative actions that may be taken to meet survival and recovery requirements. The Snake River Salmon Recovery Team selected these subpopulations primarily because of the availability of a relatively long-term series of abundance data. The BRWG developed recovery and threshold abundance levels for the index stocks, which serve as reference points for comparisons with observed escapements (Table C-4). The threshold abundances represent levels at which uncertainties (and, thus, the likelihood of error) about processes or population enumeration are likely to be biologically significant and at which qualitative changes in processes are likely to

occur. They were not developed as indicators of pseudo-extinction or as absolute indicators of critical thresholds. In any case, escapement estimates for the index stocks have generally been well below threshold levels in recent years (Table C-4).

Table C-4. Estimated number of natural-origin adult spawners plus recovery levels and BRWG threshold abundance levels for the seven SR spring/summer chinook salmon index stocks.

Brood year	Bear Valley	Marsh	Sulphur	Minam	Imnaha	Poverty Flats	Johnson
1979	215	83	90	40	238	76	66
1980	42	16	12	43	183	163	55
1981	151	115	43	50	453	187	102
1982	83	71	17	104	590	192	93
1983	171	60	49	103	435	337	152
1984	137	100	0	101	557	220	36
1985	295	196	62	625	641	341	178
1986	224	171	385	178	449	233	129
1987	456	268	67	342	401	554	175
1988	1109	395	607	306	504	765	332
1989	91	80	43	197	134	237	103
1990	185	101	170	146	84	518	141
1991	181	72	213	116	70	488	151
1992	173	114	21	10	73	524	180
1993	709	216	263	149	362	785	357
1994	33	9	0	16	52	189	50
1995	16	0	4	26	54	73	20
1996	56	18	23	213	143	127	49
1997	225	110	43	134	153	228	236
1998	372	164	140	118	90	348	119
1999	72	0	0	91	56	138	49
Recovery Level	**900**	**450**	**300**	**450**	**850**	**850**	**300**
BRWG Threshold	**300**	**150**	**150**	**150**	**300**	**300**	**150**

Spring chinook salmon index stocks: Bear Valley, Marsh, Sulphur, and Minam. Summer-run index stocks: Poverty Flats and Johnson. Run-timing for the Imnaha stocks is intermediate. Source: ODFW (2000)

As of June 1, 2000, the preliminary final aggregate count for upriver spring chinook salmon at Bonneville Dam was 178,000, substantially higher than the 2000 forecast of 134,000.[1] This is the second highest return in 30 years (after the 1972 return of 179,300 adults). Although only a small portion of these fish is expected to be natural-origin spring chinook salmon destined for the Snake River (5,800), the aggregate estimate for natural-origin SR spring chinook salmon is

[1] Source: June 1, 2000, e-mail from R. Bayley (NMFS) to Stephen H. Smith (NMFS). "Spring chinook update (end-of-season at Bonneville Dam)."

substantially higher than the contributing brood year escapements (comparable returns to the Columbia River mouth in 1995 and 1996 were 1,829 and 3,903, respectively). The 2000 forecast for the upriver summer chinook salmon stocks is 33,300, which is, again, the second highest return in over 30 years, but with only a small portion (2,000) being natural-origin fish destined for the Snake River. The return of natural-origin fish compares to brood year escapements in 1995 and 1996 of 534 and 3,046 and is generally lower than the average returns over the last 5 years (3,466).

The probability of meeting survival and recovery objectives for SR spring/summer chinook salmon under various future operation scenarios for the hydrosystem was analyzed through a process referred to as PATH (Plan for Analyzing and Testing Hypotheses). The scenarios analyzed focused on status quo management and options that emphasized either juvenile transportation or hydro-project drawdown. PATH also included sensitivity analyses to alternative harvest rates and habitat effects. PATH estimated the probability of survival and recovery for the seven index stocks using the recovery and escapement threshold levels as abundance indicators. The forward simulations estimated the probability of meeting the survival thresholds after 24 and 100 years.

A 70% probability of exceeding the threshold escapement levels was used to assess survival. Recovery potential was assessed by comparing the projected abundance to the recovery abundance levels after 48 years. A 50% probability of exceeding the recovery abundance levels was used to evaluate recovery by comparing the 8-year mean projected abundance. In general, the survival and recovery standards were met for operational scenarios involving drawdown, but were not met under status quo management or for the scenarios that relied on juvenile transportation (Marmorek et al. 1998). If the most conservative harvest rate schedule was assumed, transportation scenarios came very close to meeting the survival and recovery standards.

For the SR spring/summer chinook salmon ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[2] ranges from 0.96 to 0.80, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to the effectiveness of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated median population growth rates and the risk of absolute extinction for the seven spring/summer chinook salmon index stocks,[3] using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years for the wild component ranges from zero for Johnson Creek to 0.78 for the Imnaha River

[2]Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1999 adult returns. Population trends are projected under the assumption that all conditions will stay the same into the future.

[3] McClure et al. (2000c) have calculated population trend parameters for additional SR spring/summer chinook salmon stocks.

(Table B-5 in McClure et al. 2000b). At the high end, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years ranges from zero for Johnson Creek to 1.00 for the wild component in the Imnaha River (Table B-6 in McClure et al. 2000b).

C.4.1.2 Snake River Fall Chinook Salmon

The spawning grounds between Huntington (RM 328) and Auger Falls (RM 607) were historically the most important for this species. Only limited spawning activity was reported downstream from RM 273 (Waples et al. 1991a), about 1 mile upstream of Oxbow Dam. Since then, irrigation and hydrosystem projects on the mainstem Snake River have blocked access to or inundated much of this habitat—causing the fish to seek out less preferable spawning grounds wherever they are available. Natural fall chinook salmon spawning now occurs primarily in the Snake River below Hells Canyon Dam and the lower reaches of the Clearwater, Grand Ronde, Salmon, and Tucannon rivers.

Adult SR fall chinook salmon enter the Columbia River in July and migrate into the Snake River from August through October. Fall chinook salmon generally spawn from October through November, and fry emerge from March through April. Downstream migration generally begins within several weeks of emergence (Becker 1970, Allen and Meekin 1973), and juveniles rear in backwaters and shallow water areas through mid-summer before smolting and migrating to the ocean—thus they exhibit an ocean-type juvenile history. Once in the ocean, they spend 1 to 4 years (though usually, 3 years) before beginning their spawning migration. Fall returns in the Snake River system are typically dominated by 4-year-old fish. For detailed information on SR fall chinook salmon, see NMFS (1991a) and June 27, 1991, 56 FR 29542.

No reliable estimates of historical abundance are available. Because of their dependence on mainstem habitat for spawning, however, fall chinook salmon probably have been affected by the development of irrigation and hydroelectric projects to a greater extent than any other species of salmon. It has been estimated that the mean number of adult SR fall chinook salmon declined from 72,000 in the 1930s and 1940s to 29,000 during the 1950s. Despite this decline, the Snake River remained the most important natural production area for fall chinook salmon in the entire Columbia River basin through the 1950s. The number of adults counted at the uppermost Snake River mainstem dams averaged 12,720 total spawners from 1964 to 1968, 3,416 spawners from 1969 to 1974, and 610 spawners from 1975 to 1980 (Waples et al. 1991b).

Counts of natural-origin adult fish continued to decline through the 1980s, reaching a low of 78 individuals in 1990 (Table C-5). Since then, the return of natural-origin fish to Lower Granite Dam has varied, but has generally increased, reaching a recent year high of 797 in 1997. The 1998 return declined to 306. This was not anticipated and is of particular concern because it is close to the low threshold escapement level of 300 that indicates increased risk (BRWG 1994). The low return in 1998 may have been due to severe flooding in 1995 that affected the primary

contributing brood year. The expected return of natural-origin adults to Lower Granite Dam in 1999 given the anticipated ocean and inriver fisheries is 518.

The recovery standard identified in the 1995 Proposed Recovery Plan (NMFS 1995) for SR fall chinook salmon was a population of at least 2,500 naturally produced spawners (to be calculated as an 8-year geometric mean) in the lower Snake River and its tributaries. Before the adult counts at Lower Granite Dam can be compared to the natural spawner escapement, adults that may fall back below the dam after counting must be accounted for, as well as prespawning mortality. A preliminary estimate suggested that a Lower Granite Dam count of 4,300 would be necessary to meet the 2,500-fish escapement goal (NMFS 1995). For comparison, the geometric mean of the Lower Granite Dam counts of natural-origin fall chinook salmon over the last 8 years is 481.

A further consideration regarding the status of SR fall chinook salmon is the existence of the Lyons Ferry Hatchery stock which is considered part of the ESU. Several hundred adults have returned to the Lyons Ferry Hatchery in recent years (Table C-5). More recently, supplementation efforts designed to accelerate rebuilding were initiated, beginning with smolt outplants from the 1995 brood year. The existence of the Lyons Ferry program has been an important consideration in evaluating the status of the ESU, because it reduces the short-term risk of extinction by providing a reserve of fish from the ESU. Without the hatchery program, the risk of extinction would have to be considered high because the ESU would otherwise be comprised of a few hundred individuals from a single population, in marginal habitat, with a demonstrated record of low productivity. Although the supplementation program probably contributes to the future population of natural-origin spawners, it does little to change the productivity of the system upon which a naturally spawning population must rely. Supplementation is, therefore, not a long-term substitute for recovery. [See NMFS 1999b for further discussion of the SR fall chinook salmon supplementation program.]

Recent analyses conducted through the PATH process considered the prospects for survival and recovery given several future management options for the hydrosystem and other mortality sectors (Marmorek et al. 1998, Peters et al. 1999). That analysis indicated that the prospects of survival for SR fall chinook salmon were good, but that full recovery was relatively unlikely except under a very limited range of assumptions, or unless drawdown was implemented for at least the four lower Snake River dams operated by the U.S. Army Corps of Engineers (Corps). Consideration of the drawdown options led to a high likelihood that both survival and recovery objectives could be achieved.

For the SR fall chinook salmon ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[4] ranges from 0.94 to 0.86, decreasing as the

[4] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1996 adult returns. Population trends are projected under the assumption that all conditions will stay the same into the future.

Table C-5. Escapement and stock composition of fall chinook salmon at Lower Granite (LGR) Dam[1].

Year	LGR Dam Count	Marked Fish to Lyons Ferry Hatch.	LGR Dam Escapement	Stock Comp. of Escapement to LGR		
					Hatchery Origin	
				Wild	Snake R.	Non-Snake R.
1975	1,000		1,000	1,000		
1976	470		470	470		
1977	600		600	600		
1978	640		640	640		
1979	500		500	500		
1980	450		450	450		
1981	340		340	340		
1982	720		720	720		
1983	540		540	428	112	
1984	640		640	324	310	6
1985	691		691	438	241	12
1986	784		784	449	325	10
1987	951		951	253	644	54
1988	627		627	368	201	58
1989	706		706	295	206	205
1990	385	50	335	78	174	83
1991	630	40	590	318	202	70
1992	855	187	668	549	100	19
1993	1,170	218	952	742	43	167
1994	791	185	606	406	20	180
1995	1,067	430	637	350	1	286
1996	1,308	389	919	639	74	206
1997	1,451	444	1,007	797	20	190
1998	1,909	947	962	306	479	177
1999[2]	3,381	1,519	1,862	905	882	75

[1] Information taken from *Revised Tables for the Biological Assessment of Impacts of Anticipated 1996-1998 Fall Season Columbia River Mainstem and Tributary Fisheries on SR Salmon Species Listed Under the Endangered Species Act*, prepared by the U.S. v. Oregon Technical Advisory Committee.

[2] Source: Memorandum from Glen Mendel (WDFW) to Cindy LeFluer (WDFW), dated March 3, 2000. "Fall chinook run reconstruction at LGR for 1999."

effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated the risk of absolute extinction for the aggregate SR fall chinook salmon population, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years is 0.40 (Table B-5 in McClure et al. 2000b). At the high end, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years is 1.00 (Table B-6 in McClure et al. 2000b).

C.4.1.3 Upper Columbia River Spring-Run Chinook Salmon

The UCR spring-run chinook salmon ESU inhabits tributaries upstream from the Yakima River to Chief Joseph Dam. UCR spring-run chinook salmon have a stream-type life history. Adults return to the Wenatchee River from late March through early May, and to the Entiat and Methow rivers from late March through June. Most adults return after spending 2 years in the ocean, although 20% to 40% return after 3 years at sea. Like SR spring/summer chinook salmon, UCR spring-run chinook salmon experience very little ocean harvest. Peak spawning for all three populations occurs from August to September. Smolts typically spend 1 year in freshwater before migrating downstream. There are slight genetic differences between this ESU and others containing stream-type fish, but more importantly, the ESU boundary was defined using ecological differences in spawning and rearing habitat (Myers et al. 1998). The Grand Coulee Fish Maintenance Project (1939 through 1943) may have had a major influence on this ESU because fish from multiple populations were mixed into one relatively homogenous group and redistributed into streams throughout the upper Columbia region.

Three independent populations of spring-run chinook salmon are identified for the ESU including those that spawn in the Wenatchee, Entiat, and Methow basins (Ford et al. 1999). The number of natural-origin fish returning to each subbasin is shown in Table C-6. NMFS recently proposed interim recovery abundance levels and cautionary levels (i.e., interim levels still under review and subject to change). Ford et al. (1999) characterize cautionary levels as abundance levels that the population fell below only about 10% of the time during a historical period when it was considered to be relatively healthy. Escapements for UCR spring-run chinook salmon have been substantially below the cautionary levels in recent years, especially during 1995, indicating increasing risk to and uncertainty about the population's future status. On the other hand, preliminary returns for 1999, the primary return year for the 1995 brood, indicate that although they were low, returns were still substantially higher than the estimated cohort replacement level. Very strong 1999 jack returns suggest that survival rates for the 1996 brood will be high, as well. A total of 4,500 natural-origin UCR spring-run chinook salmon is expected to return to the mouth of the Columbia River during 2000 with a corresponding number expected to return to each subbasin (accounting for expected harvest, inter-dam loss, and prespawning mortality) at approximately its respective cautionary level (Table C-6).

Table C-6. Estimates of the number of natural-origin fish returning to subbasins for each independent population of UCR spring-run chinook salmon and preliminary interim recovery abundance and cautionary levels.

Year	Wenatchee River[1]	Entiat River	Methow River
1979	1,154	241	554
1980	1,752	337	443
1981	1,740	302	408
1982	1,984	343	453
1983	3,610	296	747
1984	2,550	205	890
1985	4,939	297	1,035
1986	2,908	256	778
1987	2,003	120	1,497
1988	1,832	156	1,455
1989	1,503	54	1,217
1990	1,043	223	1,194
1991	604	62	586
1992	1,206	88	1,719
1993	1,127	265	1,496
1994	308	74	331
1995	50	6	33
1996	201	28	126
1997	422	69	247
1998	218	52	125
1999	119	64	73
Recovery Abundance	**3,750**	**500**	**2,000**
Cautionary Abundance	**1,200**	**150**	**750**

Source: Cooney (2000)
[1] Estimates for the Wenatchee River exclude Icicle Creek/Leavenworth NFH.

Six hatchery populations are included in the listed ESU; all six are considered essential for recovery. Recent artificial production programs for fishery enhancement and hydrosystem mitigation have been a concern because a non-native (Carson Hatchery) stock was used. However, programs have been initiated to develop locally adapted brood stocks to supplement natural populations. Facilities where problems with straying and interactions with natural stock are known to occur are phasing out use of Carson stock. Captive broodstock conservation programs are under way in Nason Creek and White River (the Wenatchee basin) and in the Twisp River (Methow basin) to prevent the extinction of those spawning populations. All spring chinook salmon passing Wells Dam in 1996 and 1998 were trapped and brought into the hatchery to begin a composite-stock broodstock supplementation program for the Methow basin.

For the UCR spring chinook salmon ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[5] ranges from 0.85 to 0.83, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated median population growth rates and the risk of absolute extinction for the three spawning populations identified by Ford et al. (1999), using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years ranges from 0.97 for the Methow River to 1.00 for the Methow and Entiat rivers (Table B-5 in McClure et al. 2000b). At the high end, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of extinction within 100 years is 1.00 for all three spawning populations (Table B-6 in McClure et al. 2000b).

NMFS has also used population risk assessments for UCR spring chinook salmon and steelhead ESUs from the draft quantitative analysis report (QAR; Cooney 2000). Risk assessments described in that report were based on Monte Carlo simulations with simple spawner/spawner models that incorporate estimated smolt carrying capacity. Population dynamics were simulated for three separate spawning populations in the UCR spring chinook salmon ESU, the Wenatchee, Entiat, and Methow populations. The QAR assessments showed extinction risks for UCR spring chinook salmon of 50% for the Methow, 98% for the Wenatchee, and 99% for the Entiat spawning populations. These estimates are based on the assumption that the median return rate for the 1980 brood year to the 1994 brood year series will continue into the future.

C.4.1.4 Upper Willamette River Chinook Salmon

UWR chinook salmon are one of the most distinct groups in the Columbia basin — genetically, in terms of age structure, and in terms of their marine distribution (64 FR 14322). The narrow time window available for passage above Willamette Falls (at Willamette RKm 42) may have

[5] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1998 adult returns. Population trends are projected under the assumption that all conditions will stay the same into the future.

limited migratory access to the upper basin to spring periods of high flow (Howell et al. 1985), providing reproductive isolation and, thereby, defining the boundary of a distinct biogeographic region. Winter steelhead and spring chinook salmon were indigenous above the falls, but summer steelhead, fall chinook salmon, and coho salmon were not (Busby et al. 1996). Because the Willamette Valley was not glaciated during the last epoch (McPhail and Lindsey 1970), any reproductive isolation provided by the falls would have been uninterrupted for a considerable time, providing the potential for significant local adaptation relative to other Columbia basin populations.

The life history of chinook salmon in the Upper Willamette River ESU includes traits from both ocean- and stream-type development strategies: smolts emigrate both as young-of-the-year and as age-1 fish. Mattson (1962) reported three distinct migrations of juvenile spring chinook salmon in the lower Willamette River (Lake Oswego area), including movements of a given year class during late winter through spring (age-0 migrants; 40 to 100 mm), late fall-early winter (age-1 fish; 100 to 130 mm), and then during the following spring (age-2 fish; 100 to 140 mm). Smolt and fry migration patterns at Leaburg Dam in the McKenzie River appear to have shifted over the years; samples collected between 1948 and 1968 indicated that fry emigrated primarily during March through June (Howell et al. 1988) but now peak during January through April (earlier than in previous years) (Corps 2000). Distribution in the ocean is consistent with an ocean-type life history (most are caught off the coasts of British Columbia and Southeast Alaska).

Historically, five major basins produced spring chinook salmon: the Clackamas, North and South Santiam, McKenzie, and Middle Fork Willamette rivers. However, between 1952 and 1968, dams were built on all of the major tributaries occupied by spring chinook salmon, blocking over half of the most productive spawning and rearing habitat. Water management operations have also reduced habitat quality in downstream areas due to thermal effects (relatively warm water released during autumn leads to the early emergence of stream-type chinook salmon fry, and cold water released during spring reduces juvenile growth rates).

Spring chinook salmon on the Clackamas River were unable to reach the upper watershed after 1917, when the fish ladder washed out at Faraday Dam, but recolonized the system after 1939, when the ladder was repaired. NMFS has not been able to determine whether the recolonization of the Clackamas system was human-mediated. Regardless, NMFS included natural-origin spring chinook salmon from the Clackamas subbasin as part of the listed ESU and considers this spawning population a potentially important genetic resource for recovery.

Information ODFW (1998c) provided indicates that, at present, the only significant natural production of spring chinook salmon above Willamette Falls occurs in the McKenzie River basin. Nicholas (1995) also suggested that a self-sustaining population exists in the North Santiam River basin (BRT 1998), but ODFW contends that the thermal profile of water released from Detroit Dam significantly reduces the survival of any progeny from naturally spawning fish (64 FR 14308). The McKenzie River may now account for 50% of the production potential in

the Willamette River basin, with 80% of that above Leaburg Dam. The number of natural-origin fish counted at Leaburg Dam increased from 786 in 1994 to 1,364 in 1998 (Table C-7).

The Clackamas River currently accounts for about 20% of the production potential in the Willamette River basin, originating from one hatchery plus natural production areas that are primarily located above the North Fork Dam. The interim escapement goal for the area above North Fork Dam is 2,900 fish (ODFW 1998b). However, the system is so heavily influenced by hatchery production that it is difficult to distinguish spawners of natural stock from hatchery origin fish. Approximately 1,000 to 1,500 adults have been counted at the North Fork Dam in recent years.

More than 70% of the production capacity of the North Santiam system was blocked when Detroit Dam was built without passage facilities. The remaining downstream habitat is adversely affected by the temperature effects (i.e., warm water) of flow regulation. This system has also been substantially influenced by hatchery production, although the original genetic resource has been maintained as the Marion Forks Hatchery stock (ODFW 1998b). Despite these limitations, natural spawning continues in the lower river. The count of 194 redds in the area below Minto Dam (the lowest dam) during 1998 was marginally higher than during either of the preceding 2 years (Lindsay et al. 1998). The origin of these spawning adults has not been determined (although some coded-wire-tagged fish from Santiam River hatcheries have been recovered), nor has their reproductive success.

Mitigation hatcheries were built to offset the substantial habitat losses that resulted from dam construction. As a result, 85% to 95% of the production in the basin is now of hatchery origin. Although the hatchery programs have maintained broodlines that are relatively free of genetic influences from outside the basin, they may have homogenized within-basin stocks, reducing the population structure within the ESU. Prolonged artificial propagation of most of the production from this ESU may also have reduced the ability of Willamette River spring chinook salmon to reproduce successfully in the wild. Five of six existing hatchery stocks were included in the ESU, but none was listed or considered essential for recovery.

The spring run has been counted at Willamette Falls since 1946, but jacks were not differentiated from the total count until 1952. The geometric mean of the estimated run size from 1946 through 1950 was 43,300 fish, compared to an estimate for the most recent 5 years (1994 through 1998) of 25,500 (Table 22 in ODFW and WDFW 1999 and Table C-7). Nicholas (1995) estimated only 3,900 natural spawners in 1994 for the ESU, approximately 1,300 of these naturally produced. The number of naturally spawning fish has increased gradually in recent years, but NMFS believes that many are first-generation hatchery fish.

Table C-7. Run size of spring chinook salmon at the mouth of the Willamette River and counts at Willamette Falls and Leaburg Dam on the McKenzie River.

Return Year	Estimated Number Entering Willamette River	Willamette Falls Count	Leaburg Dam Count	
			Combined	Wild Only
1985	57,100	34,533	825	
1986	62,500	39,155	2,061	
1987	82,900	54,832	3,455	
1988	103,900	70,451	6,753	
1989	102,000	69,180	3,976	
1990	106,300	71,273	7,115	
1991	95,200	52,516	4,359	
1992	68,000	42,004	3,816	
1993	63,900	31,966	3,617	
1994	47,200	26,102	1,526	786
1995	42,600	20,592	1,622	894
1996	34,600	21,605	1,445	1,086
1997	35,000	26,885	1,176	981
1998	45,100	34,461	1,874	1,364
1999	58,000	40,410	1,458	1,416
2000		37,594		

Sources: Nicholas (1995) and ODFW and WDFW (1998); Willamette Falls count for 2000 from ODFW (2000). The Leaburg counts show wild and hatchery counts combined since 1985 and wild counts only since 1994. Estimates for 1999 are preliminary.

For the UWR chinook salmon ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[6] ranges from 1.01 to 0.63, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated the risk of absolute extinction for the aggregate UWR chinook salmon population in the McKenzie River, above Leaburg, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years is 0.01 (Table B-5 in

[6] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1998 adult returns. Population trends are projected under the assumption that all conditions will stay the same into the future.

McClure et al. 2000b). At the high end, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years is 0.85 (Table B-6 in McClure et al. 2000b).

C.4.1.5 Lower Columbia River Chinook Salmon

The LCR chinook salmon ESU includes spring stocks as well as fall tule and bright components. Spring-run chinook salmon on the lower Columbia River, like those from coastal stocks, enter freshwater in March and April, well in advance of spawning in August and September. Historically, the spring migration was synchronized with periods of high rainfall or snowmelt to provide access to upper reaches of most tributaries, where spring stocks would hold until spawning (Fulton 1968, Olsen et al. 1992, WDF et al. 1993b).

Fall chinook salmon predominate in the lower Columbia River salmon runs. Tule-type fall chinook salmon return to the river in mid-August and spawn within a few weeks (WDF et al. 1993b, Kostow 1995). Most fall-run chinook salmon emigrate to the marine environment as subyearlings (Reimers and Loeffel 1967, Howell et al. 1985, WDF et al. 1993b). Returning adults that emigrated as yearling smolts may have originated from the extensive hatchery programs within the ESU. It is also possible that modifications in the river environment have altered the duration of freshwater residence. Adult fall-run tule chinook salmon return to tributaries in the lower Columbia River at 3 and 4 years of age compared to 4 to 5 years for bright chinook salmon and spring-run fish. Marine coded-wire-tag recoveries for LCR stocks tend to occur off the British Columbia and Washington coasts, although a small proportion of the tags are recovered in Alaskan waters.

There are no reliable estimates of historical abundance for this ESU as early as the beginning of the last century, but it is generally agreed that natural production has been greatly reduced. Recent abundance estimates include a 5-year (1991 through 1995) geometric mean natural spawning escapement of 29,000 natural spawners and 37,000 hatchery spawners. However, according to the accounting of PFMC (1996), approximately 68% of the natural spawners are first-generation hatchery strays.

Hatchery programs to enhance chinook salmon fisheries in the lower Columbia River began in the 1870s, expanded rapidly, and have continued throughout this century. Although most hatchery stocks have come from within this ESU, more than 200 million fish from outside the ESU have been released since 1930. A particular concern noted at the time of listing related to straying by Rogue River fall-run chinook salmon, which are released into the lower Columbia River to augment harvest. The release strategy has since been modified to minimize straying, but it is too early to assess the effect of the change. Available evidence indicates a pervasive influence of hatchery fish on most natural populations of LCR chinook salmon, including both spring- and fall-run populations (Howell et al. 1985, Marshall et al. 1995). In addition, the exchange of eggs between hatcheries in this ESU has led to the extensive genetic homogenization of hatchery stocks (Utter et al. 1989).

The remaining spring-run chinook salmon stocks in the LCR chinook salmon ESU are found in the Sandy River, Oregon, and the Lewis, Cowlitz, and Kalama rivers, Washington. Spring chinook salmon in the Clackamas River are considered part of the UWR chinook salmon ESU. Despite the substantial influence of fish from hatcheries in the Upper Willamette River ESU in past years, naturally spawning spring chinook salmon in the Sandy River are included in the LCR chinook salmon ESU because they probably contain the remainder of the original genetic legacy for that system. Recent escapements above Marmot Dam on the Sandy River average 2,800 and have been increasing (ODFW 1998a). Hatchery-origin spring chinook salmon are no longer released above Marmot Dam; the proportion of first generation hatchery fish in the escapement is relatively low, on the order of 10% to 20% in recent years. In 1999, the escapement dropped to 1,828 fish, in part because only unmarked naturally produced fish were passed over Marmot Dam (Schroeder et al. 1999).

On the Washington side, spring chinook salmon were native to the Cowlitz and Lewis rivers and there is anecdotal evidence that a distinct spring run existed in the Kalama River subbasin (WDF 1951). The Lewis River spring run was severely affected by dam construction. During the period between the construction of Merwin Dam in 1932 and Yale Dam in the early 1950s, WDF attempted to maintain the run by collecting adults at Ariel/Merwin for hatchery propagation or (in years when returns were in excess of hatchery needs) release to the spawning grounds (WDF 1951). As native runs dwindled, Cowlitz spring-run chinook salmon were reintroduced in an effort to maintain them. In the Kalama River, escapements of less than 100 fish were present until the early 1960s when spring-run hatchery production was initiated with a number of stocks from outside the basin. Recent (1994 through 1998) average estimates for naturally spawning spring chinook salmon are 235, 224, and 372 fish in the Cowlitz, Kalama, and Lewis rivers, respectively. Some (perhaps a large) proportion of the natural spawners in each system is believed to be composed of hatchery strays (ODFW 1998a). Although, the Lewis and Kalama hatchery stocks have been mixed with out-of-basin stocks, they are included in the ESU. The Cowlitz River hatchery stock is largely free of introductions. Although it is considered essential for recovery, it is not listed because the state of Washington's hatchery and harvest practices are considered sufficiently protective of this stock to ensure that their future existence and value for recovery are not at risk (64 FR 14321). Spring chinook salmon returning to the Cowlitz, Kalama, and Lewis rivers have declined in recent years, but they still number several hundred to a few thousand in each system (Table C-8).

Apparently, three self-sustaining natural populations of tule chinook salmon that are not substantially influenced by hatchery strays occur in the lower Columbia River (Coweeman, East Fork Lewis, and Clackamas). Returns to the East Fork and Coweeman have been stable and near interim escapement goals in recent years. Recent 5- and 10-year average escapements to the East Fork Lewis River met the interim escapement goal of 300. Recent 5- and 10-year average escapements to the Coweeman River are 900 and 700, respectively, compared to an interim natural escapement goal of 1,000 (pers. comm., from G. Norman, WDFW to P. Dygert NMFS, February 22, 1999). Natural escapement on the Clackamas has averaged about 350 in recent years. There have been no releases of hatchery fall chinook salmon in the Clackamas since 1981,

and there are apparently few hatchery strays. The population is considered depressed, but stable and self-sustaining (ODFW 1998a). There is some natural spawning of tule fall chinook salmon in the Wind and Little White Salmon rivers, tributaries above Bonneville Dam (the only component of the ESU that is affected by Tribal fisheries). Although there may be some natural production in these systems, the spawners are primarily hatchery-origin strays.

LCR bright fall chinook salmon escapement to the North Fork Lewis River exceeded the escapement goal of 5,700 by a substantial margin every year from the 1970s until 1978. However, runs have been declining and, probably combined with the effect of the 1996 and 1997 floods on habitat, the 1999 return was low (about 2,300). A return of 2,700 is forecast for 2000 (PFMC 2000).

There are two smaller populations of LCR bright fall chinook salmon in the Sandy and East Fork Lewis rivers. Run sizes in the Sandy River have averaged about 1,000 and have been stable for the last 10 to 12 years. The fall chinook salmon hatchery program in the Sandy River was discontinued in 1977, with the intention of reducing the number of hatchery strays in the system. There is also a late spawning component in the East Fork Lewis River that is comparable in timing to the other bright stocks. The escapement of these fish is not as well documented, but it appears to be stable and largely unaffected by hatchery fish (ODFW 1998b).

All basins in the region are affected by habitat degradation to varying degrees. Major habitat problems are related primarily to blockages, forest practices, urbanization in the Portland and Vancouver areas, and agriculture in floodplains and low-gradient tributaries. Substantial chinook salmon spawning habitat has been blocked (or passage has been substantially impaired) in the Cowlitz (Mayfield Dam 1963, Rkm 84), Lewis (Merwin Dam 1931, Rkm 31), Clackamas (North Fork Dam 1958, Rkm 50), Hood (Powerdale Dam 1929, Rkm 7), and Sandy (Marmot Dam 1912, Rkm 48; Bull Run River dams in the early 1900s) rivers (WDF et al. 1993b, Kostow 1995).

For the LCR chinook salmon ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[7] ranges from 0.98 to 0.88, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS estimated the risk of absolute extinction for nine spawning aggregations,[8] using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years ranges from zero for the Sandy River late run and Big Creek to 1.00 for Mill Creek (Table B-5 in McClure et al. 2000b). At the high end, assuming that the hatchery fish

[7] Estimates of median population growth rate, risk of extinction, and likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1997 adult returns for most spawning aggregations. Population trends are projected under the assumption that all conditions will stay the same into the future.

[8] McClure et al. (2000c) have calculated population trend parameters for additional LCR chinook salmon stocks.

spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years is ≥0.99 for all but one of the nine spawning aggregations (zero for the Sandy River late run; Table B-6 in McClure et al. 2000b).

Table C-8. Estimated returns of adult LCR spring-run chinook salmon to tributaries, 1992 through 1999.

Year	Sandy River	Cowlitz River	Lewis River	Kalama River	Total Returns (Excluding Willamette)
1992	8,600	10,400	5,600	2,400	27,200
1993	6,400	9,500	6,600	3,000	25,500
1994	3,500	3,100	3,000	1,300	10,900
1995	2,500	2,200	3,700	700	9,100
1996	4,100	1,800	1,700	600	8,200
1997	5,200	1,900	2,200	600	9,900
1998	4,300	1,100	1,600	400	7,400
1999		1,600	1,900	600	

Source: Pettit 1998, ODFW and WDFW 1999

C.4.2 Steelhead

C.4.2.1 Snake River Steelhead

The longest consistent indicator of steelhead abundance in the Snake River basin is derived from counts of natural-origin steelhead at the uppermost dam on the lower Snake River. According to these estimates, the abundance of natural-origin summer steelhead at the uppermost dam on the Snake River has declined from a 4-year average of 58,300 in 1964 to a 4-year average of 8,300 ending in 1998. In general, steelhead abundance declined sharply in the early 1970s, rebuilt modestly from the mid-1970s through the 1980s, and declined again during the 1990s (Figure C-1).

These broad-scale trends in the abundance of steelhead were reviewed through the PATH process. The PATH report indicated that the initial, substantial decline coincided with the declining trend in downstream passage survival through the Federal hydrosystem. The more recent decline in abundance, observed over the last decade or more, does not coincide with declining passage survival, but can be at least partially be accounted for by a shift in climatic regimes that has affected ocean survival (Marmorek 1998).

The abundance of A-run versus B-run components of Snake River basin steelhead can be distinguished in data collected since 1985. Both components have declined through the 1990s,

but the decline of B-run steelhead has been more significant. The 4-year average counts at Lower Granite Dam declined from 18,700 to 7,400 beginning in 1985 for A-run steelhead and from 5,100 to 900 for B-run steelhead. Counts over the last 5 or 6 years have been stable for A-run steelhead and without apparent trend (Figure C-2). Counts for B-run steelhead have been low and highly variable, but also without apparent trend (Figure C-3).

Comparison of recent dam counts with escapement objectives provides perspective regarding the status of the ESU. The management objective for SR steelhead stated in the Columbia River Fisheries Management Plan was to return 30,000 natural/wild steelhead to Lower Granite Dam. The All Species Review (TAC 1997) further clarified that this objective was subdivided into 20,000 A-run and 10,000 B-run steelhead. Idaho has reevaluated these escapement objectives using estimates of juvenile production capacity. This alternative methodology led to revised estimates of 22,000 for A-run and 31,400 for B-run steelhead (pers. comm., S. Keifer, IDFG. with P. Dygert, NMFS).

The state of Idaho has conducted redd count surveys in all of the major subbasins since 1990. Although the surveys are not intended to quantify adult escapement, they can be used as indicators of relative trends. The sum of redd counts in natural-origin B-run production subbasins declined from 467 in 1990 to 59 in 1998 (Figure C-4). The declines are evident in all four of the primary B-run production areas. Index counts in the natural-origin A-run production areas have not been conducted with enough consistency to permit similar characterization.

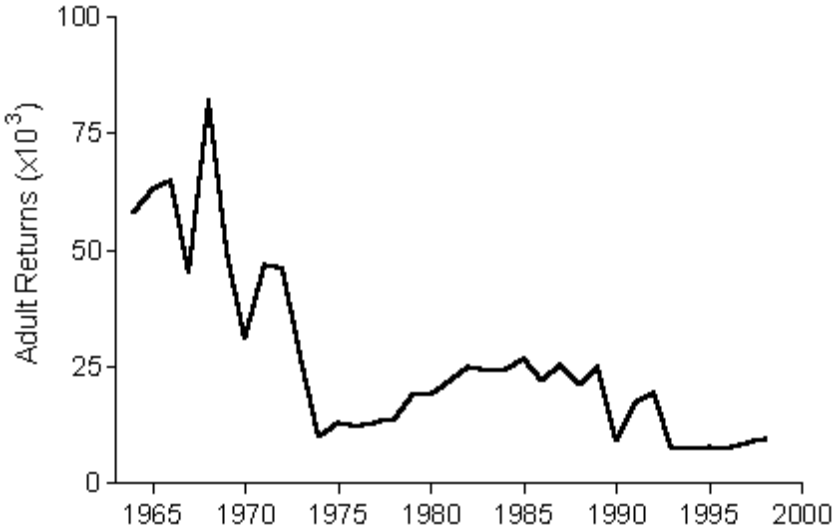
Idaho has also conducted surveys for juvenile abundance in index areas throughout the Snake River basin since 1985. Parr densities of A-run steelhead have declined from an average of about 75% of carrying capacity in 1985 to an average of about 35% in recent years through 1995 (Figure C-5). Further declines were observed in 1996 and 1997. Parr densities of B-run steelhead have been low, but relatively stable since 1985, averaging 10% to 15% of carrying capacity through 1995. Parr densities in B-run tributaries declined further in 1996 and 1997 to 11% and 8%, respectively.

The available data indicate that B-run steelhead are much more depressed than A-run steelhead. In evaluating the status of the SR basin steelhead ESU it is pertinent to consider whether B-run steelhead represent a significant portion of the ESU. This is particularly relevant for two reasons:

1) The Tribes have proposed to manage the SR basin steelhead ESU as a whole without distinguishing between components

2) This management scenario is inconsistent with NMFS' authority to manage for components of an ESU.

Figure C-1. Adult returns of wild summer steelhead to the uppermost dam on the Snake River.



Source: Escapement through 1995 from TAC (1997); escapement for 1996–1998 from pers. comm. G. Mauser (IDFG).

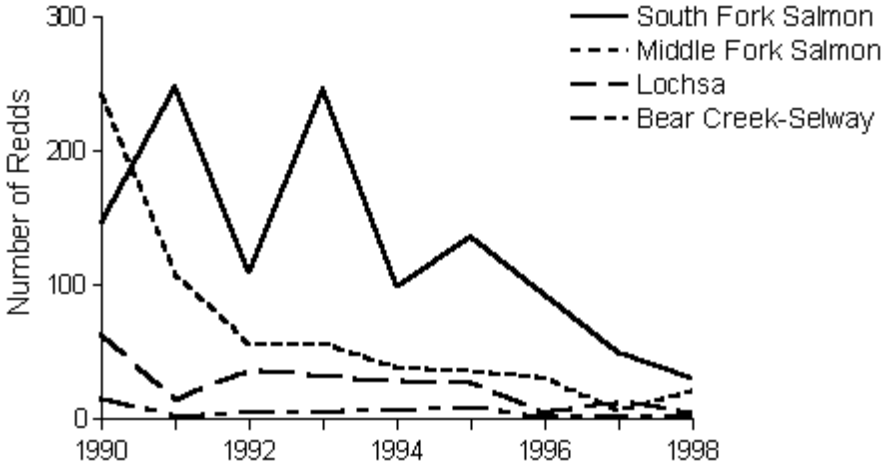
Figure C-2. Escapement of A-run Snake River steelhead to the uppermost dam.

Source: Data for 1980 through 1984 from Figures 1 and 2 of Section 8 in TAC (1997). Data for 1985 through 1998 from Table 2 of Section 8 (TAC 1997) and pers. comm. G. Mauser, IDFG.

Figure C-3. Escapement of B-run Snake River steelhead to the uppermost dam.

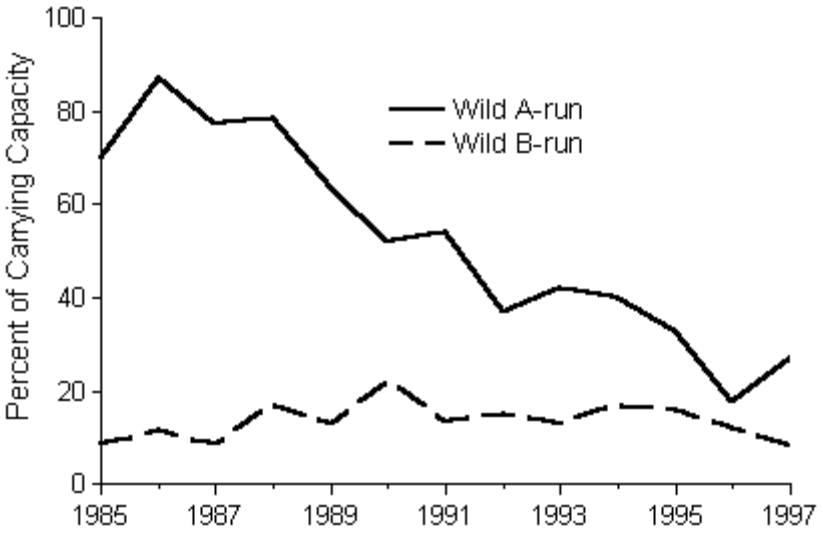
Source: Data for 1980 through 1984 from Figures 1 and 2 of Section 8 in TAC (1997). Data for 1985 through 1998 from Table 2 of Section 8 (TAC 1997) and pers. comm. G. Mauser, IDFG.

Figure C-4. Redd counts for wild Snake River (B-run) steelhead in the South Fork and Middle Fork Salmon, Lochsa, and Bear Creek-Selway index areas.



Note: Data for the Lochsa exclude Fish Creek and Crooked Fork.
Sources: Memo from T. Holubetz (IDFG), "1997 Steelhead Redd Counts," dated May 16, 1997, and IDFG (unpubl. data).

Figure C-5. Percent of estimated carrying capacity for juvenile (age-1+ and -2+) wild A- and B-run steelhead in Idaho streams.



Source: Data for 1985 through 1996 from Hall-Griswold and Petrosky (1998); data for 1997 from IDFG (unpublished).

The Snake River historically supported more than 55% of total natural-origin production of steelhead in the Columbia basin. It now has approximately 63% of the basin's natural production potential (Mealy 1997). B-run steelhead occupy four major subbasins, including two on the Clearwater River (Lochsa and Selway) and two on the Salmon River (Middle Fork and South Fork Salmon), areas that are for the most part not occupied by A-run steelhead. Some natural B-run steelhead are also produced in parts of the mainstem Clearwater and its major tributaries. There are alternative escapement objectives of 10,000 Columbia River Fisheries Management Plan and 31,400 (Idaho) for B-run steelhead. B-run steelhead, therefore, represent at least 1/3 and as much as 3/5 of the production capacity of the ESU.

B-run steelhead are distinguished from the A-run component by their unique life history characteristics. B-run steelhead were traditionally distinguished as larger and older fish with a later run timing, returning primarily to the South Fork Salmon, Middle Fork Salmon, Selway, and Lochsa rivers. The recent review by Technical Advisory Committee indicated that different populations of steelhead do have different size structures, with populations dominated by larger fish (i.e., greater than 77.5 cm) occurring in the traditionally defined B-run basins (TAC 1999). Larger fish occur in other populations throughout the basin, but at much lower rates. Evidence suggests that fish returning to the Middle Fork Salmon and Little Salmon have a more equal distribution of large and small fish.

B-run steelhead also are generally older. A-run steelhead are predominately 1-ocean fish, whereas most B-run steelhead generally spend 2 or more years in the ocean before spawning.

The differences in ocean age are primarily responsible for the differences in the size of A- and B-run steelhead. However, B-run steelhead are also thought to be larger at any given age than A-run fish. This may be due, at least in part, to the fact that B-run steelhead leave the ocean later in the year than A-run steelhead and thus have an extra month or more of ocean residence when growth rates are thought to be greatest.

Historically, a distinctly bimodal pattern of freshwater entry could be used to distinguish A-run and B-run fish. A-run steelhead were presumed to cross Bonneville Dam from June to late August, whereas B-run steelhead entered from late August to October. The TAC reviewed the available information on timing and confirmed that most large fish still have a later timing at Bonneville; 70% of the larger fish crossed the dam after August 26, the traditional cutoff date for separating A- and B-run fish (TAC 1999). However, the timing of the early part of the A-run has shifted somewhat later, thereby reducing the distinction that was so apparent in the 1960s and 1970s. The timing of the larger, natural-origin, B-run fish has not changed.

As pointed out above, the geographic distribution of B-run steelhead is restricted to particular watersheds within the Snake River basin (areas of the mainstem Clearwater, Selway, and Lochsa rivers and the South and Middle Forks of the Salmon River). No recent genetic data are available for steelhead populations in the South and Middle Forks of the Salmon River. The Dworshak National Fish Hatchery (NFH) stock and natural populations in the Selway and Lochsa rivers are, thus far, the most genetically distinct populations of steelhead in the Snake River basin (Waples et al. 1993). In addition, the Selway and Lochsa River populations from the Middle Fork Clearwater appear to be very similar to each other genetically, and naturally produced rainbow trout from the North Fork Clearwater River (above Dworshak Reservoir) clearly show an ancestral genetic similarity to Dworshak NFH steelhead. The existing genetic data, the restricted geographic distribution of B-run steelhead in the Snake (Columbia) River basin, and the unique life history attributes of these fish (i.e. larger, older adults with a later distribution of run timing compared to A-run steelhead in other portions of the Columbia River basin) clearly support the conservation of B-run steelhead as a biologically significant component of the Snake River ESU.

NMFS also considers the status of the component populations as an indicator of the status of the ESU. For this purpose, a population is defined as a group of fish of the same species spawning in a particular lake or stream (or portion thereof) at a particular season, which to a substantial degree does not interbreed with fish from any other group spawning in a different place or in the same place during a different season. Because populations as defined here are relatively isolated, it is biologically meaningful to evaluate the risk of extinction of one population independently from any other. Some ESUs may consist of only one population, whereas others will consist of many. The background and guidelines related to the assessment of the status of populations are described in a recent draft report discussing the concept of viable salmonid populations (McElhany et al. 2000).

The task of identifying populations within an ESU requires making judgements based on the available information, including the geography, ecology, and genetics of the ESU. Although NMFS has not compiled and formally reviewed all the available information for this purpose, it is reasonable to conclude that, at a minimum, each of the major subbasins in the ESU represents a population within the context of this discussion. A-run populations would, therefore, include at least the tributaries to the lower Clearwater, the upper Salmon River and its tributaries, the lower Salmon River and its tributaries, the Grand Ronde, Imnaha, and possibly the Snake mainstem tributaries below Hells Canyon Dam. B-run populations would be identified in the Middle Fork and South Fork Salmon rivers, the Lochsa and Selway rivers (major tributaries of the upper Clearwater), and possibly in the mainstem Clearwater River, as well. These basins are, for the most part, large geographical areas, and there probably is additional population structure within at least some of these basins. However, because that hypothesis has not been confirmed, NMFS assumes that there are at least five populations of A-run steelhead and five populations of B-run steelhead in the SR basin steelhead ESU. Escapement objectives for A- and B-run production areas in Idaho, based on estimates of smolt production capacity, are shown in Table C-9.

Table C-9. Adult steelhead escapement objectives based on estimates of 70% smolt production capacity.

A-Run Production Areas		B-Run Production Areas	
Upper Salmon	13,570	Middle Fork Salmon	9,800
Lower Salmon	6,300	South Fork Salmon	5,100
Clearwater	2,100	Lochsa	5,000
Grand Ronde	(1)	Selway	7,500
Imnaha	(1)	Clearwater	4,000
Total	**21,970**	**Total**	**31,400**

Note: comparable estimates are not available for populations in Oregon and Washington subbasins.

Hatchery populations, if genetically similar to their natural-origin counterparts, provide a hedge against extinction of the ESU or the gene pool. The Imnaha and Oxbow hatcheries produce A-run stocks that are currently included in the SR basin steelhead ESU. The Pahsimeroi and Wallowa hatchery stocks may also be appropriate and available for use in developing supplementation programs. In its recent biological opinion on Columbia basin hatchery operations, NMFS required that this program begin to transition to a local-origin broodstock to provide a source for future supplementation efforts in the lower Salmon River (NMFS 1999a). Although other stocks provide more immediate opportunities to initiate supplementation programs within some subbasins, it may also be necessary and desirable to develop additional broodstocks that can be used for supplementation in other natural production areas. Despite uncertainties related to the likelihood that supplementation programs can accelerate the recovery of naturally spawning populations, these hatchery stocks provide a safeguard against the further decline of natural-origin populations.

The Dworshak NFH is unique in the Snake River basin because it produces a B-run hatchery stock. The Dworshak stock was developed from natural-origin steelhead within the North Fork Clearwater River, was largely free of introductions from other areas, and was, therefore, included in the ESU, although not as part of the listed population. However, past hatchery practices and possibly changes in flow and temperature conditions related to Dworshak Dam have led to substantial divergence in spawn timing of the hatchery stock compared to what was observed historically in the North Fork Clearwater River and compared to natural-origin populations in other parts of the Clearwater basin. Because the spawn timing of the hatchery stock is now much earlier than it was historically (Figure C-6), the success of supplementation efforts using these stocks may be limited. In fact, past supplementation efforts in the South Fork Clearwater River using Dworshak NFH stock have been largely unsuccessful, although improvements in out-planting practices have the potential to yield different results. In addition, the unique genetic character of Dworshak NFH steelhead noted above will limit the degree to which the stock can be used for supplementation in other parts of the Clearwater subbasin and particularly in the Salmon River B-run basins. Supplementation efforts in those areas, if undertaken, will more likely have to rely on the future development of local broodstocks. Supplementation opportunities in many of the B-run production areas will be limited in any case because of logistical difficulties in getting to and working in these high mountain wilderness areas. Because opportunities to accelerate the recovery of B-run steelhead through supplementation, even if successful, are expected to be limited, it is essential to maximize the escapement of natural-origin steelhead in the near term.

Finally, the conclusions and recommendations of the Technical Advisory Committee's All Species Review are pertinent to this review of the status of Snake River steelhead. Considering information available through 1996, the 1997 All Species Review stated:

> Regardless of assessment methods for A and B steelhead, it is apparent that the primary goal of enhancing the upriver summer steelhead run is not being achieved. The status of upriver summer steelhead, particularly natural-origin fish, has become a serious concern. Recent declines in all stocks, across all measures of abundance, are disturbing.
>
> There has been no progress toward rebuilding upriver runs since 1987. Throughout the Columbia River basin, dam counts, weir counts, spawning surveys, and rearing densities indicate natural-origin steelhead abundance is declining, culminating in the proposed listing of upriver stocks in 1996. Escapements have reached critically low levels despite the relatively high productivity of natural- and hatchery-rearing environments. Improved flows and ocean conditions should increase smolt-adult survival rates for upriver summer steelhead. However, reduced returns in recent years are likely to produce fewer progeny and lead to continued low abundance.
>
> Although steelhead escapements would have increased (in some years substantially) in the absence of mainstem fisheries, data analyzed by the Technical Advisory Committee indicate that effects other than mainstem Columbia River fishery harvest are primarily responsible for the

> currently depressed status and the long-term health and productivity of wild steelhead populations in the Columbia River.
>
> Though harvest is not the primary cause of declining summer steelhead stocks, and harvest rates have been below guidelines, harvest has further reduced escapements. Before 1990, the aggregate of upriver summer steelhead in the mainstem Columbia River at times appeared to have led to the failure to achieve escapement goals at Lower Granite Dam. Wild Group B steelhead are presently more sensitive to harvest than other salmon stocks, including the rest of the steelhead run, due to their depressed status and because they are caught at higher rates in the Zone 6 fishery.
>
> Small or isolated populations are much more susceptible to stochastic events such as drought and poor ocean conditions. Harvest can further increase the susceptibility of such populations. The Columbia River Fisheries Management Plan recognizes that harvest management must be responsive to run size and escapement needs to protect these populations. The parties should ensure that Columbia River Fisheries Management Plan harvest guidelines are sufficiently protective of weak stocks and hatchery broodstock requirements.

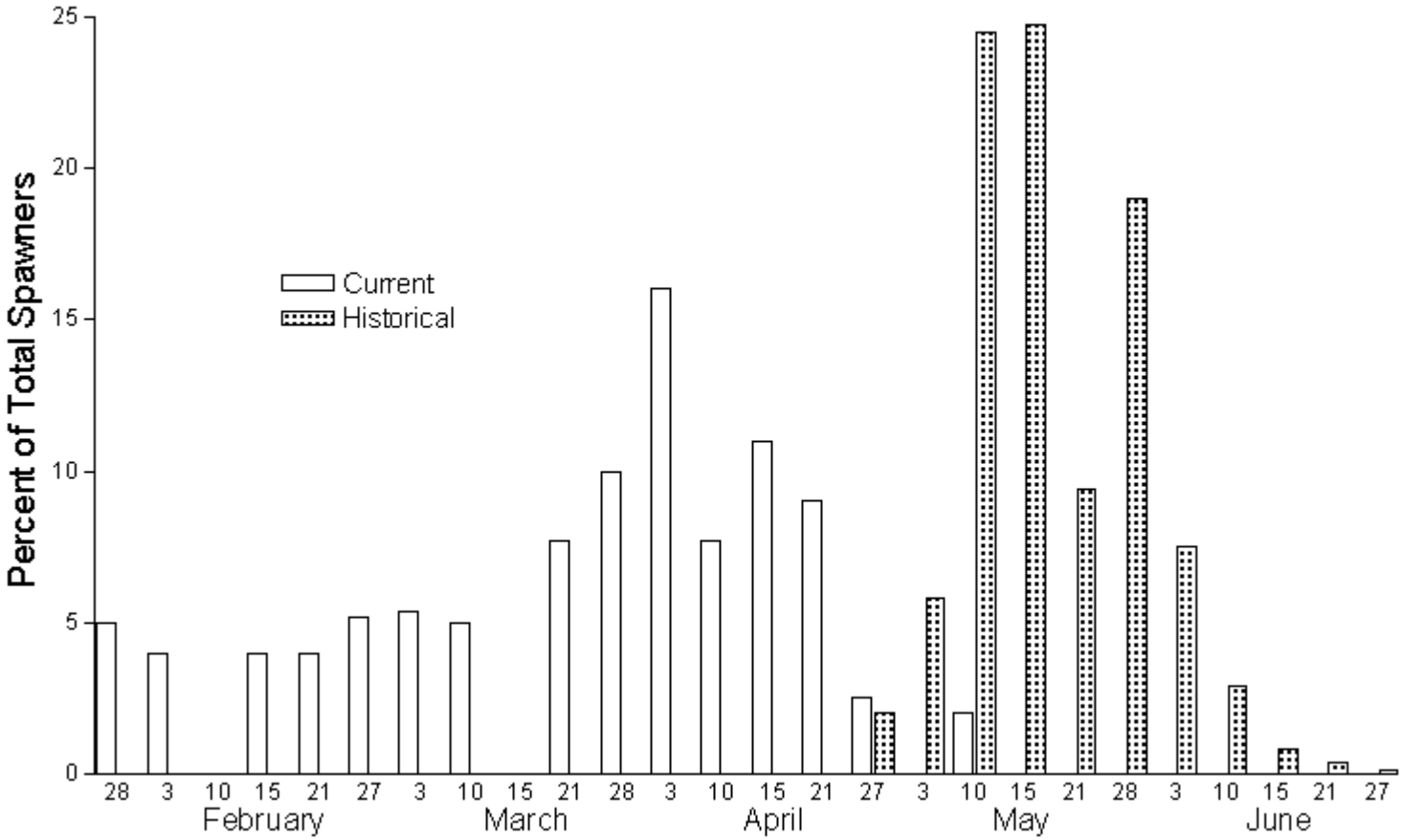
The All Species Review included the following recommendations:

- Develop alternative harvest strategies to better achieve rebuilding and allocation objectives.
- Consider modification of steelhead harvest rate guidelines relative to stock management units and escapement needs.

For the SR steelhead ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[9] ranges from 0.91 to 0.70, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated the risk of absolute extinction for the A- and B-runs, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years is 0.01 for A-run steelhead and 0.93 for B-run fish (Table B-5 in McClure et al. 2000b). At the high end, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years is 1.00 for both runs (Table B-6 in McClure et al. 2000b).

[9] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1997 adult returns. Population trends are projected under the assumption that all conditions will stay the same into the future.

Figure C-6. Historical versus current spawn-timing of steelhead at Dworshak NFH.



C.4.2.2 Upper Columbia River Steelhead

UCR steelhead inhabit the Columbia River reach and its tributaries upstream of the Yakima River. This region includes several rivers that drain the east slopes of the Cascade Mountains and several that originate in Canada (only U.S. populations are included in the ESU). Dry habitat conditions in this area are less conducive to steelhead survival than in many other parts of the Columbia basin (Mullan et al. 1992a). Although the life history of this ESU is similar to that of other inland steelhead, smolt ages are some of the oldest on the West Coast (up to 7 years old), probably due to the ubiquitous cold water temperatures (Mullan et al. 1992b). Adults spawn later than in most downstream populations, remaining in freshwater up to a year before spawning.

Although runs from 1933 through 1959 may have already been affected by fisheries in the lower river, dam counts suggest a pre-fishery run size of more than 5,000 adults above Rock Island Dam. The return of UCR natural-origin steelhead to Priest Rapids Dam declined from a 5-year average of 2,700 beginning in 1986 to a 5-year average of 900 beginning in 1994 (FPC 2000; Table C-10). The escapement goal for natural-origin fish is 4,500. Most current natural production occurs in the Wenatchee and Methow river systems, with a smaller run returning to the Entiat River. Very limited spawning also occurs in the Okanagan River basin. Most of the fish spawning in natural production areas are of hatchery origin. Indications are that natural populations in the Wenatchee, Methow, and Entiat rivers are not self-sustaining.

This entire ESU has been subjected to heavy hatchery influence; stocks became thoroughly mixed as a result of the Grand Coulee Maintenance Project, which began in the 1940s (Fish and Hanavan 1948, Mullan et al. 1992a). Recently, as part of the development of the Mid-Columbia Habitat Conservation Plan (HCP), it was determined that steelhead habitat within the range of the Upper Columbia River ESU was overseeded, primarily due to the presence of Wells Hatchery fish in excess of those collected for broodstock. This would partially explain recent observations of low natural cohort replacement rates (0.3 for populations in the Wenatchee River and no greater than 0.25 for populations in the Entiat River; Bugert 1997). The problem of determining appropriate levels of hatchery output to prevent negative effects on natural production is a subject of analysis and review in the Mid-Columbia Quantitative Analytical Report (Cooney 2000). In the meantime, given these uncertainties, efforts are under way to diversify broodstocks used for supplementation and to minimize the differences between hatchery and natural-origin fish (as well as other concerns associated with supplementation). The best use for the Wells Hatchery program in the recovery process is yet to be defined and should be integrated with harvest activities and recovery measures to optimize the prospects for recovery of the species.

Due to data limitations, the QAR steelhead assessments in Cooney (2000) were limited to two aggregate spawning groups—the Wenatchee/Entiat composite and the above-Wells populations. Wild production of steelhead above Wells Dam was assumed to be limited to the Methow

system. Assuming a relative effectiveness of hatchery spawners of 1.0, the risk of absolute extinction within 100 years for UCR steelhead is 100%. The QAR also assumed hatchery effectiveness values of 0.25 and 0.75. A hatchery effectiveness of 0.25 resulted in projected risks of extinction of 35% for the Wenatchee/Entiat and 28% for the Methow populations. At a hatchery effectiveness of 0.75, risks of 100% were projected for both populations.

For the UCR steelhead ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[10] ranges from 0.94 to 0.66, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated the risk of absolute extinction for the aggregate UCR steelhead population, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years is 0.25 (Table B-5 in McClure et al. 2000b). Assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years is 1.00 (Table B-6 in McClure et al. 2000b).

Because of data limitations, the QAR steelhead assessments in Cooney (2000) were limited to two aggregate spawning groups—the Wenatchee/Entiat composite and the above-Wells populations. Wild production of steelhead above Wells Dam was assumed to be limited to the Methow system. Assuming a relative effectiveness of hatchery spawners of 1.0, the risk of absolute extinction within 100 years for UCR steelhead is 100%. The QAR also assumed hatchery effectiveness values of 0.25 and 0.75. A hatchery effectiveness of 0.25 resulted in projected risks of extinction of 35% for the Wenatchee/Entiat and 28% for the Methow populations. At a hatchery effectiveness of 0.75, risks of 100% were projected for both populations.

C.4.2.3 Middle Columbia River Steelhead

Life history information for MCR steelhead indicates that most fish smolt at 2 years of age and spend 1 to 2 years in salt water (i.e., 1-ocean and 2-ocean fish, respectively). After re-entering freshwater, they may remain up to a year before spawning (Howell et al. 1985). Within the ESU, the Klickitat River is unusual in that it produces both summer and winter steelhead, and the summer steelhead are dominated by 2-ocean steelhead (most other rivers in this region produce about equal numbers of both 1-and 2-ocean steelhead).

[10] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1996 adult returns. Population trends are projected under the assumption that all conditions will stay the same into the future.

Table C-10. Adult summer steelhead counts at Priest Rapids, Rock Island, Rocky Reach, and Wells Dams (FPC 2000).

	Priest Rapids		Rock Island	Rocky Reach	Wells
Year	Count	Wild Origin	Count	Count	Count
1977	9,812		9,925	7,416	5,382
1978	4,545		3,352	2,453	1,621
1979	8,409		7,420	4,896	3,695
1980	8,524		7,016	4,295	3,443
1981	9,004		7,565	5,524	4,096
1982	11,159		10,150	6,241	8,418
1983	31,809		29,666	19,698	19,525
1984	26,076		24,803	17,228	16,627
1985	34,701		31,995	22,690	19,757
1986	22,382	2,342	22,867	15,193	13,234
1987	14,265	4,058	12,706	7,172	5,195
1988	10,208	2,670	9,358	5,678	4,415
1989	10,667	2,685	9,351	6,119	4,608
1990	7,830	1,585	6,936	5,014	3,819
1991	14,027	2,799	11,018	7,741	7,715
1992	14,208	1,618	12,398	7,457	7,120
1993	5,455	890	4,591	2,815	2,400
1994	6,707	855	5,618	2,823	2,138
1995	4,373	993	4,070	1,719	946
1996	8,376	843	7,305	5,774	4,127
1997	8,948	785	7,726	7,726	4,107
1998	5,837	—	4,962	4,442	2,668
1999	8,456[1]	1,428[1]	6,361	4,815	3,557

[1] Priest Rapids counts for 1999 from Brown (1999).

hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated the risk of absolute extinction for four spawning aggregations, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years ranges from zero for the South Santiam River to 0.74 for the Calapooia River (Table B-5 in McClure et al. 2000b). Assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years ranges from 0.74 for the Calapooia River to 1.00 for the Molalla River and South Santiam River spawning aggregations (Table B-6 in McClure et al. 2000b).

C.4.2.4 Upper Willamette River Steelhead

The UWR steelhead ESU occupies the Willamette River and its tributaries upstream of Willamette Falls. This is a late-migrating winter group, entering freshwater primarily during March and April (Howell et al. 1985). Only the late run is included in the ESU; the largest remaining population is in the Santiam River system. The North Santiam River hatchery stock (ODFW stock 21) is part of this ESU, but NMFS determined that it was not essential for recovery, and, therefore, listing was not warranted (64 FR 14525).

Steelhead in the UWR basin are heavily influenced by hatchery practices and introductions of non-native stocks, as well as introductions of native fish into new areas. Fishways built at Willamette Falls in 1885, modified and rebuilt several times, have facilitated the introduction of Skamania stock summer steelhead and early-migrating winter steelhead of Big Creek stock. Non-native production of summer steelhead appears quite low, and the summer population is almost entirely maintained by artificial production (Howell et al. 1985). Some naturally reproducing returns of Big Creek stock winter steelhead occur in the basin (primarily early stock; Table C-11). In recent years, releases of winter steelhead have been primarily native stock from the Santiam River system.

No estimates of abundance before the 1960s are available for this ESU. Recent run size can be estimated from redd counts, dam counts, and counts at Willamette Falls (late stock; Table C-11). Recent total-basin run size estimates exhibit general declines for winter steelhead. Most winter steelhead populations in this basin may not be self-sustaining.

Much of the Willamette River basin is urban or agricultural, and clearcut logging has been widespread in the watershed. Water temperatures and streamflows reach critical levels in the basin, and channel modification and bank erosion is substantial. Artificial production practices are a major threat to this ESU. Introgression from nonlocal winter hatchery stocks may occur. Artificial selection of later run timing may also result from competition with substantial numbers of hatchery fish and from selective fishing pressures.

For the UWR steelhead ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[11] ranges from 0.94 to 0.87, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated the risk of absolute extinction for four spawning aggregations, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years ranges from zero for the South Santiam River to 0.74 for the Calapooia River (Table B-5 in McClure et al. 2000b). Assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years ranges from 0.74 for the Calapooia River to 1.00 for the Molalla River and South Santiam River spawning aggregations (Table B-6 in McClure et al. 2000b).

C.4.2.5 Lower Columbia River Steelhead

Busby et al. (1996) summarize the available information on the historical and recent abundances LCR steelhead. No estimates of historical abundance (pre-1960s) specific to this ESU are available. Because of their limited distribution in upper tributaries and the urbanization surrounding the lower tributaries (e.g., the lower Willamette, Clackamas, and Sandy rivers run through Portland, Oregon, or its suburbs), summer steelhead appear to be more at risk from habitat degradation than winter steelhead. Based on angler surveys during a limited period, populations in the lower Willamette, Clackamas, and Sandy rivers appear to be stable or increasing slightly, but these types of data may not reflect trends in underlying abundances. Total annual run size is only available for the Clackamas River population (1,300 winter steelhead, 70% hatchery; 3,500 summer steelhead).

Population dynamics indicate that the Oregon component of the LCR steelhead ESU is at risk such that the capacity to survive future periods of environmental stress is unacceptably low (Chilcote 1998). The recent collapse of winter steelhead in the Clackamas River and the status of summer steelhead in the Hood River (which together comprise 33% of the ESU) are of special concern. The Kalama River population is the only one in Washington State considered healthy (WDFW 1997). All of the other winter steelhead populations (i.e., those in the Cowlitz, Coweeman, North Fork and South Fork Toutle, Green, North Fork Lewis, and Washougal rivers) are considered depressed (WDFW 1997). The status of populations of winter steelhead in Hamilton Creek and the Wind River is unknown. The WDFW trapped fish at Shiperd Falls on the Wind River during winter 1999-2000 and will use these data to develop preliminary estimates of steelhead abundance. Among summer steelhead, populations from the Kalama

[11] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1997 adult returns. Population trends are projected under the assumption that all conditions will stay the same into the future.

Table C-11. Escapement of winter steelhead over Willamette Falls and over North Fork Dam on the Clackamas River, 1971 through 1998.

	Willamette Falls Count			
Year[1]	Total	Early Stock[2]	Late Stock[3]	North Fork Dam
1971	26,647	8,152	18,495	4,352
1972	23,257	6,572	16,685	2,634
1973	17,900	6,389	11,511	1,899
1974	14,824	5,733	9,091	680
1975	6,130	3,096	3,034	1,509
1976	9,398	4,204	5,194	1,488
1977	13,604	5,327	8,277	1,525
1978	16,869	8,599	8,270	2,019
1979	8,726	2,861	5,865	1,517
1980	22,356	6,258	16,097	2,065
1981	16,666	7,662	9,004	2,700
1982	13,011	6,117	6,894	1,446
1983	9,298	4,596	4,702	1,099
1984	17,384	6,664	10,720	1,238
1985	20,592	4,549	16,043	1,225
1986	21,251	8,475	12,776	1,432
1987	16,765	8,543	8,222	1,318
1988	23,378	8,371	15,007	1,773
1989	9,572	4,211	5,361	1,251
1990	11,107	1,878	9,229	1,487
1991	4,943	2,221	2,722	837
1992	5,396	1,717	3,679	2,107
1993	3,568	843	2,725	1,352
1994	5,300	1,025	4,275	1,247
1995	4,693	1,991	2,702	1,146
1996	1,801	479	1,322	325
1997	4,544	619	3,925	530
1998	3,678	757	2,921	504

[1] Represents year in which passage is completed. Passage began during the previous year. Total estimates of passage were not obtained before 1971 due to problems of access to the old fishway during higher flow periods.
[2] November 1 through February 15. These are mainly introduced Big Creek stock.
[3] February 16 through May 15. These are mainly indigenous Willamette stock.

River, the North and East Forks of the Lewis River, and the Washougal River are considered depressed, and the Wind River stock is classified as critical (WDFW 1997).

Recent estimates of the proportion of hatchery fish on the winter-run steelhead spawning grounds are more than 80% in the Hood and Cowlitz rivers and 45% in the Sandy, Clackamas, and Kalama rivers. On the summer-run steelhead spawning grounds in the Kalama River, hatchery fish make up approximately 75% of the total run. Out of 14 steelhead populations for which data are available, only 3 have no hatchery influence: the Washougal River summer run and the Panther and Trout Creek runs in the Wind River basin. NMFS is unable to identify any natural populations of steelhead in this ESU that could be considered healthy, especially in light of new genetic data from WDFW that indicate some introgression between the Puget Sound Chambers Creek Hatchery stock and wild steelhead in this ESU (Phelps et al. 1997). In addition, summer steelhead, native to the Hood, Lewis, Washougal and Kalama rivers, have been introduced into the Sandy and Clackamas rivers. Naturally spawning populations of winter steelhead appear to have been negatively affected by these introductions, probably through interbreeding and competition (Chilcote 1998).

For the LCR steelhead ESU as a whole, NMFS estimates that the median population growth rate (lambda) over the base period[12] ranges from 0.98 to 0.78, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000b). NMFS has also estimated the risk of absolute extinction for seven of the spawning aggregations, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years ranges from zero for the Kalama River summer run and the Clackamas River and Kalama River winter runs to 1.00 for the Clackamas River summer run and the Toutle River winter run (Table B-5 in McClure et al. 2000b). Assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years rises to 1.00 for all but one population (the risk of extinction is 0.86 for the Green River winter run; Table B-6 in McClure et al. 2000b).

[12] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period that varies between spawning aggregations. Population trends are projected under the assumption that all conditions will stay the same into the future.

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C.5 CHUM SALMON

C.5.1 Columbia River Chum Salmon

The Columbia River historically contained large runs of chum salmon that supported a substantial commercial fishery in the first half of this century. These landings represented an annual harvest of more than 500,000 chum salmon as recently as 1942. Beginning in the mid-1950s, commercial catches declined drastically and in later years rarely exceeded 2,000 per year. Annual catch, as incidental take in the late fall mainstem Columbia River fishery, has been less than 50 fish since 1994.

Fulton (1970) reported that chum salmon used 22 of 25 historical spawning areas in the lower Columbia River below The Dalles Dam. Even at the time of publication, access to suitable tributary habitat was limited by natural (falls, heavy rubble, and boulders) and manmade structures (dams and water diversions). Habitat quality was limited by siltation where watersheds had been subjected to heavy logging. Currently, spawning is limited to tributaries below Bonneville Dam, with most spawning in two areas on the Washington side of the Columbia River: Grays River, near the mouth of the Columbia River, and Hardy and Hamilton creeks, approximately 3 miles below Bonneville Dam. Some chum salmon pass Bonneville Dam, but there are no known extant spawning areas in Bonneville pool. Grays River chum salmon enter the Columbia River from mid-October to mid-November, but do not reach the Grays River until late October to early December. These fish spawn from early November to late December. Fish returning to Hamilton and Hardy creeks begin to appear in the Columbia River earlier than Grays River fish (late September to late October) and have a more protracted spawn timing (mid-November to mid-January).

The estimated minimum run size for the Columbia River ESU has been relatively stable, although at a very low level, since the run collapsed during the mid-1950s (Figure C-7). Current abundance is probably less than 1% of historical levels, and the ESU has undoubtedly lost some (perhaps much) of its original genetic diversity. Average annual natural escapement to the index spawning areas was approximately 1,300 fish from 1990 through 1998 (ODFW and WDFW 1999).

Index spawning areas are located in the Grays River system, near the mouth of the Columbia River, and in the Hardy Creek/Hamilton Creek/Ives Island complex below Bonneville Dam. WDFW surveyed other (nonindex) areas in 1998 and found only small numbers of chum salmon (typically less than 10 fish per stream) in Elochoman, Abernathy, Germany, St. Cloud, and Tanner creeks and in the North Fork Lewis and the Washougal rivers. The state of Oregon does not conduct targeted surveys, so the current extent of chum salmon spawning on the Oregon side of the river is unknown. Kostow (1995) cited reports of 23 spawning areas in Oregon tributaries,

but these are based on incidental observations (pers. comm., K. Kostow, Fisheries Biologist, ODFW, Portland, Oregon, August 6, 1999).

In the Grays system, chum salmon spawn in the mainstem from approximately ½-mile upstream of the West Fork downstream to the Covered Bridge, a distance of approximately 4 miles (WDF et al. 1993a). Tributary spawning occurs in the West Fork, Crazy Johnson, and Gorely creeks. The historical influence of hatchery fish in the Grays system is small compared to other ESUs. Hatchery-cultured chum salmon from Willapa Bay (i.e., Pacific Coast chum salmon ESU) were transplanted into the Chinook River (a tributary to Baker Bay in the Columbia River estuary) during the late 1980s. Initial returns from this transplant were close to a thousand fish per year, but recent returns have been substantially lower (less than or equal to 20 fish per year during 1997 and 1998). In 1998, WDFW decided that non-native chum salmon should be removed from the system. Consequently, all Willapa Bay chum salmon returning to the Sea Resources Hatchery during 1999 were destroyed. The Sea Resources and Grays River hatcheries are now used to culture Columbia River chum salmon (collected from Gorely Creek) for reintroduction into the Chinook River. Overall, the abundance of the Grays River population has increased since the mid-1980s, but appears to follow a cyclical pattern. The average population rate of growth is positive (McClure et al. 2000), but the cyclical trend results in a high variability around the average estimate.

The Hardy and Hamilton creeks/Ives Island complex is located approximately 2 miles below Bonneville Dam. Hamilton Slough once separated Hamilton Island from the Washington State shoreline. Sometime before 1978, a dike was built across the slough, separating its upstream and downstream ends (Corps 1978). The waterway that now appears to be the lower end of Hamilton Creek is actually the downstream end of the former slough; the mouth of Hamilton Creek proper adjoins the remnant slough at its northern terminus. These large-scale landscape modifications have probably changed the hydraulics of the Hamilton Slough/Ives Island spawning area.

Escapements to Hamilton Creek have averaged less than 100 fish in recent years. WDFW recently completed a major habitat development project in Hamilton Springs, a spring-fed tributary to Hamilton Creek. Chum salmon escapement to Hamilton Springs averaged 170 fish during the last 3 years (1997 through 1999; Figure C-8). Hardy Creek is located just downstream of Hamilton Creek. Annual escapements have ranged from 22 to 1,153 spawners over the last 10 years, with a generally increasing trend. Hardy Creek is now incorporated into the Pierce National Wildlife Refuge, and chum salmon have benefited from recent (and ongoing) habitat improvement programs (a vehicle bridge over Hardy Creek, cattle fencing, and development of additional spawning gravels).

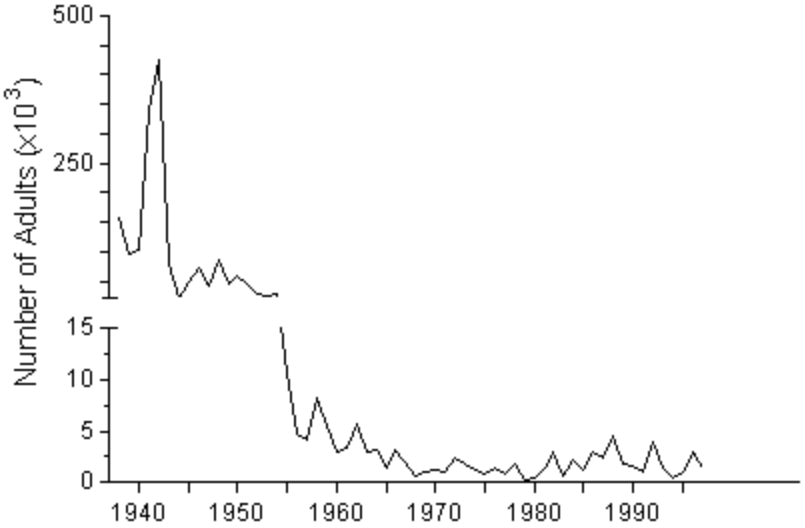
The current upstream extent of spawning by Columbia River chum salmon, and thus the effect of Bonneville Dam as a barrier to migration, is unknown. Adult chum salmon are thought to show little persistence in surmounting river blockages and falls (63 FR 11775). The 10-year average

(1989 through 1998) count for the fish ladders at Bonneville Dam was 56 adults (Table C-12), although this statistic is heavily skewed by a count of 195 chum salmon in 1998 (J. Loch, WDFW, unpubl. data). The unusually high count was due to (1) an increase in the effort applied to reviewing the videotapes for observations of chum salmon and (2) unusually high activity in the fish ladders at night, possibly related to unusual temperature conditions in Bonneville pool (pers. comm., J. Loch, WDFW, January 28, 2000). Without the 1998 data, the 9-year average would be only 31 adult chum salmon. Information on chum salmon passage at Bonneville Dam is extremely important because the passage of large numbers of adults over Bonneville implies that chum salmon may be spawning in Bonneville pool (and Federal hydrosystem operations could affect the quantity and quality of such spawning habitat).

Hatchery fish have had little influence on the wild component of the CR chum salmon ESU. NMFS estimates a median population growth rate (lambda) over the base period,[13] for the ESU as a whole, of 1.04 (Tables B-2a and B-2b in McClure et al. 2000b). Because census data are peak counts (and because the precision of those counts decreases markedly during the spawning season as water levels and turbidity rise), NMFS is unable to estimate the risk of absolute extinction for this ESU.

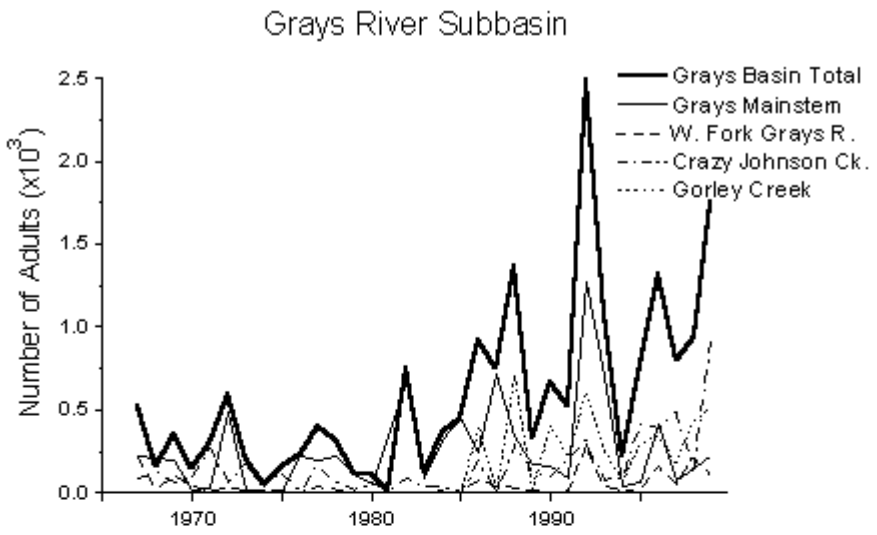
[13] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals are based on population trends observed during a base period from 1980 through 1998 adult returns for the Grays River mainstem and the West Fork, Crazy Johnson, and Hamilton Creek spawning aggregations and including the 1999 adult returns for Hardy Creek and Hamilton Springs. Population trends are projected under the assumption that all conditions will stay the same into the future.

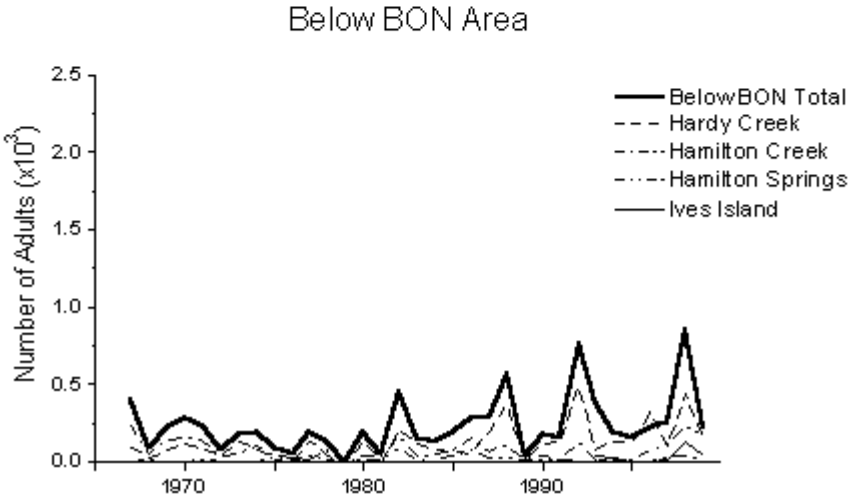
Figure C-7. Minimum run size for Columbia River chum salmon, 1938 to 1998.



Note: These values were calculated by summing harvest, spawner surveys, and Bonneville Dam counts. Data are from ODFW and WDFW (1999).

Figure C-8. Peak counts of adult chum salmon in index spawning areas, 1967 through 1999.





Source: WDFW and USFWS, unpublished data.

Table C-12. Chum salmon counted in the Bonneville Dam adult fish ladders (1989 through 1998).

Year	Total Number
1989[1]	16
1990[1]	26
1991[1]	5
1992[2]	39
1993[2]	51
1994[2]	26
1995[2]	30
1996[2]	33
1997[3]	50
1998[4]	195
1999[4]	135

Source: J. Loch, WDFW, unpublished data. The following footnotes were provided by J. Loch:

[1] Only daytime videos available for November 1989 through 1991 (8 a.m. to 4 p.m.).

[2] Wild steelhead were the target species recorded from nighttime videotapes by WDFW readers. Non-target species (e.g., chum salmon) were not always recorded.

[3] Wild steelhead were again the target species but some non-target species may have been recorded. Note: Data for non-target species were not included in the Corps' Annual Fish Passage reports.

[4] 1998 was the first year that the Corps contracted with the WDFW counting program to read videotapes for all salmonids. Although wild steelhead remained the target species for the video count program, observations of chum salmon, pink salmon, and chinook salmon were also tallied by the video reader. All counts were included in the Corps' annual reports for 1998 and 1999.

C.6 SOCKEYE SALMON

C.6.1 Snake River Sockeye Salmon

Historically, Snake River sockeye salmon were produced in the Salmon River subbasin in Alturas, Pettit, Redfish, and Stanley lakes and in the South Fork Salmon River subbasin in Warm Lake. Sockeye salmon may have been present in one or two other Stanley basin lakes (Bjornn et al. 1968). Elsewhere in the Snake River basin, sockeye salmon were produced in Big Payette Lake on the North Fork Payette River and in Wallowa Lake on the Wallowa River (Evermann 1895, Toner 1960, Bjornn et al. 1968, Fulton 1970).

The largest single sockeye salmon spawning area was in the headwaters of the Payette River, where 75,000 were taken one year by a single fishing operation in Big Payette Lake. However, access to production areas in the Payette basin was eliminated by construction of Black Canyon Dam in 1924. During the 1980s, returns to headwaters of the Grand Ronde River in Oregon (Wallowa Lake) were estimated to have been at least 24,000 and 30,000 sockeye salmon (Cramer 1990), but access to the Grand Ronde was eliminated by construction of a dam on the outlet to Wallowa Lake in 1929. Access to spawning areas in the upper Snake River basin was eliminated in 1967 when fish were no longer trapped and transported around the Hells Canyon Dam complex. All of these dams were constructed without fish passage facilities.

There are no reliable estimates of the number of sockeye salmon spawning in Redfish Lake at the turn of the century. However, beginning in 1910, access to all lakes in the Stanley basin was seriously reduced by the construction of Sunbeam Dam, 20 miles downstream from Redfish Lake Creek on the mainstem Salmon River. The original adult fishway, constructed of wood, was ineffective at passing fish over the dam. It was replaced with a concrete structure in 1920, but sockeye salmon access was impeded until the dam was partially removed in 1934. Even after fish passage was restored at Sunbeam Dam, sockeye salmon were unable to use spawning areas in two of the lakes in the Stanley basin. Welsh (1991) reported fish eradication projects in Pettit Lake (treated with toxaphene in 1960) and Stanley Lake (treated with Fish-Tox, a mixture of rotenone and toxaphene, in 1954). Agricultural water diversions cut off access to most of the lakes. Bjornn et al. (1968) stated that, during the 1950s and 1960s, Redfish Lake was probably the only lake in Idaho that was still used by sockeye salmon each year for spawning and rearing, and, at the time of listing under ESA, sockeye salmon were produced naturally only in Redfish Lake.

Escapement to the Snake River has declined dramatically in the last several decades. Adult counts at Ice Harbor Dam declined from 3,170 in 1965 to zero in 1990 (ODFW and WDFW 1998). The Idaho Department of Fish and Game counted adults at a weir in Redfish Lake Creek during 1954 through 1966; adult counts dropped from 4,361 in 1955 to fewer than 500 after 1957 (Bjornn et al. 1968). A total of 16 wild sockeye salmon returned to Redfish Lake between 1991

and 1999 (Table C-13). During 1999, seven hatchery-produced, age-3 adults returned to the Sawtooth Hatchery. Three of these adults were released to spawn naturally, and four were taken into the IDFG captive broodstock program. In 2000, 257 hatchery-produced, age-4 sockeye salmon returned to the Stanley basin (weirs at the Sawtooth Hatchery and Redfish Lake Creek). Adults numbering 243 were handled and redistributed to Redfish (120), Alturas (52), and Pettit (28) lakes, with the remaining 43 adults incorporated into the IDFG captive broodstock program at Eagle Hatchery.

Low numbers of adult Snake River sockeye salmon preclude a CRI- or QAR-type quantitative analysis of the status of this ESU. However, because only16 wild and 264 hatchery-produced adult sockeye returned to the Stanley basin between 1990 and 2000, NMFS considers the status of this ESU to be dire under any criteria.

Table C-13. Returns of Snake River sockeye salmon to Lower Granite Dam and to the weir at Redfish Lake Creek. The 2000 return is the total number of adults returning to the Stanley basin (weirs at the Sawtooth Hatchery and Redfish Lake Creek).

Year	LGR Dam Count	Adults at Weirs
1986	15	29
1987	29	16
1988	23	4
1989	2	1
1990	0	0
1991	8	4
1992	15	1
1993	12	8
1994	5	1
1995	3	0
1996	3	1
1997	11	0
1998	2	1
1999	14	7
2000	282	257

Sources: Lower Granite Dam counts from FPC (2000); Redfish Lake Creek/Stanley basin counts from StreamNet (2000).

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APPENDIX D
BIOLOGICAL EFFECTS ANALYSIS AND SIMPAS MODEL DOCUMENTATION

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D.1 BACKGROUND

Since late 1999, National Marine Fisheries Service (NMFS) has been engaged in Endangered Species Act (ESA) Section 7 consultation with the Federal Action Agencies (U.S. Corps of Engineers [Corps], Bureau of Reclamation [BOR], and Bonneville Power Administration [BPA]) to develop a biological opinion on the effects of the Action Agencies' proposed action and future operation and configuration of the Federal Columbia River Power System (FCRPS) projects. In January 2000, to facilitate completion of the Section 7 consultation process, the Federal agencies formed five action teams. The Biological Effects Team was charged with estimating effects of current operations and potential future configurations and operations on the survival of listed juvenile outmigrants. This information was used by NMFS to analyze the listed species' biological requirements in the action area (Section 6.1.1), as well as at the species level (Section 6.1.2). The team included Federal biologists and engineers representing NMFS, the Corps, and BPA. NMFS Hydro Program staff picked up where the Biological Effects Team analysis left off to complete the biological effects analysis described in this appendix.

For juvenile fish using the mainstem Columbia and Snake rivers as a migration corridor, the primary evaluation method is simulation modeling of the proposed action on the action area biological requirements. The Biological Effects Team agreed to use NMFS' Simulated Passage (SIMPAS) model to evaluate the biological benefits of juvenile salmonid passage measures. The spreadsheet model, developed by staff in the Hydro Program of NMFS' Northwest Region, is a fish passage accounting model that apportions the run to various passage routes (i.e., turbines, fish bypass system, sluiceway/surface bypass, spillway, and/or fish transportation) based on empirical data and input assumptions for fish passage parameters. The model accounts for "successful fish passage" (survival) and "losses" (mortalities) through each of the alternative passage routes to estimate survival past each project. The model also accounts for the proportions of juvenile fish transported and left to migrate inriver. The model also provides survival estimates at each project (dam plus pool) and throughout the system (from the head of Lower Granite Reservoir to the tailrace of Bonneville Dam).

The Biological Effects Team reviewed and analyzed fish passage assumptions used by NMFS in earlier fish passage modeling exercises, those developed in the Plan for Analyzing and Testing Hypotheses (PATH) process, and the most recent empirical data to determine fish passage parameters for input into the SIMPAS model. The team also used the latest compilation of fish passage information contained in the four white papers recently prepared by the Northwest Fisheries Science Center (NWFSC):

- "Passage of Juvenile and Adult Salmonids Past Columbia and Snake River Dams" (NMFS 2000c)

- "Predation on Salmonids Relative to the Federal Columbia River Power System" (NMFS 2000d)
- "Salmonid Travel Time and Survival Related to Flow in the Columbia River Basin" (NMFS 2000e)
- "Summary of Research Related to Transportation of Juvenile Anadromous Salmonids Around Snake and Columbia River Dams" (NMFS 2000f)

Examples of the fish passage parameters reviewed by the Biological Effects Team include spill efficiency, fish guidance efficiency, spill/gas caps, turbine survival, spillway survival, sluiceway survival, bypass system survival, and diel passage patterns. The parameter values were quantified for each FCRPS dam and for both spring and fall chinook salmon (considered indicator species for the spring and summer passage seasons, respectively). The parameter values selected for modeling represent the best available scientific information, and, in cases where empirical information was unavailable, outdated, or limited, represent the team's best professional judgment.

As a result of this collaborative analytical effort, on March 20, 2000, the Biological Effects Team prepared a draft Biological Effects Team report and sent it out for review to the 13 Tribes and other regional fisheries comanagers. The draft report documented preliminary results of SIMPAS model runs incorporating current passage conditions. The assumptions and estimated dam passage survival rates used in this analysis were updated on the basis of comments on that draft and on drafts of this biological opinion.

There are limitations in modeling juvenile fish survival based solely on empirical data gathered during a single year. Fish passage conditions differ from year to year, environmentally as well as operationally and structurally. Flow, temperature, runoff timing, fish condition, spill level, and extended- versus standard-length screens in turbine intakes are some of the factors that can change. To address these limitations, the NMFS Hydro Program staff used all the most recent empirical passive integrated transponder (PIT)-tag reach survival information collected from 1994 through 1999 to model a range of fish passage and environmental conditions for yearling and subyearling chinook and steelhead. Because water conditions ranged from low flow (in 1994) to high flow (1997) during this period, this approach demonstrated the modeled variation in juvenile passage survival that results from different environmental (and the resulting operational) conditions.

The Biological Effects Team also recognized that survival estimates for relatively long river reaches are less subject to error than those for shorter reaches. PIT-tag data were used to estimate survival probabilities between successive dams (i.e., detection sites). The estimate for the overall reach was calculated as the product of the estimates for each of the shorter reaches.

The statistical model resulted in consecutive estimates that are inversely correlated: an underestimate in one reach tends to be followed by an overestimate in the next (or vice versa). Even though this property indicates that the product of two (or more) estimates should be more precise than the individual estimates, the use of project-by-project survival estimates does not result in substantially decreased accuracy.

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D.2 DEVELOPMENT AND HISTORY OF SIMPAS SPREADSHEET MODEL

The SIMPAS (simulated passage) spreadsheet model was first developed by NMFS' Hydro Program staff to evaluate potential actions for the 1995 FCRPS Biological Opinion. Since then, it has been used regularly as an exploratory tool to evaluate the structural or operational measures for their potential to reduce the mortality of juvenile salmon and steelhead at these projects. In 1999, the Federal Caucus' Hydro Workgroup and the Multispecies Framework's Ecological Working Group used a variant of this model (SIMPAS2) to evaluate hydrosystem alternatives that were not modeled by PATH. The Hydro Workgroup used this model as a tool for generating point estimates of likely survival improvements for several new alternatives. Most recently, to more fully evaluate potential actions for the 2000 FCRPS Biological Opinion, NMFS updated the original SIMPAS model to accommodate additional passage routes (for example, raised spillway crest and surface bypass routes).

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D.3 METHODOLOGY

The SIMPAS model starts with a group of fish (1.00) and applies an estimated pool survival to these fish prior to their reaching a project. The model then assigns the surviving fish to various routes of passage at the project, applies an estimated survival rate for the respective routes of passage, removes the estimated proportion of fish that are transported from a given project (if it is a collector project), and then recombines the surviving fish in the tailrace of the project. This process is repeated for each additional project. Fish guidance and survival estimates are typically averages of empirically measured rates through various routes of dam passage (or derived from average fish passage efficiency estimates) or various reservoir pools. When empirically based estimates are not available, passage parameter estimates are obtained from studies at other similar projects or from best professional judgement.[1]

For each species, model input includes:

- Seasonal average flows and spill levels
- Average spill, sluiceway, and guidance efficiency estimates
- Average survival rates through various passage routes and reservoirs

For each species, model output estimates include:

- Proportion of fish transported and left inriver
- Project-specific and system survival estimates
- Fish passage efficiency at each project
- Mortality due to passage through turbines

[1] A report prepared by the Biological Effects Team (March 16, 2000) also documents the parameter estimates used in the initial SIMPAS modeling work for the 2000 FCRPS Biological Opinion.

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D.4 CAVEATS TO SIMPAS MODELING RESULTS

The SIMPAS model is a useful analytical tool to enable screening of alternative fish passage options, however, there are a number of important caveats to the appropriate use of SIMPAS modeling results. These include:

- The juvenile survival rates shown in Tables D-7 through D-23 are based on juvenile passage studies only and cannot be used to infer the likelihood of adult returns.

- The juvenile survival rates shown, as well as the input passage parameters, are point estimates, i.e., confidence intervals are not calculated or implied.

- The model does not contain a time-step function, so both inputs and outputs are scaled to seasonal averages.

- The model does not account for the potential effects of various fish passage options on forebay passage in terms of reducing delay, residence time, or predation.

- Best professional judgment was used to develop some of the passage parameters, e.g., in some cases, fish passage data gathered at one dam during a single passage season were applied to several other similar hydrosystem projects.

In addition, the reach survival data available for calibration of the SIMPAS analysis and for estimating reservoir effects is limited to NMFS PIT-tag data collected between 1994 and 1999. The analysis used these empirical data to calibrate, or "ground truth," the model results. These years represent a range in flow and environmental conditions. In several years, reach survival data were extrapolated from some of the upper projects in the Snake River (on a per-mile basis) to the entire system (see discussion in the Pool Survival section below). The reach survival estimates are point estimates roughly classified by the volume of runoff during the year in which the data were collected. These survival estimates do not represent the kind of multi-year analysis that ideally would be used to estimate the range of reach survival rates expected under a 50-year record of flow conditions. They do, however, provide a general sense of the between-year variation observed in the last 6 years.

Although there may be uncertainty about the accuracy of the resulting pool and dam survival estimates, the Biological Effects Team and NMFS found that the model output for 1994 through 1999 was reasonable and produced reach survival estimates similar to the empirical estimates. Once the model was calibrated to data for the current operation, the Biological Effects Team and NMFS considered that they had a reasonable base case from which to make comparisons of

additional model studies of potential future juvenile fish passage actions over a range of water conditions represented by water years 1994 to 1999 (see Table 9.7-1 for SIMPAS model results of intensive Reasonable and Prudent Alternative [RPA] hydro actions).

Other models attempting to characterize these same effects have relied on flow/survival or travel time/predation relationships applied to a simulated monthly flow condition. Each approach has its own limitations. On balance, however, NMFS determined that this relatively simple and straightforward approach made the best use of the most recent empirical survival information and was adequate for the purposes of this analysis. The framework for this analysis is now also consistent with the monitoring and evaluation program described in Section 9.6.5; therefore, as additional information is collected, it can be incorporated directly into future versions of this analysis.

D.4.1 Example of SIMPAS Model Calculations

This simple example, using a single hypothetical project, is provided to illustrate how the model works. The example provides the necessary input parameter estimates, demonstrates the types of calculations made by the SIMPAS model, and provides the model output based on these calculations.

D.4.1.1 SIMPAS Input Parameters

Flow:

- Total project flow = 100 thousand cubic feet per second (kcfs)
- Total project spill = 40 kcfs (24 hours per day)

Project configuration:

- Only three passage routes are available to fish: spillway, fish bypass system, and turbines
- Spill effectiveness (i.e., ratio of fish per unit volume of water through the spillway) = 1.25
- Fish guidance efficiency of turbine intake screens = 50%

Survival estimates:

- Pool survival = 96 %
- Spillway survival = 98 %
- Bypass system survival = 96 %
- Turbine survival = 90 %

D.4.1.2 SIMPAS Calculations and Output

Step 1: Determine proportion of fish arriving at project

Proportion surviving pool and arriving at the project (0.960) = starting proportion (1.000) x pool survival (0.960)

Step 2: Calculate proportion of fish passing via spillway, bypass system, and turbines

Proportion of fish passing via spillway (0.480) = proportion of fish arriving at project (0.960) x proportion of water spilled (0.400) x spill effectiveness (1.250)

Proportion of fish passing via fish bypass system (0.240) = proportion of fish remaining (0.960 - 0.480 = 0.480) x fish guidance efficiency of the turbine screens (0.500)

Proportion of fish passing via turbines (0.240) = proportion of fish remaining (0.960 - 0.480 - 0.240 = 0.240)

Step 3: Calculate the proportion of fish surviving the spillway, bypass system, and turbines

Proportion of fish surviving the spillway (0.470) = proportion of fish passing via spillway (0.480) x survival rate through spillway (0.980)

Proportion of fish surviving the fish bypass system (0.230) = proportion of fish passing via the bypass system (0.240) x survival through the bypass system (0.960)

Proportion of fish surviving the turbines (0.216) = proportion of fish passing via the turbines (0.240) x survival through the turbines (0.900)

Step 4: Calculate the proportion of fish surviving to the project tailrace (assuming project does not collect fish from the fish bypass system for transport)

Proportion of starting population surviving to project tailrace (0.916) = proportion surviving spillway (0.470) + proportion surviving fish bypass system (0.230) + proportion surviving turbines (0.216)

Step 5: Calculate Output Parameters

Proportion of fish surviving the reservoir and project = 0.916 proportion surviving to tailrace (0.916) ÷ starting proportion (1.000)

Proportion of fish surviving the project only = 0.954 proportion surviving to tailrace (0.916) ÷ proportion arriving at the project (0.960)

Proportion of fish avoiding turbine passage (fish passage efficiency) = 0.750 (proportion of fish passing via spillway [0.480] + proportion of fish passing via fish bypass system [0.240]) ÷ proportion of fish arriving at the project (0.960)

Proportion of fish killed by turbines at this project = 0.024 proportion of fish passing via turbines (0.240) - proportion of fish surviving turbines (0.216)

D.4.1.3 SIMPAS Model Parameters

Tables D-1 through D-6 identify the SIMPAS model input parameters used by the Biological Effects Team and NMFS for yearling chinook, subyearling chinook, and steelhead for both the existing conditions and the conditions expected under full implementation of the RPA.

D.4.1.3.1 Pool Survival. Pool survival estimates were developed for yearling chinook (spring migrants), subyearling fall chinook (summer migrants), and steelhead (spring migrants) at each of the eight FCRPS mainstem projects for use in the SIMPAS model. The methods used to derive the pool survival estimates from empirical PIT-tag measurements collected over a range of water conditions from 1994 to 1999 are described below. The methods used to estimate pool survivals for all three species are discussed in the following sections, beginning with 1994, a low-flow year.

Empirical reach survival data used for determining pool survival estimates were derived from the following sources: Muir et al. in press (chinook and steelhead 1994 to 1998, Lower Granite tailrace to McNary tailrace); Smith et al. 2000b (chinook and steelhead 1999, head of Lower Granite pool to Bonneville tailrace); Smith et al. 1998 (chinook, 1994 to 1996, and steelhead, 1995 to 1996, head of Lower Granite pool to Lower Granite tailrace); Hockersmith et al. 1999 (steelhead, 1997, head of Lower Granite to Lower Granite tailrace); Smith et al. 2000a (chinook, 1998, head of Lower Granite to Lower Granite tailrace and McNary tailrace to John Day tailrace, and steelhead, 1998, head of Lower Granite to Lower Granite tailrace and McNary tailrace to Bonneville tailrace); and Williams et al. in press (steelhead, 1997, McNary tailrace to John Day tailrace).

<u>Yearling Chinook Salmon, 1994 to 1999</u>

Yearling Chinook Salmon, 1994. Estimates of pool survival in 1994, a low-flow year,[2] were based on empirical (PIT-tag) reach survival data for mixed stock (hatchery and wild) yearling chinook (Table D-7).

[2] 1994 April through August modified runoff volume at Lower Granite Dam was 12.15 million acre-feet (maf), or 53% of the 71-year (1929 through 1999) average. The Columbia River runoff volume at The Dalles Dam over the same period was 67.2 maf, or 73% of average.

Table D-1. Estimated dam passage parameter values for juvenile SR spring/summer chinook salmon. These values were used in the SIMPAS modeling of the effects of current FCRPS operations on the action area biological requirements of yearling migrants. Passage parameters shown in this table for SR spring/summer chinook salmon are assumed to represent those of all yearling chinook salmon migrants.

Project	Spill Efficiency	Spill Cap	FGE	Turbine	Survival Spillway	Survival Bypass	SBC or Sluice Eff.	SBC or Sluice S	Diel Pass
LWG	Eqn.[7]	60 kcfs	75%[3]	93%[1]	98%[2]	98%[1]	n/a	n/a	68%[9]
LGS	Eqn.[7]	45 kcfs	78%[3]	92%[1]	100%[1]	99%[1]	n/a	n/a	68%[7]
LMN	Eqn.[7]	40 kcfs	49%[3]	92%[16]	97%[16]	95%[1]	n/a	n/a	83%[10]
IHR	Eqn.[8]	105 kcfs night, 45 kcfs day	54%[7]	90%[2]	98%[2]	98%[2]	n/a	n/a	50%[11]
MCN	1:1[2]	135 kcfs (120-150 range)	83%[3]	90%[2]	98%[2]	98%[2]	n/a	n/a	50%[7]
JDA	1:1[2]	85 kcfs or 60% (70-100 range)	73%[12]	90%[2]	98%[2]	98%[2]	n/a	n/a	80%[1]
TDA	1.2:1[4]	230 kcfs or 64%	3%[14]	90%[2]	90%[5]	n/a	12%[4]	96%[6]	50%[2]
BON I	1:1[2]	135 kcfs (120-150 range)	39%[12]	90%[1,2]	98%[2]	90%[7,15]	22%[13]	98%[7]	50%[2]
BON II			48%[12]	90%[1,2]		98%[2]	n/a	n/a	

Sources:
[1] NMFS (2000c).
[2] Marmorek et al. (1998).
[3] NMFS (1998).
[4] Ploskey et al. (1999) (reported as a percent of project passage).
[5] E. Dawley (1998, 2000a,b), average of all 64% spill tests, 1997 to 1999.
[6] Dawley et al. (1998)
[7] Best professional judgment.
[8] Eppard et al (2000).
[9] BioSonics' powerhouse hydro acoustic estimate (Kuehl 1986).
[10] Mean of 1988 and 1989 hydro acoustic estimates (McFaden 1988).
[11] 1986 hydro acoustic estimate (Sullivan et al. 1986).
[12] NMFS (2000a).
[13] NMFS (2000b).
[14] Estimated with 6-inch orifice passage (ends up in sluiceway).
[15] Estimate no better than turbine survival. No data, known problem area.
[16] Based on calibration using 1999 Little Goose tailwater to Lower Monumental tailwater reach survival estimate.

Table D-2. Estimates of passage parameters for juvenile SR fall chinook salmon: current passage conditions at FCRPS hydro projects. These values were used in SIMPAS modeling of effects of current FCRPS operations on action area biological requirements. Passage parameters shown for SR fall chinook salmon are assumed to represent those of all subyearling chinook migrants.

Project	Spill Efficiency	Spill Cap	FGE	Turbine S	Spillway S	Bypass S	Sluice Eff.	Sluice S	Diel Pass
LWG	Eqn.[2]	N/A	53%[1]	90%[3]	98%[3]	98%[2]	n/a	n/a	68%[2]
LGS	Eqn.[2]	N/A	53%[2]	90%[3]	98%[3]	98%[2]	n/a	n/a	68%[2]
LMN	Eqn.[2]	N/A	49%[2]	90%[3]	98%[3]	98%[2]	n/a	n/a	83%[2]
IHR	Eqn.[2]	45 kcfs day 100% - 9 kcfs night	54%[2]	90%[3]	98%[3]	98%[2]	n/a	n/a	50%[2]
MCN	1:1[3]	200 minus 155 kcfs Ph capacity	62%[1]	90%[3]	98%[3]	97%[9]	n/a	n/a	50%[2]
JDA	1:1[3]	85 kcfs or 60% (70-100 range)	32%[10]	90%[3]	98%[3]	98%[2]	n/a	n/a	80%[1]
TDA	1.2:1[8]	230 kcfs or 64%	3%[12]	90%[3]	88%[7]	n/a	10%[6]	89%[13]	50%[3]
BON I[14]	1:1[2]	75 kcfs day[15] 135 kcfs night	9%[10]	90%[3]	98%[5]	82%[4]	6%[11]	95%[2]	50%[3]
BON II		(120-150 kcfs range)	28%[10]	94%[4]		98%[2]	n/a	n/a	

Sources:
[1] NMFS (2000c).
[2] Based on observations and best professional judgment.
[3] Marmorek et al. (1998).
[4] Ledgerwood et al. (1990), with adjustments for tailrace mortality and predator removal since 1990.
[5] Holmes (1952) and Ledgerwood et al. (1990).
[6] Ploskey et al. (1999).
[7] Dawley (1998, 2000a,b) reports, mean of 1997 to 1999 data.
[8] 1.2:1 @64% spill (Allen et al. 1999).
[9] NMFS unpublished data (Muir 1999).
[10] NMFS 2/ /00 memo to Hydro files.
[11] NMFS 2/ /00 memo to Hydro files.
[12] Estimated with 6-inch orifice passage (ends up in sluiceway).
[13] Dawley et al. (1998).
[14] Assume BON Ph 1 priority in summer.
[15] min. PH flow of 30 kcfs.
[16] Based on Corps (Years) Transport Reports for LGR, LGS, LMN, MCN for 1994 and 1996 (low and high flow years).
[17] Low, medium, high flows.

Table D-3. Estimates of the values of dam passage parameters for juvenile steelhead. These values were used in the SIMPAS modeling of the effects of current FCRPS operations on the action area biological requirements. Passage parameters shown in this table for SR steelhead are assumed to represent those of all steelhead yearling migrants.

Project	Spill Efficiency	Spill Cap	FGE	Survival Turbine	Survival Spillway	Survival Bypass	SBC or Sluice Eff.	SBC or Sluice S	Diel Pass
LWG	Eqn.[5]	60 kcfs	81%[3]	93%[5]	98%[2]	98%[1]	n/a	n/a	76%[1]
LGS	Eqn.[5]	45 kcfs	81%[3]	92%[1]	100%[1,5]	95%[1]	n/a	n/a	76%[5]
LMN	Eqn.[5]	40 kcfs	82%[1]	93%[5]	97%[1]	93%[1]	n/a	n/a	83%[6]
IHR	Eqn.[5]	105 kcfs night, 45 kcfs day	93%[1]	90%[5]	98%[5]	98%[5]	n/a	n/a	50%[5,7]
MCN	1:1[5]	135 kcfs (120-150 range)	89%[1]	90%[5]	98%[5]	98%[5]	n/a	n/a	50%[5]
JDA	Eqn[10]	85 kcfs or 60% (70-100 range)	85%[1]	90%[5]	98%[5]	98%[5]	n/a	n/a	83%[1]
TDA	1.2:1[5,11]	230 kcfs or 64%	3%[5]	90%[5]	90%[5]	n/a	12%[4]	96%[5,6]	50%[5]
BON I	1:1[5]	135 kcfs (120-150 range)	41%[1]	90%[5]	98%[5]	90%[5,9]	22%[5]	98%[7]	50%[5]
BON II			48%[8,1]	90%[1,5]		98%[5]	n/a	n/a	

Sources:
[1] NMFS (2000c,a).
[2] Marmorek et al. (1998).
[3] NMFS (1998).
[4] Ploskey et al. (1999) (reported as a % of project passage).
[5] Best professional judgment.
[6] Mean of 1988 and 1989 hydro acoustic estimates (McFaden 1988, Ransom and Sullivan 1989).
[7] 1986 hydro acoustic estimate (Sullivan et al. 1986).
[8] NMFS (2000b).
[9] Estimate no better than turbine survival. No data, known problem area.
[10] Hansel et al. (1999).
[11] BioSonics (1999).

Table D-4. Estimates of passage parameters for juvenile SR spring/summer chinook salmon. These values were used in SIMPAS modeling of the effects of RPA actions and FCRPS operations on action area biological requirements. Passage parameters shown in this table for SR spring/summer chinook salmon are assumed to represent those of all yearling chinook salmon migrants.

				Survival							
	Proj.	Spill Eff.	Spill Cap	FGE	Turbine	Spillway	Bypass	SBC or Sluice Eff.	SBC or Sluice S	Diel Pass	Qualitative Comments
Gas Fast Track	LWG	Eqn.[6]	80 kcfs	75%[3]	93%[1]	98%[2]	98%[1]	n/a	n/a		TDG abate. during forced spill
			12-hr spill							68%[8]	
Improved Spill			24-hr spill							68%	Reduced forebay delay/predation/stress
SBS w/BGS, spill		Eqn.[6,13]		75%[3]						50%	
SBS Ph w/SWI+BGS				75%[3]		98%[6]		29%[18]	98%	50%	Could increase fish guidance efficiency
SBS Ph w/SWI-BGS				75%[3]				17%[18]			
JBS Improve.		Eqn.[6]					99%				Reduced stress, direct loading
Gas Fast Track	LGS	Eqn.[6]	70 kcfs	78%[3]	92%[1]	100%[1]	99%[1]	n/a	n/a		TDG abate. during forced spill
			12-hr spill							68%[11]	
Improved Spill			24-hr spill							68%	Reduced foreb. delay/pred/stress
SBS w/BGS, spill		Eqn.[6,13]		78%[3]						50%	
SBS PH w/SWI+BGS				78%[3]		98%[6]		29%[18]	98%	50%	Could increase FGE
SBS Ph w/SWI-BGS				78%[3]				17%[18]			
Gas Fast Track	LMN	Eqn. [6]	70 kcfs	49%[3]	92%[14]	98%[6]	95%[1]	n/a	n/a	83%[9]	TDG abate. during forced spill
			12-hr spill							83%[9]	
Improved spill			24-hr spill							50%	Reduced foreb. delay/pred/stress
SBS w/BGS, spill		Eqn.[6,13]								50%	
SBS Ph w/SWI+BGS						98%[11]		29%[18]	98%		Could increase FGE
SBS Ph w/SWI-BGS								17%[18]			
JBS Improve.				78%[6]			98%				
JBS outfall relocation							99%				

Table D-4 Continued. Estimates of passage parameters for juvenile SR spring/summer chinook salmon. These values were used in SIMPAS modeling of the effects of RPA actions and FCRPS operations on action area biological requirements. Passage parameters shown in this table for SR spring/summer chinook salmon are assumed to represent those of all yearling chinook salmon.

					Survival						
	Proj.	Spill Eff.	Spill Cap	FGE	Turbine	Spillway	Bypass	SBC or Sluice Eff.	SBC or Sluice S	Diel Pass	Qualitative Comments
24-hr spill	IHR	Eqn.[7]	105 kcfs	54%[6]	90%[2,6]	98%[2,6]	98%[2,6]	n/a	n/a	50%[10]	TDG increased
24-hr spill	IHR		45 kcfs/day	54%[6]	90%[2,6]	98%[2,6]	98%[2,6]	n/a	n/a	50%[10]	TDG reduced
Gas Fast Track	MCN	1:1[2]	135 kcfs	83%[3]	90%[2]	98%[2]	98%[2]	n/a	n/a	50%[6]	
12-hr spill			160 kcfs							50%	
24-hr spill			160 kcfs.							50%	TDG increas., reduc. delay/stress
JBS Improve.							99%				Reduced stress, direct loading
Surf. Bypass						98%	98%				
Gas Fast Track	JDA	1:1 1/	180 kcfs	73%[11]	90%[2]	98%[2]	98%[2]	n/a	n/a	50%	
Ext.-length screens				82%[16]							FGE based on prototype testing
Raised S. crest		Eqn.[6,13]								50%	
I/T sluice relo.	TDA	1.2:1[4,6] @64%	230 kcfs	n/a	90%[1]	90%[5]	n/a		98%[6]	50%[3]	Reduced Stress
Surface bypass								22%[4]			Sluice eff =12% + 10% improve.
Gas Fast Track			30-45% to 230 kcfs			98%[6]					3% Gatewell Orifice Passage
Surface bypass		1.7:1[4,6] @40%								50%	
JBS Improve.	Bon I			72%[15]			98%[2,6]	22%[12]	98%[6]		
MGRs	Bon I				92%[17]						
Surface bypass	Bon I			80%			98%[6]			50%	
Gas Fast Track		1:1[2]	175 kcfs			98%[2]				50%[2]	135 kcfs 24-hrs interim operation
JBS Improve.	Bon II			60%[6]	90%[1,2]		98%[2]	n/a	n/a		
Corner Coll.	Bon II							60%[6]	98%[6]		

Sources:

[1] NMFS (2000c).
[2] Marmorek et al. (1998).
[3] NMFS (1998).
[4] Ploskey et al. (1999) (percent of total project passage).
[5] Dawley (1998, 2000a,b).
[6] Best professional judgment.
[7] Eppard et al. (2000).
[8] BioSonics 1985 powerhouse hydro acoustic estimate (Kuehl 1986).
[9] Mean of 1988 and 1989 hydro acoustic estimates (McFaden 1988, Ransom and Sullivan 1989).
[10] 1986 hydro acoustic estimate (Sullivan et al. 1986).
[11] NMFS (2000a).
[12] NMFS (2000b).
[13] Variable spill efficiency: 5@10%, 3@20%, 2@40%, 1.5@50%, 1@60% spill.
[14] Based on calibration using 1999 Little Goose tailwater to Lower Monumental tailwater reach survival estimate.
[15] Monk et al. (1999).
[16] Brege et al. (1997).
[17] Based on potential improvement due to minimum gap runners (MGRs).
[18] Adams and Rondorf (1999).

Table D-5. Estimates of passage parameters used for juvenile SR fall chinook salmon. These values were used in SIMPAS modeling of the effects of RPA actions and FCRPS operations on action area biological requirements. Passage parameters shown in this table for SR fall chinook salmon are assumed to represent those of all subyearling chinook migrants.

	Proj.	Spill Eff.	Spill Cap	FGE	Survival Turbine	Survival Spillway	Survival Bypass	SBC or Sluice Eff.	SBC or Sluice S	Diel Pass	Qualitative Comment
JBS Improve.	LWG	Eqn.[2]	n/a	53%[1]	90%[3]	98%[3]	99%[2]	n/a	n/a	68%[2]	
JBS Improve.	LGS	Eqn.[2]	n/a	53%[2]	90%[3]	98%[3]	98%[2]	n/a	n/a	68%[2]	Reduced stress
Ext.-length screens	LMN	Eqn.[2]	n/a	56%[2]	90%[3]	98%[3]	98%[2]	n/a	n/a	83%[2]	Higher FGE than at LWG due to fish more smolted
Gas Fast Track	IHR	Eqn.[2]	100% night, 45 kcfs day, 45kcfs 24-hrs	54%[2]	90%[3]	98%[3]	98%[2]	n/a	n/a	50%[2]	
JBS Improvements	MCN	1:1[3]	Invol only-155 kcfs PH capacity	62%[1]	90%[3]	98%[3]	99%[2]	n/a	n/a	50%[2]	
Raised spill crest	JDA	Eqn.[9]	180 kcfs or 60%	60%[7]	90%[3]	98%[3]	98%[2]	n/a	98%[2]	50%[2]	Raised crest flow = 14 k/bay
	TDA	1.7:1[6]@ 40%, 1.2:1@ 64%	230 kcfs or 40%	3%[8]	90%[1]	98%[2]	n/a	18%[11]	96%[2]	50%[3]	
Surface Bypass	Bon I		175 kcfs day[13]	35%[10]	92%[12]		98%[2]	55%[2]	96%[2]		
		1:1[2]	175 kcfs night			98%[5]				50%[3]	
Corner Coll.	Bon II			40%[2]	94%[4]		98%[2]	60%[2]	96%[2]		

Sources:
[1] NMFS(2000c).
[2] Based on observations and best professional judgment.
[3] Marmorek et al. (1998).
[4] Ledgerwood et al. (1994) reported estimate minus 3% indirect mortality.
[5] Holmes (1952).
[6] Same as spring/summer chinook.
[7] Brege et al. (1997).
[8] Estimated with 6-inch orifice passage (ends up on sluiceway).
[9] Variable spill efficiency: 5@10%, 3@20%, 2.5@30%, 2@40%, 1.5@50%, 1@60%.
[10] Monk et al. (1999).
[11] Ploskey et al. (1999). Reported numbers were doubled for effect of blocked trash racks.
[12] Based on potential improvement due to MGR installation.
[13] Assumes adult fallback problem is corrected, otherwise limit is 120 kcfs.

Table D-6. Estimates of passage parameters for juvenile SR steelhead. These values were used in SIMPAS modeling of the effects of RPA actions and FCRPS operations on action area biological requirements. Note: passage parameters shown in this table for SR steelhead are assumed to represent those of all steelhead yearling migrants.

					Survival						
	Proj.	Spill Eff.	Spill Cap	FGE	Turbine	Spillway	Bypass	SBC or Sluice Eff.	SBC or Sluice S	Diel Pass	Qualitative Comments
Gas Fast Track	LWG	Eqn.[5]	80 kcfs	81%[3]	93%[5]	98%[1,5]	98%[1]	n/a	n/a		TDG abate. during forced spill
			12-hr spill							76%[1,18]	
Improved Spill			24-hr spill							50%[5]	Reduced forebay delay/predation/stress
SBS w/BGS, spill		Eqn.[5,11]		81%[3]						50%	
SBS Ph w/SWI+BGS				81%[3]		98%[1,5]		29%[5,16]	98%[5]	50%	Could increase fish guidance efficiency
SBS Ph w/SWI-BGS				81%[3]				17%[5,16]			
JBS Improve.		Eqn.[5]					99%[5]				Reduced stress, direct loading
Gas Fast Track	LGS	Eqn.[5]	70 kcfs	81%[3]	93%[1]	100%[1]	98%[5]	n/a	n/a		TDG abate. during forced spill
			12-hr spill							76%[5]	
Improved Spill			24-hr spill							50%[5]	Reduced foreb.delay/pred/stress
SBS w/BGS, spill		Eqn.[5,11]		81%[3]						50%[5]	
SBS PH w/SWI+BGS				81%[3]		100%[1]		29%[5,16]	98%[5]	50%[5]	Could increase FGE.
SBS Ph w/SWI-BGS				81%[3]				17%[5,16]			
Gas Fast Track	LMN	Eqn. [5]	70 kcfs		93%[5]	99%[12]	99%[5,12]	n/a	n/a	50%[5,7]	TDG abate. during forced spill
			12-hr spill							50%[5,7]	
Ext-length screens				84%[5]							
Improved spill			24-hr spill							50%[5]	Reduced foreb. delay/pred/stress
SBS w/BGS, spill		Eqn.[5,11]								50%[5]	

Table D-6, continued.

JBS outfall relocation						99%[5]					
24-hr spill	IHR	Eqn.[6]	105 kcfs	93%[1]	90%[5]	98%[5]	98%[5]	n/a	n/a	50%[5,8]	TDG increased
24-hr spill	IHR		45 kcfs day	93%[1]	90%[5]	98%[5]	98%[5]	n/a	n/a	50%[5,8]	TDG reduced
Gas Fast Track	MCN	1:1[2,5]	135 kcfs	89%[3]	90%[2,5]	98%[2,5]	98%[5]	n/a	n/a	50%[5]	
12-hr spill			160 kcfs							50%[5]	
24-hr spill			160 kcfs							50%[5]	TDG increased, reduced delay/stress
JBS Improve.							99%[5]				Reduced stress, direct loading
Surf. Bypass						98%[5]	98%[5]				
Gas Fast Track	JDA	Eqn.[17]	180 kcfs	73%[9]	90%[2,5]	98%[2,5]	98%[2,5]	n/a	n/a	50%[1]	
Ext.-length screens				94%[14]							FGE based on prototype testing
Raised S. crest		Eqn.[5,11]								50%[5]	
I/T sluice relo.	TDA	1.6[5,18] @64%	230 kcfs	3%[5]	90%[1]	98%[5]	n/a		98%[5]	50%[3,5]	Reduced stress
Surface bypass								22%[4]			Sluice eff. =12% + 10% improve.
Gas Fast Track			30-45% to 230 kcfs			98%[5]					3% gatewell orifice passage
Surface bypass		1.7:1[4,5] @40%								50%	
JBS Improve.	Bon I			85%[13]			98%[2,5]	22%[5,10]	98%[5]		
MGRs	Bon I				92%[5,15]						
Surface bypass	Bon I			85%[1]			98%[5]			50%[5]	
Gas Fast Track		1:1[2,5]	175 kcfs			98%[2,5]				50%[2]	135 kcfs 24-hrs interim operation
JBS Improve.	Bon II			60%[5]	90%[1,5]		98%[2,5]	n/a	n/a		
Corner Coll.	Bon II							62%[5,19]	98%[5]		

Sources:
[1] NMFS (2000c).
[2] Marmorek et al. (1998).
[3] NMFS (1998).
[4] Ploskey et al. (1999) (percent of total project passage).
[5] Best professional judgment.
[6] Eppard et al. (2000).
[7] Mean of 1988 and 1989 hydroacoustic estimates (McFaden 1988, Ransom and Sullivan 1989).
[8] 1986 hydroacoustic estimate (Sullivan et al. 1986).
[9] NMFS (2000a).
[10] NMFSs (2000b) (percent of powerhouse passage).
[11] Variable spill efficiency: 5@10%, 3@20%, 2@40%, 1.5@50%, 1@60% spill.
[12] Based on calibration using 1999 Little Goose tailwater to Lower Monumental tailwater reach survival estimate.
[13] Monk et al. (1999).
[14] Brege et al. (1997).
[15] Based on potential improvement due to MGRs.
[16] Adams and Rondorf (1999).
[17] Hansell et al. (1999).
[18] BioSonics (1999).
[19] Hensleigh et al. (1998).

Empirical reach survival data were partitioned into survival estimates for each of the FCRPS projects where data were available. Because data were only available as far downstream as Lower Monumental Dam, reach survival estimates from the head of Lower Granite pool to the tailrace of Lower Granite Dam, from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam, and from the tailrace of Little Goose Dam to the tailrace of Lower Monumental Dam were used. Each tailrace-to-tailrace reach survival estimate in Table D-7 can be partitioned into its component pool and dam survival estimates. To estimate survival through each reservoir, the appropriate empirical measurement of reach survival was divided by the modeled dam survival estimates for the same project (i.e., from the SIMPAS analysis). At Little Goose Dam, for example, the 1994 reach survival of spring chinook salmon of 0.830 (the empirical reach survival value shown in Table D-7), was divided by 0.975 (the SIMPAS dam survival estimate), to obtain the pool survival value of 0.852. The model was calibrated with no spill at Lower Granite, Little Goose, and Lower Monumental dams, as the system was operated with no spill until May 10 in 1994.

Pool survivals for FCRPS projects downstream from Lower Monumental Dam were estimated for mixed stock (hatchery and wild) Snake River yearling chinook salmon by developing a per-mile survival rate through Lower Granite, Little Goose, and Lower Monumental pools. After determining the actual reservoir miles for each of the five mainstem FCRPS dams downstream from Lower Monumental, the per-mile survival rate was applied to each pool to obtain a pool survival estimate. The assumption was that applying a constant per-mile survival rate through the Ice Harbor Dam and the four lower Columbia River projects would be representative through these FCRPS reservoirs, as empirical data were unavailable to define pool survival rates more accurately at these projects.

Table D-7. Reach survival rates of juvenile yearling chinook salmon during 1994 (tailrace to tailrace).

Survival	Lewiston to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.936	0.830	0.847	0.89[1]	0.858[1]	0.773[1]	0.845[1]	0.829[1]
Pool Survival (Modeled)	0.967	0.852	0.906	0.909	0.882	0.796	0.931	0.874
Dam Survival (Modeled)	0.968	0.975	0.935	0.979	0.972	0.971	0.908	0.949

[1] Calculated from per-mile survival rate in Lower Granite, Little Goose, and Lower Monumental pools.

Yearling Chinook Salmon, 1995. Estimates of pool survival in 1995, which was an average to slightly above average water year, were based on empirical (PIT-tag) reach survival data from 1995 (Table D-8). Pool survival estimates for mixed stock yearling chinook in 1995 were

developed in the same manner as yearling chinook in 1994 except for the Lower Monumental to Ice Harbor and Ice Harbor to McNary pools. For 1995, NMFS now has empirical data for the Lower Monumental to McNary reach. The square root of this empirical value was used for each reach estimate because these reaches are approximately the same length. Because data were available only as far downstream as McNary Dam, NMFS applied the approach described above for yearlings in 1994 for the reach below Lower Monumental Dam to estimate yearling pool survivals for 1995 in the reach below McNary Dam.

Table D-8. Project survival rates (tailrace to tailrace) of juvenile yearling chinook salmon in 1995.

Survival	Lewiston to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.906	0.882	0.925	0.936[1]	0.936[1]	0.852[2]	0.872[2]	0.869[2]
Pool Survival (Calculated)	0.930	0.895	0.972	0.859	0.962	0.878	0.960	0.926
Dam Survival (Modeled)	0.974	0.985	0.952	0.976	0.973	0.970	0.908	0.939

[1] Calculated from Lower Monumental to McNary reach survival data.
[2] Calculated from per-mile survival rate from Lower Granite to McNary Dam.

Yearling Chinook Salmon, 1996. Estimates of pool survival in 1996, which was an above-average water year (i.e., 130% of average runoff from April through August, measured at Lower Granite Dam over the 71-year [1929 through 1999] water record), were based on empirical (PIT-tag) reach survival data for mixed stock yearling chinook from 1996 (Table D-9). Pool survival rates were estimated as described above for 1995.

Table D-9. Project survival rates of juvenile yearling chinook salmon in 1996 (from tailrace to tailrace).

Survival	Lewiston to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.979	0.926	0.929	0.870[1]	0.870[1]	0.844[2]	0.869[2]	0.870[2]
Pool Survival (Modeled)	1.000	0.940	0.977	0.893	0.893	0.871	0.957	0.922
Dam Survival (Modeled)	0.979	0.986	0.951	0.974	0.974	0.969	0.908	0.944

[1] Calculated from Lower Monumental to McNary reach survival data.
[2] Calculated from per-mile survival rate from Lower Granite to McNary Dam.

Yearling Chinook Salmon, 1997. Estimates of pool survival in 1997, which was one of the highest runoff years on record[3], were based on empirical (PIT-tag) reach survival data for combined hatchery and wild yearling chinook from 1997 (Table D-10). Pool survivals, including the Lower Granite pool, were estimated as described above for the 1994 and 1995 year cases.

Table D-10. Project survival rates of juvenile yearling chinook salmon in 1997 (from tailrace to tailrace).

Survival	Lewiston to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.913[1]	0.942	0.894	0.893[2]	0.893[2]	0.835[1]	0.865[1]	0.869[1]
Pool Survival (Calculated)	0.937	0.955	0.942	0.916	0.916	0.857	0.853	0.913
Dam Survival (Modeled)	0.974	0.986	0.949	0.975	0.975	0.972	0.908	0.952

[1] Calculated from per-mile survival rate from Little Goose to McNary Dam.
[2] Calculated from Lower Monumental to McNary reach survival data.

Yearling Chinook Salmon, 1998. Estimates of pool survival in 1998, which was a near average water runoff year, were based on empirical (PIT-tag) reach survival data for combined hatchery and wild yearling chinook from 1998 (Table D-11). Pool survivals were estimated as described above for the 1994 and 1995 years. Because data were available only as far downstream as John Day Dam, NMFS used the approach described above for yearlings in 1994 for the reach below Lower Monumental to estimate 1998 yearling pool survivals in the reach below John Day Dam, i.e., John Day tailrace to Bonneville Dam tailrace.

Yearling Chinook Salmon, 1999. The 1999 passage year was an above-average flow year in the context of the 71-year water record (1929 through 1999). It was also the first year for which survival estimates for combined wild and hatchery yearling chinook were available for the full FCRPS reach (from the head of Lower Granite pool to the tailrace of Bonneville Dam). Empirical reach survival data were partitioned into tailrace-to-tailrace survival estimates for each of the FCRPS projects (Table D-12) (W. Muir, NMFS, NWFSC, Cook, Washington, pers. comm.). Pool survivals were then estimated as described above for 1994.

[3] The 1997 April through August modified runoff volume at Lower Granite Dam was 35.3 maf, or 155% of the 71-year (1929 though 1999) average. The Columbia River runoff volume at The Dalles Dam over the same period was 111.1 maf, or 121% of average.

Table D-11. Project survival rates of juvenile yearling chinook salmon in 1998 (from tailrace to tailrace).

Survival	Lewiston to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.924	0.985	0.853	0.957[1]	0.957[1]	0.822	0.877[2]	0.880[2]
Pool Survival (Calculated)	0.950	1.000	0.898	0.981	0.984	0.848	0.966	0.937
Dam Survival (Modeled)	0.973	0.985	0.950	0.975	0.973	0.970	0.908	0.940

[1] Calculated from Lower Monumental to McNary reach survival data.
[2] Calculated from per-mile survival rate from Lower Granite to John Day Dam.

Table D-12. Project survival rates of juvenile yearling chinook salmon in 1999 (from tailrace to tailrace).

Survival	Lewiston to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.941	0.950	0.924	0.951[1]	0.951[1]	0.853	0.893[2]	0.911[2]
Pool Survival (Calculated)	0.967	0.965	0.973	0.975	0.978	0.880	0.984	0.970
Dam Survival (Modeled)	0.973	0.985	0.950	0.976	0.973	0.969	0.908	0.939

[1] Calculated from Lower Monumental to McNary reach survival data.
[2] Calculated from John Day to Bonneville reach survival data.

Using the approach described for 1994 yearling chinook to partition project survivals into pool and dam survivals, the Biological Effects Team's preliminary estimate of dam passage survival at Lower Monumental Dam (0.950) was lower than at the other lower Snake River projects, due largely to relatively high estimates of turbine and spillway survival derived from the low end of the range presented in the NMFS White Paper on dam passage (Table 9 in NMFS 2000c). The lower survival values were initially chosen to achieve a conservative result. However, the resulting SIMPAS estimate of dam passage survival was so low that when it was evaluated with the empirically-derived estimate of reach survival it resulted in an estimate of reservoir survival greater than 1, a highly unlikely outcome. To adjust for this, the Biological Effects Team considered the values for the turbine, spillway, and other passage parameters at Lower

Monumental Dam that were reported in NMFS (2000c), as well as other means of partitioning the reach survival between the dam and reservoir components. In the end, the Biological Effects Team decided to raise spill and turbine survival rates to values similar to those of Lower Granite and Ice Harbor. This provided a Lower Monumental pool survival estimate of 0.973, a value similar to that of the other Snake River pools.

The Biological Effects Team made another exception to its general approach for The Dalles and Bonneville dams. Because there is no juvenile fish PIT-tag detection facility at The Dalles Dam, the empirical reach survival data spanned the reach between the John Day and Bonneville tailraces. Estimated dam survival at the two projects was removed from the reach survival estimate leaving a pool survival estimate for both reservoirs. A per-mile survival rate was determined from this estimate and used to calculate reach survival for each project, using methods described above for the 1994 year case.

Subyearling Chinook Salmon, 1994 to 1999

Subyearling Chinook Salmon, 1994. No empirical information is available for the survival of subyearling chinook salmon below Lower Granite Dam in 1994. Thus, project survival estimates were not developed for subyearling chinook for 1994.

Subyearling Chinook Salmon, 1995. Empirical PIT-tag reach survival information from 1995 were available for wild subyearling fall chinook salmon from the point of release to Lower Granite Dam. In 1995, data for the reach between the Lower Granite and Lower Monumental tailraces were limited to hatchery fish.

The Biological Effects Team selected the survival of wild fish during 1995 to estimate the reach from release to Lower Granite Dam and to represent 1995 flow augmentation and temperature control operations. The measured reach survival (66.8%), divided by the modeled survival at Lower Granite Dam (94.2%), provided an estimate of the survival through Lower Granite pool of approximately 71% (Table D-13). The 1995 reach survival data for hatchery fish were used for the reach from Lower Granite to Lower Monumental Dam.

Pool survivals for projects downstream from Lower Monumental Dam were estimated for subyearling Snake River fall chinook salmon in the same manner as for yearling chinook in 1994. The assumption was that applying a constant per-mile survival rate through the Ice Harbor Dam and the four Lower Columbia River projects would be representative in those reservoirs, as data were unavailable to better define the pool survival rates at these projects. Another consideration was that although empirical data indicate that subyearling chinook salmon tend to migrate at a faster rate as they move downstream (which implies decreased exposure to predators), the number of predators increases through the lower Columbia River. Thus, these two factors tend to balance each other.

Table D-13. Project survival rates (tailrace to tailrace) of juvenile subyearling chinook salmon in 1995.

Survival	Release to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.668	0.890	0.795	0.878[1]	0.820[1]	0.738[1]	0.815[1]	0.804[1]
Pool Survival (Calculated)	0.709	0.944	0.846	0.897	0.867	0.771	0.921	0.858
Dam Survival (Modeled)	0.942	0.942	0.939	0.978	0.946	0.957	0.884	0.937

[1] Calculated from per-mile survival rate in Little Goose and Lower Monumental pools.

Subyearling Chinook Salmon, 1996. Estimates of pool survival for subyearling chinook salmon during 1996 were based on empirical (PIT-tag) reach survival data from 1996 (Table D-14). Pool survivals were derived as described above for 1995. Because data were available only as far downstream as Lower Monumental Dam, NMFS used the approach described above for subyearlings at downstream projects in 1995 to estimate pool survivals of subyearlings for 1996.

Table D-14. Project survival rates of juvenile subyearling chinook salmon in 1996 (from tailrace to tailrace).

Survival	Lewiston to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.479	0.898	0.782	0.873[1]	0.828[1]	0.727[1]	0.811[1]	0.791[1]
Pool Survival (Calculated)	0.508	0.953	0.828	0.892	0.860	0.760	0.917	0.850
Dam Survival (Modeled)	0.942	0.942	0.944	0.979	0.963	0.957	0.884	0.931

[1] Calculated from per-mile survival rate in Little Goose and Lower Monumental pools.

Subyearling Chinook Salmon, 1997. Estimates of pool survival for subyearling chinook salmon during 1997 were based on empirical (PIT-tag) reach survival data from 1996 (Table D-15). Pool survivals were derived as described above for the 1995 year case. Because data were available only as far downstream as Lower Monumental Dam, the Biological Effects Team used the approach described above for subyearlings at downstream projects in 1995 to estimate pool survivals of subyearlings for 1997.

Table D-15. Project survival rates of juvenile subyearling chinook salmon in 1997 (from tailrace to tailrace).

Survival	Lewiston to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.353	0.566	0.644	0.635[1]	0.546[1]	0.340[1]	0.639[1]	0.504[1]
Pool Survival (Calculated)	0.375	0.601	0.682	0.649	0.566	0.355	0.722	0.543
Dam Survival (Modeled)	0.942	0.942	0.944	0.978	0.964	0.957	0.884	0.928

[1] Calculated from per-mile survival rate in Little Goose and Lower Monumental pools.

Subyearling Chinook Salmon, 1998. Estimates of pool survival for subyearling chinook salmon during 1998 were based on empirical (PIT-tag) reach survival data from 1998 (Table D-16). Pool survivals were derived as described above for 1995. Because data were available only as far downstream as Lower Monumental Dam, the NMFS used the approach described above for subyearlings at downstream projects in 1995 to estimate pool survivals of subyearlings in 1998.

Table D-16. Project survival rates of juvenile subyearling chinook salmon in 1998 (from tailrace to tailrace).

Survival	Lewiston to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.558	0.771	0.921	0.878[1]	0.830[1]	0.737[1]	0.815[1]	0.802[1]
Pool Survival (Calculated)	0.592	0.818	0.976	0.897	0.866	0.770	0.921	0.857
Dam Survival (Modeled)	0.942	0.942	0.944	0.979	0.958	0.957	0.884	0.936

[1] Calculated from per-mile survival rate in Little Goose and Lower Monumental pools.

Subyearling Chinook Salmon, 1999. Estimates of pool survival for subyearling chinook salmon during 1999 were based on empirical (PIT-tag) reach survival data from 1999 (Table D-17). Pool survivals were derived as described above for 1995. Because data were available only as far downstream as Lower Monumental Dam, the Biological Effects Team used the approach described above for subyearlings at downstream projects in 1995 to estimate pool survivals of subyearlings for 1999.

Table D-17. Project survival rates of juvenile subyearling chinook salmon in 1999 (from tailrace to tailrace).

Survival	Lewiston to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.766	0.665	0.890	0.804[1]	0.743[1]	0.595[1]	0.762[1]	0.703[1]
Pool Survival (Calculated)	0.813	0.706	0.943	0.821	0.771	0.623	0.861	0.757
Dam Survival (Modeled)	0.942	0.942	0.944	0.979	0.964	0.955	0.884	0.929

[1] Calculated from per-mile survival rate in Little Goose and Lower Monumental pools.

Steelhead, 1994 to 1999

Steelhead, 1994. Pool survival estimates for juvenile hatchery steelhead in 1994 were developed in the same manner as with yearling chinook salmon (above). Survival data are shown in Table D-18.

Table D-18. Project survival rates of juvenile steelhead during 1994 (tailrace to tailrace).

Survival	Lewiston to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.900[1]	0.844	0.892	0.908[1]	0.882[1]	0.813[1]	0.858[1]	0.850[1]
Pool Survival (Calculated)	0.927	0.892	0.959	0.927	0.905	0.835	0.945	0.899
Dam Survival (Modeled)	0.971	0.946	0.930	0.980	0.975	0.974	0.908	0.945

[1] Calculated from per-mile survival rate in Little Goose and Lower Monumental pools.

Steelhead, 1995. Pool survival estimates for juvenile hatchery steelhead in 1995 were developed in the same manner as for yearling chinook in 1994 and 1995. Survival data are shown in Table D-19.

Table D-19. Project survival rates of juvenile steelhead in 1995 (from tailrace to tailrace).

Survival	Lewiston to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.944	0.899	0.950	0.926[1]	0.926[1]	0.884[2]	0.881[2]	0.887[2]
Pool Survival (Calculated)	0.967	0.925	1.000	0.946	0.950	0.908	0.970	0.945
Dam Survival (Modeled)	0.976	0.972	0.950	0.979	0.975	0.974	0.908	0.939

[1]Calculated from survival data for Lower Monumental to McNary reach.
[2]Calculated from per-mile survival rate from Lower Granite to McNary pools.

Steelhead, 1996. Pool survival estimates for juvenile hatchery steelhead in 1996 were developed in the same manner as for yearling chinook in 1994 and 1995. Survival data are shown in Table D-20.

Table D-20. Project survival rates of juvenile steelhead in 1996 (from tailrace to tailrace).

Survival	Lewiston to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.934	0.938	0.937	0.889[1]	0.889[1]	0.860[2]	0.873[2]	0.878[2]
Pool Survival (Calculated)	0.957	0.967	0.988	0.908	0.911	0.884	0.962	0.930
Dam Survival (Modeled)	0.976	0.970	0.948	0.979	0.976	0.973	0.908	0.944

[1]Calculated from survival data for Lower Monumental to McNary reach.
[2]Calculated from per-mile survival rate in Little Goose and Lower Monumental pools.

Steelhead, 1997. Empirical reach survival estimates for combined hatchery and wild hatchery steelhead were available from Lower Granite through Bonneville Dam; however, individual reach survivals were not available for reaches below Lower Monumental Dam. The Lower Monumental to Ice Harbor and the Ice Harbor to McNary reaches were calculated as explained for 1995 yearling chinook. The reaches and pool survivals for projects below McNary Dam were calculated using a per-mile survival rate derived from the empirical McNary to Bonneville reach survival estimate and calculation techniques explained for 1999 yearling chinook. Survival data are shown in Table D-21.

Steelhead, 1998. Pool survivals were calculated for combined hatchery and wild steelhead in 1997, except that an empirical reach estimate was used for the McNary to John Day reach. Survival data are shown in Table D-22.

Table D-21. Project survival rates of juvenile steelhead in 1997 (from tailrace to tailrace).

Survival	Lewiston to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.963	0.966	0.902	0.913[1]	0.913[1]	0.851[2]	0.870[2]	0.880[2]
Pool Survival (Calculated)	0.987	0.995	0.953	0.932	0.935	0.874	0.958	0.924
Dam Survival (Modeled)	0.976	0.971	0.946	0.979	0.977	0.974	0.908	0.952

[1]Calculated from survival data for Lower Monumental to McNary reach.
[2]Calculated from per-mile survival rate from McNary to Bonneville Dam.

Table D-22. Project survival rates of juvenile steelhead in 1998 (from tailrace to tailrace).

Survival	Lewiston to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.925	0.930	0.889	0893[1]	0.893[1]	0.831	0.897[2]	0.918[2]
Pool Survival (Calculated)	0.949	0.959	0.939	0.912	0.916	0.854	0.988	0.977
Dam Survival (Modeled)	0.975	0.970	0.947	0.979	0.975	0.974	0.908	0.940

[1]Calculated from survival data for Lower Monumental to McNary reach.
[2]Calculated from per-mile survival rate from McNary to Bonneville Dam.

Steelhead, 1999. Pool survivals were calculated the same way they were for combined hatchery and wild steelhead, 1998. Survival data are shown in Table D-23.

Table D-23. Project survival rates of juvenile steelhead in 1999 (from tailrace to tailrace).

Survival	Lewiston to LWG	LWG to LGS	LGS to LMN	LMN to IHR	IHR to MCN	MCN to JDA	JDA to TDA	TDA to BON
Reach Survival (Empirical)	0.908	0.926	0.915	0.913[1]	0.913[1]	0.920	0.840[2]	0.812[2]
Pool Survival (Calculated)	0.931	0.954	0.966	0.932	0.936	0.945	0.925	0.865
Dam Survival (Modeled)	0.975	0.970	0.947	0.979	0.975	0.973	0.908	0.939

[1]Calculated from survival data for Lower Monumental to McNary reach.
[2]Calculated from per-mile survival rate from John Day to Bonneville Dam.

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APPENDIX E
RISK ASSESSMENT FOR SPILL PROGRAM
DESCRIBED IN 2000 DRAFT BIOLOGICAL OPINION

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E.1 SUMMARY

This paper addresses the 120% dissolved gas ceiling in light of the findings of the "Spill and 1995 Risk Management" report (1995 report) prepared by the region's fishery agencies and tribes (WDFW et al. 1995), the findings of research before and during implementation of the 1995 FCRPS Biological Opinion, and the results of the physical and biological monitoring program conducted from 1995 to the present. Two spill program scenarios are evaluated using the SIMPAS model, which compares the potential juvenile salmonid survival improvement due to increased spill against the risks of increasing total dissolved gas above the 110% water quality standard. The National Marine Fisheries Service (NMFS) concludes in this updated assessment that the risk associated with a managed spill program to the 120% total dissolved gas (TDG) level is warranted by the projected 4% to 6% increase in system survival of juvenile salmonids. Recent research and biological monitoring results support the findings of the 1995 report, which predicted that TDG in the 120%-to-125% range, coupled with vertical distribution fish passage information indicating that most fish migrate at depths providing some gas compensation, would not cause juvenile or adult salmon mortalities exceeding the expected benefits of spillway passage. NMFS finds little evidence that this expected survival improvement would be reduced by mortality related to gas bubble trauma (GBT). NMFS also concludes that physical and biological monitoring of GBT signs can continue to be used to indicate dissolved gas exposure in adult and juvenile salmon migrants.

E.2 INTRODUCTION AND BACKGROUND

Risk assessment is the comparison of alternative paths of action to determine the probability of an adverse outcome. The 1995 report was based on a risk model described by Rowe (1997). In that model, risk is characterized and managed by identifying the hazards and the degree of exposure to those associated with different paths of action. In the 1995 report, two paths of juvenile fish passage were compared: a) juvenile fish through turbines, where they are subjected to physical hazards, changes in pressure, etc., or, b) routing them over project spillways by increasing the volume of water spilled. The main hazard involved in the second alternative is the potential effect of dissolved gas supersaturation and the debilitating, and potentially lethal, GBT. The 1995 report found that, within limits, spill had merit compared with turbine passage. As a result of that report, NMFS recommended spill to achieve 80% fish passage efficiency (FPE) up to a gas level of 120% in the tailrace (and 115% in the forebay) at mainstem hydroprojects where juvenile salmon pass.

The region now has 5 years' experience in implementing the spill program recommended by the 1995 FCRPS Biological Opinion. Additional dissolved gas research has been conducted. Moreover, 5 years of physical and biological monitoring results are now available to characterize the results of the spill program adopted by NMFS in 1995. Finally, the NMFS SIMPAS model,

used to estimate the projected survival effects of management alternatives, was updated in 2000 with the most recent quantitative input to various fish passage functions. The model allows predicting the project and system survival effects for listed juvenile salmonids at different spill levels. Here, we investigate the risk to salmonids of TDG levels greater than the 110% water quality standard. The investigation does not assess risk to other aquatic species. For further information on that topic, see Schrank et al. (1996 and 1997); Ryan and Dawley (1998); and Ryan et al. (2000).

E.2.1 1995 Spill and Risk Management Report

In 1995, a group of the region's agencies and tribes developed the 1995 report, which evaluated the risks of alternate strategies for the passage of juvenile salmonids at hydroelectric projects in the Columbia River basin. The two main passage routes scrutinized were passage through turbines and voluntary spill at the FCRPS projects. The work was done jointly by technical staffs of the Columbia River Intertribal Fish Commission, the Idaho Department of Fish and Game, the Oregon Department of Fish and Wildlife, and the Washington Department of Fish and Wildlife. Also contributing to the report were the U.S. Fish and Wildlife Service, NMFS, and the Fish Passage Center.

Spill has long been known as a valid and relatively safe strategy for increasing passage efficiency and improving the survival of juvenile migrants. However, spill generates dissolved gas supersaturation, which represents a risk to fish if the gas level is too high. When the 1995 report was written, there had already been approximately 30 years of laboratory and field research on the subjects of spill, TDG production, the biological effects of dissolved gas supersaturation, and other hydroelectric project effects on juvenile and adult salmonid passage. The 1995 report reviewed the research on spill and its effect on dissolved gas generation and subsequent GBT and mortality in fish. Relative risks were then mathematically assessed on the basis of an analysis of quantitative information concerning direct fish mortality from both turbine and spill passage. The 1995 report concluded that, as long as spill-generated TDG levels did not exceed 120% to 125% supersaturation, the risk of passing juvenile salmonids through the spillways remained lower than the risk of passing juveniles through turbines. The 1995 assessment also indicated that the same level of TDG would not harm adult salmon.

E.2.2 NMFS 2000 Approach

The dissolved gas water quality standard was established in the 1970s by the U.S. Environmental Protection Agency (EPA). The standard is enforced by the water quality agencies in each state. The dissolved gas standard is limited to a dissolved gas supersaturation of 110%. It applies to all fish and aquatic life and incorporates a margin of safety. Since the implementation of the first biological opinion, the states recognized the value of spill to increasing the survival of

downstream migrants. They have, therefore, granted temporary waivers of the TDG standard to a level of 115% TDG in project forebays and 120% TDG in tailraces during the juvenile migration season. The pertinent question in this risk analysis concerns the increase in juvenile survival represented by the additional 5% to 10% of dissolved gas permitted by the states' temporary waiver limits.

NMFS employed the SIMPAS model to evaluate the potential increase in juvenile survival due to the difference in spill levels generating TDG of 110% or 120% supersaturation. The SIMPAS model includes all the current information on species-specific fish passage parameters: spill efficiency; fish guidance efficiency; spill/gas caps, turbine, spillway, sluiceway, and bypass survivals; and diel passage patterns.[1]

The increase in survival due to the added spill is compared with the risk potential due to the added 5% to 10% of TDG. The results of 5 years of monitoring TDG levels (during the 1995-to-1999 spill seasons) and the biological reactions in the juvenile migrant population detected by the monitoring program are reviewed. The results of research during the same period are also reviewed to validate the monitoring methods and to verify the assumptions of the SIMPAS modeling.

E.3 1995 TURBINE VERSUS SPILL MORTALITY RISK ASSESSMENT

E.3.1 Juvenile Salmonid Assessment

The hydroelectric projects on the Columbia and Snake rivers impede salmonid migrations (Raymond 1969, 1979). Passage of juveniles through turbines, bypass systems, and spill represents sources of injury and mortality (NMFS 2000a). For example, recent NMFS studies of turbine survival for yearling chinook in the Snake River produced estimates of 92.0% in 1993, 86.5% in 1994, and 92.7% in 1995 at Little Goose, Lower Monumental, and Lower Granite dams. Steelhead survival from turbine passage at Little Goose in 1997 was 93.4% (Muir et al., In review: No. Am. J. Fish. Mgt.).

The most benign method for improving passage is to pass fish over the project, through the spillway, and avoid the powerhouse altogether (NMFS 2000a; ISAB 1999). The range of spillway mortality for standard spillway structures is 0% to 2% (Whitney et al. 1997).

[1]For a more complete description of the SIMPAS model and a listing of its passage parameters, see Appendix D.

The 1995 report assessed the risks of turbine passage and spill as alternate routes of passage through FCRPS hydropower projects. Specifically, the 1995 assessment compared the anticipated mortalities from turbine passage with the mortalities that could occur as a result of elevated TDG due to spill and associated GBT effects. The assessment hypothesized that mortality due to controlled dissolved gas levels from the NMFS spill program would be less than mortality due to turbine passage.

The assessment methods required estimating turbine mortality under different river management (spill/no spill) schemes, and estimating mortality from TDG created by increased spill. Turbine mortality was then used as a benchmark for comparison with projected mortality from TDG under increased spill programs. At some level of TDG, juvenile mortality due to gas supersaturation will equal or exceed that due to turbine passage. Spill-generated TDG levels above that point will be increasingly detrimental to juvenile migrants.

Turbine mortality estimates were derived from 1992 smolt monitoring program data, which provided a measure of fish population size and timing. The numbers of fish passing through turbines were estimated by applying the fish guidance efficiencies identified in the Columbia Basin Fish and Wildlife Authority's Detailed Fishery Operating Plan to the population figures. The population numbers were also adjusted to reflect fish capture for the transportation program and for losses to the population from reservoir mortalities. Finally, the river project operations component of the assessment was chosen to represent three levels of spill:

1) Hydrosystem operated for power generation only (baseline, no spill)
2) Hydrosystem operated according to 1992 FCRPS Biological Opinion spill
3) Hydrosystem operated to 80% FPE (115% to 120% TDG spill caps)

Each operational scenario yielded an estimate of juvenile turbine mortality under the described conditions.

The estimates of mortality due to TDG were more difficult. In the mid-1990s, bioassays had determined lethal TDG levels primarily under shallow-water laboratory conditions, which are not representative of the conditions experienced by migrating juveniles. The Columbia River is sufficiently deep throughout the FCRPS that migrants could benefit from depth compensation for supersaturated conditions. In 1995, many fisheries scientists believed depth compensation was significant in determining fish responses to TDG.

Because of their depth limitations, the laboratory TDG bioassay data were not used in the 1995 assessment. Dissolved gas mortalities were estimated using the results of in situ field studies in which fish were exposed in live cages and held at specified depths. The exposures and amount of depth compensation experienced by the test fish were, therefore, more representative of the

condition experienced by migrants. Dissolved gas mortality functions were calculated from data for coho, chinook, and steelhead exposed at representative depths, to gas levels ranging from 110% to 140% and for periods from 3 to 92 days (Ebel 1969; Beiningen and Ebel 1969; Ebel 1971; Meekin and Turner 1974; Blahm et al. 1975, 1976; Dawley 1986; and Toner et al. 1995). The mortality function for dissolved gas, developed statistically, described the percent of fish mortality as a function of TDG. The analysis also considered exposure duration, species, and depth. The data were fitted to a logistical model.

The risk model used by the agencies and tribes in 1995 is demonstrated in Figure 1, which plots turbine mortality (y-axis) against percent dissolved gas (x-axis). The calculations of mortality, in numbers of juvenile fish, estimated the difference in project mortality between a no-spill (maximum turbine passage and mortality) and an 80% FPE scenario (minimum mortality due to maximized spill). The difference in mortality between the two extremes was termed a mortality "ceiling," and represents the expected benefit of 80% FPE spill up to the gas cap, excluding TDG-induced mortality. The expected benefit in terms of number of fish is shown as a horizontal line in Figure 1. The sigmoid line in the figure is an example of a mortality function curve, which represents the estimated loss of fish due to TDG. The point where the turbine mortality line and the gas mortality curve intersect is where the mortality due to dissolved gas from spill equals the mortality due to turbine passage. That is, additional spill and resulting gas would be predicted by the model to kill more fish than would turbine passage.

A shortcoming of the risk assessment model is determining how to incorporate exposure time in the mortality function. The 1995 report therefore assessed risk in two time frames, i.e., the model assumed that dissolved gas mortality was either instantaneous at the project, or occurred after an exposure period equal to the travel time from Ice Harbor Dam to Bonneville Dam. Even with such an oversimplification, the dissolved gas concentration at which no further benefit could be achieved by increasing spill exceeded the 120% tailrace gas cap set by the FCRPS 1995 Biological Opinion.

The 1995 report concluded that spill provided a safe route of project passage compared with turbines, up to the spill levels that would generate a downstream gas equivalent to 120% to 125% TDG in the tailraces.

E.3.2 Adult Salmonid Assessment

The 1995 report estimated potential adult mortality due to elevated TDG levels for chinook, sockeye, and steelhead. Using published laboratory and field mortality data for those species, the assessment focused on a TDG range of 115% to 130% and on actual river conditions and spill levels during the spring and summer. The analysts made two assumptions: 1) there would be no

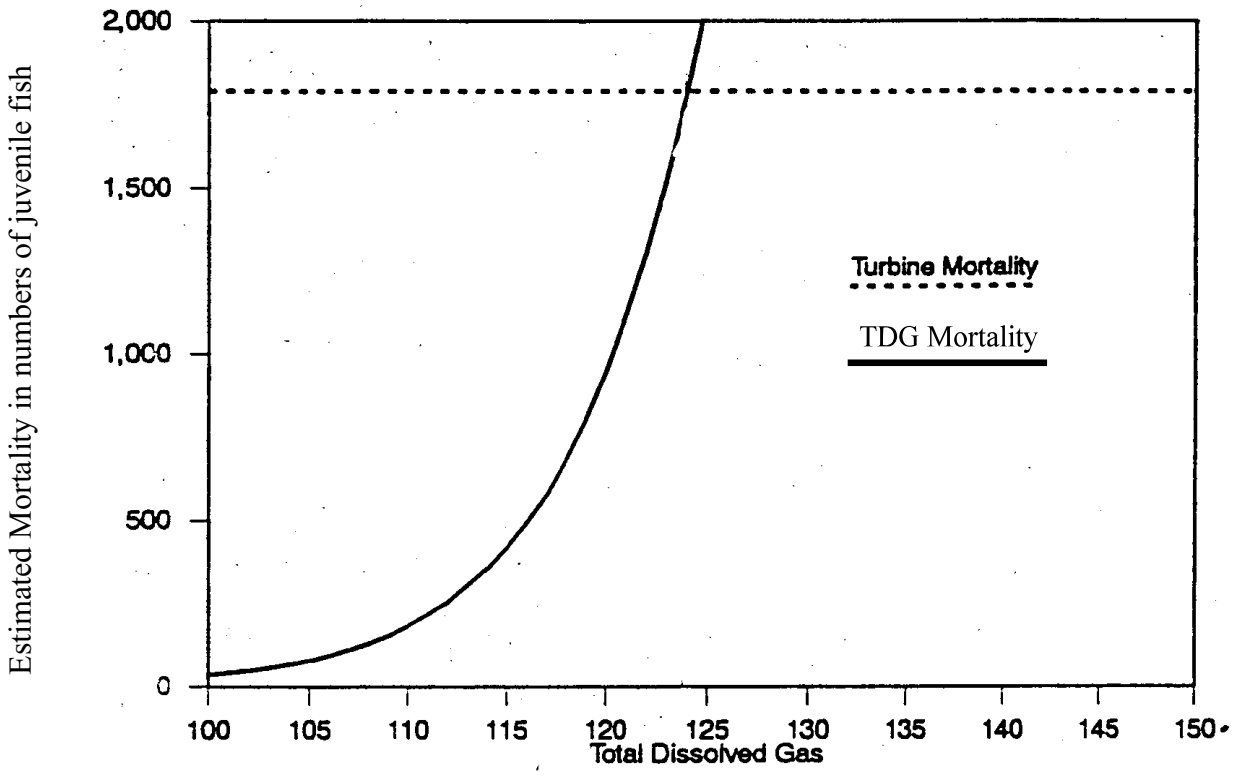

Figure E-1. Risk assessment model example.

dissolved gas-related mortality at gas levels less than 110%, and 2) only fish occupying water less than 3 meters deep would be vulnerable to GBT. The latter assumption factored in effects of depth compensation.

The model that was developed estimated the size of the population exposed, the exposure time, and the expected mortality for fish in three depth zones (0 to 1, 1 to 2, and 2 to 3 meters). Mortality was estimated by regression analysis for spring chinook, sockeye, and summer and winter steelhead.

The analysis projected no adult chinook, sockeye, or steelhead mortalities at 115% or 120% TDG, assuming depth compensation. Mortality for summer chinook and sockeye was predicted to increase between 125% and 130% TDG. The predicted mortality of steelhead at 125% and 130% was less than that of chinook and sockeye, because of the migration timing of the species.

Another step taken in this 1995 analysis considered the fate of the juveniles protected by an increased spill program, i.e., juveniles that were spilled and thus avoided turbine passage. The anticipated increase in numbers of juveniles was converted to an estimated survival-to-adult number. The adult equivalent estimate was also used to assess the impact of TDG on the adult population.

E.4 2000 TURBINE MORTALITY VERSUS SPILL MORTALITY ASSESSMENT

The 2000 FCRPS Biological Opinion analyzes the biological effects of many actions, strategies, and scenarios, separately or in concert. To assist in the biological analysis, a Biological Effects Team was formed. The team was one of five formed to assist in the Section 7 consultation process. It was agreed that the biological effects of juvenile salmonid passage measures, including spill, would be evaluated by the Biological Effects Team and NMFS using the SIMPAS model. The details of the biological effects analysis and the SIMPAS model are discussed in Appendix D.

The SIMPAS model is particularly appropriate for spill questions, because it accounts for successful passage through each route available to juvenile fish, including turbines, sluiceways, surface and conventional fish bypasses, and spillways. The model also accounts for juvenile fish transportation and reservoir passage. The model produces juvenile survival estimates at each project individually and systemwide. The model incorporates the latest qualitative and quantitative information on spill efficiency, fish guidance efficiency, turbine survival, bypass survival, spill/gas caps, spillway survival, sluiceway survival and diel passage patterns (NMFS 2000b,c,d,e).

The spill scenarios were analyzed for this assessment using the SIMPAS model. It was assumed that the 2000 FCRPS Biological Opinion reasonable and prudent alternative (RPA) spill program was fully implemented. The RPA condition was selected because the long-term TDG goal (i.e., over the next 10 years or so), as stated in Section 9.6.1.7.1 of the 2000 FCRPS Biological Opinion, is to reach the 110% standard in all critical habitat in the Columbia River and Snake River basins, including the mainstem. Achieving this goal in the long term still requires juvenile fish system survival levels to be consistent with the performance standards for the mainstem FCRPS hydropower projects (see Section 9.2.2.2.1 of the biological opinion).

The spill conditions in the SIMPAS model reflect current state water quality guidelines. TDG is 110% in Washington and Oregon. Each year since 1995, the states have temporarily waived the 110% limit and allowed spill to a gas level not to exceed 115% in project forebays or 120% in the tailrace. The modeled spill volumes are based on the current U.S. Army Corps of Engineers' estimates of spill expected to yield the above levels of TDG supersaturation. A 1995 water

condition was selected for the spill studies as an approximate average water condition.[2] The 1995 water year resulted in involuntary spill only at McNary Dam.

For the present assessment, SIMPAS survival modeling was conducted for juvenile spring chinook (yearling), juvenile fall chinook (subyearlings), and juvenile steelhead migrants under 110% TDG spill levels and under 115% or 120% TDG spill levels. Additional spill at the 115% or 120% TDG levels would yield an improvement of 5.7% in inriver survival for juvenile spring chinook yearlings. The increases in inriver system survival are estimated to be 4.9% for subyearling chinook and 3.9% for juvenile steelhead.

E.5 SUMMARY OF BIOLOGICAL MONITORING SINCE 1995

The 1995 FCRPS Biological Opinion called for physical and biological monitoring programs to accompany implementation of the spill programs. The purpose was to track and record spill, dissolved gas, and effects on aquatic biota. The physical monitoring program deployed about 40 dissolved-gas saturometers at various forebay and tailrace stations throughout the FCRPS. Some monitoring stations were also established and operated by the Mid-Columbia Public Utility Districts (PUDs).

The biological component of the monitoring program required collecting and examining juveniles and adult salmonids for GBT. Juveniles are collected as the fish pass through the juvenile collection/bypass facilities at Lower Granite, Little Goose, Lower Monumental, Rock Island (a Mid-Columbia PUD project), McNary, and Bonneville dams. The fish are inspected for fin, eye, and lateral line signs of GBT. Adults are examined at Bonneville and Lower Granite dams. Adults have also been examined at the Priest Rapids and Three Mile (Umatilla River) dams. All adults are examined for signs of GBT in the fins and eyes. Detailed results of the physical and biological monitoring programs are reviewed in annual reports to the Oregon Department of Environmental Quality (ODEQ) (NMFS 2000a).

E.5.1 Results of Physical Monitoring Program, 1995 to 1999

The physical monitoring program results from 1995 to 1999 should be differentiated into two conditions to clarify the potential impact of the NMFS spill program on salmonids. The two spill conditions are 1) a program managed or planned to keep spill levels within 115% or 120% TDG, and 2) involuntary, or forced, spill conditions. The first condition is controllable; spill for fish

[2]Specifically, the 1995 modified April-to-August runoff volume at Lower Granite Dam on the Snake River was 22.4 million acre-feet (maf), or 98% of average, while the April-to-August runoff volume for the Columbia River at The Dalles was 86.1 maf, or 94% of average.

can generally be managed within the state water quality limits in average to below-average runoff conditions. The second condition is uncontrollable because it results from average to above-average runoff that creates high river flows beyond the hydraulic capacity of the FCRPS powerhouses. The differences in the two spill conditions are reflected in the percent of days during the spring and summer migration periods when TDG exceeds 120% and 130% in the tailraces of lower Snake and Columbia River dams. For example, 1995 was the only year during the period with near-average runoff. The percent of days exceeding 120% TDG in 1995 was only about 8%, and for 130% TDG, only about 2%. The exceedances were due to short periods of involuntary spill, and to lack of gas-abatement structures at Ice Harbor and John Day dams. Thus, for most of the 1995 migration period, gas levels were managed to below 120% TDG.

That was not the case for the higher runoff years of 1996 through 1999. In most of those years, flows exceeded hydraulic capacity and caused involuntary spill for stretches of days. The highest runoff years were 1996 and 1997, which experienced 130% and 155% of average runoff in the Snake River and 122% and 121% of average runoff in the Columbia River, respectively. The 1997 April-to-August runoff volume at Lower Granite Dam on the Snake River, for example, was the third highest since 1928. During these two years, the percent of days exceeding 120% and 130% TDG was about 48% and 15% to 22%, respectively. Again, the exceedances were due largely to involuntary spill. In 1998 and 1999, runoff was 112% and 119% of average in the Snake River and 98% and 118% of average in the Columbia River, respectively. The percent of days during the migration period exceeding 120% TDG ranged between 16% and 18%, respectively, with only one day in 1998 exceeding 130% TDG. Most exceedances were due to involuntary spill.

The tailraces of John Day and Ice Harbor dams, however, regularly exceeded the state 120% waiver limit from 1995 to 1997. Ice Harbor tailwater exceeded 130% almost 44% of the migration period in 1996, and the John Day tailwater exceeded that level about 48% of the time in 1997. Those levels were due largely to the high runoff volumes and flows that frequently exceeded the hydraulic limits of the projects, but also to lack of gas-abatement structures. Installing gas-abatement structures at both Ice Harbor and John Day dams in 1998 and 1999 contributed to the observed reductions in the gas levels in the tailwaters of those projects. The number of days when TDG levels exceeded the waiver level was reduced on average by about 50 days in 1998 and about 10 days in 1999.

E.5.2 Results of Biological Monitoring Program, 1995 to 1999

The biological monitoring program has been implemented each spring and summer since 1995. The results from 1995 to 1999 are evaluated and presented in the NMFS annual reports to ODEQ (NMFS 1996, 1997, 1998, 1999, 2000a). On capture, juvenile fish are anesthetized and

examined for the presence and severity of GBT signs. The severity of the signs is ranked according to the criteria in Table E-1, with ranks 3 and 4 classified as severe.

Table E-1. Criteria for ranking prevalence and severity of gas bubble trauma signs (NMFS 1997).

Rank	Area Covered With Bubbles (%)
0	0
1	1 - 5
2	6 -25
3	26 - 50
4	> 50

GBT signs (bubbles and blisters in the fins, eyes, gills, lateral line, mouth, and skin) have been recognized since the late 1960s. However, no clear correlation has been made between the various signs and mortality. Although it is generally accepted that the proximate cause of death in fish is gill emboli (Maule et al. 1997), a nonlethal technique has never been developed to examine gill lamellae. Therefore, fin bubbles continue to be the sign conventionally used to monitor and rank for biological effects of TDG supersaturation.

An important application of the GBT ranking system is in managing the spill program. Early on, it was determined that action to reduce voluntary spill and TDG levels would be taken if more than 5% of the fish examined exhibited bubbles covering 25% or more (rank 3) of the surface of any unpaired fin, or if 15% of the fish showed any bubbles on unpaired fins. These are referred to as the spill program "action levels." The action levels incorporate a margin of safety and are based on uncertainties raised in earlier research by the U.S. Geological Survey, Biological Resources Division (Maule et al. 1997a, 1997b). Those studies found that significant mortality did not occur in the test fish until approximately 60% of the exposed population exhibited bubbles in the fins or 30% displayed bubbles covering 25% or more of any unpaired fin. The action levels were then reduced primarily because the research results indicated a substantial uncertainty between fin bubble percentage and the onset of mortality.

The data in Table E-2 were reported in the 2000 NMFS annual report to the ODEQ. Reported are the number and percent of juveniles with severe GBT signs (rank 3 or 4) observed in fish collected during the past 5 years. Table E-2 shows that severe signs were observed primarily in 1996 and 1997. The management strategy for the spill program is to reduce spill in response to severe signs. That has never happened during managed (or voluntary) spill conditions. For

example, in 1996 and 1997, when severe GBT signs were recorded, spill reduction was not an option because high runoff conditions exceeded the hydraulic capacity of FCRPS powerhouses. There were also six instances of severe or action-level signs in 1998. They occurred in the early part of the spill season, when flows were large and spill responsible for elevated TDG was due to involuntary conditions (Filardo, personal communication).

Table E-2. Summary of severe GBT signs monitored at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, and Bonneville dams.

Year	Fish Examined	Severe GBT Signs	
		No.	%
1995	71,230	0	0.00
1996	38,925	47	0.12
1997	42,751	117	0.27
1998	46,498	6	0.01
1999	25,184	0	0.00

From 1995 to 1999, the smolt monitoring program collected and observed 192,832 juvenile salmonids for GBT signs in the mainstem Snake and lower Columbia rivers. A total of 3,033, or 1.6%, showed some signs of GBT in their paired fins. The yearly incidence of signs was related to TDG exposure. For 1996 and 1997, higher levels of TDG were associated with higher percentages of GBT signs in salmonids (3.2% to 3.3%). Whereas in 1995, 1998, and 1999, with lower levels of TDG, the percentage of fish showing signs ranged from only 0.04% to 0.7%.

Figures E-2 and E-3 display the percent of sampled yearling chinook and steelhead in the lower Snake and lower Columbia rivers with observed signs of GBT relative to the TDG levels and the ranked response. It is apparent that few fish exposed to TDG levels below 120% exhibited GBT signs. However, fish with signs of GBT that were exposed to gas levels above 120% showed both an increasing incidence and severity. The more severe signs of rank 3 follow a similar pattern but do not begin to appear until TDG exceeds 116% to120%. Rank 3 signs become more prevalent above 131% TDG. The more severe signs affect only about 0.5% of the fish collected throughout the 5 years of the monitoring program.

Over the same 5-year period, steelhead sampled in the smolt monitoring program that displayed signs of GBT showed exactly the same trends in incidence and severity as did chinook. Rank 3 signs became more prevalent above 131% TDG and only affected about 1% of the fish collected during the 5 years.

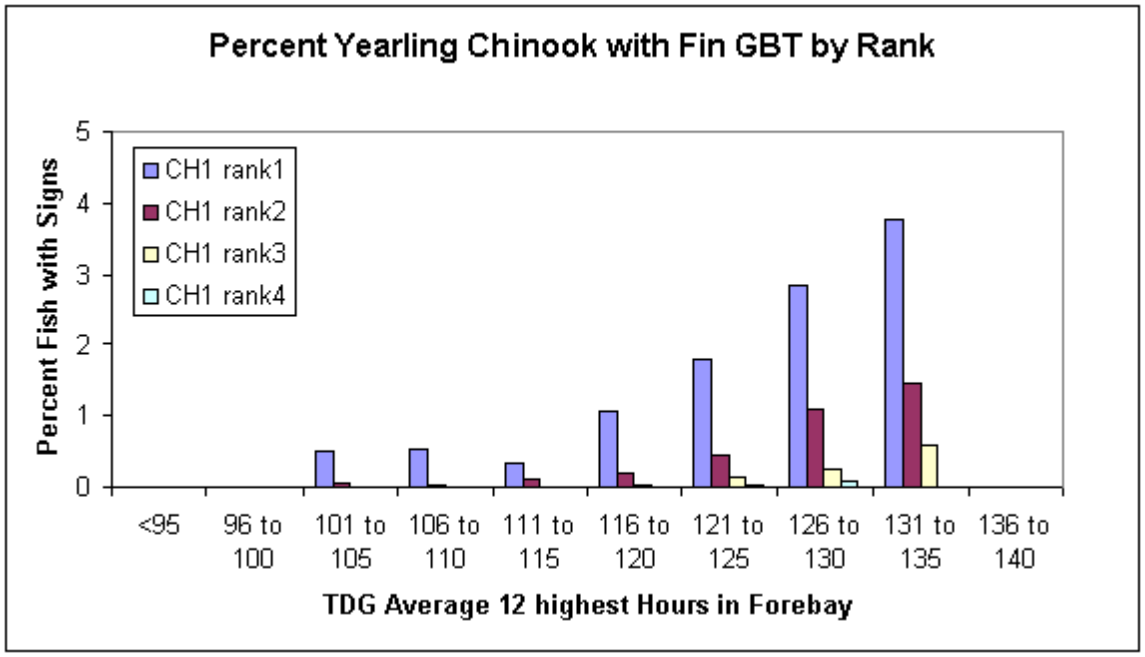

Figure E-2. Percent yearling chinook salmon examined for GBT from 1995 to 1999 that exhibited fin bubbles of rank 1 through 4 versus forebay TDG levels (average of 12 highest hours) measured the day the fish were examined (Rock Island Dam monitoring not included).

E.5.3 Adult Monitoring

Since 1996, adult fish have routinely been examined for the effects of TDG exposure during their upriver migration. The fish have been collected at Bonneville and Lower Granite dams, and less regularly at Ice Harbor, Priest Rapids, and Three Mile dams. Because of the high value of the adult fish and their potential for mortality due to handling, adult sampling for GBT is ancillary to other research on adult fish. The results of 4 years of adult fish monitoring are summarized in Table E-3.

As with juvenile monitoring, spring 1997 was the period of highest dissolved gas and the most significant degree of GBT in adult salmonids since the start of the spill program. In 1997, because of high runoff and forced spill conditions, TDG below Bonneville Dam was 135% or higher for 16 days, and above 130% for 24 days. During the spring and early summer, gas levels remained above 125% for an extended period in many sections of the river. Sockeye were most affected in 1997, with 15.6% of the fish collected at Bonneville Dam displaying signs of GBT. At Priest Rapids Dam, 4.2% of the collected sockeye were also affected. No sockeye were collected at Lower Granite Dam. During the same period, 0.5% of the chinook population was afflicted with GBT at Bonneville Dam, 0.1% at Lower Granite Dam, and 3.2% at Priest Rapids Dam. In the other years of monitoring (1996, 1998, and 1999), only a small number of fish collected at the sampling sites displayed signs of GBT. At Bonneville Dam, for example, none of the caught fish showed GBT signs.

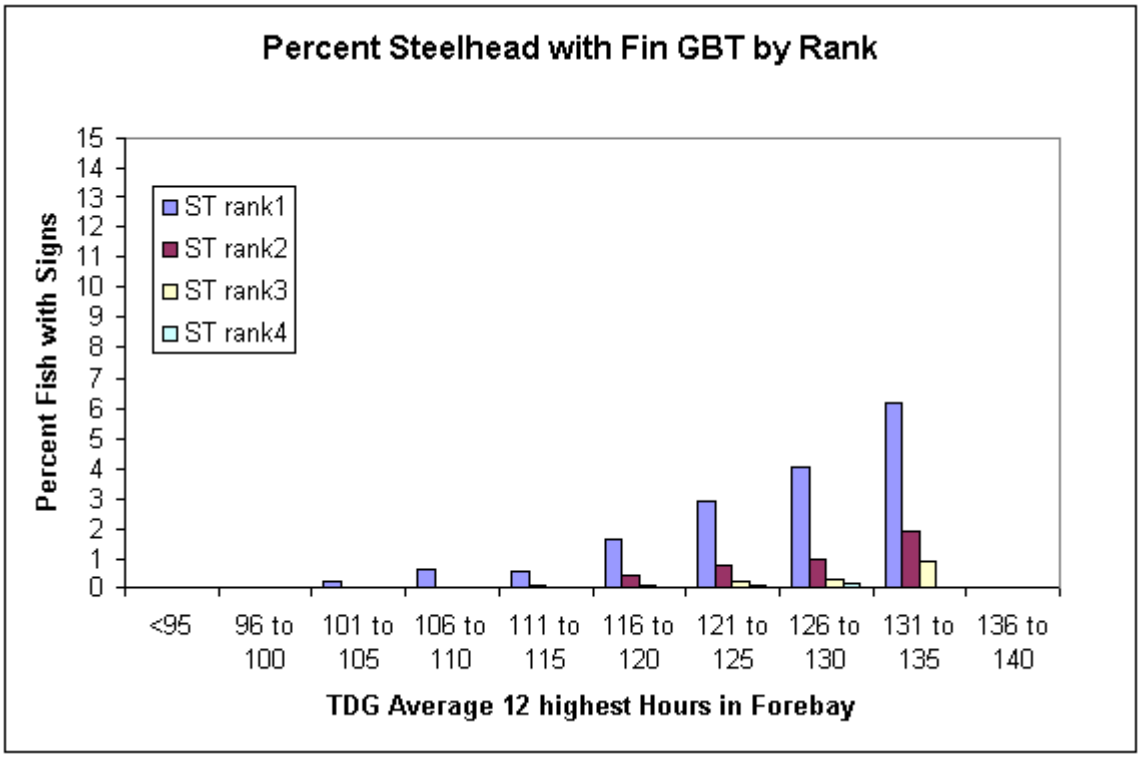

Figure E-3. Percent of steelhead examined for GBT from 1995 to 1999 that exhibited fin bubbles of rank 1 through 4 versus forebay TDG levels (average of 12 highest hours) measured the day the fish were examined (Rock Island Dam monitoring not included).

The action levels established by NMFS for adults are more stringent than those for juveniles. The adult levels stipulate reduction of spill if two or more fish are observed to have external signs of GBT in a single day at a sampling site. Action is also prompted if signs are found on one fish in two or more sampling periods at the same project. The results of the monitoring program show that the action levels were surpassed only in the high spill years of 1996 and 1997. However, the substantial involuntary spill in those years eliminated the ability of river managers to respond to the action levels by reducing spill and the associated TDG levels.

E.5.4 Resident Aquatic Species

The sensitivity of resident fishes and invertebrates to TDG supersaturation was investigated in the early 1990s. Species observed for GBT signs included suckers, sculpins, sticklebacks, and several minnows as well as crayfish, clams, and insect larvae. Gas exposure levels ranged from 117% to 130%. Only rarely were GBT signs observed (Toner 1993). It was concluded that resident fishes and invertebrates are relatively tolerant of elevated TDG.

Table E-3. Adult salmonid GBT recorded at FCRPS projects between 1996 and 1999.

Site	Species	Fish Examined	Fish With GBT Signs	
			No.	%
1996				
Bonneville	Chinook	*	4	0.2
	Steelhead	*	3	0.1
	Sockeye	*	1	0.05
Lower Granite	Chinook	2652	4	0.1
1997				
Bonneville	Chinook	1042	5	0.5
	Steelhead	336	24	7.1
	Sockeye	648	101	15.6
Lower Granite	Chinook	6312	5	0.1
Priest Rapids	Chinook	280	9	3.2
	Steelhead	95	2	2.1
	Sockeye	852	36	4.2
1998				
Bonneville	Chinook	729	0	0.0
	Steelhead	260	0	0.0
	Sockeye	184	0	0.0
Lower Granite	Chinook	3755	4	0.1
1999				
Bonneville	Chinook	745	0	0.0
	Steelhead	273	0	0.0
	Sockeye	184	0	0.0
Lower Granite	Chinook	3755	4	0.1

*Total number of fish examined = 2026.

More recent studies have concluded that the current knowledge about TDG effects on resident fish allows reliance on a model to predict signs in resident species on the basis of physical measurements of TDG. Ryan and Dawley (1998) investigated the responses of resident fish held in net pens. They observed that a relationship could be developed to predict signs at various TDG levels for resident species. Shrank et al. (1998) developed an algorithm model that predicts GBT signs in resident fishes where continuous TDG monitoring is available. They concluded that extensive biological monitoring of resident species is unnecessary.

E.6 SUMMARY OF RESEARCH RESULTS

E.6.1 Mortality

Seasonal periods of high spill and gas supersaturation in the Columbia River basin system have been a problem for decades. The effect of high TDG on the aquatic species of the rivers is well documented (Beiningen and Ebel 1970; Ebel et al. 1975; Weitkamp and Katz 1980). The precise relationship between dissolved gas and fish mortality was unknown in the 1960s and 1970s. Early studies did, however, demonstrate a relationship between biological effects and TDG level, exposure duration, depth of exposure, water temperature, species, fish condition, and life stage (Ebel et al. 1975; Blahm et al. 1973; Dawley et al. 1975; Dawley and Ebel 1975; Blahm et al. 1975; Weitkamp 1976; Weitkamp and Katz 1980; Jensen et al. 1986).

Ebel et al. (1975) reviewed the findings of several bioassay studies and reported substantial fish mortality at 115% TDG after 25 days of exposure in shallow water. Blahm et al. (1973) recorded 98% (chinook) and 80% (coho) mortality at greater than or equal to120% TDG at a depth of 1 meter. However, in 2.5 meters at the same TDG level, mortalities were reduced to 8.7% and 4.2%, respectively. If fish are allowed access to deeper water during the tests, mortality will be observed at TDG levels greater than 120% after more than 20 days. Dawley et al. (1975) found that all species tested in deep-water tanks reached 50% mortality in 24 hours at 130% TDG, but had no recorded deaths at 110% TDG in 24 hours.

Efforts to protect fish in the late 1960s and through the 1970s focused on determining a lethal TDG threshold. Most of the research investigated dissolved gas levels ranging from 110% to 140% TDG supersaturation. However, many of the early studies were conducted in shallow laboratory tanks and found mortalities at 115% TDG after 3 to 4 weeks of exposure (Dawley and Ebel 1975). On the basis of those early bioassays, the EPA set the dissolved gas standard at 110% TDG. However, it has been suggested that defensible gas limits for a free-flowing river environment could be set as high as 120% TDG (Weitkamp and Katz 1980).

E.6.2 Gas Bubble Trauma Signs

Columbia River fish managers realized early that the effects of TDG on fish populations could not be assessed merely on the physical measurements of dissolved gas. Knowledge of the incidence, severity, and progression of GBT signs was essential.

An important finding in early research was that death from TDG exposure can occur in the absence of any external signs (Meekin and Turner 1974, Weitkamp 1975, and Bouck et al. 1976). Signs of GBT were found to be most severe in lower, marginally lethal gas supersaturation exposures (Bouck et al. 1976). Several researchers observed that fish that do not die from GBT may undergo a reduction in prevalence and severity of signs on return to air-equilibrated water (Meekin and Turner 1974, Blahm et al. 1973, Weitkamp 1974, Knittel et al. 1980, Dawley and Ebel 1975). Ebel et al. (1975) also noted that the signs of GBT disappear after death. The results

from these early studies indicate that it is necessary to monitor migrants for signs of GBT as the biological threshold indicator of TDG supersaturation stress. However, there is no clear set of signs, or a clear time correlation between TDG level and exposure duration, that allows impending fatality to be predicted.

The signs of GBT in adults are like those observed in juveniles. They include emphysema, circulatory emboli, tissue necrosis, and hemorrhages in brain, muscle, gonads, and eyes (Weitkamp and Katz 1980). Nebeker et al. (1976) found that death in adults was due to massive blockages of blood flow from gas emboli in the heart, gills, and other capillary beds. Investigators in the 1970s reported many and varied lesions in fish exposed in the 115%-to-120% TDG range in shallow water. At higher gas exposures, e.g.,120% to 130% TDG, death frequently ensued before GBT signs appeared (Bouck et al. 1976). External signs of GBT, e.g., blisters forming in the mouth and fins of fish exposed to chronic high gas, often disappeared rapidly after death. The signs were largely gone within 24 hours (Countant and Genoway 1968).

Recent studies have pursued the relationship of exposure to TDG supersaturation and the presence, progression, severity, and relevance of GBT signs, especially as related to the monitoring program. Maule et al. (1997) found that no single GBT sign can be relied on as the sole precursor of lethal conditions in the field. However, GBT signs did worsen with longer exposure to the conditions. However, it is necessary to better understand the severity and prevalence of signs in several tissues and relate them to exposure time and adverse reactions. The conventional signs used in GBT studies and monitoring are the lateral line, fins, and gill filaments.

According to Maule et al. (1997a), Elston et al. (1997), Hans et al. (1999), and Mesa et al. (1999), each of the following tissues manifests unique tissue bubble characteristics:

Lateral line	Earliest tissue to display signs Signs may disappear quickly Progressive worsening with time Low degree of individual specimen variation Progressiveness of sign is indicator of exposure severity May not be relevant in chronic exposure to low TDG
Fins	Bubbles may not develop in acute exposure High prevalence in most exposures Progressive worsening with time Bubbles are persistent Quantitative ranking of severity difficult
Gills	Bubbles proximate cause of mortality Little progression with time High degree of variation Poor predictors of severity Difficult to observe and quantify Bubbles may collapse easily on recompression

Maule et al. (1997) reviewed the implications of their findings with lateral line, gill, and fin signs as they might relate to monitoring programs. Lateral line bubbles were often the first observed. They showed progression with exposure and displayed little variation between specimens, but developed slowly under chronic, low gas treatments. Gill bubbles were usually the likely cause of death but did not progressively worsen. Individual variations were high in gill bubbles.

Although fin bubbles are prevalent and worsen with time, the practical use of fin bubbles as an indicator is hindered by lack of a rigorous quantitative method for evaluating severity. Mesa et al. (1999) summarized the findings of studies of GBT signs. Mesa pointed out the usefulness of the progressive nature of signs to monitoring programs, but also highlighted the following impediments:

1. Variability in persistence of GBT signs
2. Inconsistent relation of GBT signs to mortality
3. Insufficient knowledge of relation between exposure history and development of GBT signs
4. Extreme amount of variability of GBT signs

In spite of this, Maule et al. (1997) observed that GBT is most often progressive, and that its severity is a function of TDG level and exposure time. If a group of fish is exposed to TDG supersaturation for a sufficiently long period, the outcome is not in question. Signs of GBT will develop. Therefore, careful, rigorous monitoring of a population of migrants as they move through the FCRPS will detect GBT. If TDG is low and passage time exceeds the threshold time for development of signs, the juveniles will have moved beyond dissolved gas effects of the river.

E.6.3 Depth Compensation

Gas solubility increases with increasing pressure. For each meter of depth there is a 10% reduction in the TDG saturation level relative the surface saturation (Weitkamp and Katz 1980). By the mid-1970s, researchers had gathered information suggesting that depth compensation occurs and has the biological effect that gas solubility calculations would predict. Weitkamp (1976) observed that juvenile salmonids held in live cages up to 4 meters deep in the Columbia River suffered no mortality in test ranges from 119% to 128% TDG. Dawley et al. (1975) conducted tests in a 10-meter-deep tank and found no steelhead mortality at 130% TDG and no spring chinook mortality at 133 % TDG. GBT signs were noted in both species, however.

Technological advances provide ways of studying depth compensation more closely. Using a pressure-sensitive radio frequency tag accurate to 0.3 meters of the true depth, Maule et al. (1997) observed that salmonids may migrate at protective depths. In that pilot study, few fish were successfully tagged and tracked, and the data were insufficient for statistical analysis. However, the results suggested that the depth of the tagged fish would compensate for a surface TDG level of up to approximately 124%.

In subsequent years, Beeman et al. (1998, 1999) employed depth-sensitive radio tags to determine the depths of juveniles from Ice Harbor to McNary Dam. The 1997 studies indicate that fish were tracked at depths between 1.8 and 2.5 meters in water with a surface TDG level of 120%. The recorded depths would have provided protection and reduced the risk of GBT. The next year, the median depth of juveniles in McNary pool was sufficient to protect fish from TDG levels of between 117% and 124%. This level of depth compensation is enough to negate predicted mortalities from the mid-1970s laboratory studies conducted in shallow water. It also may explain why the annual biological monitoring program detects fewer GBT signs than might be expected. The authors concluded that a voluntary spill program with gas caps of 115% in forebays and 120% in tailraces can be expected to prevent gas bubble trauma in juvenile chinook and pose little threat to the more sensitive steelhead.

Gray and Haynes (1977) reported that spring and fall chinook adults implanted with pressure-sensitive radio transmitters swam deeper in gas supersaturated water than in air-equilibrated conditions. They concluded that 89% of the test fish migrated at a depth providing compensation for gas levels that would normally prove lethal.

More recent studies have employed a data storage radio tag to record both the depth and temperature history of migrating adults. Preliminary analysis of results indicate that tagged fish migrate in the depth range of 1.5 to 4 meters, some deeper than 4 meters. Thus, it appears that most of the chinook or steelhead adults may be negotiating the lower Snake River at compensatory depths for gas levels to at least 130% (Bjornn, personal communication, 2000).

E.7 CONCLUSIONS

A risk assessment was described earlier as a comparison of alternative paths to consider the probability of adverse action. Using the SIMPAS model, it was determined that an increase of 4% to 6% in system survival of juveniles would result from spill up to the biological opinion gas cap, i.e., 120% TDG, as compared to spilling to the 110% water quality standard. The question is whether there is any adverse effect resulting from the 10% increase in TDG. The potential adverse effects of this TDG increase can be judged by reviewing the findings of the 1995 report, the information gained in the last 5 years of monitoring, and relevant research.

The 1995 risk assessment estimated turbine mortality and compared it with a TDG mortality curve. The report concluded that, at the point where projected dissolved gas mortality equaled the lethality of turbine passage, higher TDG levels due to additional spill beyond a certain point would be counter-productive. That point ranged between 120% and 125% TDG. The assessment was conducted for spring, summer, and fall chinook, sockeye, and steelhead—the salmonid species of concern. The 1995 report concluded that a spill level of 120% to 125% TDG represented a conservative, controllable, and reasonable risk compared with turbine passage. Since a managed biological opinion spill program will result in gas up to 120% TDG, spill to this gas level is expected to provide a safer route of project passage than turbine passage.

The 1995 report also strongly urged establishing monitoring programs to track dissolved gas and monitor for signs of GBT. The results of 5 years of physical monitoring show that TDG generated as a result of implementing the spill program is adequately detected and recorded. When water conditions allow voluntary spill to increase FPE, the spill and resulting dissolved gas can be managed to comply with the temporary state waivers. In periods of involuntary spill, the sensitivity of the monitoring system records the frequency, intensity, and duration of high levels of gas supersaturation, as in 1996 and 1997. The physical monitoring system also demonstrates the beneficial effects of the construction and operation of gas-abatement structures. For example, after spillway deflectors were built at Ice Harbor and John Day dams, their gas-abating effects were reflected in the physical monitoring data.

The biological component of the 5-year monitoring program is consistent with TDG records. When the TDG exceeds the waiver limits, a biological effect is recorded in both the smolt and adult monitoring program (Tables E-2 and E-3). For example, severe signs (rank 3) of GBT were restricted to the years 1996 and 1997 during the periods of highest involuntary spill, which resulted in TDG levels of 130% or more on many days. Although severe signs have been noted in the monitoring program, such instances have been rare and confined to periods of involuntary spill when gas levels are greater than 120% TDG.

GBT in juvenile salmonids is observed at all gas levels. Even at a relatively low gas supersaturation level of 110%, signs can develop if the exposure is long and the water is shallow. However, based on 5 years of data from the biological monitoring program, the average incidence of GBT signs has been low. The accumulated data on GBT in chinook and steelhead show few GBT signs below 120% TDG. When fish with signs are exposed to gas levels above120%, the incidence and severity of GBT signs increase. A similar pattern is observed in fish with the more severe ranks 3 and 4 signs. Only few fish with severe GBT signs are detected until TDG approaches 130%, and the prevalence of signs does not begin to increase until TDG is between 121% and 125%. The overall number of fish affected with GBT signs proved to be less than originally assumed in the 1995 report.

The monitoring program for adult salmonids shows a similar relationship between gas bubble signs and TDG. For example, when the inriver TDG level is below 120%, few adult fish—in some cases none—display signs of GBT. Oregon and Washington used that information, coupled with the extreme importance of adult migrants to salmon recovery efforts, to dispense with continued adult monitoring (and associated handling) requirements in their 1999 water quality waiver stipulations. Investigators observe adult tolerance to TDG and hypothesize that it is attributable to the migration depth of adult salmonids. The depth-sensitive radio tags being used in adult migration studies now corroborate that adults migrate at depths up to 4 meters and find depth compensation protection from GBT. Thus, NMFS believes that the 120% tailrace gas cap recommended by the 1995 FCRPS Biological Opinion places no special TDG burden on adult migrants.

The results of the 1995-to-1999 monitoring program are consistent with reports in the literature on dissolved gas and gas bubble disease research. In the late 1960s and in the 1970s, studies

used dissolved gas exposures in the 110%-to-140% TDG range. In deep-tank or field studies, few effects were noted below 120% TDG, unless the exposure periods were very long (weeks).

From analysis of the biological monitoring program, NMFS concludes that biological monitoring of GBT signs can continue to be used to indicate dissolved gas exposure in adult and juvenile salmon migrants. The monitoring program indicates that the prevalence of GBT signs in the adult and juvenile salmonid migrant populations is well below the action levels supported by GBT mortality research, as long as TDG levels are kept below the levels recommended in the 2000 FCRPS Biological Opinion.

NMFS also concludes that the apparent contradiction between the current 110% TDG water quality standard limit and the biological opinion TDG limits is explained as an effect of depth compensation in migrating adult and juvenile salmonids. Finally, NMFS concludes that the risk associated with a 10% exceedance of the 110% TDG standard is more than compensated for by the improvement of an estimated 4% to 6% in FCRPS passage survival for juvenile salmon. NMFS finds little evidence that this survival improvement would be reduced by GBT-related mortality.

It should be kept in mind that the present assessment narrowly focused on salmonid migrants in the relatively deep mainstem reaches of the Columbia and Snake rivers, and was set against the mitigating factor of improved system passage survival. Applying the conclusions toward a change in national or state water quality standards would be inappropriate without additional research and monitoring data on other aquatic species and habitats.

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APPENDIX F
THE RPA ACTION SUMMARY

F. THE RPA ACTION SUMMARY

The FCRPS Biological Opinion RPA incorporates 199 actions aimed at protecting or improving the survival of listed salmon and steelhead stocks. The actions span a wide range of activities, including updating annual operations of the FCRPS, short- and long-term construction at FCRPS projects, early action offsite mitigation proposals, and research efforts aimed at gaining future improvements. Section 9.5.1.2 of the biological opinion calls for a major checkpoint on implementation at year 3. The following table lists the actions called for in the RPA and summarizes specific expectations for the 3-year check-in. The table includes a brief summary statement highlighting the particular question or questions associated with the actions that are the focus of the 3-year review. The categories in the table are as follows:

- Annual planning and operations consisting of the actions intended for annual implementation or that will be reported on through the process of developing and critiquing annual water management/facility operations plans.

- Key actions called for the biological opinion are scheduled for detailed review at the 3-year checkpoint. Actions that are assigned to this category generally reflect the types described in the midpoint check-in sections of the biological opinion: early implementation actions, major planning initiatives, key actions that dictate other actions, pilot studies aimed at providing essential information on the potential survival gains from particular types of actions, and studies aimed at key uncertainties (e.g., hatchery versus wild spawner effectiveness).

- Status updates are important projects that do not have a specific milestone identified for the 3-year check-in. The 3-year update for these projects will be a status review and/or decisions on future actions, scheduling priorities, and other such items.

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			Category I		Category II		Category III
Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
9.4.1	Action 1	The Action Agencies, coordinating with NMFS and USFWS, shall annually develop 1- and 5-year plans to implement specific measures in hydro, habitat, hatcheries, harvest, research, monitoring, and evaluation needed to meet and evaluate the performance standards contained in this biological opinion.	Annual Planning		Review Current 5 year plan	01, '02 & '03 plans completed	
9.4.2	Action 2:	The Action Agencies shall coordinate development and implementation of the hydro portion of the 1- and 5-year implementation plans through the Regional Forum, chaired by NMFS.	Annual Planning				
	Action 3:	The Action Agencies, coordinating through the Technical Management Team, shall develop and implement a 1- and 5-year water management plan and in-season action plans for the operation of the FCRPS.	Annual Planning				
	Action 4:	The Action Agencies, coordinating through the System Configuration Team, shall annually develop and implement a 1- and 5-year capital investment plan for the configuration of the FCRPS projects.	Annual Planning				
	Action 5:	The Action Agencies, coordinating through the Water Quality Team, shall annually develop a 1- and 5-year water quality plan for operation and configuration measures at FCRPS projects.	Annual Planning				
	Action 6:	The Corps and BPA, through the annual planning process, shall develop and implement 1- and 5-year operations and maintenance (O&M) plans and budgets that enhance the capability to operate and maintain fish facilities at FCRPS projects for listed salmonid stocks.	Annual Planning				
	Action 7:	The Action Agencies, with assistance from NMFS and USFWS, shall annually develop 1- and 5-year plans for habitat measures that provide offsite mitigation.	Annual Planning				
	Action 8:	The Action Agencies, with assistance from NMFS and USFWS, shall annually develop 1- and 5-year plans for hatchery and harvest measures that provide offsite mitigation.	Annual Planning				
	Action 9:	The Action Agencies, with assistance from NMFS and USFWS, shall annually develop 1- and 5- year plans for research, monitoring, and evaluation to further develop and to determine the effectiveness of the suite of actions in this RPA.	Annual Planning				
	Action 10:	The Action Agencies shall work with NMFS and others to promptly incorporate the results of recovery planning into annual Fish and Wildlife Program implementation funding, including support for incorporation of the results into the NWPPC's Fish and Wildlife Program.	Annual Planning				
	Action 11:	By September 30, 2001, the Action Agencies shall develop procedures for carrying out actions that could not be anticipated in the planning process, but that are necessary or prudent to achieve the performance standards.		Annual Operations			
	Action 12:	The Action Agencies shall coordinate with NMFS and USFWS in the review of the 1- and 5-year plans to facilitate timely review and approval as part of the annual decision process.	Annual Planning				
	Action 13:	The Action Agencies shall issue annual reports to NMFS and USFWS on progress toward achieving the performance standards set out in this biological opinion, including comprehensive cumulative reviews in years 3, 5, and 8.			3 Yr Implementation Check	Reports complete?	
9.6.1	Action 14:	The Action Agencies shall operate FCRPS dams and reservoirs with the intent of meeting the flow objectives (Table 9.6-1) on both a seasonal and weekly average basis for the benefit of migrating juvenile salmon.		Annual Operations			
	Action 15:	The Action Agencies shall operate the FCRPS to provide flows to support chum salmon spawning in the Ives Island area below Bonneville Dam.		Annual Operations			
	Action 16:	The Action Agencies shall operate the FCRPS to provide access for chum salmon spawning in Hamilton and Hardy creeks.		Annual Operations			

			Category I		Category II		Category III
Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 17:	The Action Agencies shall coordinate with NMFS, USFWS, and the states and Tribes in preseason planning and in-season management of flow and spill operations. This coordination shall occur in the Technical Management Team process (see Section 9.4.2.2).		Annual Operations			
	Action 18:	The Action Agencies shall operate the FCRPS during the fall and winter months in a manner that achieves refill to April 10 flood control elevations, while meeting project and system minimum flow and flood control constraints before April 10. During the spring, the Action Agencies shall operate the FCRPS to meet the flow objectives and refill the storage reservoirs (Albeni Falls, Dworshak, Grand Coulee, Hungry Horse, and Libby) by approximately June 30.		Annual Operations			
	Action 19:	The Action Agencies shall operate specific FCRPS projects as follows:		Annual Operations	3 Yr Implementation Check	FWS Review of Albeni drawup 2003	
	Action 20:	The Corps shall operate the lower Snake River reservoirs within 1 foot of MOP from approximately April 3 until small numbers of juvenile migrants are present and shall operate the John Day pool within a 1½-foot range of the minimum level that provides irrigation pumping from April 10 to September 30.		Annual Operations			
	Action 21:	The Corps shall routinely identify opportunities to shift system flood control evacuation volumes from Brownlee and Dworshak reservoirs to Lake Roosevelt and identify such opportunities for the Technical Management Team. The Corps shall implement flood control shifts as necessary to best protect listed fish, as called for by NMFS in coordination with the Technical Management Team, taking into account water quality issues and the concerns of all interested parties.		Annual Operations			
	Action 22:	The Corps and BOR shall implement VARQ flood control operations, as defined by the Corps (1999d), at Libby by October 1, 2001, and at Hungry Horse by January 1, 2001. By February 1, 2001, the Corps shall develop a schedule to complete all disclosures, NEPA compliance, and Canadian coordination necessary to implement VARQ flood control at Libby.		Annual Operations	3 Yr Implementation Check	VARQ operations implemented?	
	Action 23:	BOR shall operate Banks Lake at an elevation 5 feet from full during August by reducing the volume of water pumped from Lake Roosevelt into Banks Lake by about 130 kaf during this time.		Annual Operations			
	Action 24:	BPA and the Corps shall continue to request and negotiate agreements to annually provide 1 Maf of Treaty storage from January through April 15, release the water during the migration season, and seek additional storage amounts.		Annual Operations			
	Action 25:	BPA and the Corps shall continue to request, and negotiate with BC Hydro for storage of water in non-Treaty storage space during the spring for subsequent release in July and August for flow enhancement, as long as operations forecasts indicate that water stored in the spring can be released in July and August.		Annual Operations			
	Action 26:	BPA and the Corps shall continue to evaluate, request, and negotiate with BC Hydro the shaping and release of water behind Canadian Treaty storage projects in addition to the non-Treaty storage water previously discussed during July and August.		Annual Operations			

			Category I		Category II		Category III
Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 27:	Before entering into any agreement to commit currently uncontracted water or storage space in any of its reservoirs covered by this biological opinion to any other use than salmon flow augmentation, BOR shall consult with NMFS under ESA Section 7(a)(2). Such consultations shall identify the amount of discretionary storage or water being sought, the current probability of such storage or water being available for salmon flow augmentation, and any plan to replace the storage volume currently available to salmon flow augmentation that would be lost as a result of the proposed commitment. Also, BOR shall consult with NMFS before entering into any new contract or contract amendment to increase the authorized acreage served by any irrigation district receiving BOR-supplied water. NMFS' criterion in conducting such reviews is to ensure that there be zero net impact from any such BOR commitment on the ability to meet the seasonal flow objectives established in this biological opinion. Replacement supplies should have at least an equal probability of being available for salmon flow augmentation a					Status Check
	Action 28:	BOR shall pursue water conservation improvements at its projects and shall use all mechanisms available to it under state and Federal law to ensure that a reasonable portion of any water conserved will benefit listed species.					Status Check
	Action 29:	Within 2 years from the date this opinion is signed, BOR shall provide NMFS with a detailed progress report addressing possible instances where BOR-supplied water within the Columbia River basin is being used without apparent BOR authorization to irrigate lands. In the report, BOR shall indicate how it shall proceed to identify and address instances of unauthorized use.			3 Yr Implementation Check	Report Received?	
	Action 30:	For those BOR projects located in the Columbia River and its tributaries downstream from Chief Joseph Dam (Table 9.6-2), BOR shall, as appropriate, work with NMFS in a timely manner to complete supplemental, project-specific consultations. These supplemental consultations shall address effects on tributary habitat and tributary water quality, as well as direct effects on salmon survival (e.g., impingement, entrainment in diversions, false attraction to return flows, and others). These supplemental consultations shall address effects on mainstem flows only to the extent to which they reveal additional effects on the in-stream flow regime not considered in this biological opinion (e.g., flood control).			3 Yr Implementation Check	Supplemental consultations completed	
	Action 31:	BOR shall assess the likely environmental effects of operating Banks Lake up to 10 feet down from full pool during August. The assessment and NEPA compliance work shall be completed by June 2002 to determine future operations at this project by the summer of 2002.			3 Yr Implementation Check	Assessment & NEPA compliance complete?	
	Action 32:	The Action Agencies shall acquire water for instream use from BOR's Upper Snake River basin projects and Idaho Power Company's Hells Canyon Complex during the spring and summer flow augmentation periods to improve the likelihood of achieving spring and summer flow objectives at Lower Granite Dam.					Status Check
	Action 33:	The Corps, in coordination with USFWS, shall design and implement appropriate repairs and modifications to provide water supply temperatures for the Dworshak National Fish Hatchery that are conducive to fish health and growth, while allowing variable discharges of cold water from Dworshak Reservoir to mitigate adverse temperature effects on salmon downstream in the lower Snake River.			3 Yr Implementation Check	Project Completed?	

			Category I		Category II		Category III
Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 34:	The Action Agencies shall evaluate potential benefits to adult Snake River steelhead and fall chinook salmon passage by drafting Dworshak Reservoir to elevation 1,500 feet in September. An evaluation of the temperature effects and adult migration behavior should accompany a draft of Dworshak Reservoir substantially below elevation 1,520 feet.			3 Yr Implementation Check	Study underway?	5 year Implementation Check
	Action 35:	The Corps shall develop and conduct a detailed feasibility analysis of modifying current system flood control operations to benefit the Columbia River ecosystem, including salmon. The Corps shall consult with all interested state, Federal, Tribal, and Canadian agencies in developing its analysis. Within 6 months after receiving funding, the Corps shall provide a feasibility analysis study plan for review to NMFS and all interested agencies, including a peer-review panel (at least three independent reviewers, acceptable to NMFS, with expertise in water management, flood control, or Columbia River basin anadromous salmonids). A final study plan shall be provided to NMFS and all interested agencies 4 months after submitting the draft plan for review. The Corps shall provide a draft feasibility analysis to all interested agencies, NMFS, and the peer-review panel by September 2005.			3 Yr Implementation Check	Feasibility Study Plan developed and under implemenation?	5 year Implementation Check
	Action 36:	By October 1, 2002, the Corps shall develop and, if feasible, implement a revised storage reservation diagram for Libby Reservoir that replaces the existing fall draft to a fixed end-of-December elevation. One option is to evaluate variable drafts based on the El Niño Southern Oscillation Index (SOI) predictions or other forecast methodologies of runoff volume. To implement this change, the Corps shall complete successful coordination with Canada under the Columbia River Treaty.			3 Yr Implementation Check	Revised storage reservation diagram in place?	
	Action 37:	BOR shall investigate the attraction of listed salmon and steelhead into wasteways and natural streams receiving waste water from the Columbia Basin Project. If listed fish are found to be attracted into these channels, BOR shall work with NMFS to identify and implement structural or operational measures to avoid or minimize such use, as warranted.					Status Check
	Action 38:	By March 1, 2002, BOR shall install screens meeting NMFS' screen criteria at the canal intakes to the Burbank No. 2 and Burbank No. 3 pump plants. BOR shall connect the Burbank No. 3 intake canal to Burbank Slough to provide juvenile fish egress. BOR shall coordinate with NMFS on each of the actions identified above.			3 Yr Implementation Check	Screens installed?	
	Action 39:	BOR shall evaluate the water quality characteristics of each point of surface return flows from the Columbia Basin Project to the Columbia River and estimate the effects these return flows may have on listed fish in the Columbia River and in the wasteways accessible to listed fish. By June 1, 2001, BOR shall provide NMFS with a detailed water quality monitoring plan, including a list of water quality parameters to be evaluated. If the water quality sampling reveals enough water quality degradation to adversely affect listed fish, BOR shall develop and initiate implementation of a wasteway water quality remediation plan within 12 months of the completion of the monitoring program.			3 Yr Implementation Check	Water Quality plan complete and, if required, remediation plan developed?	
	Action 40:	The Corps shall continue to transport all non-research juvenile salmonids collected at the Snake River collector projects. The Corps and BPA shall continue to implement voluntary spill at all three Snake River collector projects when seasonal average flows are projected to meet or exceed 85 kcfs.		Annual Operation			

			Category I		Category II		Category III
Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 41:	The Corps and BPA shall continue (pending results of the McNary Transport Evaluation) to bypass juvenile spring migrants collected at McNary Dam and shall provide the spring spill levels described for that project.		Annual Operation			
	Action 42:	The Corps and BPA shall operate the collector projects to maximize collection and transportation during the summer migration (i.e., no voluntary spill except as NMFS deems necessary for approved research).		Annual Operation			
	Action 43:	The Corps shall not initiate collection of subyearling fall chinook for transportation at McNary Dam until inriver migratory conditions are deteriorating (i.e., no longer spring-like).		Annual Operation			
	Action 44:	The Corps shall extend the period of barge transportation from the lower Snake River dams and McNary to further reduce reliance on trucking.					Status Check
	Action 45:	By the end of 2001, the Corps shall develop, in coordination with NMFS and the other Federal, state, and Tribal salmon managers, a McNary Dam transportation evaluation study plan specifically focusing on the response of UCR spring chinook and steelhead to transportation. Approved research should begin by 2002, if feasible.			3 Yr Implementation Check	Research Plan developed and implemented?	
	Action 46:	The Corps and BPA, in coordination with NMFS through the annual planning process, shall evaluate transport to inriver return ratios for wild SR yearling chinook salmon and steelhead. In addition, the Corps and BPA shall also evaluate the effects of transportation on summer-migrating subyearling SR chinook salmon.			3 Yr Implementation Check	Subyearling transport experiments underway?	
	Action 47:	During all transport evaluations, the Corps and BPA, in coordination with NMFS through the annual planning process, shall include an evaluation of delayed mortality (D) of transported versus inriver migrating juvenile anadromous salmonids.	Annual Planning		3 Yr Implementation Check	Updated estimates of transport delayed Mortality (D)?	
	Action 48:	The Corps and BPA shall evaluate the effects of prior transport as smolts on the homing of adults.					Status Check
	Action 49:	The Corps shall evaluate strategies to enhance post-release survival of transported fish; examples of such strategies include timing releases so that fish arrival at the estuary corresponds to minimal interactions with predators and maximum availability of forage and locating releases so as to decrease passage time through areas of high predation.					Status Check
	Action 50:	BPA and the Corps shall install necessary adult PIT-tag detectors at appropriate FCRPS projects before the expected return of adult salmon from the 2001 juvenile outmigration.			3 Yr Implementation Check	Adult PIT tag detectors installed?	
	Action 51:	If results of Snake River studies indicate that survival of juvenile salmon and steelhead collected and transported during any segment of the juvenile migration (i.e., before May 1) is no better than the survival of juvenile salmon that migrate inriver, the Corps and BPA, in coordination with NMFS through the annual planning process, shall identify and implement appropriate measures to optimize inriver passage at the collector dams during those periods.					Status Check
	Action 52:	The Corps shall identify and implement improvements to the transportation program.		Annual Operation			
	Action 53:	The Corps shall evaluate and implement structural and operational alternatives to improve juvenile transportation at the collector dams.		Annual Operation			

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Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 54:	The Corps and BPA shall implement an annual spill program, consistent with the spill volumes and TDG limits identified in Table 9.6-3, at all mainstem Snake and Columbia River FCRPS projects as part of the annual planning effort to achieve the juvenile salmon and steelhead performance standards.		Annual Operation			
	Action 55:	To improve the future flexibility of the transmission system, BPA's Transmission Business Line shall initiate planning and design necessary to construct a Schultz-Hanford 500-kV line or an equivalent project, with a planned schedule for implementation by 2004 or 2005.			3 Yr Implementation Check	On schedule for 2004/5 implementation?	
	Action 56:	BPA's Transmission Business Line shall continue efforts to evaluate, plan, design, and construct a joint transmission project to upgrade the west-of-Hatwai cutplane and improve the transfer limitations from Montana.			3 Yr Implementation Check	On schedule for 2003/4 implementation	
	Action 57:	BPA's Transmission Business Line shall continue to evaluate strategically located generation additions and other transmission system improvements and report progress to NMFS annually. BPA's Transmission Business Line shall also limit future reservations for transmission capacity, as needed, to enable additional spill to meet performance standards, while minimizing effects on transmission rights holders.					Status Check
	Action 58:	The Corps and BPA, in coordination with the Fish Passage Operations and Maintenance Coordination Team (FPOM), shall operate all turbine units at FCRPS dams for optimum fish passage survival. Methods to achieve this objective shall include, but are not limited to, activities outlined in the following paragraphs. (See RPA)		Annual Operations			
	Action 59:	The Action Agencies, in coordination with the Regional Forum, shall determine the appropriate operating range of turbines equipped with minimum gap runners (MGRs) to increase survival of juvenile migrants passing through these new turbine designs.					Status Check
	Action 60:	The Corps and BPA shall evaluate adult fallback and juvenile fish passage under daytime spill to the gas cap at Bonneville Dam in 2002 and 2003, after deflector optimization improvements allow for increased spill above current levels. Research results will be considered, in consultation with NMFS through the annual planning process, to determine implementation of additional changes in spill to further improve fish survival.			3 Yr Implementation Check	Spill Improvements Identified?	5 Yr Implementation Check
	Action 61:	The Corps shall complete the ongoing prototype powerhouse system surface collection evaluations at Bonneville First Powerhouse in 2000. The Corps shall compare the prototype with screened bypass systems and, if warranted, design and construct permanent facilities after full consideration and resolution of biological and engineering uncertainties, especially high-flow outfall investigations.					Status Check
	Action 62:	The Corps shall complete Bonneville First Powerhouse prototype evaluations of extended submerged intake and gatewell vertical barrier screens, including an assessment of fry passage.					Status Check
	Action 63:	The Corps shall complete the design of debris removal facilities for the Bonneville First Powerhouse forebay.					Status Check
	Action 64:	The Corps shall continue the investigation of minimum gap runners at the Bonneville First Powerhouse.					Status Check
	Action 65:	The Corps shall complete Bonneville Second Powerhouse post-construction evaluation of the new juvenile fish bypass outfall and address design and operational refinements as warranted.					Status Check

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Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 66:	The Corps shall continue design development and construction of a Bonneville Second Powerhouse permanent corner collector at the existing sluice chute, pending results of high-flow outfall investigations. The Corps shall construct new facilities if, and as soon as, evaluations confirm the optimum design configuration and survival benefits.					Status Check
	Action 67:	The Corps shall continue Bonneville Second Powerhouse investigations of measures to improve intake screen fish guidance efficiency and safe passage through the gatewell environment. This work shall include an assessment of fry passage.					Status Check
	Action 68:	The Corps and BPA shall continue spill and passage survival studies at The Dalles Dam in 2001. Research results shall be considered, in consultation with NMFS through the annual planning process, to assess the need for additional changes in spill to further improve fish survival by 2002, if possible, but no later than 2005.			3 Yr Implementation Check	Spill Improvements Identified?	
	Action 69:	The Corps shall continue design development and 2001 prototype testing of upper turbine intake occlusion devices at The Dalles, with a goal of increased non-turbine passage rates through either the sluiceway or the spillway. The Corps shall install occlusion devices across the entire powerhouse, as warranted.					Status Check
	Action 70:	The Corps shall continue biological and engineering investigations and design of a composite ice and trash sluiceway outfall relocation and adult ladder auxiliary water system at The Dalles Dam and shall construct such devices as warranted.					Status Check
	Action 71:	The Corps and BPA shall continue investigation of 24-hour spill at John Day Dam in 2001. Research results will be considered, in consultation with NMFS through the annual planning process, to determine implementation of daytime spill to further improve juvenile fish survival as needed for its contribution to the performance standard.			3 Yr Implementation Check	Spill Improvements Identified?	
	Action 72:	The Corps shall continue design development of a prototype RSW and extended deflector for testing at John Day in 2002. The Corps should synthesize evaluation results, determine the fish survival benefits of one or more RSWs or a skeleton bay surface bypass, and install the units as warranted.			3 Yr Implementation Check	Prototype RSW tests completed?	
	Action 73:	The Corps shall continue John Day prototype development and investigations of extended submerged intake screens, gatewell vertical barrier screens, and, if necessary, orifices to optimize guidance and safe passage through the system, including a gatewell debris cleaning plan. This work shall include an assessment of fry passage. The Corps shall design and construct new screen systems for safe passage of juvenile salmonids, as warranted. Juvenile bypass outfall survival investigations shall also be conducted.			3 Yr Implementation Check	Prototype assessments complete?	
	Action 74:	The Corps shall continue evaluations to assess the need for improvements of the existing intake screens, gatewell vertical barrier screen cleaning system, and bypass facilities (including debris containment and removal systems, separation, sampling, loading, and outfall facilities) at McNary to determine where improvements are necessary to reduce problems experienced during the 1996 flood, increase fish survival, and resolve holding and loading facility problems, including raceway jumping by juvenile salmon and steelhead and debris plugging of bypass lines. Additionally, the Corps shall evaluate whether the existing juvenile bypass system outfall should be relocated.					Status Check

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Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 75:	The Corps shall investigate a surface bypass RSW at McNary Dam, based on prototype results at other locations, and shall install the unit in multiple spillway bays, as warranted.					Status Check
	Action 76:	The Corps shall investigate, design, and construct, as warranted, a new juvenile bypass outfall at Lower Monumental Dam. Investigations shall be conducted in conjunction with spillway deflector and spill pattern optimization studies.					Status Check
	Action 77:	The Corps shall investigate surface bypass (e.g., RSW) at Lower Monumental Dam, based on prototype results at other locations, and install in multiple spillway bays, as warranted.					Status Check
	Action 78:	The Corps shall initiate design development and testing of extended submerged intake screens and vertical barrier screens at Lower Monumental Dam and construct units as warranted.					Status Check
	Action 79:	The Corps shall conduct a post-construction evaluation of the new debris containment boom at Little Goose to monitor populations and behavior of aquatic predators when debris accumulates at the log boom.					Status Check
	Action 80:	The Corps shall continue the design development, fabrication/deployment, and testing of a prototype RSW at Lower Granite, in conjunction with the existing prototype powerhouse occlusion devices, including the forebay behavioral guidance structure (BGS) and upper turbine intake occlusion devices. As warranted by prototype test results, the Corps shall install one or more permanent RSWs and occlusion devices at appropriate lower Snake hydro projects, in coordination with the annual planning process.			3 Yr Implementation Check	Prototype Testing Completed?	
	Action 81:	The Corps shall complete design for new juvenile bypass facilities at Lower Granite Dam, including enlarged orifices and bypass gallery, open-channel flow bypass, improved separator for juvenile separation by size, and improved fish distribution flumes and barge-loading facilities and shall proceed to construction, as warranted.					Status Check
	Action 82:	The Action Agencies, in coordination with NMFS through the annual planning process, shall investigate the spillway passage survival of juvenile salmonids at appropriate FCRPS dams. These investigations shall assess the effect of spill patterns and per-bay spill volumes on fish survival, across a range of flow conditions. The Action Agencies shall develop a phased approach (including costs and schedules) and set priorities, in consultation with NMFS in the annual planning process, to continue spillway passage survival studies in 2001 and future years.					Status Check
	Action 83:	The Action Agencies, in coordination with NMFS through the annual planning process, shall evaluate the effect of spill duration and volume on spillway effectiveness (percent of total project passage via spill), spill efficiency (fish per unit flow), forebay residence time, and total project and system survival of juvenile steelhead and salmon passing FCRPS dams. Studies shall include both collector and non-collector projects. Adult passage considerations and potential adult fallback shall also be considered in study designs. Little Goose and Lower Granite dams shall be specifically considered for daytime spill studies. An overall phased study approach for spill evaluations will be determined in the 1- and 5-year implementation plans.					Status Check
	Action 84:	The Corps shall continue high-flow outfall investigations to determine whether it is appropriate to modify bypass outfall criteria in the context of high-discharge bypass discharges.					Status Check

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Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 85:	The Corps shall continue to develop and evaluate improved fish-tracking technologies and computational fluid dynamics (numerical modeling). The ability to integrate these technologies and fluid dynamics shall be assessed as a potentially improved means of determining fish responses to forebay hydraulic conditions.					Status Check
	Action 86:	The Corps shall continue to investigate a way to increase entry rates of fish approaching surface bypass/collector entrances.					Status Check
	Action 87:	The Corps and BPA shall assess less-intrusive, PIT-tag interrogation methods at FCRPS juvenile bypass systems with interrogation sites, including McNary, John Day, and Bonneville dams. The Corps and BPA shall also assess providing a similar detection capability for the Ice Harbor juvenile bypass system.					Status Check
	Action 88:	The Corps and BPA, in coordination with the Fish Facility Design Review Work Group and the Fish Passage Improvement Through Turbines Technical Work Group, shall continue the program to improve turbine survival of juvenile and adult salmonids.					Status Check
	Action 89:	The Action Agencies shall investigate hydraulic and behavioral aspects of turbine passage by juvenile steelhead and salmon through turbines to develop biologically based turbine design and operating criteria. The Corps shall submit a report to NMFS stating the findings of the first phase of the Turbine Passage Survival Program by October 2001. Annual progress reports will be provided after this date.					Status Check
	Action 90:	The Action Agencies shall examine the effects of draft tubes and powerhouse tailraces on the survival of fish passing through turbines.					Status Check
	Action 91:	The Action Agencies shall remove all unnecessary obstructions in the higher velocity areas of the intake-to-draft tube sections of the turbine units.					Status Check
	Action 92:	The Action Agencies shall consider all state-of-the-art turbine design technology to decrease fish injury and mortality before the implementation of any future turbine rehabilitation program (including any major repair programs, the ongoing rehabilitation program at The Dalles Dam, and any future program at Ice Harbor Dam). The Action Agencies shall coordinate within the annual planning process before making decisions that would preclude the use of fish-friendly technologies and to minimize any adverse effects of project downtime.					Status Check
	Action 93:	The Action Agencies shall determine the number of adults passed through turbines, then, if warranted, investigate the survival of adult salmonid passage through turbines (including steelhead kelts).					Status Check
	Action 94:	The Corps shall continue to evaluate the need for improvements of the existing intake screens, gatewell vertical barrier screens' cleaning system, and bypass facilities (including debris containment and removal systems, separation, sampling, loading, and outfall facilities) at the four lower Snake River hydropower projects.					Status Check
	Action 95:	The Corps shall complete investigations of improved wet separator designs in 2002. The Corps shall design and construct a new wet separator at McNary, Lower Monumental, and Little Goose dams, as warranted.					Status Check
	Action 96:	The Corps shall complete the extended submerged intake screen systemwide letter report and implement recommended improvements.					Status Check

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Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 97:	By January 2002, the Action Agencies shall develop an analysis that compares the relative passage survival benefits of an extended-length, intake screen bypass system, a surface-collection bypass system, and hybrid alternatives at Bonneville First Powerhouse. Through the annual planning process, the Corps shall determine which of these configurations to implement.			3 Yr Implementation Check	Implementation decision ?	
	Action 98:	By January 2003, the Action Agencies shall develop an analysis that compares the relative passage survival benefits of replacing existing standard-length intake screens with extended-length screens at the John Day Dam powerhouse to surface collection at one or more skeleton or spillway bays. Through the annual planning process, the Action Agencies shall then determine the need for, and the implementation priority of, these configuration alternatives.			3 Yr Implementation Check	John Day analysis available?	
	Action 99:	By January, 2003, the Action Agencies shall develop an analysis that compares the relative passage survival benefits of replacing existing standard-length intake screens with extended-length screens at the Lower Monumental Dam powerhouse turbines to a removable RSW surface bypass system.					Status Check
	Action 100:	The Action Agencies shall continue to implement and study methods to reduce the loss of juvenile salmonids to predacious fishes in the lower Columbia and lower Snake rivers. This effort will include continuation and improvement of the ongoing Northern Pikeminnow Management Program and evaluation of methods to control predation by non-indigenous predacious fishes, including smallmouth bass, walleye, and channel catfish.			3 Yr Implementation Check	Program updated?	
	Action 101:	The Corps, in coordination with the NMFS Regional Forum process, shall implement and maintain effective means of discouraging avian predation (e.g., water spray, avian predator lines) at all forebay, tailrace, and bypass outfall locations where avian predator activity has been observed at FCRPS dams. These controls shall remain in effect from April through August, unless otherwise coordinated through the Regional Forum process. This effort shall also include removal of the old net frames attached to the two submerged outfall bypasses at Bonneville Dam. The Corps shall work with NMFS, FPOM, USDA Wildlife Services, and USFWS on recommendations for any additional measures and implementation schedules and report progress in the annual facility operating reports to NMFS. Following consultation with NMFS, corrective measures shall be implemented as soon as possible.					Status Check
	Action 102:	The Action Agencies, in coordination with the Caspian Tern Working Group, shall continue to conduct studies (including migrational behavior) to evaluate avian predation of juvenile salmonids in the FCRPS reservoirs above Bonneville Dam. If warranted and after consultation with NMFS and USFWS, the Action Agencies shall develop and implement methods of control that may include reducing the populations of these predators.			3 Yr Implementation Check	Actions being implemented?	
	Action 103:	The Action Agencies shall quantify the extent of predation by white pelicans on juvenile salmon in the McNary pool and tailrace. A study plan shall be submitted to NMFS by September 30, 2001, detailing the study objectives, methods, and schedule. Based on study findings, and in consultation with USFWS and NMFS, the Action Agencies shall develop recommendations and, if appropriate, an implementation plan.			3 Yr Implementation Check	Study plan by 2001	
	Action 104:	The Action Agencies shall recover PIT-tag information from predacious bird colonies and evaluate trends, including hatchery-to-hatchery and hatchery-to-wild depredation ratios.					Status Check

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Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 105:	The Action Agencies shall develop a pilot study to assess the feasibility of enhancing the function of ecological communities to reduce predation losses and increase survival in reservoirs and the estuary.					Status Check
	Action 106:	The Action Agencies, in coordination with NMFS, shall investigate marine mammal predation in the tailrace of Bonneville Dam. A study plan shall be submitted to NMFS by June 30, 2001, detailing the study objectives, methods, and schedule.					Status Check
	Action 107:	The Action Agencies shall conduct a comprehensive evaluation to assess survival of adult salmonids migrating upstream and factors contributing to unaccounted losses.			3 Yr Implementation Check	Evaluations underway?	
	Action 108:	The Corps and BPA shall conduct a comprehensive evaluation to investigate the causes of headburn in adult salmonids and shall implement corrective measures, as warranted.					Status Check
	Action 109:	The Corps shall initiate an adult steelhead downstream migrant (kelt) assessment program to determine the magnitude of passage, the contribution to population diversity and growth, and potential actions to provide safe passage.			3 Yr Implementation Check	Study report available?	
	Action 110:	The Corps shall use information from previous and ongoing investigations regarding the problem of adult steelhead holding and jumping in the fish ladders at John Day Dam, develop a proposed course of action, and implement it, as warranted.					Status Check
	Action 111:	The Corps shall investigate and enumerate fallback of upstream migrant salmonids through turbine intakes at all lower Snake and lower Columbia River dams. The Corps shall implement corrective measures to reduce turbine mortality, as warranted.					Status Check
	Action 112:	The Corps shall investigate ways to provide egress to adult fish that have fallen back into juvenile collection galleries and primary dewatering facilities at Ice Harbor and McNary dams. The Corps shall either install structural, or implement operational, remedies to minimize delay and injury of fish that fall back, as warranted.					Status Check
	Action 113:	The Corps shall investigate measures to reduce adult steelhead and salmon fallback and mortality through the Bonneville Dam spillway. A final report shall be submitted to NMFS stating the findings of these investigations and recommending corrective measures. Potential remedies shall be included in the annual planning process.			3 Yr Implementation Check	Final report completed? Implemented?	
	Action 114:	The Corps shall examine existing fish-ladder water temperature and adult radio-telemetry data to determine whether observed temperature differences in fishways adversely affect fish passage time and holding behavior. If non-uniform temperatures are found to cause delay, means for supplying cooler water to identified areas of warmer temperatures should be developed and implemented in coordination with the annual planning process.					Status Check
	Action 115:	The Corps and BPA shall conduct a comprehensive depth and temperature investigation to characterize direct mortality sources at an FCRPS project considered to have high unaccountable adult losses (either from counts and/or previous adult evaluations).					Status Check
	Action 116:	The Corps shall investigate adult fish delay and fallback at ladder junction pools and implement remedies to reduce this problem, as warranted.					Status Check

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Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 117:	The Corps shall evaluate adult count station facilities and rehabilitate where necessary at all projects to either minimize delay of adults or minimize counting difficulties that reduce count accuracy.		Annual Operation			
	Action 118:	The Corps shall develop and implement a program to better assess and enumerate indirect prespawning mortality of adult upstream-migrating fish. Such mortality may be due to, or exacerbated by, passage through the FCRPS hydro projects. If measures are identified which will reduce the unaccountable adult loss rate and/or the prespawning mortality rate, the Corps shall implement these measures as warranted. The program should also enhance efforts to enumerate unaccountable losses associated with tributary turnoff, harvest, or other factors in FCRPS mainstem reservoirs and upstream of FCRPS projects.			3 Yr Implementation Check	Studies underway?	Status Check
	Action 119:	The Corps shall ensure that alterations to fish ladders and adult passage facilities to accommodate Pacific lamprey passage do not adversely affect salmonid passage timing and success.					Status Check
	Action 120:	The Corps shall develop improved operations for adult fishway main entrances at FCRPS dams so that the best possible attraction conditions are provided for adult migrants, both at the four Columbia River hydro projects and the four lower Snake hydro projects (where reservoir elevations are held near MOP). The Corps shall report the findings of fishway entrance flow-balancing investigations in a report to NMFS by the end of 2001 and shall continue to work through FPOM to evaluate and implement, as warranted, structural changes to satisfy fish passage plan fishway entrance criteria.					Status Check
	Action 121:	The Corps shall develop and maintain an auxiliary water-supply, emergency-parts inventory for all adult fishways where determined necessary, in coordination with NMFS.					Status Check
	Action 122:	The Corps shall continue design development and, subsequently, construct an emergency auxiliary water supply system at The Dalles Dam's east ladder.					Status Check
	Action 123:	The Corps shall continue to investigate alternatives to dewater adult auxiliary water system floor diffusers for inspection at The Dalles adult fishway powerhouse collection channel. The Corps shall implement design and construction of needed changes, as warranted.					Status Check
	Action 124:	The Corps shall investigate methods to provide additional emergency auxiliary water to The Dalles Dam north fishway when the normal auxiliary water supply is interrupted.					Status Check
	Action 125:	The Corps shall develop and implement an automated monitoring and alarm system at appropriate FCRPS projects, as determined in the NMFS Regional Forum, to monitor changes in head differential remotely between the primary auxiliary water supply conduits/channels and the adult collection channels and to minimize diffuser damage due to excessive differentials. The Corps shall ensure that diffuser gratings for all auxiliary water supply systems are securely fastened. The Corps shall work through FPOM to develop a monitoring program for inspecting diffuser gratings and grating fasteners.					Status Check
	Action 126:	The Corps shall initiate an investigation and prepare a report on the Bonneville First Powerhouse Bradford Island and Cascade Island adult fishway auxiliary water system by the end of 2001. In the report, the Corps shall identify measures that will improve or replace aging components, thereby enhancing current and long-term performance and reliability.					Status Check

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Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 127:	The Corps shall continue its investigation of the Bonneville Second Powerhouse adult fishway auxiliary water system and shall identify measures to satisfactorily address emergency backup auxiliary water needs.					Status Check
	Action 128:	The Corps shall initiate an engineering study to evaluate existing limitations relating to its inability to satisfy fish passage plan operating criteria at the John Day Dam north shore ladder.					Status Check
	Action 129:	The Corps shall complete adult fishway auxiliary water supply evaluations at each lower Snake River hydro project and implement corrective measures as warranted.					Status Check
	Action 130:	The Corps shall complete its DGAS by April 2001. The results of this study will be used to guide future studies and decisions about implementation of some long-term structural measures to reduce TDG.					Status Check
	Action 131:	The Action Agencies shall monitor the effects of TDG. This annual program shall include physical and biological monitoring and shall be developed and implemented in consultation with the Water Quality Team and the Mid-Columbia PUDs' monitoring programs.		Annual Operations			
	Action 132:	The Action Agencies shall develop a plan to conduct a systematic review and evaluation of the TDG fixed monitoring stations in the forebays of all the mainstem Columbia and Snake river dams (including the Camas/Washougal monitor). The evaluation plan shall be developed by February 2001 and included as part of the first annual water quality improvement plan. The Action Agencies shall conduct the evaluation and make changes in the location of fixed monitoring sites, as warranted, and in coordination with the Water Quality Team. It should be possible to make some modifications by the start of the 2001 spill season.			3 Yr Implementation Check	Plan developed?	
	Action 133:	As part of DGAS, the Corps shall complete development of a TDG model to be used as a river operations management tool by spring 2001. Once a model is developed, the applications and results shall be coordinated through the Water Quality Team. The Corps shall coordinate the systemwide management applications of gas abatement model studies with the annual planning process, the Transboundary Gas Group, the Mid-Columbia Public Utilities, and other interested parties.					Status Check
	Action 134:	The Corps shall continue the spillway deflector optimization program at each FCRPS project and implement it, as warranted. The Corps and BPA shall conduct physical and biological evaluations to ensure optimum gas abatement and fish passage conditions. Implementation decisions will be based on the effect of spill duration and volume on TDG, spillway effectiveness, spill efficiency, forebay residence time, and total project and system survival of juvenile salmon and steelhead passing FCRPS dams.					Status Check
	Action 135:	The Corps shall include evaluations of divider walls at each FCRPS project in the spillway deflector optimization program. Design development and construction of divider walls would begin only after coordination within the annual planning process, and only if warranted.					Status Check
	Action 136:	The Corps shall continue to develop and construct spillway deflectors at Chief Joseph Dam by 2004 to minimize TDG levels associated with system spill.			3 Yr Implementation Check	On schedule?	

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Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 137:	The Corps shall investigate TDG abatement options at Libby Dam, including the installation of spillway deflectors and/or additional turbine units. The Corps shall construct gas abatement improvements at Libby on the Kootenai River, as warranted, to reduce TDG levels below the project.					Status Check
	Action 138:	The Corps shall continue to investigate RSWs, in conjunction with extended spillway deflectors, as a means of optimizing safe spillway passage of adult steelhead kelts and juvenile migrants.					Status Check
	Action 139:	The Corps shall investigate TDG abatement options at Dworshak Dam and implement options, as warranted, in coordination with the annual planning process.					Status Check
	Action 140:	The Corps shall design the spillway Number 1 (end bay) deflector at John Day Dam, and implement as warranted, in coordination with the annual planning process.					Status Check
	Action 141:	The Action Agencies shall evaluate juvenile fish condition due to disease in relation to high temperature impacts during critical migration periods. This evaluation should include monitoring summer migrants at lower Columbia and lower Snake river dams to clarify the possible link between temperature and fish disease and mortality. This information will be used to assess the long-term impacts of water temperature on juvenile fish survival.					Status Check
	Action 142:	The Corps shall work through the regional forum process to identify and implement measures to address juvenile fish mortality associated with high summer temperatures at McNary Dam. As a starting point, the Corps shall assemble and analyze the temperature data that have been recorded in the McNary forebay, collection channel, and juvenile facilities. The Corps shall examine relationships among juvenile mortality, temperatures, river flow rates, and unit operations in detail. The Corps shall investigate the feasibility of developing a hydrothermal computational fluid dynamics model of the McNary forebay to evaluate the potential to determine optimal powerhouse operations or structural modifications for minimizing thermal stress of juvenile salmon collected in the summer and to conduct a modeling program, if warranted.					Status Check
	Action 143:	By June 30, 2001, the Action Agencies shall develop and coordinate with NMFS and EPA on a plan to model the water temperature effects of alternative Snake River operations. The modeling plan shall include a temperature data collection strategy developed in consultation with EPA, NMFS, and state and Tribal water quality agencies. The data collection strategy shall be sufficient to develop and operate the model and to document the effects of project operations.			3 Yr Implementation Check	Complete?	
	Action 144:	The Corps, in coordination with the Regional Forum, shall maintain juvenile and adult fish facilities within identified criteria and operate FCRPS projects within operational guidelines contained in the Corps' Fish Passage Plan. The Corps shall coordinate with NMFS on the development of these criteria and operational guidelines before the start of each fish passage season (generally February 1).		Annual Operation			
	Action 145:	The Corps shall develop and implement preventative maintenance programs for fish passage facilities that ensure long-term reliability, thereby minimizing repair costs.		Annual Operation			

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Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 146:	The Corps shall address debris-handling needs and continue to assess more efficient and effective debris-handling techniques to ensure that the performance of both new and old fish passage facilities will not be compromised.		Annual Operation			
	Action 147:	As a contingency plan, the Corps (in cooperation with other Federal agencies) shall develop a project management plan to reevaluate more intensive hydropower-related actions (including breaching) for the four lower Snake River dams. The project management plan will identify the scope, schedule, costs, tasks, products, and responsibilities for the reevaluation study. The study should assess all significant changed conditions to the Lower Snake River Feasibility Report and Environmental Impact Statement (Corps 1999c). The project management plan should be consistent with direction from Congress, Corps authorities, and other legal requirements. The completed project management plan should be coordinated with the appropriate regional interests. The project management plan should include, but not be limited to, plans to mitigate disproportionate impacts to communities, industries, and Tribes, detailed water and air quality effects, implementation plans, and a complete public involvement program. The decision to start the reevaluation study should result from the NMFS check-in process in Sec					Action contingent on check-in
	Action 148:	The Corps shall conduct detailed engineering and design work for improvements recommended in the general reevaluation report and supplemental environmental impact statement described in the preceding action. The Corps shall seek funding to allow initiation of the engineering and design work to occur immediately upon completion of the final general reevaluation report. The engineering and design work shall include only those activities on (or near) the implementation schedule critical path for the recommended actions, up to the award of the first construction contract. For a dam breach recommendation, the critical path activities shall include turbine physical modeling (for use as low level outlets), rock source explorations for embankment erosion protection (riprap), and hydraulic (physical) modeling for the embankment removal and channelization. Tentative milestones for the general reevaluation report/EIS and engineering and design work are as follows, based on the check-in process identified in Section 9.5. (see RPA for list)					Action contingent on check-in
9.6.2	Action 149:	BOR shall initiate programs in three priority subbasins (identified in the Conceptual Recovery Plan) per year over 5 years, in coordination with NMFS, FWS, the states and others, to address all flow, passage, and screening problems in each subbasin over 10 years. The Corps shall implement demonstration projects to improve habitat in subbasins where water-diversion-related problems could cause take of listed species. Under the NWPPC program, BPA addresses passage, screening, and flow problems, where they are not the responsibility of others. BPA expects to expand on these measures in coordination with the NWPPC process to complement BOR actions described in the action above.			3 Yr Implementation Check	9 basins under implementation?	
	Action 150:	In subbasins with listed salmon and steelhead, BPA shall fund protection of currently productive non-Federal habitat, especially if at risk of being degraded, in accordance with criteria and priorities BPA and NMFS will develop by June 1, 2001.			3 Yr Implementation Check	Priorities Set and implementation underway?	

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Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 151:	BPA shall, in coordination with NMFS, experiment with innovative ways to increase tributary flows by, for example, establishing a water brokerage. BPA will begin these experiments as soon as possible and submit a report evaluating their efficacy at the end of 5 years.			3 Yr Implementation Check	On track for 2005?	
	Action 152:	The Action Agencies shall coordinate their efforts and support offsite habitat enhancement measures undertaken by other Federal agencies, states, Tribes, and local governments by the following: (See RPA)					Status Check
	Action 153:	BPA shall, working with agricultural incentive programs such as the Conservation Reserve Enhancement Program, negotiate and fund long-term protection for 100 miles of riparian buffers per year in accordance with criteria BPA and NMFS will develop by June 1, 2001.			3 Yr Implementation Check	Meeting Goal?	
	Action 154:	BPA shall work with the NWPPC to ensure development and updating of subbasin assessments and plans; match state and local funding for coordinated development of watershed assessments and plans; and help fund technical support for subbasin and watershed plan implementation from 2001 to 2006. Planning for priority subbasins should be completed by the 2003 check-in. The action agencies will work with other Federal agencies to ensure that subbasin and watershed assessments and plans are coordinated across non-Federal and Federal land ownerships and programs.			3 Yr Implementation Check	Priority basins complete, remainder on track for completion by 2006?	
	Action 155:	BPA, working with BOR, the Corps, EPA, and USGS, shall develop a program to 1) identify mainstem habitat sampling reaches, survey conditions, describe cause-and-effect relationships, and identify research needs; 2) develop improvement plans for all mainstem reaches; and 3) initiate improvements in three mainstem reaches. Results shall be reported annually.			3 Yr Implementation Check	Tasks under 1) and 2) complete?	
	Action 156:	The Action Agencies and NMFS shall study the feasibility (including both biological benefits and ecological risks) of habitat modification to improve spawning conditions for chum salmon in the Ives Island area.			3 Yr Implementation Check	Feasibility study complete?	
	Action 157:	BPA shall fund actions to improve and restore tributary and mainstem habitat for CR chum salmon in the reach between The Dalles Dam and the mouth of the Columbia River.			3 Yr Implementation Check	Restoration efforts identified, funding and implementation initiated?	
	Action 158:	During 2001, the Corps and BPA shall seek funding and develop an action plan to rapidly inventory estuarine habitat, model physical and biological features of the historical lower river and estuary, identify limiting biological and physical factors in the estuary, identify impacts of the FCRPS system on habitat and listed salmon in the estuary relative to other factors, and develop criteria for estuarine habitat restoration.			3 Yr Implementation Check	Action Plan complete?	
	Action 159:	BPA and the Corps, working with LCREP and NMFS, shall develop a plan addressing the habitat needs of salmon and steelhead in the estuary.			3 Yr Implementation Check	Overview Complete?	

			Category I		Category II		Category III
Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 160:	The Corps and BPA, working with LCREP, shall develop and implement an estuary restoration program with a goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats over 10 years, beginning in 2001, to rebuild productivity for listed populations in the lower 46 river miles of the Columbia River. The Corps shall seek funds for the Federal share of the program, and BPA shall provide funding for the non-Federal share. The Action Agencies shall provide planning and engineering expertise to implement the non-Federal share of on-the-ground habitat improvement efforts identified in LCREP, Action 2.			3 Yr Implementation Check	Restoration efforts identified, funded and underway?	
	Action 161:	Between 2001 and 2010, the Corps and BPA shall fund a monitoring and research program acceptable to NMFS and closely coordinated with the LCREP monitoring and research efforts (Management Plan Action 28) to address the estuary objectives of this biological opinion.			3 Yr Implementation Check	Program underway?	
	Action 162:	During 2000, BPA, working with NMFS, shall continue to develop a conceptual model of the relationship between estuarine conditions and salmon population structure and resilience. The model will highlight the relationship among hydropower, water management, estuarine conditions, and fish response. The work will enable the agencies to identify information gaps that have to be addressed to develop recommendations for FCRPS management and operations.			3 Yr Implementation Check	Model available?	
	Action 163:	The Action Agencies and NMFS, in conjunction with the Habitat Coordination Team, will develop a compliance monitoring program for inclusion in the first 1- and 5-year plans.			3 Yr Implementation Check	Compliance program developed?	
9.6.3	Action 164:	The Action Agencies shall work with NMFS, USFWS, and Tribal and state fishery management agencies in a multiyear program to develop, test, and deploy selective fishing methods and gear that enable fisheries to target nonlisted fish while holding incidental impacts on listed fish within NMFS-defined limits. The design of this program and initial implementation (i.e., at least the testing of new gear types and methods) shall begin in FY 2001. Studies and/or pilot projects shall be under way and/or methods deployed by the 3-year check-in.			3 Yr Implementation Check	Studies and/or pilot projects underway and/or methods deployed?	
	Action 165:	The Action Agencies shall work with NMFS, USFWS, Tribal and state fishery managers, and the relevant Pacific Salmon Commission and Pacific Fishery Management Council (PFMC) technical committees to develop and implement methods and analytical procedures (including revising and/or replacing current fishery management and stock assessment models based on these methods and procedures) to estimate fishery and stock-specific management parameters (e.g., harvest rates). The Action Agencies shall place particular emphasis on current methods and procedures affected by the transition to mass marking of Columbia River basin hatchery produced fish and/or deployment of selective fishery regimes in the Columbia River basin, addressing these concerns within a time frame necessary to make the new selective fishing regimes feasible. Specifically, the Action Agencies shall facilitate the development of models, methods, and analytical procedures by the 3-year check-in.			3 Yr Implementation Check	Models, methods, analytical procedures developed?	

			Category I		Category II		Category III
Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 166:	The Action Agencies shall work with NMFS, USFWS, the Pacific States Marine Fisheries Commission, and Tribal and state fishery management agencies to implement and/or enable changes in catch sampling programs and data recovery systems, including any required changes in current databases (e.g., reformatting) and associated data retrieval systems, pursuant to the time frame necessary to implement and monitor mass marking programs and/or selective fishery regimes in the Columbia River basin. Specifically, the Action Agencies shall facilitate the revision of programs and systems, as needed, by the 3-year check-in.			3 Yr Implementation Check	Programs and systems revised as necessary?	
	Action 167:	The Action Agencies shall work with NMFS, USFWS, and Tribal and state fishery management agencies to develop improved methods for estimating incidental mortalities in fisheries, with particular emphasis on selective fisheries in the Columbia River basin, doing so within the time frame necessary to make new marking and selective fishery regimes feasible. The Action Agencies shall initiate studies and/or develop methods by the 3-year check-in.			3 Yr Implementation Check	Studies and/or development of methods underway?	
	Action 168:	The Action Agencies shall work with NMFS, USFWS, and Tribal and state fishery management agencies to develop methods for crediting harvest reforms, and the survival benefits they produce, toward FCRPS offsite mitigation responsibilities. A crediting approach shall be agreed upon by the 3-year check-in.			3 Yr Implementation Check	Crediting approach agreed upon?	
9.6.4	Action 169:	The Action Agencies shall fund the development of NMFS-approved HGMPs for implementation, including plans for monitoring and revising them as necessary as new information becomes available. HGMPs have to be completed first for the facilities and programs affecting the most at-risk species (Upper Columbia and Snake River ESUs), followed by those affecting mid-Columbia, and then the Lower Columbia ESUs. HGMPs for all the Columbia basin hatchery programs and facilities should be completed (and approved by NMFS) by the 3-year check-in.			3 Yr Implementation Check	NMFS-approved HGMPs completed?	
	Action 170:	Using new authorizations and appropriations and/or BPA funds as necessary and appropriate, the Corps, working with USFWS, shall oversee the design and construction of capital modifications identified as necessary in the HGMP planning process for Lower Snake River Compensation Plan anadromous fish hatchery programs. These improvements shall begin immediately after the relevant HGMPs are completed and approved by NMFS, and shall be completed as expeditiously as is feasible. BPA shall provide for the operations and maintenance costs of these reforms and shall reimburse the Federal Treasury for an appropriate share of the capital costs. The Corps shall have begun to implement reforms for programs affecting the most at-risk species by the 3-year check-in.			3 Yr Implementation Check	Reforms begun for programs affecting most at-risk species?	
	Action 171:	BOR shall implement the reforms identified in the HGMP planning process for the Grand Coulee mitigation anadromous fish hatchery programs, beginning immediately following completion of the relevant (NMFS approved) HGMPs and completing the work as expeditiously as feasible. BPA shall fund the operations and maintenance costs of the reforms and shall reimburse the Federal Treasury for an appropriate share of the capital costs. BOR shall have begun to implement reforms for programs affecting the most at-risk species by the 3-year check-in			3 Yr Implementation Check	Reforms begun for programs affecting most at-risk species?	

			Category I		Category II		Category III
Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 172:	The Corps shall implement the reforms identified in the HGMP planning process for the Corp's Columbia River basin mitigation anadromous fish hatchery programs, beginning immediately after the relevant HGMPs are completed and are approved by NMFS. The work shall be completed as expeditiously as feasible. BPA shall fund the operations and maintenance costs of the reforms and shall reimburse the Federal Treasury for an appropriate share of the capital costs. The Corps shall have begun to implement reforms for the programs affecting the most at-risk species by the 3-year check-in.			3 Yr Implementation Check	Reforms begun for programs affecting most at-risk species?	
	Action 173:	BPA shall implement the reforms identified in the HGMP planning process for Federal and Federally funded hatcheries, beginning immediately after the relevant HGMPs are completed and approved by NMFS. The work shall be completed as expeditiously as possible. BPA shall have begun to implement reforms for the programs affecting the most at-risk species by the 3-year check-in.			3 Yr Implementation Check	Reforms begun for programs affecting most at-risk species?	
	Action 174:	Working through regional prioritization processes to the extent feasible and in coordination with NMFS, BPA shall collaborate with the regional, state, Tribal, and Federal fish managers and the Pacific States Marine Fisheries Commission to enable the development and implementation of a comprehensive marking plan. Included in this action are the following four steps:			3 Yr Implementation Check	see below	
		1. Develop a comprehensive marking strategy for all salmon and steelhead artificial production programs in the Columbia River basin by the end of 2001.				Marking strategy completed?	
		2. Provide funding by March 1, 2001, to begin marking all spring chinook salmon that are currently released unmarked from Federal or Federally funded hatcheries.				Funding provided and marking implemented?	
		3. Provide funding, beginning in FY 2002, to implement the Action Agencies' share of the comprehensive marking plan for production not addressed in (2) above.				Funding provided and marking implemented?	
		4. Obtain funding contributions as appropriate for additional sampling efforts and specific experiments to determine relative distribution and timing of hatchery and natural spawners.				Funding available and sampling efforts, experiments in place?	
	Action 175:	BPA shall, in coordination with NMFS, USFWS, and the relevant state and Tribal comanagers, fund the four-step planning process described above as quickly as possible and, if so determined by that process, implement safety-net projects as quickly as possible at least for the following salmon and steelhead populations: 1) A-run steelhead populations in the Lemhi River, main Salmon River tributaries, East Fork Salmon River, and Lower Salmon River; 2) B-run steelhead populations in the Upper Lochsa River and South Fork Salmon River; and 3) spring/summer chinook populations in the Lemhi, East Fork, and Yankee Fork Salmon rivers, and Valley Creek.			3 Yr Implementation Check	Four-step planning process completed for initial set of safety-net candidate populations?	
	Action 176:	BPA shall, in coordination with NMFS, USFWS, and the relevant state and Tribal comanagers, fund the development of HGMPs for the Grande Ronde and Tucannon spring/summer chinook safety-net programs.			3 Yr Implementation Check	Complete?	

			Category I		Category II		Category III
Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 177:	In 2002, BPA shall begin to implement and sustain NMFS-approved, safety-net projects.			3 Yr Implementation Check	check relative to 174	
	Action 178:	BPA shall commit to a process whereby funds can be made quickly available for funding the planning and implementation of additional safety-net projects for high-risk salmon and steelhead populations NMFS identified during the term of this biological opinion.			3 Yr Implementation Check	Process available?	
9.6.5	Action 179:	The Action Agencies and NMFS shall work with affected parties to establish regional priorities within the congressional appropriations processes to set and provide the appropriate level of FCRPS funding to develop recovery goals for listed salmon ESUs in the Columbia River basin. Tasks shall include defining populations based on biological criteria and evaluating population viability in accordance with NMFS' viable salmonid population approach. These tasks shall be completed by 2003.			3 Yr Implementation Check	Complete?	
	Action 180:	The Action Agencies and NMFS shall work within regional prioritization and congressional appropriation processes to establish and provide the level of FCRPS funding to develop and implement a basinwide hierarchical monitoring program. This program shall be developed collaboratively with appropriate regional agencies and shall determine population and environmental status (including assessment of performance measures and standards) and allow ground-truthing of regional databases. A draft program including protocols for specific data to be collected, frequency of samples, and sampling sites shall be developed by September 2001. Implementation should begin no later than the spring of 2002 and will be fully implemented no later than 2003.			3 Yr Implementation Check	Draft program compete and implementation on schedule?	
	Action 181:	The Action Agencies and NMFS shall work within regional prioritization and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for a program to acquire and digitize aerial or satellite imagery of the entire Columbia River basin once every 3 to 5 years.			3 Yr Implementation Check	Coordinated program defined and underway?	
	Action 182:	The Action Agencies and NMFS shall work within regional priorities and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for studies to determine the reproductive success of hatchery fish relative to wild fish. At a minimum, two to four studies shall be conducted in each ESU. The Action Agencies shall work with the Technical Recovery Teams to identify the most appropriate populations or stocks for these studies no later than 2002. Studies will begin no later than 2003.			3 Yr Implementation Check	Priority studies initiated?	
	Action 183:	Initiate at least three tier 3 studies (each necessarily comprising several sites) within each ESU (a single action may affect more than one ESU). In addition, at least two studies focusing on each major management action must take place within the Columbia River basin. The Action Agencies shall work with NMFS and the Technical Recovery Teams to identify key studies in the 1-year plan. Those studies will be implemented no later than 2003.			3 Yr Implementation Check	Priority studies initiated?	
	Action 184:	The Action Agencies and NMFS shall work within regional prioritization and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for a hatchery research, monitoring, and evaluation program consisting of studies to determine whether hatchery reforms reduce the risk of extinction for Columbia River basin salmonids and whether conservation hatcheries contribute to recovery.			3 Yr Implementation Check	Priority studies identified or initiated?	

			Category I		Category II		Category III
Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 185:	The Action Agencies shall continue to fund and expand, as appropriate, fish marking and recapturing programs aimed at defining juvenile migrant survival for both transported and nontransported migrants and adult returns for both groups. These studies shall also compare the SARs of transported and nontransported fish to calculate the differential delayed mortality (D), if any, of transported fish.			3 Yr Implementation Check	Expanded studies underway?	
	Action 186:	The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for comparative evaluations of the behavior and survival of transported and downstream migrants to determine whether causes of D can be identified for the reach between Bonneville Dam and the mouth of the Columbia River.			3 Yr Implementation Check	Studies underway?	
	Action 187:	The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies and analyses to evaluate relationships between ocean entry timing and SARs for transported and downstream migrants.			3 Yr Implementation Check	Studies underway?	
	Action 188:	The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies of PIT-tagged wild stocks from the lower river streams. The studies shall be used to contrast stock productivity and hydrosystem effects.			3 Yr Implementation Check	Studies underway?	
	Action 189:	The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to investigate the causes of discrepancies in adult return rates for juvenile salmonids that have different passage histories through the hydrosystem.			3 Yr Implementation Check	Study plans under development or implementation?	
	Action 190:	The Action Agencies shall continue to fund studies that monitor survival, growth, and other early life history attributes of Snake River wild juvenile fall chinook.					Status report
	Action 191:	The Action Agencies shall continue to implement adult salmonid counting programs at FCRPS dams, but shall improve the reporting of these counts.		Annual Operation			
	Action 192:	As set out in Action 50 (Section 9.6.1.3.4), BPA and the Corps shall install necessary adult PIT-tag detectors at appropriate FCRPS projects before the expected return of adult salmon from the 2001 juvenile outmigration. These adult PIT-tag detectors shall be used as needed for calculating transport benefits, conversion rates, and SARs for listed salmon and steelhead.			3 Yr Implementation Check	See #50	
	Action 193:	The Action Agencies shall investigate state-of-the-art, novel fish detection and tagging techniques for use, if warranted, in long-term research, monitoring, and evaluation efforts.			3 Yr Implementation Check	Study plans under development or implementation?	
	Action 194:	The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to develop a physical model of the lower Columbia River and plume. This model will characterize potential changes to estuarine habitat associated with modified hydrosystem flows and the effects of altered flows where they meet the California Current to form the Columbia River plume.			3 Yr Implementation Check	Study plans under development or implementation?	

			Category I		Category II		Category III
Section	**Action #**	**Action**	***Monitor through annual Planning cycle (Summarize in 3 Year Progress Report)***		***Specific 3 Yr Checkpoint***	***Key 3 Yr criteria***	***Status Check***
	Action 195:	The Action Agencies shall investigate and partition the causes of mortality below Bonneville Dam after juvenile salmonid passage through the FCRPS.			3 Yr Implementation Check	Study plans under development or implementation?	
	Action 196:	The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River estuary. These studies support the actions to develop criteria for estuarine restoration (Action 158), restoration planning (Action 159), and implementation (Action 160) in Section 9.6.2.2.			3 Yr Implementation Check	Studies being implemented?	
	Action 197:	The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River plume.			3 Yr Implementation Check	Study plans under development or implementation?	
	Action 198:	The Action Agencies, in coordination with NMFS, USFWS, and other Federal agencies, NWPPC, states, and Tribes, shall develop a common data management system for fish populations, water quality, and habitat data.			3 Yr Implementation Check	Under implementation?	
	Action 199:	The Action Agencies shall implement the specific research/monitoring actions outlined in Appendix H.			3 Yr Implementation Check	Research in support of actions identified above.	

APPENDIX G
PRELIMINARY OUTLINE FOR
COMPREHENSIVE MONITORING AND EVALUATION PROGRAM

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G.1 INTRODUCTION: KEY CHALLENGES FOR MONITORING AND EVALUATION

Monitoring and evaluation[1] are not merely the periodic collection of data. Rather, properly designed monitoring programs will provide the necessary data for resolving a wide range of uncertainties, including determining population status, establishing causal relationships between habitat (or other) attributes and population response, and assessing the effectiveness of management actions.

To be most useful, a monitoring and evaluation program, like any other scientific endeavor, should be question-driven. The five main areas and questions that the Columbia Basin monitoring and evaluation program must address are as follows:

- **Population status monitoring.** What areas do juvenile salmonids and spawning adults occupy? What is the status of the population (i.e., abundance, trend and variation)? Does that status change through time?
- **Environmental status monitoring.** What is the status of environmental attributes, including non-native species, potentially affecting salmonid populations? Does it change through time? Are there associations between environmental attributes and salmonid population status?
- **Effectiveness monitoring.** Are management actions having the intended effects on the aquatic system, and what is the response of salmonid populations to those effects?
- **Quality of regional databases.** How accurate and complete are currently available databases that represent habitat quality throughout the basin?
- **Compliance monitoring.** Have management actions been properly implemented and maintained?

Economies can be achieved by designing a monitoring and evaluation program so that different sampling sites and efforts intersect other sampling sites and efforts in a way that serves multiple needs. Outlined below is a hierarchy of three sampling tiers that is designed to fulfill these several purposes efficiently. Sampling activities in each tier are conducted at different spatial scales, consider different levels of biological detail, and assess different types of habitat attributes.

Monitoring is a scientific activity. As such, it will evolve as salmon science progresses. However, the backbone of any monitoring program should be solid enough to remain in place for decades to come—with the changes that occur taking the form of additional measurements or supplementary efforts.

[1]This preliminary outline for a comprehensive monitoring and evaluation program was formulated In November 2000 by the Northwest Fisheries Science Center (NWFSC), National Marine Fisheries Service (NMFS). It will be fully developed through a collaborative effort of NWFSC, regional agencies, and scientists.

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G.2 HIERARCHICAL SYSTEM OF MONITORING

To meet the challenge of monitoring and evaluation, NMFS intends to deploy a monitoring program that involves three tiers of sampling, in ascending detail, in both freshwater systems and the estuary. Table G-1 summarizes the entire monitoring scheme. For each of these two areas (monitoring and evaluation), the purpose of each tier is described first, then the data that will be collected at each tier are described in general terms. Following this, specific details are provided for environmental status and compliance monitoring programs that complete the necessary data collection. Finally, the further analyses and activities that must be completed before a detailed monitoring program can be established are briefly outlined.

Tier 1. Tier 1 sampling is the broadest of the sampling levels, comprising the greatest number of sites, sampled at the lowest frequency. It is designed to give the broadest picture of salmonid population status and the condition of the habitats in which they are found. Tier 1 data will contribute to population status monitoring, environmental status monitoring, the quality of databases, and compliance monitoring. They have the potential to contribute to effectiveness monitoring in those situations where the expected population response is range expansion. Specific goals associated with this tier are 1) defining areas currently used by adults and juveniles, 2) detecting altered status of populations due to range expansion or shrinkage, 3) identifying associations between salmon presence and habitat attributes, and 4) ground-truthing regional habitat quality databases.

Freshwater Systems

a. *Fish*
   - Status of spawners and/or juveniles
   - Status of hatchery-origin spawners

b. *Habitat.* Habitat variables selected for tier 1 monitoring and database ground-truthing are either linked to annual population growth rate by preliminary statistical analyses or have not been collected, although they are important. These variables are listed below:
   - Stream temperature
   - Pesticide and heavy metal contamination (water sample)
   - Number of diversions or dams
   - Qualitative or quantitative assessment of erosion processes
   - Channel modification (including placer mining)
   - Channel morphology

Table G-1. Outline of proposed monitoring and evaluation sampling design.

	Tier 1	Tier 2	Tier 3	Landscape Imagery	Compliance Logbook
Sampling frequency	Once every 3-4 years	Annually	Frequency depends on study; minimum annually	Once every 3 years	Once every 6 months (action agency); arbitrarily to monthly (regulatory agency)
Relevant to monitoring types[1]	1,2,3,4,5	1,2,3,4,5	3,5	2	5
Goals[2]	A, B	B, C	C, D	B	
Number of sites	To cover all potentially used areas in a population	To be determined by power analyses	Minimum 3 per ESU; minimum 2 for each major management action	Entire Columbia Basin	All management actions
Data type—salmonid population	Presence/absence	Counts of juveniles and spawners	Depends on management action; hatchery spawner reproductive success	None	None
Data type—habitat	General, qualitative	Qualitative and quantitative	Quantitative, depends on management action	Landscape-level attributes	None

[1]Relevant to monitoring types: 1 = population status monitoring, 2 = environmental status monitoring, 3 = effectiveness monitoring, 4 = quality of regional databases, 5 = compliance (implementation) monitoring.

[2]Goals as follows: A = establish fish habitat use or range; B = establish associations between environmental characteristics and population status; C = estimate population growth rates or stage-specific survival rates; D = establish mechanistic links between management actions and salmon population response.

- Instream flow
- Substrate
- Riparian condition
- Land use categories in the riparian area
- Habitat types (side channels, pools, etc.)
- Status of nonindigenous fish species or dominant riparian plant species

c. *Compliance monitoring.*
- Checklist of required actions in sampling area (e.g., status of riparian fences)

Estuary

a. *Fish.*
- Status of wild juveniles
- Status of hatchery-origin juveniles

b. *Habitat.* Habitat variables selected for tier 1 monitoring in the estuary are very general and will be refined as the database of fish use of the estuary and plume increases. Preliminary tier 1 habitat variables are listed below:
- Temperature
- Salinity
- Pesticide and heavy metal contamination (water sample)
- Depth
- Turbidity
- Zooplankton concentration
- Status of nonindigenous species

c. *Compliance monitoring.*
- Checklist of otherwise unmonitored actions in sampling area

Tier 1 sites will be sampled on a 3- to 4-year rotation, with each site being sampled once in that interval. Sites will be distributed to sample the full range of habitats in the area potentially occupied by the population of interest. A seasonal component will be important, particularly for juvenile surveys, to determine habitat use and availability at different times of the year.

Tier 2 sites: The monitoring at tier 2 sites is designed to give a more detailed picture of population status, allowing, in turn, a more detailed assessment of relationships between environmental characteristics and trends in salmonid populations. Tier 2 data will form the backbone of population status monitoring, as well as environmental status monitoring. They also have the potential to contribute to both effectiveness and compliance monitoring.

Freshwater

For freshwater systems, specific goals associated with this tier are 1) defining population growth rates; 2) detecting changes in those growth rates, or changes in relative abundance in a reasonable time; and 3) identifying associations between population trends and environmental

attributes (particularly with changes in those attributes over time). Data to be collected at this tier are as follows:

a. *Fish*
   - Spawner or redd counts at spawning sites [This element will be developed in the monitoring plan to determine the most effective measure to estimate population size and minimize sampling error.]
   - Juvenile counts
   - Counts of hatchery fish at spawning sites
   - Counts at dams and weirs
   - Age of spawners (subset of sites)
b. *Habitat.* Tier 2 habitat factors will emphasize variables that may be improved by management actions and that probably will have a direct impact on salmonid survival. The following tier 2 data will be collected:
   - Aquatic insect diversity and abundance
   - Primary production
   - Abundance of nonindigenous species
c. *Compliance monitoring.*
   - Checklist of required actions in sampling area

Estuary

Specific goals associated with sampling at this tier in the estuary are 1) estimating relative smolt abundance in the estuary and survival rates during the estuarine phase, 2) detecting changes in relative abundance and survival rates between years, and 3) identifying associations between smolt abundance or survival rates and environmental attributes (particularly with changes in those attributes over time). Specific data to be collected are as follows:

a. *Fish*
   - Number of wild and hatchery-origin smolts
   - PIT-tag data from all fish caught during sampling
b. *Habitat.* The following data will also be collected:
   - Status of predator species
   - Status of nonindigenous species
c. *Compliance monitoring*
   - Checklist of required actions in sampling area

Tier 2 sites will be sampled annually. The number of adult sampling sites within each population will be determined by a power analysis that requires a 75% likelihood of detecting a 5% change in lambda over 8 years. This means that ESUs made up of populations that fluctuate widely will

require more tier 2 sites than ESUs with less variable spawner counts. Sites will be distributed probabilistically within a population, ensuring that both good and bad sites are appropriately represented. To obtain the maximum benefit from habitat data, it may be important to include some stratification (channel type, for example) in the distribution of sites.

Juvenile counts, coupled with spawner or redd counts, will ultimately provide a measure of egg-to-smolt survival. This will improve estimates of population growth rate and can serve as a baseline in other monitoring efforts (see tier 3).

The number of sites to be sampled in the estuary will also be determined by a power analysis, once sufficient data are available to conduct such an analysis.

Tier 3 sites: Tier 3 monitoring is the most detailed of the monitoring levels. The specific goals of this tier are 1) establishing mechanistic links between management actions and fish population response and 2) determining the relative fitness of hatchery fish. The information gathered at this level will address some of the most fundamental questions to be answered for effective management of anadromous salmonids. First, the relative fitness of hatchery fish must be determined before NMFS can assess the true status of populations to establish appropriate recovery goals. Second, by establishing causal and quantitative links between management actions and population responses, monitoring at this tier will contribute to NMFS' predictive ability and, therefore, to a better understanding of which actions are necessary and sufficient for population recovery.

Sampling at tier 3 sites used for effectiveness monitoring will be specific to the management action being studied. Each study must, however, assess age-specific survival appropriate to the management action. In many cases, this may involve several life stages. Sediment reduction, for instance, may affect both egg-to-fry and fry-to-smolt survival rates. Whenever possible, PIT-tags or other individual marking techniques should be used in order to follow the fates of individual fish as a function of their history. Such individually based studies are important for identifying the effects of environmental conditions that are realized at later life stages. Size or growth rates, as well as demographic rates, may be important parameters in these studies. In addition, both habitat and population response to the management action should be assessed in order to identify the factors causing any fish population responses. Finally, appropriate control sites must be paired with the treatment sites in order to establish those links unambiguously. Studies conducted under the tier 1 and 2 monitoring programs will be important for identifying the important variables by which sites should be paired. When possible, these studies should be conducted in the context of a BACI (before-after-control index) design, which allows environmental impacts, such as ocean cycles, to be filtered out. Information from other monitoring tiers (especially tier 2) will also provide important controls against which changes in tier 3 studies can be assessed.

Specific sites and management activities to be included in tier 3 monitoring will be rigorously identified. Associations of environmental condition and population status identified through tier 1 and 2 monitoring will play an important role in prioritizing activities for tier 3 evaluation. Specific sites for these actions (and for controls for those actions) should be identified, considering important environmental factors (or strata). In some instances, however, pragmatic concerns may play a role in choosing sites. For instance, historically sampled index stocks will be especially valuable contributors to the tier 3 network because their historical time series offer special opportunities for distinguishing responses to management from chance fluctuations. Or, local groups may plan and fund a management activity that provides an opportunity for detailed effectiveness monitoring.

As a general rule, at least three tier 3 studies (each necessarily comprising several sites) should be identified within each ESU. In addition, at least two studies in the Columbia River basin aimed at each major management action (e.g., alteration of grazing practices, compliance with water quality standards, road closures) must be conducted.

Monitoring Outside Three Tiers

The three-tier system appropriately addresses population status and the effectiveness of management actions. It addresses environmental status, regional database quality, and compliance monitoring only on local scales, however. Two programs in addition to the three-tier system will, therefore, provide a more thorough picture of important environmental attributes.

Landscape-level Environmental Attributes

Because much of the data compiled in regional databases, or important in assessing environmental status, are more appropriately collected at subwatershed or watershed scales, the Action Agencies shall acquire and digitize aerial or satellite imagery of the entire Columbia River basin once every 3 years. This will allow a more detailed assessment of land use and land cover variables than is currently available for the region. This assessment, in turn, will allow the association of potentially important watershed-level characteristics with salmon population status. In addition, the repeated assessment of the variables through time will allow changes in environmental characteristics to be associated with changes in salmonid population status. These data will have value for resource and wildlife management well beyond listed salmon species.

Compliance Monitoring Logbooks

Compliance monitoring is necessary to determine how well management actions are implemented. While the question of proper implementation might appear trivial, this component of a monitoring program is very important for two reasons. From a regulatory perspective,

compliance monitoring is necessary to ensure that agencies and individuals responsible for mitigation or restoration activities, in fact, complete their responsibilities. From a biological perspective, we must know how well a management action is implemented. If salmon do not respond, NMFS can then distinguish between management that does not work and management that was not implemented.

Some compliance monitoring can be conducted during the three-tier system, as described above. However, not all sites will be checked during this program at the appropriate frequency. For the major management actions, compliance monitoring will be part of the tier 3 monitoring sites designed to also quantify fish responses. There will be many small management actions (involving local habitat or stream improvements) that cannot, however, be associated with detailed tier-3 sites. For these many small management actions, the agency or party conducting each action will be responsible for keeping a log book of implementation, which is entered into a web-based data archive monthly. NMFS will send out field staff on a random basis to check on the log books and validate their entries.

Logistics, Implementation, and Coordination

Refining this framework is a large task. A number of groups, most notably the Forest Service's Pacific Northwest Forest Science Laboratory, EPA, and the Oregon Coastal Salmon Restoration Initiative, have developed scientifically rigorous monitoring protocols for aquatic systems. This effort should be coordinated with those efforts and draw on these previously developed systems. NWFSC will work in conjunction with these groups and other regional agencies to refine the proposed monitoring scheme, to evaluate formally the necessary temporal and spatial replication, to identify specific localities at which the monitoring program will take place, and to develop data collection protocols. Collaboration will be especially important for identifying novel variables (such as stream invertebrates, riparian productivity, or nonindigenous species) for consideration as monitored factors. Collaboration is also necessary for the error rate in all databases to be estimated and documented.

Implementing this ambitious monitoring program will require an extraordinary degree of coordination among an enormous number of regional management agencies. Population status data are fundamental not only to risk assessment, but also to determining mechanisms of population regulation. Local agencies will necessarily play an important role in acquiring and processing these data. Environmental condition data are important both for identifying patterns between salmonid productivity and natural or anthropogenic factors and in providing the important “before” component of a BACI experiment. Some of these data will probably be collected during subbasin assessment programs. Additional coordination will be important to ensure that the full complement of environmental factors are assessed during these efforts and that ongoing data are collected as needed. Monitoring aimed at determining mechanistic cause-

and-effect relationships between environmental conditions or management actions and population responses will be conducted on a case-by-case basis, depending on the scale of the action. In these cases, agencies implementing actions and the monitoring design team may coordinate with groups or local agencies with specific expertise to apply appropriate data-collection protocols.

Because this effort will be conducted on such a large scale, it will be imperative that all data collection and reporting be conducted in a manner that allows the data to be used not only for scientific support of management actions, but also to address more basic or theoretical issues that have the potential to inform management decisions. In particular, standards for data must encompass data collection, reporting, and accessibility.

APPENDIX H
RESEARCH/MONITORING ACTIONS PURSUANT TO THE RPA

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As described in Section 9.6.5.5, some of the research and monitoring activities associated with the RPA can be anticipated in sufficient detail now, based on elements of the RPA described in Section 9.6.1. The RPA therefore instructs the Action Agencies to implement the activities listed below.

H.1 RESEARCH AND MONITORING ACTIVITIES

Research Action 900: Research to determine the relative survival of migrating juvenile salmonids passing through the spillway of The Dalles Dam. Run-of-the-river fish, including ESA-listed fish, will be collected at John Day Dam and/or obtained from the smolt monitoring program. Study fish will be handled (anesthetized and sorted) and released or PIT-tagged, transported to The Dalles Dam, held for up to 24 hours, and released at selected locations. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.4.5 and 9.6.1.4.6.

Research Action 946: Research to assess the migration timing and relative survival of transported and inriver juvenile chinook salmon migrating volitionally from Bonneville Dam to the mouth of the Columbia River. Run-of-river fish, including ESA-listed juvenile fish, will be observed/harassed while they pass through a PIT-tag interrogation net or captured, anesthetized, examined for PIT-tags and the degree of descaling, allowed to recover from the anesthetic, and released. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.3.3 and 9.6.5.3.5.1.

Research Action 994: Research to assess the passage success of migrating adult salmonids at the eight dams and reservoirs on the lower Columbia and the lower Snake rivers, to evaluate specific flow and spill conditions, and to evaluate measures to improve adult anadromous fish passage. Adult salmonids will be captured at Bonneville, Ice Harbor, and/or Lower Granite dams, anesthetized, fitted with radio transmitters and identifier tags, allowed to recover from the anesthetic, transported, and released. Once the fish are returned to the river, the movement and migration timing of each fish will be recorded at fixed-site and mobile receiver stations as the fish migrate upstream. The primary benefits of the research will be identifying problematic areas in the migration corridor for adult passage and determining the proportion of salmonids that ultimately pass the upstream dams and enter tributaries to spawn, that enter hatcheries, that are taken in fisheries, or that are losses. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.2.6, 9.6.1.6.2, and 9.6.1.7.2.

Research Action 996: Research to monitor the effects of the juvenile fish bypass system at Ice Harbor Dam on the Snake River in Washington. Run-of-the-river juvenile fish, a proportion of which will be ESA-listed fish, will be collected from the bypass system at the dam, anesthetized, handled, allowed to recover from the anesthetic, and released. The primary purpose of the sampling is to ascertain fish condition and, thereby, to certify that the bypass system functions

correctly. Some adult fish, including ESA-listed adult salmon, are expected to fall back through the juvenile bypass system and be captured and handled in the effort to return them to the river. The research is necessary to satisfy elements of the RPA described in Section 9.6.1.4.5.

Research Action 1036: Research to document the growth, migration timing, survival, and SARs for wild juvenile fall chinook salmon migrating from the Snake River to the mouth of the Columbia River. Wild fall chinook salmon will be collected along the Hells Canyon Reach of the Snake River and PIT-tagged. The results will be used to monitor the effects of supplementation, to forecast passage at Lower Granite Dam to help plan summer flow augmentation, and to assess the relative impacts due to predation. Observed migration timing and survival will be used to evaluate the effectiveness of summer flow augmentation. If feasible, one group of PIT-tagged fish will be transported from Lower Granite Dam, and another group will be allowed to continue inriver migration. The research consists of six assessment tasks for which ESA-listed fish will be taken: 1) life cycle, 2) food and growth, 3) predation, 4) temperature response, 5) migratory behavior, and 6) race and residualism. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.2.1, 9.6.1.2.6, 9.6.1.3.3, 9.6.1.5.2, 9.6.1.7.2, 9.6.2.1, and 9.6.5.3.5.

Research Action 1058: Research designed to monitor and evaluate adult returns of hatchery-origin fall chinook salmon released as juveniles above Lower Granite Dam on the Snake River. Information on ESA-listed, natural-origin fish is needed to assess the impacts of fish management (e.g., hatchery supplementation) and other human activities (e.g., regulated river flows) on wild fish populations. The research has two components: 1) radio-tagging returning adult salmon at Lower Granite Dam to document the movements and spawning distribution of known natural-origin fall chinook salmon above the dam and 2) collecting data and scale or tissue samples from spawned-out adult fish in the Snake River and tributaries above Lower Granite Dam to augment information on spawning distribution collected from the radio-tagged fish. The research is necessary to satisfy elements of the RPA described in Section 9.6.1.6.2.

Research Action 1130: Research to determine the movement, distribution, and passage behavior of radio-tagged juvenile salmonids at Bonneville, The Dalles, and John Day dams on the lower Columbia River. The results will be used to assess fish passage efficiency at John Day and The Dalles dams and to increase bypass efficiency for juvenile salmonids at the dams by designing and positioning prototype surface bypass/collection structures. ESA-listed fish will be acquired from smolt-monitoring program personnel at Bonneville, John Day, and/or McNary dams, implanted with radio transmitters, transported, held for as long as 24 hours, released, and tracked electronically. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.4.5 and 9.6.1.4.6.

Research Action 1136: Research to compare the biological and physiological indices of wild and hatchery juvenile fish exposed to stress from bypass, collection, and transportation at the dams on the lower Snake and Columbia rivers. The goal is to provide information that can be used to improve outmigrating juvenile salmonid survival by determining the effects of manmade structures and management activities on the fish. ESA-listed juvenile fish will be captured at Lower Granite and Little Goose dams on the lower Snake River and at Bonneville, John Day, and McNary dams on the lower Columbia River, or acquired from smolt-monitoring-program personnel. The captured juvenile fish will be examined and released or tagged with radio transmitters, released, and tracked electronically. A lethal take of ESA-listed juvenile fish will also occur. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.3.3, 9.6.1.3.4, and 9.6.1.4.6.

Research Action 1193: Research to produce information on migrational characteristics of Columbia and Snake river basin salmon and steelhead. The smolt monitoring program produces information on the migrational characteristics of the various salmon and steelhead stocks in the Columbia and Snake River basins and provides management information for implementing flow and spill measures designed to improve fish passage conditions in the mainstem lower Snake and Columbia rivers. The smolt-monitoring sites include tributary monitoring at the Whitebird trap on the Salmon River, the lower Grande Ronde River trap, and the Lewiston (Snake River) trap. The program also includes monitoring at Lower Granite, Little Goose, Lower Monumental, McNary, and John Day dams and at Bonneville Dam First and Second Powerhouses. Monitoring, including tagging actively migrating smolts with PITs at the tributary traps, yields information on migration timing to FCRPS dams, travel time, and relative survival data from release to Lower Granite Dam, the first dam encountered by outmigrating Snake River salmonids. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1 and 9.6.5.3.5.1.

Research Action 1194: Research to develop and evaluate adult PIT-tag interrogation systems for future installation at mainstem FCRPS facilities on the lower Columbia and Snake rivers. Studies will evaluate the ability of new PIT-tag detection technology to detect and read tag codes in orifices of fish ladders and to evaluate the effects of the detection system on the behavior of adults as they approach the system and pass through. Initial efforts will provide information about adult salmonid behavior during passage through Bonneville Dam and will help evaluate fish passage at other hydropower dams in the future. The new technology will allow tag readings from a greater distance than is currently feasible to allow data collection in a more natural fishway environment. The study is directed at nonlisted adult hatchery fish, but authorization is provided for ESA-listed adult hatchery fish because they often cannot be distinguished while collecting run-of-the-river fish. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.3.3, 9.6.1.3.4, and 9.6.5.3.5.2.

Research Action 1212: Research consisting of four studies at the hydropower dams on the lower Snake and Columbia rivers. Study 1 will provide up-to-date survival estimates of juvenile salmonids as they migrate past McNary Dam. Study 2 will identify specific trouble areas in the juvenile fish bypass system at Lower Monumental Dam. Study 3 will compare the performance of juvenile salmonids tagged with sham radio-transmitters with the performance of juvenile salmonids PIT-tagged at Lower Granite Dam. The use of radio tags reduces research fish requirements, but the larger tag size could affect fish behavior. If survival studies can be conducted with radio-tagged juveniles, handling of ESA-listed species for important research would be significantly reduced. Study 4 will determine the tailrace residence times and behavior of radio-tagged hatchery chinook salmon under various operational conditions at Lower Monumental Dam and will identify spill conditions that maximize fish passage efficiency at Ice Harbor Dam. The research will be used to develop corrective measures to improve juvenile fish passage at the dams. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.4.5, 9.6.1.4.6, and 9.6.5.3.5.1.

Research Action 1224: Research to evaluate the conversion rates (i.e., survival through the FCRPS), travel times, and passage routes of adult steelhead that have spawned (kelts) and are emigrating past hydroelectric facilities on their migration back to the ocean. Fish will be obtained from smolt-monitoring-program personnel at John Day and McNary dams on the lower Columbia River, anesthetized, handled (examined for spawning condition, length, fin condition, and descaling), and released, or they will be obtained from smolt-monitoring-program personnel, tagged/marked (tagged with PIT, radio-telemetry, or visual implant tags), and released. Fish migrating past downstream dams and reservoirs will be monitored by aerial and underwater telemetry arrays. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.6.2 and 9.6.5.3.5.2.

Research Action 1240: Research to provide fishery managers with detailed information on the response of outmigrating juvenile anadromous salmon to operation of a prototype surface bypass structure (removable spillway weir) at Lower Granite Dam. Juvenile fish for the study will be collected at preselected trap sites operated by smolt monitoring program personnel. ESA-listed juvenile fish may also be collected by purse seine in Lower Granite reservoir or from smolt monitoring program personnel at Lower Granite Dam. The fish will then be transported as necessary, anesthetized, implanted with radio transmitters, allowed to recover, transported to an upstream release site, released, and tracked electronically. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.4.5 and 9.6.1.4.6.

Research Action 1241: Studies to provide fishery managers with data on the timing, passage, and survival of outmigrating juvenile salmonids in relation to the operations of John Day, The Dalles, and Bonneville dams. Fish for the study will be collected from the juvenile fish bypass facilities at Bonneville, John Day, and/or McNary dams on the lower Columbia River by smolt

monitoring program personnel. The fish will then be transported as necessary, anesthetized, implanted with radio transmitters, allowed to recover, transported to an upstream release site, released, and tracked electronically. Some research tasks will result in lethal takes of ESA-listed juvenile fish. Those tasks are designed to 1) statistically evaluate the survival rates of juvenile salmonids through John Day, The Dalles, and Bonneville dams and 2) evaluate the stress of juvenile salmonids that pass through the new bypass outfall pipe at Bonneville Dam Second Powerhouse DSM by measuring physiological indices (blood cortisol and lactate concentrations). For item 1), above, fish will be acquired from smolt monitoring program personnel at the dams, exposed to a lethal dose of anesthetic, and released in paired groups with the live radio-tagged fish to test the potential for dead research fish to be mistaken for live research fish. For item 2), run-of-the-river fish will be netted from the sampling flume at Bonneville Dam to acquire the target fish; ESA-listed juvenile fish will be captured, handled, and released, or captured and sacrificed. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.4.5 and 9.6.5.3.5.1.

Research Action 1242: Research to evaluate inriver migration survival versus transportation survival from Lower Granite Dam to below Bonneville Dam. Whether the transportation of depressed anadromous fish species should be maximized to enhance recovery is one of the most controversial and critical questions before fisheries managers today. Among other work, this research is designed to provide definitive information on this important question. ESA-listed juvenile fish will be captured at Lower Granite Dam, handled (checked for condition), and released, or they will be captured at Lower Granite Dam, PIT-tagged, and returned to the river below the dam. Study fish will be tracked downriver as juveniles, and when they return to the Snake River basin as adults, by using automated PIT-tag detectors at the mainstem FCRPS dams. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.3.3 and 9.6.1.3.4.

Research Action 1243: Research to evaluate juvenile fish survival through the Ice Harbor Dam spillway on the Snake River. Survival estimates for juvenile chinook salmon that migrate through the reservoirs, hydroelectric projects, and free-flowing sections of the Snake and Columbia rivers are essential for developing effective strategies to recover depressed stocks. Recent survival studies have evaluated passage through various routes at all of the dams on the lower Snake River except Ice Harbor Dam. ESA-listed juvenile fish will be collected at Lower Monumental Dam on the Snake River by smolt-monitoring-program personnel. The fish will then be tagged with radio transmitters and/or PITs, transported to Ice Harbor Dam, held for recovery, and released into the spillway or transferred to a small barge, transported, and released into the tailrace. Tagged fish will be tracked downriver as juveniles, and later when they return to the Snake River as adults, using automated PIT-tag detectors at FCRPS dams. The research is necessary to satisfy elements of the RPA described in Section 9.6.1.4.5.

Research Action 1244: Six research studies to evaluate juvenile fish collection/bypass facilities at selected Snake and Columbia river FCRPS dams. Problems associated with juvenile fish passage through mainstem FCRPS facilities are major factors in the decline of ESA-listed anadromous fish species. Based on the results of bypass studies, guidance devices and bypass system components can be redesigned, modified, or deployed using specific configurations to improve juvenile fish passage. ESA-listed juvenile fish will be collected at Ice Harbor Dam on the Snake River (study 1) and at McNary (studies 2 and 3) and Bonneville dams (studies 4, 5, and 6) on the Columbia River. Once collected, the fish will be routed to holding tanks, handled (checked for fish condition and fork length), and released or routed to holding tanks, tagged/marked (with PITs, radio transmitters, and/or fin clips), and released. For study 4, artificially propagated chinook salmon juveniles will be PIT-tagged at the Idaho Department of Fish and Game's McCall Hatchery in Idaho. Tagged fish will be tracked downriver as juveniles, and later when they return to the Columbia and Snake river basins as adults, using automated PIT-tag detectors at FCRPS dams. Lethal takes of ESA-listed juvenile fish will occur for studies 2, 4, and 5. For study 4, previously PIT-tagged hatchery yearling chinook salmon will be collected at Bonneville Dam, held in artificial seawater for extended periods, and ultimately sacrificed for physiological characteristics and disease profiles. For study 5, ESA-listed juvenile fish that are not guided by intake screens will be collected in fyke nets as a way to estimate the number of unguided fish during the FGE research on submersible traveling screens at that dam. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.4.5 and 9.6.5.3.5.1.

Research Action 2000: Research at several mainstem FCRPS dams (Lower Granite, Little Goose, Lower Monumental, and McNary dams) to identify and enumerate adult steelhead kelts that pass through associated juvenile fish bypass facilities by using mark-recapture methods. Corps project personnel will remove ESA-listed adult steelhead from the juvenile fish separators during their downstream emigration, examine them using ultrasound, treat them for parasites, mark them (with Floy anchor tags, radio transmitters, or PITs), and release them into the tailrace through the flume used to remove adults from the wet separator. Alternatively, the fish will be held for up to 3 days, transported, and released below Bonneville Dam. A small (0.5 cm^2) piece of fin tissue will be excised. Up to 5 ml of milt will be collected from a maximum of 60 wild male steelhead that 1) are positively identified by ultrasound as kelts, 2) are in good condition, and 3) are readily able to express milt. The samples will be useful in future population restoration efforts, in conjunction with the population of origin identification provided by DNA analysis. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.6.2 and 9.6.5.3.5.2.

Research Action 2001: Research to collect relevant information for lower Columbia River fall chinook and chum salmon so that recommendations can be made for configuration and operation of the FCRPS to protect and/or enhance mainstem spawning populations. Additional studies are

planned to characterize stranding of juvenile fish associated with fluctuating stream flows (due to FCRPS operations). The project will provide baseline data to properly manage natural spawning fall chinook and chum salmon in the mainstem Columbia River downstream of McNary Dam. Research will also evaluate the effects of fluctuating flows and power system load on fall chinook and chum salmon and their habitat as outlined in NWPPC (1994). The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.2.1, 9.6.1.2.3, and 9.6.5.3.3.

Research Action 2002: Research to evaluate modifications to the juvenile fish PIT-tag diversion systems at Lower Granite and Little Goose dams on the Snake River. The evaluation will include fish condition (descaling, injury, and mortality rates), travel time, detection efficiency, and relative survival for PIT-tagged fish. In addition, primary bypass survival will be compared with PIT-tag bypass survival, and a new three-way, diversion sampling system will be evaluated at Little Goose Dam. If injuries, descaling, or mortalities for PIT-tagged fish passing through the modified PIT-tag diversion systems are observed, additional PIT-tagged fish will be released at various locations along the passage route to determine where injuries or descaling occur. The research is necessary to satisfy elements of the RPA described in Section 9.6.1.4.5.

Research Action 2003: Research to compare SARs of marked yearling and subyearling chinook salmon and steelhead juveniles transported from McNary Dam to below Bonneville Dam with the SARs of marked inriver migrating juveniles of these species released into the tailrace of McNary Dam. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.3.3 and 9.6.1.3.4.

Research Action 2004: Research to identify empirically the benefit to juvenile salmon of tidal freshwater and oligohaline transition zones in the Columbia River estuary. The long history of wetland loss in the Columbia River estuary, coupled with changed flow patterns, suggests that restoring these habitats may benefit the recovery of depressed salmon stocks. Habitat-salmon linkages in the Cathlamet Bay region (upstream of Tongue Point) will be evaluated using a combined monitoring and modeling approach to identify and validate the salmon-habitat associations in the lower Columbia River and estuary. That information will be coupled with a historical reconstruction of flow and sediment input in the system and a historical reconstruction of critical salmon habitat change using the geographic information system (GIS) to compare the historical data with present conditions. The approach will be to determine the relationship among shallow water habitats and the presence, use, and benefit to juvenile salmon (emphasizing subyearling chinook salmon) in the Columbia River estuary; understand change in flow and sediment input to the Columbia River estuary in the past and change in habitat availability throughout the lower river and estuary; and develop a numerical model of the lower Columbia River and estuary that can be used to evaluate associations between salmon use and habitat affected by both natural processes and human actions. The research is necessary to satisfy elements of the RPA described in Section 9.6.5.3.6.

Research Action 2005: Research to quantify the abundance of potential predators before and after a trash boom is installed in the forebay of Little Goose Dam. Potential predator fishes (smallmouth bass-*Micropterus dolomieu*, northern pikeminnow-*Ptychocheilus oregonensis*, and channel catfish-*Ictalurus punctatus*) will be collected using nighttime boat electrofishing along the shoreline (effective depth 2 to 4 m) and baited set-lines in deeper water. Sampling will be conducted for 3 to 4 nights over each 2-week period during the study until an acceptable population estimate (±95% confidence interval) can be determined. Adult and juvenile salmonids that encounter the electrical field are expected to move rapidly out of it. As proposed, sampling will cover the area along both the south and north shorelines and open water from Little Goose Dam (approximately RM 70) upstream to approximately RM 71.4. Most predator fishes will be marked with a Floy tag, except for about 50 individuals of all species that will be used for radiotelemetry distribution studies. The recapture of marked fish will make it possible to calculate predator populations by using closed and open population estimators before and after installation of the trash boom. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.4.5 and 9.6.1.5.2.

Research Action 2006: Research designed to evaluate the large-scale predation patterns of northern pikeminnow on juvenile salmonids and American shad (BPA project 9007800). The goal is to investigate large, systemwide (upriver versus downriver) patterns in predation processes, which may have consequences for salmonid survival and management. The large-scale patterns may include higher rates of predation on salmonids and higher growth and reproductive rates for predators in the Columbia River below Bonneville Dam than in the Columbia or lower Snake river reservoirs. The primary task will be to collect data on the size, age structure, and growth of northern pikeminnow populations at upriver versus downriver locations. Temporal variation in northern pikeminnow predation rates and diet will be emphasized. Two particular hypotheses will be examined: 1) temperature differences in the mainstem rivers can explain predation patterns, and 2) the abundance of alternative prey, especially juvenile American shad, can explain predation patterns. Boat electroshocking will be used to collect northern pikeminnow annually during May through October in the tailrace areas of Bonneville, The Dalles, and McNary dams on the Columbia River and at Lower Monumental Dam on the lower Snake River. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.5.1, 9.6.1.5.2, 9.6.1.5.3, and 9.7.1.5.

Research Action 2007: Research on the energy expenditure of upstream migrating adult salmon and steelhead in the Columbia and Snake rivers, for assessing the potential influence of delay, fallback, water temperature, and dam operations (e.g., spill) on migration energetics and, ultimately, on the reproductive performance of these fish. Adult spring chinook salmon en route to upstream locations will be collected from the Bonneville Dam collection facility. The fish will be surgically tagged with electromyogram/temperature radio transmitters and released either downstream or upstream of the Bradford Island fishway. The fish will be tracked using both

mobile and fixed receivers and antennas. Telemetered electromyograms and fish temperature data will be collected as the fish move upstream through the tailrace, fishway, and forebay of Bonneville Dam (or other projects recommended by fish managers). Some of the fish will be tracked through Bonneville pool to the tailrace of The Dalles Dam. The research, funded by the Corps, will begin in 2001 and continue for an undetermined number of years. The research is necessary to satisfy elements of the RPA described in Sections 9.6.1.2.6, 9.6.1.6.2, and 9.6.1.7.2.

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H.2 ESTIMATES OF TAKE ASSOCIATED WITH JUVENILE FISH RESEARCH/MONITORING

Juvenile fish passage research and monitoring are required by the RPA. Most of the research and monitoring activities identified in this biological opinion will take place on the mainstem lower Columbia and Snake rivers or at the mainstem, Federally operated hydropower dams. The scientific research and monitoring activities, compared with the overall effects of FCRPS operation, will cause relatively small effects on ESA-listed species and will not present any significant effects beyond those already estimated through other means (SIMPAS modeling). The application of information from research and monitoring is expected to benefit the survival of ESA-listed species.

Some scientific research and monitoring activities evaluated in the take tables that follow (Tables H-1 to H-12) are multiyear projects that will require annual takes of ESA-listed species. NMFS must assess the cumulative impacts to ESA-listed anadromous fish species that result from annual research and monitoring. Cumulative impacts on ESA-listed fish are best expressed as total annual rates of mortality per individual ESU. To assess annual cumulative impacts due to scientific research and monitoring, NMFS will require each Action Agency (or its designated contract researcher) to submit a take report at the end of each annual sampling season. On the basis of the annual report, each research and monitoring activity will be subject to annual authorization by NMFS. For fish research and monitoring on the mainstem rivers, a cumulative impact assessment is not sensitive enough to evaluate the effects of scientific research and monitoring on ESA-listed salmonids at the population level. Annual cumulative impact analyses will treat the effects on ESA-listed fish populations the same as effects on the ESU as a whole.

Annual-take estimates of ESA-listed juvenile fish associated with scientific research activities are derived from preseason estimates of abundance for each species at various hydropower dams on the mainstem Snake and Columbia rivers. Abundance estimates of outmigrating juvenile salmonids are calculated every year, using an algorithm NWFSC developed, and are distributed to the Action Agencies, researchers, and regional comanagers for the derivation of annual take estimates. The take estimates in this biological opinion were developed from the abundance estimates for the 2000 juvenile fish outmigration (Schiewe 2000). The juvenile outmigration estimates are calculated assuming a full transportation with spill scenario. The abundance estimates of ESA-listed juvenile salmonids can vary significantly from year to year, so the estimates will have to be revised in subsequent years as more complete scientific information is acquired. One of the objectives of the research proposed in this biological opinion is to obtain data for improving the precision of future abundance estimates.

Table H-1. Annual-take estimates of ESA-listed juvenile salmonids: SR sockeye salmon.

Research Action	Location	Handle % of Listed Run	Handle #s in 2000	Tag	Mortality	Lethal
900	JDA	0.198	30		0	
946	EST	2.691	408		0	
996	IHR	0.093	29		1	
1136	LGR	0.0008	4		0	
	MCN	0.0026	1		0	
	JDA	0.0023	1		0	
	BON	0.0036	1		0	
1193	WhT	0.100	20		0	
	LeT	9.900	1,500		30	
	LGR	13.200	2,000		40	
	LGS	9.900	1,500		30	
	LMN	6.600	1,000		20	
	MCN	1.300	200		4	
	JDA	0.500	75		2	
	BON	0.300	50		1	
1212	LGR	2.315	351		4	
	LMN	1.049	159		2	
1240	LGR	0.002	44		2	
1242	LGR	56.964	8,638		211	
1243	LMN	1.286	195		2	
1244	IHR	2.420	367		4	
	MCN	0.310	47		0	
	JDA	0.014	2		0	
	BON	0.053	8		0	8
2002	LGS	2.585	392		9	
2003	MCN	0.198	30		0	
2005	LGS	0.001	10		0	

Notes for Tables H-1 to H-7:

Column descriptions

Handle: number of fish captured (or obtained from others), handled, and released
% of listed run: estimated take of ESA-listed fish expressed as a proportion of the listed population/location
#s in 2000: estimated take of ESA-listed fish in 2000 expressed as a whole number
Tag: number of fish captured (or obtained from others), handled, tagged/marked, and released
Mortality: number of fish unintentionally killed as a result of handling or tagging
Lethal: number of fish intentionally killed

Location abbreviations

HAN	Hanford Reach
HCY	Hell's Canyon
MH	McCall Hatchery
WhT	Whitebird Trap
GrT	Lower Grande Ronde Trap
LeT	Lewiston Trap
LGR	Lower Granite Dam
LGS	Little Goose Dam
LMN	Lower Monumental Dam
IHR	Ice Harbor Dam
MCN	McNary Dam
JDA	John Day Dam
TDA	The Dalles Dam
BON	Bonneville Dam
EST	Columbia River Estuary

Table H-2. Annual-take estimates of ESA-listed juvenile salmonids: SR spring/summer chinook salmon.

		Handle									
		% of listed run		#s in 2000		Tag		Mortality		Lethal	
Research Action	Location	Art-Prop	Nat-Prod	Art-Prop	Nat-Prod	Art-Prop	Nat-Prod	Art-Prop	Nat-Prod	Art-Prop	Nat-Prod
900	JDA	0.061	0.033	197	300	1,310	2,002	28	43		
946	EST	3.918	2.964	12,610	27,158			4	9		
996	IHR	0.203	0.110	655	1,005			7	10		
1036	HCY	1.8977	2.6151	2,650	10,400	2,500	10,000	52	205		
	LGR	0.0715	0.1258	100	500			0	0		
	LGS	0.1310	0.2237	100	500			0	0		
	LMN	0.1132	0.2585	100	300			0	0		
1130	MCN	0.077		72		72	0	4	0		
1136	LGR	0.0018	0.0020	246	780	4	0	7	23	12	0
	LGS	0.0019	0.0002	138	33			4	1	0	238
	MCN	0.0001	0.0001	3	4			0	0		
	JDA	0.0015	0.0017	13	23			0	1		
	BON	0.0004	0.001	3	11	2	0	0	0		
1193	WhT	004.3	000.9	13,800	8,200	1,200	3,200	300	228		
	GrT	001.9	000.3	6,000	2,500	1,400	1,800	148	86		
	LeT	001.6	000.5	5,000	5,000	1,200	2,800	124	156		
	LGR	005.0	004.3	16,000	39,000			320	780		
	LGS	002.2	002.1	7,000	19,000			140	380		
	LMN	002.2	001.3	7,000	12,000			140	240		
	MCN	002.5	000.7	8,000	6,800			160	136		
	JDA	000.9	000.2	3,000	2,000			60	40		
	BON	000.4	0.002	1,400	1,700			28	34		
1212	LGR	0.109	0.109	352	1,000	3,515	10,000	74	210		
	LMN	1.849	0.853	5,950	7,814	4,267	0	145	78		
	MCN	0.006	0.003	18	27	359	549	7	11		
1240	LGR	0.052	0.001	73	350	176	0	10	14	9	0
1241	MCN	1.06	2.010	433	1,256	93	0	21	38	9	0
1242	LGR	36.661	1.701	117,987	15,587	100	71,500	1,182	1,742		
1243	LMN	0.423	0.738	1,360	6,762	3,871	0	72	68		
1244	MH	0.510	0.000	1,000	0	75,000	0	1,510	0		
	IHR	1.470	0.793	4,732	7,266			47	73		
	MCN	1.454	0.782	4,679	7,163			46	73	4	
	JDA	0.067	0.036	216	330			2	3	26	40
	BON	0.035	0.019	113	172	5	7	0	1	79	122
2002	LGR	0.004	0.000	14	0	42	0	1	0		
	LGS	0.685	0.704	2,205	6,450	2,663	0	75	65		
2003	MCN	0.697	0.375	2,243	3,433	4,485	6,866	112	171		
2004	EST	0.000	0.000	1	3			0	0		
2005	LGS	0.001	0.001	25	25			0	0		
2006	LGR	0.0100	0.0100	15	42			0	0		
	LGS	0.0100	0.0200	15	43			0	0		
	MCN	0.0200	0.0200	9	14			0	0		
	JDA	0.0300	0.0400	3	5			0	0		
	TDA	0.0090	0.0120	2	4			0	0		
	BON	0.0640	0.0590	5	7			0	0		

Table H-3. Annual-take estimates of ESA-listed juvenile salmonids: SR fall chinook salmon.

Research Action	Location	Handle % of Listed Run	Handle #s in 2000	Tag	Mortality	Lethal
900	JDA	0.011	74	286	7	
946	EST	0.777	5,265		4	
996	IHR	0.068	462		5	
1036	HCY	3.3315	11,550	10,400	230	
	LGR	0.1442	500	400	10	
	LGS	0.4501	500		0	
	LMN	0.6166	300		0	
	MCN	0.3319	50		0	2
	JDA	1.0513	50		0	2
1130	MCN	0.033	5	10	1	
1136	LGR	0.0008	73	29	3	118
	LGS	0.0000	0		0	
	MCN	0.0000	0	1	0	1
	JDA	0.0003	1		0	
	BON	0.0000	0	1	0	1
1193	WhT	0.0100	100		2	
	GrT	0.0600	400		2	
	LeT	0.0100	100		8	
	LGR	5.9000	40,000		800	
	LGS	5.1700	35,000		700	
	LMN	4.4300	30,000		600	
	MCN	0.3000	2,000		40	
	JDA	0.0700	500		10	
	BON	0.0300	200		4	
1212	LGR	0.017	118		1	
	LMN	1.858	12,586	6,936	265	
	MCN	0.004	25	200	4	
1240	LGR	0.043	148	295	18	47
1241	MCN	1.63	246	11	10	1
1242	LGR	0.295	2,000		20	
1243	LMN	1.229	8,323	30,001	684	
1244	IHR	0.231	1,567		16	
	MCN	0.121	820		9	
	JDA	0.008	51		0	8
	BON	0.000	2		0	1
2002	LGS	0.057	386		4	
2003	MCN	0.011	75	500	11	
2004	EST	0.001	7		0	1
2005	LGS	0.001	15		0	
2006	LGR	0.06	197		2	
	LGS	0.18	197		2	
	MCN	0.02	3		0	
	JDA	0.042	2		0	
	TDA	0.078	2		0	
	BON	0.042	1		0	

Table H-4. Annual-take estimates of ESA-listed juvenile salmonids: SR steelhead.

Research Action	Location	Handle % of Listed Run	Handle #s in 2000	Tag	Mortality	Lethal
900	JDA	1.008	7,486		37	
946	EST	3.281	19,444		6	
996	IHR	0.111	656		7	
1036	HCY	0.1525	524		10	
1136	LGR	0.0008	257	72	10	
	LGS	0.0004	33		1	119
	MCN	0.0001	1		0	
	JDA	0.0013	24		1	
	BON	0.0011	9		0	
1193	WhT	0.100	500	1,400	38	
	GrT	0.400	2,500	1,200	64	
	LeT	0.300	2,000	1,400	78	
	LGR	1.700	10,000		200	
	LGS	0.800	5,000		100	
	LMN	0.500	3,000		60	
	MCN	0.300	1,500		30	
	JDA	0.100	850		17	
	BON	0.100	500		10	
1212	LGR	0.169	1,000	10,000	110	
	LMN	1.061	6,289		63	
	MCN	0.025	146		1	
1240	LGR	0.001	350	700	32	
1241	MCN	0.130	1,684		34	
1242	LGR	6.915	40,984	94,000	1,350	
1243	LMN	0.865	5,129		51	
1244	IHR	4.348	25,770		258	
	MCN	1.824	10,813		108	
	JDA	0.255	1,897		19	24
	BON	0.082	487		2	276
2002	LGR	0.000	0		0	
	LGS	1.663	9,853		99	
2003	MCN	1.440	8,533	11,378	199	
2004	EST	0.011	62		0	
2005	LGS	0.001	30		0	
2006	LGR	0.0060	19		0	
	LGS	0.0200	20		0	
	MCN	0.0900	12		0	
	JDA	0.0100	2		0	
	TDA	0.0060	2		0	
	BON	0.2400	2		0	

Table H-5. Annual-take estimates of ESA-listed juvenile salmonids: UCR spring chinook salmon and UCR steelhead.

		Handle				Tag		Mortality		Lethal	
		% of Listed Run		#s in 2000							
Research Action	Location	Art-Prop	Nat-Prod	Art-Prop	Nat-Prod	Art-Prop	Nat-Prod	Art-Prop	Nat-Prod	Art-Prop	Nat-Prod
UCR Spring Chinook Salmon											
900	JDA	0.123	0.018	1,607	111	10,711	739	230	16		
946	EST	1.821	0.270	23,730	1,647			8	1		
1036	HAN	0.1699	0.3052	1,628	202			6	3		
1130	MCN	0.077	0	257	0	588	0	34	0		
1136	MCN	0.0001	0.0001	21	2			1	0		
	JDA	0.0015	0.0018	104	9			3	0		
	BON	0.0004	0.0010	21	4	9	0	1	0		
1193	MCN	1.400	7.600	12,000	4,500			240	90		
	JDA	0.200	1.000	1,500	600			30	12		
	BON	0.100	0.400	600	250			12	5		
1212	MCN	0.011	0.002	147	10	2,933	203	60	4		
1241	MCN	1.06	2.010	3,538	464	756	0	172	19	71	0
1244	MCN	2.935	0.433	38,248	2,644			383	26	36	
	JDA	0.135	0.020	1,766	122			18	1	212	15
	BON	0.071	0.011	922	64	39	3	4	0	652	45
2003	MCN	1.407	0.208	18,332	1,267	36,665	2,534	916	64		
2004	EST	0.001	0.000	14	0			0	0		
2006	MCN	0.0200	0.0200	73	5			1	0		
	JDA	0.0300	0.0400	22	2			0	0		
	TDA	0.0100	0.0080	20	1			0	0		
	BON	0.0610	0.0680	39	3			0	0		
UCR Steelhead											
900	JDA	4.531	4.698	49,508	11,956			248	60		
946	EST	1.711	1.714	18,700	3,481			6	1		
1036	HAN	0.025	0.032	200	49			2	2		
1130	MCN	0.448	0	497	0	1,177	0	50	0		
1136	MCN	0.0001	0.0001	8	2			0	0		
	JDA	0.0009	0.0013	134	37			4	1		
	BON	0.0008	0.0011	50	14	95	0	4	0	91	0
1193	MCN	2.200	3.800	16,000	5,100			320	102		
	JDA	1.200	2.200	9,000	2,900			180	58		
	BON	0.700	1.200	5,100	1,600			102	32		
1212	MCN	0.108	0.115	1,177	233			12	2		
1241	MCN	7.91	0.047	8,783	6,189	1,883	0	360	186	198	0
1244	MCN	8.640	8.505	94,422	17,269			945	173	95	
	JDA	1.190	1.147	12,544	3,030			126	31	157	38
	BON	0.369	0.383	4,031	778			17	3	2,290	442
2003	MCN	6.819	6.711	74,513	13,628	99,350	18,170	1,739	318		
2004	EST	0.000	0.006	0	11			0	0		
2006	MCN	0.0900	0.0900	99	18			1	0		
	JDA	0.0100	0.0100	16	3			0	0		
	TDA	0.0050	0.0060	14	3			0	0		
	BON	0.0170	0.0150	12	2			0	0		

Table H-6. Annual-take estimates of ESA-listed juvenile salmonids: MCR steelhead, UWR chinook salmon, and UWR steelhead.

Research Action	Location	Handle % of Listed Run	Handle #s in 2000	Tag	Mortality	Lethal
		MCR Steelhead				
900	JDA	8.060	23,984		120	
946	EST	5.552	9,663		3	
1136	MCN	0.0001	1		0	
	JDA	0.0013	93		3	
	BON	0.0024	48		1	
1193	MCN	1.900	1,300		26	
	JDA	5.000	3,500		70	
	BON	3.600	2,500		50	
1212	MCN	0.174	121		1	
1241	MCN	0.130	1,388		28	
1244	MCN	12.841	8,915		90	
	JDA	2.042	6,077		61	76
	BON	1.516	2,587		12	1,470
2003	MCN	10.133	7,036	9,381	164	
2004	EST	0.018	31		0	
2006	MCN	0.090	9		0	
	JDA	0.010	8		0	
	TDA	0.005	8		0	
	BON	0.020	9		0	
		UWR Chinook Salmon				
946	EST	3.303	82,675		26	
2004	EST	0.000	8		0	
		UWR Steelhead				
946	EST	3.362	6,186		2	
2004	EST	0.011	20		0	

Table H-7. Annual-take estimates of ESA-listed juvenile salmonids: LCR chinook salmon, LCR steelhead, and CR chum salmon.

Research Action	Location	Handle		Tag	Mortality	Lethal
		% of Listed Run	#s in 2000			
LCR Chinook Salmon						
946	EST	32.576	189,864		90	
1136	BON	0.0009	51	6	2	24
1193	BON	1.700	3,593		72	
1241	BON	2.070	4,375	140	181	33
1244	BON	0.268	1,536	36	6	1,034
2001	BON	0.940	235		0	
2004	EST	0.003	11		0	17
2006	TDA	0.072	113		1	
	BON	0.072	113		1	
LCR Steelhead						
946	EST	3.361	7,629		2	
1136	BON	0.0012	6		0	
1193	BON	0.900	304		7	
1241	BON	1.300	439		9	
1244	BON	0.935	318		1	181
2004	EST	0.011	24		0	
2006	TDA	0.180	1		0	
	BON	0.018	1		0	
CR Chum Salmon						
946	EST	3.302	16,531		5	
2001	BON	1.000	340		0	
2004	EST	0.002	50		1	

H.3 ESTIMATES OF TAKE ASSOCIATED WITH ADULT RESEARCH AND MONITORING

Adult passage research and monitoring activities are also required by the RPA. Most of the research and monitoring activities identified in this biological opinion will take place on the mainstem lower Columbia and Snake rivers, at the mainstem Federally operated hydropower dams, and in major tributary streams. The scientific research and monitoring activities, compared with the overall results of FCRPS operation, will have relatively small effects on ESA-listed species and will not exceed those already estimated through other means (e.g., radio-telemetry and PIT-tag conversion rates). Estimates of the take of downstream migrating adult steelhead (kelts) would not change the estimates in Table 9.7-2, given the low survival of these fish to repeat spawning (see Section 6.2.4.1.1). The application of information resulting from research and monitoring efforts is expected to benefit the survival of ESA-listed species.

Some scientific research and monitoring activities evaluated in the take tables that follow (Tables H-8 and H-9) are multiyear projects that will require annual takes of ESA-listed species. NMFS must assess the cumulative impacts to ESA-listed anadromous fish species resulting from annual research and monitoring. Cumulative impacts on ESA-listed fish are best expressed as total annual rates of mortality per individual ESU. To assess annual cumulative impacts due to scientific research and monitoring, NMFS will require each action agency (or its designated contract researcher) to submit a take report at the end of each annual sampling season. On the basis of the annual report, each research and monitoring activity will be subject to annual authorization by NMFS. For fish research and monitoring on the mainstem rivers, a cumulative impact assessment is not sensitive enough to evaluate the effects of scientific research and monitoring activities on ESA-listed salmonids at the population level. Annual cumulative impact analyses will treat the effects on ESA-listed fish populations the same as effects on the ESU as a whole.

Annual-take estimates of ESA-listed adult salmonids associated with scientific research activities are derived using an estimate of the relative abundance for each species at selected mainstem hydropower dams on the Snake and Columbia rivers. Annual abundance estimates of adult salmonids are determined from adult fishway counts at the dams in previous years and from projections of adult salmonid returns. Annual abundance estimates of adult salmonids can vary significantly from year to year and depend on factors such as smolt survival, aquatic conditions (in nursery areas, the mainstem migration corridor, and the ocean), climatological conditions, and incidental harvest impacts.

Table H-8. Annual-take estimates of ESA-listed adult salmonids: Snake River ESU.

Research Action	Location	Handle	Tag	Mortality
		Sockeye Salmon		
994	LGR		35	1
	BON		18	0
1194	LGR	59		1
2007	BON		1	0
		Spring/Summer Chinook Salmon		
994	LGR		150	2
	BON		420	4
996	IHR	23		1
1036	HCY	5		0
1194	LGR	107	70	2
	MCN	24	21	0
	JDA	6	18	0
	TDA	6	16	0
	BON	4	6	0
2006	LGR	14		0
2007	BON		35	0
		Fall Chinook Salmon		
994	LGR		100	1
	BON		44	0
996	IHR	20		1
1036	HCY	3		0
1058	LGR	220	10	2
1194	LGR	39		0
2005	LGS	2		0
2006	LGR	5		0
2007	BON		4	0

Table H-8 (continued). Annual-take estimates of ESA-listed adult salmonids: Snake River ESU.

Research Action	Location	Handle	Tag	Mortality
		Steelhead		
994	LGR		300	3
	BON		112	1
996	IHR	10		0
1036	HCY	5		0
1194	LGR	100		1
	MCN	29		0
	JDA	15		0
	TDA	13		0
	BON	12		0
1224[1]	MCN	115	105	2
	JDA	50	50	1
2000[1]	LGR	400	2,600	30
	LGS	900		9
	LMN	450		5
	MCN	250		3
2005	LGS	2		0
2006	LGR	7		0
2007	BON		20	0

[1]Downstream migrating adult (kelt) studies

Notes for Tables H-8 and H-9:

Column descriptions

Handle: number of fish captured (or obtained from others), handled, and released
Tag: number of fish captured (or obtained from others), handled, tagged/marked, and released
Mortality: number of fish unintentionally killed as a result of handling or tagging

Location abbreviations

HAN Hanford Reach
HCY Hells Canyon
LGR Lower Granite Dam
LGS Little Goose Dam
LMN Lower Monumental Dam
IHR Ice Harbor Dam
MCN McNary Dam
JDA John Day Dam
TDA The Dalles Dam
BON Bonneville Dam

Table H-9. Annual-take estimates of ESA-listed adult salmonids: UCR, MCR, and LCR ESUs.

Research Action	Location	Handle	Tag	Mortality
UCR Spring Chinook Salmon				
994	BON		153	2
1036	HAN	10		0
1194	MCN	25	168	2
	JDA	16	149	2
	TDA	14	129	2
	BON	6	51	1
2006	MCN	21		0
2007	BON		18	0
UCR Steelhead				
994	BON		55	1
1036	HAN	19		0
1194	MCN	94	471	6
	JDA	66	418	5
	TDA	57	369	4
	BON	52	329	4
1224[1]	MCN	3	3	0
2000[1]	MCN	200		2
2006	MCN	20		0
2007	BON		5	0
MCR Steelhead				
994	BON		23	0
1194	MCN	24		0
	JDA	61		1
	TDA	68		1
	BON	62		1
1224[1]	MCN	42	42	1
	JDA	115	15	1
2000[1]	MCN	300		3
2006	MCN	2		0
2007			2	0
LCR Chinook Salmon				
994	BON		11	0
1194	BON	24		0
2006	BON	4		0
2007	BON		2	0
LCR Steelhead				
994	BON		3	0
1194	BON	8		0
2006	BON	2		0
2007	BON		1	0

[1]Downstream migrating adult (kelt) studies

H.4. REFERENCES

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