U.S. Army Corps of Engineers, Northwestern Division
Anadromous Fish Evaluation Program
2012 Review Agenda
Tuesday, November 27 – Thursday, November 29
DoubleTree Hotel & Conference Center - 1000 NE Multnomah Street, Portland, OR

Time	Topics (Click on topic title to link to abstract)	Presenter (Link to contact list)
Tuesday --- November 27, 2012		
8:30 – 8:50	Opening Remarks	Col. John Eisenhauer
ESTUARY STUDIES		
8:50	Variations in Habitats and Their Use by Juvenile Salmon in Tidal Freshwater: Implications for Evaluating Restoration	Nichole Sather
9:10	An Index of Early Life History Diversity for Pacific Salmon and Steelhead	Gary Johnson
9:30	Detection of PIT-Tagged Fish Using Pair Trawl and Pile Dike Antenna Systems in the Columbia River Estuary, 2012	Dick Ledgerwood
9:55	Estuary Habitat and Recovery of At-Risk Columbia River Salmon (Session 1)	Dan Bottom
10:15	Estuary Habitat and Recovery of At-Risk Columbia River Salmon (Session 2)	
10:35	**Break** – 15 minutes	
10:55	Development of a Salmon Estuarine Habitat Index (SEHI)	Kate Buenau
11:15	Planning and Management Applications of Wetland Reference Sites in the Lower Columbia River and Estuary	Amy Borde
11:35	Evidence-Based Assessment of the Cumulative Effects of Tidal Freshwater and Estuarine Ecosystem Restoration: Early Life-Stage Habitat Functions for Endangered Salmonids	Heida Diefenderfer
11:55	Geospatial Scientific Database for the Columbia Estuary Ecosystem Restoration Program	Andre Coleman
12:10	**Lunch** – 1 hour	

Time	Topics (Click on topic title to link to abstract)	Presenter (Link to contact list)
Tuesday --- November 27, 2012		
PREDATION STUDIES – Avian and Pinniped		
13:15	Avian Predation on Juvenile Salmonids in the Columbia River Estuary: New Developments in 2012	Dan Roby
13:35	Avian Predation on Juvenile Salmonids on the Columbia Plateau: New Findings in 2012	Dan Roby
13:55	Electronic Recovery of PIT-Tags on Avian Breeding Colonies in the Columbia River Basin, 2012	Jeannette Zamon
14:15	Monitoring Avian Predators at FCRPS Dams: Development and Implementation of a Standardized Data Collection Protocol	Nathan Zorich
14:35	Evaluation of Pinniped Predation on Adult Salmonids and White Sturgeon at Bonneville Dam, 2011-2012	Bjorn van der Leeuw
14:55	**Break** – 15 minutes	
ADULT STUDIES		
15:15	Hydroacoustic Evaluation of Adult Steelhead Fallback and Kelt Passage at McNary Dam, Winter 2011-2012	Kenneth Ham
15:35	Steelhead Kelt Passage, Survival and Return Rates for Fish Tagged Above and Below Lower Granite Dam	Alison Colotelo
15:55	Evaluation of Steelhead Kelt Migration Success through The Dalles and Bonneville Dams	Mark Weiland
16:15	Use of the Mainstem Columbia River by Walla Walla Basin Bull Trout	Marshall Barrows

Time	Topics (Click on topic title to link to abstract)	Presenter (Link to contact list)
Wednesday --- November 28, 2012		
PASSAGE & SURVIVAL STUDIES		
8:30	Lower Snake River Performance Standards Assessments 2012: Experimental Design and Methods	Geoff McMichael
8:50	Results of Snake River Survival Compliance Studies for 2012	John Skalski
9:10	Little Goose Dam Passage Route and Survival	Eric Oldenburg
9:30	Lower Monumental Dam Passage Route and Survival	Ryan Harnish
9:50	Lower Columbia River Survival Study Methods Overview and Juvenile Salmonid Condition Evaluation	Christa Woodley
10:10	Results of Mainstem Columbia River Survival Compliance Studies for 2012	John Skalski
10:30	**Break** – 15 minutes	
10:50	McNary Dam Route-Specific Passage Metrics and Survival Estimates of Juvenile Salmonids	James Hughes
11:10	Performance Evaluation of Externally JSATS-Tagged Subyearling Chinook Salmon	Rich Brown
11:30	Development of an Injectable Micro-Acoustic Transmitter for Fish Passage Evaluation	Daniel Deng
11:50	Implantation and Bio-Effects Assessments of Injectable JSATS Acoustic Transmitters	Christa Woodley
12:10	Determination of Initial Inflation of the Swim Bladder and Vulnerability to Barotrauma in Juvenile White Sturgeon	Katrina Cook
12:25	**Lunch** – 1 hour	
SYSTEM SURVIVAL STUDIES		
13:30	PIT-Tag Reach Survival Estimates, 2012	Steve Smith
13:50	Recent Developments of COMPASS – a Model of Survival Through the Hydrosystem and Beyond	Rich Zabel

Time	Topics (Click on topic title to link to abstract)	Presenter (Link to contact list)
Wednesday --- November 28, 2012		
14:10	Life-Cycle Models for Interior Columbia Basin Salmonid Populations	Rich Zabel
14:30	**Break** – 15 minutes	
TRANSPORTATION STUDIES		
14:50	Study to Determine Seasonal Effects of Transporting Fish from the Snake River to Optimize a Transportation Strategy	Steve Smith
15:10	Study to Compare SARs of Snake River Fall Chinook Salmon Under Alternative Transport and Dam Operational Strategies	Steve Smith
15:30	Identifying Overwintering Location and Natal Origin for Snake River Fall Chinook Salmon	Rich Zabel
15:50	Review of Adult Salmon and Steelhead Straying with Emphasis on Columbia River Populations	Matt Keefer
16:10	Species, Life History, and Population-Specific Patterns of Straying by Salmonids in the Columbia River	Peter Westley
16:30	Evaluation of Methods to Reduce Straying Rates of Barged Juvenile Salmonids	Andy Dittman

Time	Topics (Click on topic title to link to abstract)	Presenter (Link to contact list)
Thursday --- November 29, 2012		
LAMPREY STUDIES		
8:30	Improving Adult Pacific Lamprey Passage at Bonneville Dam using Lamprey Passage Structures (LPS) and Refuges	Steve Corbett
8:50	General Migration and Upstream Passage Patterns for HD PIT-Tagged Adult Pacific Lamprey in the Lower Columbia River, 2012	Matt Keefer
9:10	Evaluation of Lamprey Behavior at Lower Fishway Sections of Bonneville and John Day Dams using DIDSON, 2012	Chris Caudill
9:30	Development of 3-D Modeling Tools to Document Fish Passage Information and Prioritize Improvements at Lower Columbia River Dams	Chris Caudill
9:50	Using the JSATS System to Evaluate Adult Pacific Lamprey Movement and Fate in Columbia River Reservoirs	Chris Noyes
10:10	**Break** – 15 minutes	
10:30	Use of Non-Invasive Methods to Evaluate Pacific Lamprey Counts and Passage Behavior at The Dalles and John Day Dams - 2012	Christopher Peery
10:50	Enumeration and Evaluation of Adult Pacific Lamprey Escapement and Behavior in Underwater Video at McNary and Ice Harbor Dams with the Application of Computerized Imaging Software (AVEDac), 2012	Frank Loge
11:10	Application of DIDSON and Underwater Video to Evaluate Adult Pacific Lamprey Behavior and Passage Performance at McNary Dam South Fishway Entrance, 2012	Frank Loge
11:30	Passage Bottlenecks and Prioritization Planning: Highlights from the Adult Pacific Lamprey Data Synthesis Project	Matt Keefer

Variations in Habitats and Their Use by Juvenile Salmon in Tidal Freshwater: Implications for Evaluating Restoration

Nichole K. Sather, Gary E. Johnson, Adam J. Storch, David J. Teel, and Jeffrey R. Johnson

ABSTRACT

The Columbia Estuary Ecosystem Restoration Program seeks to implement ecosystem restoration informed by research, monitoring, and evaluation in the lower Columbia River and estuary (LCRE). Research activities in the LCRE have increased our knowledge of juvenile salmon ecology. However, research pertaining to the response of juvenile salmon to ecosystem restoration actions has fallen short of expectations. Inadequate spatial and temporal coverage of action effectiveness research, as well as lack of applied statistical designs and analyses presents significant challenges for systematically evaluating the collective successes or failures of restoration projects. In this talk, we explain efforts to link habitat conditions to juvenile salmon responses. The results include a combination of metrics used to elucidate biotic and abiotic conditions relevant to juvenile salmon, such as water temperature, prey production, salmon growth, and genetic stock composition. We demonstrate the importance of moving away from relying solely on controlling factors, structural features, and habitat classification schemes to reliance on functional ecological attributes to inform the effects of restoration for juvenile salmon. The findings are especially relevant to program managers prioritizing restoration activities in the estuary.

An Index of Early Life History Diversity for Pacific Salmon

Gary E. Johnson, Nichole K. Sather, John R. Skalski, and David Teel

ABSTRACT

We developed an index of early life history diversity for Pacific salmon (*Oncorhynchus spp*., including migratory steelhead *O. mykiss* and *O. clarki*). Early life history diversity is the variation in morphological and behavioral traits expressed within and among populations by individual juvenile salmon during their downstream migration. A standard quantitative method does not exist for this prominent concept in salmon biology. Increasing life history diversity to improve resilience and aid recovery of diminished salmon and steelhead populations is a common strategy in fish population recovery efforts. In this paper, we characterize early life history traits and prioritize them selecting *timing and size* as two appropriate, measurable dimensions for an ELHD index. We reviewed diversity index literature, identified an approach based on effective number of species, and tested several candidates indices for performance and usefulness in case studies using juvenile salmon catch data from the LCRE. We found the ELHD approach applies to multiple life history strategies; incorporates fish abundance, density, or catch per unit effort data, and both richness and evenness; produces understandable and interpretable values. The selected ELHD index is the diversity expressed as effective number of species for the Shannon index, modified to account for unequal sample sizes. The ELHD index should support comparisons across like locales and examinations of trends through time at a given locale. It has application as a high-level indicator to track trends in the status of the recovery of salmon and steelhead populations in the Columbia basin and elsewhere where salmon recovery efforts are underway.

Detection of PIT-Tagged Fish using Pair-Trawl and Pile-Dike Antenna Systems in the Columbia River Estuary, 2012

Richard D. Ledgerwood, Robert J. Magie, Matthew S. Morris, and Jeremy P. Bender

ABSTRACT

During 2012, we continued a multi-year effort to sample PIT-tagged juvenile salmon in the upper Columbia River estuary (rkm 61-83) using a surface pair-trawl detection system. From March to October, we also deployed an adult PIT-tag detection system mounted on a pile dike adjacent to the navigation channel (rkm 70).

The trawl system was built by replacing the cod end of a pair trawl with a 6-coil matrix detection antenna. The matrix was configured with separate front and rear arrays, each of which formed a 2.6-m wide x 3.0-m tall opening. Fish passing into the trawl were guided toward this opening and interrogated on both the front and rear components as they exited the net. Sampling effort with the trawl began with daily cruises in mid-March and continued through the end of July. From 1 May to 15 June, we intensified the sample effort, with two cruises per day during both daylight and darkness hours. During this period, we sampled for an average of 14 h/d and detected 1.7% of the PIT-tagged yearling Chinook and 2.6% of the PIT-tagged steelhead previously detected at Bonneville Dam (PTAGIS site code TWX). Yearling Chinook and steelhead released from transport barges just below Bonneville Dam were detected in similar proportions. Near the end of the yearling migration, we returned to a single daily cruise schedule targeting subyearling migrants. Sampling was terminated on 30 July. Over the entire season, we sampled for a total of 951 h and detected 16,732 fish: 5,636 spring/summer Chinook, 1,875 fall Chinook, 7,802 steelhead, 843 sockeye, and 469 Coho salmon. We also detected an additional 105 fish with no release information in PTAGIS. These detection data were used to estimate survival through the entire hydropower system, from just below Lower Granite Dam to the tailrace of Bonneville Dam: mean estimated survival from Lower Granite to Bonneville Dam tailrace was at 64% (SE 4.3%) for yearling Chinook and 60% (13.8%) for steelhead.

The adult detection system used a similar matrix of individual antenna coils configured to form an array 3.0-m wide by 6.7-m deep. This system was mounted on a pile dike and operated continuously from 9 August to 25 October 2011, but only 13 adults were detected during this time (PTAGIS site code PD7). The adult system was removed for modifications during winter 2011-2012. We reinstalled the system and operated it again from 21 March to 24 October 2012. During this second deployment, system efficiency increased considerably, with 63 adults detected. This improvement indicated that our wintertime modifications to reduce fish avoidance had been successful. Of the 63 adult detections in 2012, 12 were spring Chinook (7 jacks), 1 was a summer Chinook jack, 32 were fall Chinook (7 jacks), 1 was a Coho jack, and 17 were steelhead. For these fish, travel time to Bonneville Dam ranged 3-33 d, and survival ranged 82-92%. We also detected 41 salmon juveniles and 14 sturgeon on the stationary pile dike system.

Estuary Habitat and Recovery of At-Risk Columbia River Salmon

Daniel Bottom, Antonio Baptista, Lance Campbell, Kurt Fresh, Pascale Goertler, Susan Hinton, Regan McNatt, Curtis Roegner, Charles Simenstad, Lia Stamatiou, David Teel

ABSTRACT

In recent years diked wetlands and other shallow habitats have been the focus of an extensive estuary restoration program to aid recovery of Columbia River salmon. However, many resource managers remain skeptical that estuary restoration will benefit upper-river stocks—e.g., upper Columbia River spring Chinook and steelhead and Snake River Chinook and steelhead—that are a primary concern of FCRPS mitigation efforts. Conventional wisdom holds that salmon populations from the upper basin produce only large subyearling or yearling smolts that migrate rapidly to the river mouth through deep estuary channels, and therefore, may not benefit from restoring shallow, off-channel habitats.

Recent studies have provided a broader perspective of the estuary's contributions and potential contributions to upper-river stocks. Results indicate that (1) at least some hatchery and naturally produced Chinook and steelhead from the upper Columbia and Snake rivers enter shallow estuary habitats; (2) interior stocks are not uniformly distributed, and proportions generally increase in upper-estuary reaches; and (3) contemporary stock-composition and habitat-use patterns in the estuary are driven by hatchery programs that tend to favor large, fluvial phenotypes with short estuary residence times. Even the small numbers of upper-river stocks found in shallow estuary habitats is likely significant: natural production of threatened and endangered stocks from the interior basin is low, the estuary area sampled by beach seines and trap nets is small, and the amount of shallow habitat available (and potentially available) below Bonneville Dam is great. Recent studies also have documented a number of alternative life histories—for example, upper Columbia and Snake River fall Chinook that overwinter near the Sandy River delta—contradicting assumptions that only lower Columbia River stocks rear in the estuary. Finally, food-web studies show that all size classes of juveniles may benefit from the organic material and prey taxa produced in estuary wetlands, whether or not they enter these habitats. Juveniles sampled in shallow- and deep-water habitats consume similar prey taxa, including insect and amphipod groups that are produced primarily in wetland or other shallow estuary habitats. Stable-isotope studies indicate that a broad size range of subyearling Chinook select disproportionately for wetland-based food sources. Other studies reveal that organic matter and invertebrates are transported far from their wetland sources and may benefit salmon in other habitats.

The purpose of our research is to investigate estuary habitat linkages to diverse Columbia River stocks and to quantify the estuary's contributions to adult returns and population viability. We are currently studying use of upper-estuary habitats by all stocks. Field surveys are monitoring salmon stock composition and life histories, invertebrate prey production, and salmon consumption in poorly-studied main-stem, off-channel, and flood-plain habitats in Reaches E/F. Adult otolith studies are quantifying life-history contributions (i.e., juvenile sizes and times of estuary entry) to spawning populations in a diversity of ESUs. We are adapting life-cycle models to assess the estuary's role in population viability, including the sensitivity of interior Columbia River populations to estuary survival improvements. For Willamette River Chinook we are using both hydrologic and life-cycle models to explore the recovery benefits of diverse juvenile life histories and the restoration actions necessary to achieve these benefits.

Development of a Salmon Estuarine Habitat Index (SEHI)

Kate E. Buenau, Amy B. Borde, Heida L. Diefenderfer, Roy K. Kropp, Nichole K. Sather, Christa M. Woodley, and Andrew J. Tyre

ABSTRACT

Effectively planning estuarine habitat restoration for juvenile salmon requires a means of evaluating alternative restoration actions at a site. The Columbia River estuary currently lacks a quantitative model to describe how juvenile salmonids benefit from estuarine habitat. Therefore, we are developing the Salmon Estuarine Habitat Index (SEHI) to quantify the benefits of hydrological reconnection actions to juvenile salmon. We began the model development process by compiling a conceptual model to describe the connections between the physical characteristics of a site, the biotic components (microbes, plants, and invertebrates), and salmon growth and survival. We used this information, derived from a review of the literature, as the basis for identifying and defining key quantitative relationships that together produce a numerical estimation of the effects of physical habitat characteristics on salmon growth. We built the model using a Bayesian belief network framework to combine different types and qualities of data while explicitly accounting for uncertainty in functions and parameter estimates. We began with a rapid prototyping process during which subject matter experts defined key relationships and estimated parameter values to create a working model. We are now in the process of iteratively revising and testing the model. Model inputs are measures of geomorphology and hydrology at a site and can be measured or projected for a site during the planning process, before actions are implemented. We relate the physical characteristics either directly to juvenile salmon growth (e.g. water temperature) or indirectly through a trophic pathway (e.g. primary production, detritus, and invertebrate salmon prey). Effects on growth are indexed then combined with habitat area to estimate the habitat units for a proposed alternative action following standard methods. We will also develop an index to estimate benefits from materials exported from the site (detritus and prey) for juvenile salmon that do not enter the site but feed nearby. As the availability and quality of data for the relationships in this model vary widely, some components of the model are further developed than others. In the process of identifying relevant data, we also identify where data are unavailable, which will allow us to make quantitative estimates about the utility of additional research. Initial model development has focused on subyearling Chinook salmon, but the framework can be adapted to other species or life histories when information becomes available. Similarly, while the model is designed to evaluate alternative hydrological reconnection actions at a site, the model will be applicable to broader questions about habitat suitability and restoration.

Planning and Management Applications of Wetland Reference Sites in the Lower Columbia River and Estuary

Amy B. Borde, Heida L. Diefenderfer, Valerie I. Cullinan, Ronald M. Thom, and Shon A. Zimmerman

ABSTRACT

Through multiple research programs in the lower Columbia River and estuary (LCRE) including those funded by BPA through the Estuary Partnership and the Columbia River Fish Mitigation Program, 58 tidal wetland reference sites have been surveyed since 2005. The overall goals of this research were to increase understanding of existing wetland habitat structure, ecological processes, and habitat function and to inform ecosystem restoration planning and design. To date, using these data we have evaluated several critical factors influencing existing wetland patterns and potential juvenile salmonid habitat usage in the LCRE. These factors include the vegetation assemblages present, the elevation ranges at which they occur, and the inundation dynamics (i.e., controlling factors) that result in their current distribution. Such controlling factors also have the potential to serve as predictive models for future habitat distribution. For this presentation, we have synthesized the data from field surveys to address the following uncertainties relative to restoration planning and assessment in the Columbia Estuary Ecosystem Restoration Program (CEERP): elevations, soil characteristics, and inundation ranges required by native tidal wetland vegetation controlling factors on non-native and invasive plant species distribution channel morphology and inundation patterns that can optimize access for juvenile salmonids.

In addition, the synthesis of field data was combined with spatial data and historical data to examine the influence of disturbance history and landscape position on wetland habitats. This presentation will summarize how the results from this extensive data collection and synthesis effort can be used to inform restoration planning, engineering, design and adaptive management to improve effectiveness of projects in the CEERP.

Evidence-Based Assessment of the Cumulative Effects of Tidal Freshwater and Estuarine Ecosystem Restoration: Early Life-Stage Habitat Functions for Endangered Salmonids

Heida L. Diefenderfer, Gary E. Johnson, Ronald M. Thom, Amy B. Borde, Christa M. Woodley, Laurie A. Weitkamp, Kate E. Buenau, and Roy K. Kropp

ABSTRACT

The purpose of this research is to evaluate the effect of the federal Columbia Estuary Ecosystem Restoration Program (CEERP) on ESA-listed salmon and steelhead stocks. Linking changes in the quality and landscape pattern of tidal wetlands in the lower Columbia River and estuary (LCRE) to salmon recovery is a complex problem for reasons related to the characteristics of the ecosystem, the salmonids, the restoration actions, and available sampling technologies. We designed a formal approach to develop and evaluate evidence regarding early-stage outcomes of the CEERP. Our evaluation included cumulative effects assessment because restoration is occurring at multiple sites, the collective effect is important to salmon recovery, and the direct and indirect interactions of juvenile salmon can include multiple visits and multiple restored sites. Based on an ecosystem conceptual model, we developed a working hypothesis that habitat restoration activities in the LCRE have a cumulative beneficial effect on juvenile salmon. Two necessary conditions are that habitat-based indicators of ecosystem controlling factors and structures show positive effects from restoration actions and fish-based indicators of ecosystem processes and functions show positive effects from habitats undergoing restoration. We assessed available evidence for and against these conditions using ten causal criteria: strength, consistency, specificity, temporality, biological gradient, plausibility, coherence, experiment, analogy, and complete exposure pathway.

The assessment included systematic review and scoring of global literature on the subject, assessment of trends in landscape condition, and multiple lines of evidence from the LCRE involving field measurements, modeling, meta-analysis and other reanalysis of existing data sets. Key results reviewed in this presentation include the following:

1) evidence from the global literature indicates strong support for benefits to salmon from tidal wetland reconnection, measured by four indicators, presence, residence, prey, and diet;

2) observations of historically reconnected sites in the LCRE indicate all are emergent marshes with high potential fish access;

3) at recent restoration sites in the LCRE, salmonid response is mixed but fast-response variables (i.e. water surface level dynamics, sediment accretion rates) indicate that restorative ecosystem processes have been initiated;

4) net ecosystem improvement in prey and plant biomass indicates wetlands support salmonid foraging;

5) a particulate organic transport model indicates matter produced at restoration sites can be exported >7 km to the main-stem river, which is important because most restored sites are not located on the main-stem river but influence its food web;

6) stomachs of Chinook salmon and steelhead near the mouth of the estuary (rkm 15) are substantially fuller than those of fish exiting the hydropower system (Bonneville and John Day dams) and gut contents at rkm 15 contain large quantities of marsh-produced dipteran insects.

These data provide local confirmation of evidence in the literature that tidal habitats provide forage for juvenile salmon. Of the 34 documented complete hydrologic reconnection projects, data on the area affected are available for 19 (683 ha), data on the length of channel or stream affected are available for eight (39 km), and no spatial measure of effect that can be used for this evaluation is available for seven. We concluded that all lines of evidence from the LCRE indicated positive habitat-based and salmonid-based responses, except in cases of tide gate installation on small sloughs. On this basis, we concluded that the habitat restoration activities in the LCRE are likely having a cumulative beneficial effect on juvenile salmonids that access restored areas or actively transit the main-stem river. In summary, tidal wetlands in the LCRE currently support juvenile salmonids, including interior basin salmonids, and this effect would be expected to increase over time as existing restoration projects mature and new ones are implemented.

A Geospatial Scientific Database for the Columbia Estuary Ecosystem Restoration Program

Andre M. Coleman, Gary E. Johnson, Heida L. Diefenderfer, Timothy E. Seiple, Amy B. Borde, Nichole K. Sather

ABSTRACT

An estuary-wide, enterprise-scale, geospatial data management system is being developed for research, monitoring and evaluation (RME) studies and restoration project development under the federal Columbia Estuary Ecosystem Restoration Program (CEERP) in the floodplain study area of the lower Columbia River and estuary (LCRE). The data management system being developed under this project support the Action Agencies' implementation of LCRE ecosystem restoration under CEERP and called for in the 2008 FCRPS BiOp. Specifically, this system is designed with managers, researchers, and restoration practitioners in mind, to quickly retrieve data by region, site, analysis question, data event, data type, collection type, location, proximal location, etc., as well as allowing for a formal mechanism of data sharing while maintaining data pedigree and appropriate data use. A comprehensive and scalable data model, referred to as the Estuary Data Model, is an integral component of the data management system and is implemented to support theme-based managed (local) and selected unmanaged (external through web services) data. The Estuary Data Model provides the architectural blueprint for populating an enterprise geospatial database that is designed for gathering estuary-wide meta analysis of effectiveness data. To facilitate the use of the Estuary Data Model, an intuitive and state-of-the-art web-based data portal system supports the use of traditional data queries along with spatial analysis tools to discover, retrieve, visualize, analyze, and download scientific data that have been collected by multiple organizations. Regional stakeholders, comprised of estuary practitioners, database experts, spatial analysts, environmental and fisheries scientists, and end users, are actively providing recommendations of functionality, complementary resources, existing data, analysis questions, etc., that can be brought in and used for BiOp comprehensive reporting related queries.

Avian Predation on Juvenile Salmonids in the Columbia River Estuary: New Developments in 2012

Daniel D. Roby, K. Collis, D. Lyons, A. Evans, Y. Suzuki, J. Adkins, P. Loschl, T. Lawes, N. Hostetter, A. Peck-Richardson, A. Patterson, B. Cramer, S. Collar, K. Bixler, J. Zamon, D. Kuligowski, and M. Hawbecker

ABSTRACT

We continued field studies in 2012 to (1) assess the impact of avian predation on survival of juvenile salmonids in the Columbia River estuary, (2) monitor the efficacy of ongoing Caspian tern management designed to reduce their impact on smolt survival in the estuary, and (3) test management strategies to limit nesting habitat availability for double-crested cormorants on East Sand Island.

The Caspian tern colony on East Sand Island, the largest in the world, consisted of about 6,400 breeding pairs in 2012, continuing the downward trend in colony size from the peak of about 10,000 pairs in 2008. The Caspian tern colony on East Sand Island produced a total of 412 fledglings this year, compared to complete breeding failure at this colony in 2011. The proximal factor responsible for colony failure in 2011 and very poor nesting success in 2012 (an average of 0.06 young raised per breeding pair) was intense disturbance by bald eagles and associated gull predation on tern eggs and chicks. The average proportion of juvenile salmonids in tern diets during the 2012 nesting season was 34%, similar to 2009-2011. The estimated smolt consumption by Caspian terns nesting at East Sand Island in 2012 was 4.9 million (95% CI: 3.9 - 5.8 million), similar to 2011.

Caspian tern management actions continued in 2012, with the U.S. Army Corps of Engineers, Portland District (Corps) further reducing the area of suitable tern nesting habitat on East Sand Island to 1.58 acres, 32% of its former area. This habitat restriction caused Caspian terns to nest at higher densities (1.06 nests per meter squared) than previously seen in the Columbia River estuary. The Corps has built a total of nine new islands as alternative tern nesting sites since early 2008, six in interior Oregon and three in the Upper Klamath Basin region of northeastern California. Six of these nine new islands supported nesting Caspian terns in 2012, including the new 1-acre rock-core island on Malheur Lake in Malheur National Wildlife Refuge, where 232 pairs nested. Nest predators, both mammalian and avian, and apparent low forage fish availability, limited Caspian tern colony size and nesting success at five of the six alternative colonies in 2012. A substantial number of terns from the colony on East Sand Island in the Columbia River estuary, however, are visiting these new islands; 64 terns originally banded in the Columbia River estuary were seen on the Malheur Lake tern island and 83 were seen on the Upper Klamath Basin islands this past season.

The double-crested cormorant colony on East Sand Island consisted of about 12,300 breeding pairs in 2012, the largest colony of its kind in western North America and similar in size to 2011 (ca. 13,000 breeding pairs). Juvenile salmonids represented about 20% of the double-crested cormorant diet (by biomass) in 2012, compared to 19% in 2011. Estimates of total smolt consumption by double-crested cormorants from the East Sand Island colony and stock-specific predation rates (based on smolt PIT-tag recoveries on-colony) for 2012 are not yet available.

Estimated consumption in 2011 was about 20 million smolts and predation rates ranged from ca. 3% to 25% of available fish, depending on salmonid population. In 2012, the Corps expanded a pilot study initiated in 2011 to test possible strategies for limiting the size of the East Sand Island cormorant colony. An eight-foot-high privacy fence was built to bisect the colony and visually separate 62% of the 2010 nesting area from the remainder of the colony. Using human disturbance to haze cormorants during the nest initiation period, cormorants were successfully dissuaded from using this 62% of their former nesting area. Some hazed cormorants were satellite- or radio-tagged to follow their movements to prospective new nesting sites. Roughly 55% of these tagged cormorants dispersed from the East Sand Island colony after tagging but eventually returned to the Columbia River estuary and attempted to nest there. Tagged cormorants dispersing from East Sand Island were detected at colonies and roost sites (1) on the lower Columbia River below Bonneville Dam, (2) the outer Washington coast (Willapa Bay and Grays Harbor), (3) Puget Sound, and (4) northern Salish Sea (San Juan Islands, Strait of Georgia, Vancouver, BC area). Only one tagged cormorant was detected on the north coast of Oregon (Cannon Beach).

Avian Predation on Juvenile Salmonids on the Columbia Plateau: New Findings in 2012

Daniel D. Roby, K. Collis, A. Evans, D. Lyons, P. Loschl, N. Hostetter, K. Bixler, J. Tennyson, K. Dickson, G. Gasper, B. Cramer, Y. Suzuki , M. Hawbecker, and T. Lawes

ABSTRACT

Background: Caspian terns, double-crested cormorants, American white pelicans, California gulls, and ring-billed gulls are native piscivorous colonial waterbirds that nest in the Columbia Plateau region. As part of a comprehensive multi-year study, research was conducted to assess the impact of these species on the survival of juvenile anadromous salmonids. Presented here are new research findings for 2012.

Results/Management Action: Total numbers of Caspian terns nesting on the Columbia Plateau increased from an average of 850 breeding pairs during 2005-2011 to about 1,000 breeding pairs at six colonies in 2012; the three largest colonies were on Goose Island (459 pairs) in Potholes Reservoir, WA, on Crescent Island (422 pairs) on the Columbia River, and an incipient colony on Badger Island (60 pairs), also on the Columbia River. A small number of banded terns that originally nested on East Sand Island in the Columbia River estuary –where management actions have been implemented – have relocated to nesting sites on the Columbia Plateau in 2011 and 2012; movement to the Plateau of banded terns that had nested on East Sand Island was not seen during 2006-2010, before tern management intensified at East Sand Island. Caspian tern movements from East Sand Island to colonies on the Columbia Plateau could off-set benefits to salmonids of tern management in the estuary because per bird impacts on smolt survival are higher for terns nesting on the Columbia Plateau relative to the estuary, where marine forage fish (anchovy, etc.) tend to dominate the diet.

Total numbers of double-crested cormorants nesting on the Columbia Plateau also increased, from an average of 1,350 pairs during 2005-2011 to about 1,550 pairs at four colonies in 2012; the largest colonies were in North Potholes Reserve (992 pairs) and on Foundation Island (390 pairs) on the mid-Columbia River. Numbers of American white pelicans nesting on Badger Island, a colony that experienced rapid growth during 2004-2010, appear to have stabilized at about 2,100 adults. The numbers of gulls nesting on Miller Rocks, a colony located just downstream of John Day Dam on the Columbia River, were similar to those observed in recent years (ca. 4,500 adults).

Salmonid smolts represented 83% of Caspian tern prey items at the Crescent Island colony and 30% of prey items at the Goose Island colony, resulting in an estimated 730,000 juvenile salmonids consumed by terns in 2012 at the two tern colonies combined. Predation rate estimates from PIT-tag recoveries on Caspian tern colonies indicate that impacts were highest on upper Columbia River steelhead (17.3% by Goose Island terns), Snake River steelhead (2.8% by Crescent Island terns), and upper Columbia River spring Chinook (2.5% by Goose Island terns). Smolt PIT-tag recoveries on Caspian tern colonies located at Twining Island on Banks Lake (> 45 km from the Columbia River) and at Harper Island on Sprague Lake (> 65 km from the Snake River) indicate that these birds are commuting to the mainstem rivers to consume ESA-listed juvenile salmonids. Impacts on survival of salmonid smolts from predation by other species of

colonial fish-eating waterbirds (cormorants, pelicans, gulls) nesting at other colonies are in preparation and will be presented, if available.

Management of the Caspian tern colonies at Crescent and Goose islands to reduce their impacts on ESA-listed salmonids is currently under consideration. Existing biological information was gathered on Caspian terns throughout their breeding range in western North America (Alaska to northwestern Mexico, west of the Continental Divide) to assess potential locations as alternative nesting sites for terns currently nesting on the Columbia Plateau. Band re-sighting data suggest that there is connectivity between tern nesting sites on the Columbia Plateau and the western North America population from Mexico to Alaska, both inland and along the coast. Analysis of potential alternative sites is ongoing as part of developing a Draft Inland Avian Predation Management Plan by the Walla Walla District – Corps and the Bureau of Reclamation.

Electronic Recovery of PIT-Tags in Avian Breeding Colonies in the Columbia River Basin, 2012

Jeannette E. Zamon, Tiffanie Cross, Benjamin Sandford, Daniel D. Roby, and Allen Evans

ABSTRACT

Background Avian predation in freshwater and estuary habitats is known to be a significant source of mortality for ESA-listed juvenile salmon (*Oncorhynchus spp.*) making their seaward migration in the Columbia River. During 2012, biologists with NOAA Fisheries and the Pacific States Marine Fisheries Commission collaborated with biologists from Bird Research Northwest to quantify avian predation on PIT-tagged juvenile salmon from the Columbia River Basin. We sampled in and around recently vacated nest sites of Caspian terns (*Hydroprogne caspia*), double-crested cormorants (*Phalacrocorax auritus*), and Brandt's cormorants (*P. penicillatus*) on East Sand Island in the Columbia River Estuary for PIT-tags from salmon which migrated in 2012.

Methods PIT-tag codes were electronically recovered using either a flat-plate, six-coil antenna (tern colony) or hand-held antennas (cormorant colonies). In 2012, detection efficiencies on the colonies were measured by distributing PIT-tags with known codes on the colonies before and after the nesting season. Codes recovered on East Sand Island were compared with detection efficiency tags, codes previously detected at hydropower facilities, codes in tagged fish released upstream of avian colonies, and codes in other experimental treatments. The tern colony contained only one habitat type (bare sand) whereas nesting habitat in the cormorant colony was divided into two types (rip-rap and bare sand). Scanning at the tern colony began on 01 October 2012 and at the cormorant colony on 10 October 2012. To assess avian predation on lower Columbia River Chinook, we PIT-tagged and released approximately 3,000 subyearling fall Chinook salmon (*Oncorhynchus tshawytscha*) from three hatcheries in 2012: Warrenton High School, OR on 02 May; Big Creek, OR on 03 May; and Kalama Falls, WA on 25 June. We are in the process of evaluating predation vulnerability of salmon by species, run, rear type, origin, and in-river migration or transportation history.

Results/Management Action Results are pending because at the time this abstract was submitted, PIT-tag recovery activities for tern and cormorant colonies on East Sand Island were ongoing. Measuring annual, stock-specific avian predation rates is necessary for implementing Reasonable and Prudent Alternative (RPA) Actions 45 and 46. RPA 45 specifies implementation of the Caspian Term Management Plan, which includes quantitative reduction in tern nesting habitat on East Sand Island and subsequent measurement of any change in tern predation rates on basin-wide ESUs, including lower Columbia River ESUs. RPA 46 specifies development and implementation of a Draft Cormorant Management Plan. RPA 46 includes dissuasion and hazing of cormorants on East Sand Island to prevent them from nesting in some habitat used for nesting in prior years. To evaluate whether these tern and cormorant management actions have the desired effect of reducing avian predation on juvenile salmon, it is therefore necessary to measure avian predation rates on salmon during years when management action occurs. RPA Action 66 also specifically requires that tern predation be monitored in the Columbia River Estuary. The core components of RPA 66 monitoring are electronic recovery of PIT-tags from East Sand Island and the subsequent analysis of tern predation rates based on tag recoveries.

Monitoring Avian Predators at Corps FCRPS Dams: Development and Implementation of a Standardized Data Collection Protocol

Nathan A. Zorich, Michael R. Jonas, and Patricia L. Madson

ABSTRACT

Background: The 2008/2010 FCRPS Biological Opinion requires the Corps to monitor and respond to avian predators at its dams to protect ESA listed salmonids. While there is a long history of monitoring bird abundance at Corps dams efforts have been site specific, slightly changing from dam-to-dam making them difficult to comparable.

In 2012, we developed and implemented a standardized protocol and trained multiple observers, at multiple dams, to collect and upload data to a centralized database. The results are comparable both within and between dams and can be accessed, managed, and analyzed in real time via a web based portal; a secure online data hub used to manage survey data.

Our objectives were to: 1) work with Corps project fisheries staff to develop a standard protocol for recording bird numbers, behavior, and location; 2) provide this protocol in writing; 3) manage data collection and analysis via electronic devices or manual entry; and 4) provide an end of year report summarizing the data.

Methods: We worked with project biologists, technicians, and other trained observers to standardize data collection methods (via protocol and data forms) for monitoring the number, location (zone), and behavior (foraging, resting, scavenging, or fly-by) of nine piscivorous birds species at eight dams. Site-specific coordination consisted of developing zone maps and counting methods resulting in a written standardized protocol applicable to all participants.

Data collection was managed through either electronic devices (tablet PCs) or paper datasheets entered manually to the online data portal. Analysis was standardized by applying methods developed in previous FFU studies and are presented in bar graphs for comparisons of dam to dam or zone to zone, line graphs to show trends, and maps to provide spatial context.

Results/Management Action: Currently, data from 28 observers at 8 dams are available via a secure data portal. Over the peak smolt outmigration (1 April to 31 July) the most common piscivors in order of prevalence were: California and ring-billed gulls (*Larus* spp.), double-crested cormorants (*Phalacrocorax auritus*), American White Pelicans (*Pelecanus erythrorhynchos*), Western and Clark's Grebes (*Aechmophorus* spp.), and 5 less common species.

System-wide, foraging bird numbers peak in early May and by early August were similar to pre-smolt migration level. The seasonal mean count of foraging birds was highest at McNary and The Dalles Dams with less than half that number counted at any of the six remaining dams. We will present the online data portal and more summary data of the avian survey. This new tool will continue to be developed and in the future will be more widely available in-season to assess potential impacts to salmonids and assist in making informed avian predation management decisions.

Evaluation of Pinniped Predation on Adult Salmonids and White Sturgeon in the Bonneville Dam Tailrace: An Update for 2011-2012

Robert J. Stansell, Bjorn K. van der Leeuw, and Karrie M. Gibbons

ABSTRACT

Background The Corps has conducted surface observations to evaluate the seasonal presence, abundance, and predation activities of California (CSL) and Steller (SSL) sea lions in the Bonneville Dam tailrace each year since 2002.

Methods Observers stationed at each of the three major tailrace areas of the dam recorded pinniped presence and predation events. Observations took place from sunrise to sunset five days a week from early January until late May. Pinniped abundance and fish predation estimates were derived from observed data that were interpolated for hours and days not observed. For this presentation we will use the *Adjusted Consumption Estimate* when discussing predation. In addition to expansion for hours and days not observed, the *Adjusted Consumption Estimate* corrects for "unknown" prey and nocturnal predation.

In 2011, in addition to the regular January-May observation season, we began a small-scale fall observation season. Observations were conducted from October 1 to December 31 to understand the impacts that early-arriving SSL may be having on white sturgeon and salmonids.

Results In 2011, pinnipeds consumed an estimated 3,970 adult salmonids (Chinook salmon and steelhead), in the tailrace of Bonneville Dam between January 7 and May 31. This represents 1.8% of the salmonid run during this time period. CSL accounted for 70.9% of the observed salmonid catches in 2011, while SSL consumed 29.1%. In 2012, pinnipeds consumed an estimated 2,360 adult salmonids between January 6 and May 31. This represents 1.4% of the salmonid run during this time period. SSL accounted for 53.3% of the observed salmonid catches in 2012, while CSL consumed 46.7%. This marks the first year that SSL consumed more salmonids than CSL since the project began.

Pinnipeds consumed an estimated 3,003 white sturgeon between January 7 and May 31, 2011. This level of sturgeon predation is the highest observed since this project began in 2002. In 2012, pinnipeds consumed an estimated 2,498 white sturgeon between January 6 and 31 May. Sturgeon were almost exclusively consumed by SSL, which made 99.8% of the observed sturgeon catches in 2011 and 100% of the catches in 2012.

Between October 1 and December 31, 2011 SSL were commonly observed in the Bonneville tailrace, with 11 unique individuals observed. Adjusted consumption estimates were 527 salmonids, 828 sturgeon and 27 other fish species.

In 2011, 54 individual CSL and 89 SSL were observed in Bonneville tailrace between January 7 and May 31. This marks the first year that SSL were the predominant pinniped species at Bonneville. 2012 showed a similar trend with 79 SSL being identified throughout the season and only 39 individual CSL being observed. This is the lowest number of CSL identified since the initial year of the project in 2002.

Hydroacoustic Evaluation of Adult Steelhead Fallback and Kelt Passage at McNary Dam, Winter 2011-2012

Kenneth D. Ham, P. Scott Titzler, Robert P. Mueller, Donna M. Trott

ABSTRACT

Background: Pacific Northwest National Laboratory conducted a second year study of adult steelhead downstream passage rates and distribution at the powerhouse of McNary Dam in the winter of 2011-2012. The previous study was conducted during the winter of 2001-2011. The primary purpose of the study was to enumerate and determine the vertical and horizontal distribution of adult steelhead as they passed through the powerhouse.

Methods: Fixed-aspect hydroacoustic techniques were used to estimate adult steelhead passage rates through 12 of 14 turbine units from December 1, 2011 through April 16, 2012. The two units that were not monitored (1 and 10) were expected to be out of service for the duration of the study, but were operated during periods of high river flows. Sampling coverage was increased by 50% over the previous study year to better define distributions and reduce confidence intervals around estimates. A BlueView high resolution multi-beam acoustic imaging device was used to monitor the region immediately upstream of the trash rack at unit 6A to identify and estimate the relative abundance of adult steelhead and similar-sized individuals of other fish species.

Results/Management Action: We estimated 2184 (± 129 CI) adult steelhead passed downstream through the 12 monitored turbines during this study. If a similar rate of passage through the two unmonitored turbine intakes is assumed, the estimate of total powerhouse passage would be 6% higher, at 2313 fish. We speculate that even more adult steelhead would have passed through turbines if not for the unexpected spill, due to high flows, during this study. Turbine passage was higher than the 2010-2011 study (total passage was approximately 1400 fish). However, it should be noted that spill started later in this study than it did during the previous study. Although spill is thought to influence passage, there was limited evidence of it in turbine passage trends.

The distribution of adult steelhead passage among turbine units was similar to the 2010-2011 study; passage was greatest at turbine units closest to the north or south ends of the powerhouse and least near the center. Passage was concentrated near the ceiling of the turbine intakes.

Managers should note that passage was highest near the edges of the powerhouse and that kelts passed at shallow depths. Spill appeared to reduce turbine passage, but it did not greatly influence the distribution of passage across the powerhouse. These findings suggest that kelts would likely discover a surface entrance, for example, but might not be drawn from as far away as the spillway.

Steelhead Kelt Passage Distributions and Survival and Return Rates for Fish Tagged Above and At Lower Granite Dam

Alison H.A. Colotelo

ABSTRACT

Steelhead (*Oncorhynchus mykiss*) populations have declined throughout their range in the last century and many populations, including those of the Snake River Basin are listed under the Endangered Species Act. The reasons for their population decline are many, but include habitat loss and degradation, overharvest, and the construction of dams. Unlike pacific salmon, which all die after they spawn, post-spawning steelhead (known as “kelts”) can migrate back down to the ocean to feed and replenish their energy stores then return to freshwater and spawn in a subsequent year (known as iteroparity). However in the Snake River it is estimated that <2% are able to make a second spawning run. Kelts may be vulnerable to delays in their migration caused by main stem dams and reservoirs in the Snake and Columbia rivers, and may also suffer higher mortality than smolts while actually passing the dams.

As a strategy for improving steelhead survival through the Federal Columbia River Power System (FCRPS), a Snake River Kelt Management Plan (KMP) has been implemented to improve the productivity of interior basin B-run steelhead populations. The KMP uses a 3-prong approach to increase Snake River B-run kelt female production to the 6% target estimate of the 2008 FCRPS BiOp: 1) short- and long-term reconditioning, 2) transportation, and 3) in-river passage survival improvement since spillway surface passage has been implemented throughout the FCRPS, for which this research investigates.

The primary goal of this research was to estimate steelhead kelt returns to Lower Granite Dam (LGR) by passage route and estimate route survival to the estuary using the virtual single-release model. In 2012, Juvenile Salmon Acoustic Telemetry System (JSATS) transmitters were surgically implanted into 324 steelhead kelts captured at LGR and several tributaries of the Snake River basin. Using a combination of autonomous and cabled JSATS receivers, steelhead kelt survival through up to seven FCRPS dams (LGR, LGS, LMN, MCN, JDA, TDA, BON) was determined. In addition, passage metrics such as forebay retention, tailrace egress and project passage timing were calculated at each FCRPS dam. The results of this research will provide information on where survival bottlenecks may exist as well as identify any needed dam passage improvements.

Evaluation of Steelhead Kelt Migration Success through The Dalles and Bonneville Dams

Mark Weiland, Gene Ploskey, Christa Woodley, Derrek Faber, Bishes Rayamajhi, and Jina Kim

ABSTRACT

The goal of this study was to evaluate the route-specific migration success of steelhead kelt passing downstream through The Dalles Dam (TDA) and Bonneville Dam (BON). Routes at TDA included the sluiceway, turbines, and spillway. Routes at BON included Powerhouse 1 (B1) sluiceway, B1 turbines, Powerhouse 2 (B2) Corner Collector (B2CC), B2 turbines, B2 Juvenile Bypass System (JBS), and spillway.

Between April 14 and June 4 Oregon Department of Fish and Wildlife personnel collected, tagged and released out-migrating steelhead kelt in tributaries of the Deschutes River, 15 Mile Creek and Hood River to evaluate the migration success of steelhead kelt passing BON and TDA Dams. The kelt were tagged with a PIT and were tagged externally with JSATS acoustic micro-transmitter attached to a Floy T-bar tag. The T-bar was inserted into the dorsal back musculature using a Floy tagging gun. Juvenile Salmon Acoustic Telemetry System (JSATS) cabled arrays were deployed at TDA and BON to monitor kelt tagged with JSATS micro-transmitters as they passed the dams. Four arrays of autonomous nodes were also deployed to detect kelt passage and for use in calculating single-release survival estimates.

Due to delays and high flows, 90% of kelt had out-migrated prior to the start of the study in mid April. A total of 58 kelt were tagged and released at the site of collection, 24 in the tributaries upstream of TDA and 34 in the tributaries downstream of TDA. Of the 24 kelt released above TDA, 14 were detected at TDA and of the 58 total kelt released upstream of BON 25 were detected on the JSATS acoustic array at BON. Kelt tagged with JSATS tags on the Snake River that were detected on our arrays were incorporated into our study to increase our sample size and the precision of our estimates. Of the 324 kelt tagged and released in the Snake River, 177 were detected at TDA (Table 1) and 163 at BON (Table 2).

Table 1. Route-specific Passage Percentages for TDA.

Route	N	Passage by Route
TDA	177	100%
Spillway	149	84.2%
Powerhouse	28	15.8%

Table 2. Route-specific Passage Percentages for BON.

Route	N	Passage by Route
BON	163	100%
Spillway	83	50.9%
Powerhouses (B1 and B2)	80	49.1%
B1	41	25.2%
B2	39	23.9%

Route-specific passage percentages for surface flow routes and the B2 JBS and survival rates are still being evaluated and should be available in the upcoming presentation.

Use of the Columbia River Mainstem by Walla Walla Basin Bull Trout

Marshall Barrows, Ryan Koch, Donald Anglin, Joe Skalicky, Courtney Newlon, Dean Holecek, Terry McCall, Mike Berger, and Carla Hurlbert

ABSTRACT

Background: A significant gap in our knowledge of migratory bull trout *Salvelinus confluentus* life history is associated with their use of the mainstem Columbia River and/or Snake rivers. Very little data is available regarding movements within the mainstem, the use of mainstem habitats, or bull trout presence and/or passage at the mainstem dams. To better understand bull trout mainstem use, we used acoustic telemetry and passive integrated transponder (PIT) tags to monitor migratory bull trout movements and presence/passage at Columbia and/or Snake river mainstem dams.

Methods: During FY2012, we conducted our sampling effort for bull trout during the October through February time period when most of the emigration from the Walla Walla Basin occurs. We used rotary screw traps at two locations, a fyke net at one location and angling in the lower Walla Walla River to capture migratory bull trout for acoustic and PIT-tagging. Four remote hydrophones were deployed in the lower Walla Walla River to monitor movement of tagged fish into the Columbia River. A network of stationary hydrophones, in addition to mobile tracking was utilized to better define the spatial and temporal aspects of mainstem movements and distribution. Concurrently, we also PIT-tagged migratory bull trout in mid-basin areas to maintain a tagged population for subsequent detection at instream PIT arrays and at mainstem dams.

Results/Management Action: Seventeen bull trout were captured between November 2011 and February 2012, of which fifteen were tagged with both an acoustic transmitter and a PIT-tag. Five of the acoustic tagged bull trout were detected entering the Columbia River from November through February. One of these fish was located during mobile tracking surveys between the mouth of the Walla Walla River and McNary Dam. Another fish was detected by a stationary hydrophone downstream from the mouth of the Walla Walla River. Only two of the five acoustic tagged bull trout that entered the Columbia River were subsequently detected returning to the Walla Walla River from February through May. No acoustic tagged bull trout were detected at or near mainstem dams during the year. Seventy-four bull trout were PIT-tagged in mid-basin portions of the Walla Walla River between October and February. Twenty-six PIT-tagged bull trout were detected at the Oasis Road Bridge PIT detection array en route to the Columbia River, one fish was detected while ascending the McNary Dam fish ladder, and one fish was recaptured at the Three Mile Falls Dam fish ladder in the lower Umatilla River. These findings could provide guidance for future FCRPS management actions.

Lower Snake River Performance Standards Assessments 2012: Experimental Design and Methods

Geoffrey A. McMichael, John R. Skalski, Katherine A. Deters, Alison H.A. Colotelo, Ryan A. Harnish, Eric W. Oldenburg, Kenneth D. Ham, P. Scott Titzler, and Z. Daniel Deng

ABSTRACT

To determine whether Little Goose and Lower Monumental dams on the lower Snake River were in compliance with performance standards set forth in the 2008 BiOp and Fish Accords, a study using the virtual/paired-release design with acoustic telemetry technology was conducted in 2012. To conduct this study with the required precision levels, large numbers of three species/stocks of fish were collected and surgically implanted with a Juvenile Salmon Acoustic Telemetry System (JSATS) acoustic transmitter and a PIT-tag at Lower Monumental Dam. Low percentages of the fish available for tagging were not used based on the established rejection criteria and the fish tagged were typically representative of the run-at-large. Over 6,000 each of yearling Chinook salmon and steelhead and nearly 11,000 subyearling Chinook salmon were tagged and released at five different locations between Central Ferry (river kilometer (rkm) 133) and Snake River Road (rkm 40). Releases were conducted during daylight and darkness and were timed to achieve mixing in the tailraces of the dams. To detect tagged fish, cabled receiver systems were deployed on the upstream dam-face to provide high detection probabilities and detailed information on routes of passage at the dams. In addition, autonomous receivers were deployed in arrays in dam forebays and tailraces to provide further detection data to support the survival estimation and for determination of metrics specified in the Fish Accords. Quality control measures throughout the field and data analyses portions of the project ensured that the results are reliable.

Results of Snake River Survival Compliance Studies for 2012

John R. Skalski, Geoffrey A. McMichael, and Kenneth D. Ham

ABSTRACT

An integrated study was performed at Little Goose and Lower Monumental dams to estimate dam passage survival as specified in the 2008 BiOp. The spring study estimated dam passage survival and associated Fish Accord performance measures for yearling Chinook salmon and steelhead. The summer study estimated survival for subyearling Chinook salmon through the two dams. A total of 6159, 6202, and 10,963 acoustic-tagged smolts were used in the joint two-dam study for yearling Chinook salmon, steelhead, and subyearling Chinook salmon, respectively. The assumptions of the virtual/paired-release design used in estimating dam passage survival were met for all studies.

- Estimates of dam passage survival for the spring stocks (i.e., yearling Chinook salmon and steelhead) at both dams exceeded the 2008 BiOp standard of survival at $\hat{S}_{\text{Dam}} \geq 0.96$ with $\hat{\text{SE}} \leq 0.015$.
- Estimates of dam passage survival for the summer stock (i.e., subyearling Chinook salmon) also exceeded the 2008 BiOp requirement of $\hat{S}_{\text{Dam}} \geq 0.93$ with $\hat{\text{SE}} \leq 0.015$ at both dams.

This was the first year of compliance testing at these two Snake River projects.

Little Goose Dam Passage Route and Survival

Eric W. Oldenburg, Geoffrey A. McMichael, John R. Skalski, Kenneth D. Ham, R. L. Townsend, Katherine A. Deters, Alison H.A. Colotelo, and Z. Daniel Deng

ABSTRACT

A dam passage survival study was conducted to determine whether Little Goose Dam (LGS) was in compliance with performance standards set forth in the 2008 BiOp and Fish Accords for three species/stocks (i.e., yearling and subyearling Chinook salmon and juvenile steelhead) of fish. Over 4,000 each of yearling Chinook salmon and steelhead and over 7,000 subyearling Chinook salmon were implanted with JSATS acoustic transmitters and released as part of this effort. Little Goose Dam passage routes were identified for 1,771 yearling Chinook salmon, 1,749 juvenile steelhead, and 2,789 subyearling Chinook salmon. The majority of yearling Chinook salmon passed LGS through the spillway weir (44% passage; 100% survival) or the juvenile bypass system (31% passage; 99% survival). The most common routes of passage for steelhead were the juvenile bypass system (42% passage; 100% survival) and the spillway weir (40% passage; 100% survival). The majority of subyearling Chinook salmon passed LGS through the spillway weir (48% passage; 96% survival) or through deep spill (25% passage; 94% survival). Turbines were the least common route of passage and were associated with the lowest survival probabilities for yearling Chinook salmon (4% passage; 87% survival), steelhead (2% passage; 81% survival), and subyearling Chinook salmon (5% passage; 81% survival).

Lower Monumental Dam Passage Route and Survival

Ryan A. Harnish, Geoffrey A. McMichael, John R. Skalski, Kenneth D. Ham, R. L. Townsend, Katherine A. Deters, Alison H.A. Colotelo, and Z. Daniel Deng

ABSTRACT

A dam passage survival study was conducted to determine whether Lower Monumental Dam (LMN) was in compliance with performance standards set forth in the 2008 Biological Opinion and Fish Accords for three species/stocks (i.e., yearling and subyearling Chinook salmon and juvenile steelhead). Over 6,000 each of yearling Chinook salmon and steelhead and nearly 11,000 subyearling Chinook salmon were implanted with Juvenile Salmon Acoustic Telemetry System (JSATS) acoustic transmitters and released as part of this effort. LMN passage routes were identified for 4,026 yearling Chinook salmon, 3,997 juvenile steelhead, and 6,269 subyearling Chinook salmon. The majority of yearling Chinook salmon (62%), steelhead (53%), and subyearling Chinook salmon (58%) passed LMN via the spillway weir. The next most commonly used routes were through deep spill for yearling (17%) and subyearling (25%) Chinook salmon and the juvenile bypass system (JBS) for steelhead (31%). Less than 8% of yearling and subyearling Chinook salmon and steelhead passed LMN through the turbines. Survival of all three species/stocks exceeded 98% for fish that passed LMN through the spillway weir. Fish that passed through the turbines experienced the lowest survival for all three species/stocks, ranging from 81% for juvenile steelhead to 93% for yearling Chinook salmon. Survival through the LMN JBS, with its recently completed new bypass outfall, was estimated to be 100% for yearling and subyearling Chinook salmon and 99% for steelhead.

Lower Columbia River Survival Study Methods Overview and Juvenile Salmonid Condition Evaluation, 2012

Christa M. Woodley, Gene Ploskey, James Hughes, Mark A. Weiland, Eric Fischer, Aaron Cushing, Tyler Mitchell, Darin Etherington, Scott Carpenter, Matt Hennan, Katie Wagner, George Batton, Shon Zimmerman, Jina Kim, Michael Greiner, Bishes Rayamajhi, and Thomas J. Carlson

ABSTRACT

In spring and summer 2012, performance measures were evaluated at the Lower Columbia River (LCR) dams (McNary, John Day, The Dalles, and Bonneville) as stipulated in the 2008 Federal Columbia River Power System Biological Opinion (BiOp) and 2008 Columbia Basin Fish Accords. The performance standards required 96% dam-passage survival for yearling Chinook salmon and juvenile steelhead in spring and 93% survival for subyearling Chinook salmon in summer and an estimated standard error (SE) ≤ 1.5%. These studies were based on the culmination of several years of planning, standardization of study methods and metrics, enhanced and adaptive techniques, and rigorous quality control. Out-migrating steelhead and juvenile Chinook were monitored with the Juvenile Salmon Acoustic Telemetry System (JSATS). Accordingly, each dam was outfitted with a cable array detection system, and autonodes placed at 14 in-river locations (18 locations including dams). Two models of the JSATS acoustic transmitters(AT), weighting a mean 0.303 g (implanted into CH1 and CH0) and 0.438 g (implanted into STH) in air, were programmed with a transmission rate of 1 pulse every 3 seconds at a source level of 156 dB. Tagged fish released below Bonneville Dam in summer were programmed to ping every two seconds.

Collection of Chinook salmon and steelhead occurred at the John Day Dam smolt monitoring facility during normal facility collection events. Based on project criteria, candidate fish were assessed for condition, and then held overnight for tagging the next day. Overall the tagging process follows the guidelines set for by the Columbia Basin Surgical Protocol Committee (http://www.nwp.Corps.army.mil/environment) for intra-coelomic acoustic transmitter implantation. Incisions were closed using 2 simple interrupted sutures of monofilament. Tagging data crew and surgeons noted fish condition pre- and post-surgery. The tagging data crew noted fish condition before tagging and the surgeons noted any tagging effect that may have occurred during the surgical implantation process. Surgeon teams were balance based on skill sets and proportion of fish tagged.

Steelhead and yearling Chinook were released daily from April 27 to June 2, resulting in 36 consecutive days of release, alternating daily between day and night, at 5 release locations. Subyearling Chinook were released daily from June 13 to July 22, resulting in 40 consecutive days of release, alternating daily between day and night, at 9 release locations. Release timing and schedules were developed to ensure adequate mixing of fish in the river for each dam and associated virtual paired release model.

Results of Mainstem Columbia River Survival Compliance Studies for 2012

John R. Skalski, Thomas J. Carlson, Gene R. Ploskey, and Mark A. Weiland

ABSTRACT

An integrated compliance study was performed at McNary and John Day dams to estimate dam passage survival for spring stocks (i.e., yearling Chinook salmon and steelhead). In the summer, an integrated four-dam study was performed at McNary, John Day, The Dalles, and Bonneville dams to estimate dam passage survival for subyearling Chinook salmon. A total of 5789, 5797, and 14027 acoustic-tagged smolts were used in the yearling Chinook, steelhead, and subyearling Chinook salmon investigations, respectively. Assumptions of the virtual/paired-release design were met in the case of all eight survival investigations.

- Estimates of dam passage survival for yearling Chinook salmon at McNary and John Day dams met the 2008 BiOp survival requirement for spring stocks of $\hat{S}_{\text{Dam}} \geq 0.96$ with $\widehat{\text{SE}} \leq 0.015$.
- The estimates of dam passage survival for steelhead at the two dams also exceeded $\hat{S}_{\text{Dam}} \geq 0.96$ for spring stocks, but the standard error at McNary was estimated to be too large, $\widehat{\text{SE}} > 0.015$.
- Each of the four subyearling Chinook salmon survival studies met the 2008 BIOP survival requirement for summer stocks of $\hat{S}_{\text{Dam}} \geq 0.93$ with $\widehat{\text{SE}} \leq 0.015$.

McNary Dam Route-Specific Passage Metrics and Survival Estimates, 2012

James S. Hughes, Mark Weiland, Gene Ploskey, Christa Woodley, Scott Carpenter, Fenton Khan, Eric Fischer, Aaron Cushing, Tyler Mitchell, Darin Etherington, Matt Hennen, George Batten, Shon Zimmerman, Jina Kim, Michael Greiner, Bishes Rayamajhi, and Thomas Carlson

ABSTRACT

Background: The purpose of this study was to estimate fish passage and survival metrics for yearling (CH1) and subyearling (CH0) Chinook salmon smolts and juvenile steelhead (STH) passing McNary Dam (MCN) at rkm 470 during 2012.

Methods: The 2012 spring and summer studies at McNary dam estimated fish passage and survival metrics using a virtual/paired release (VIPRE) model design and active tag life adjusted survival (ATLAS) software. The studies also estimated spill passage efficiency, fish passage efficiency, route specific survival, and travel time metrics, including project passage time, forebay residence time, and tailrace egress time. A Juvenile Salmon Acoustic Telemetry System (JSATS) tag weighing 0.303 g (CH1 and CH0) and 0.438 g (STH) in air and PIT-tags were surgically implanted in 3,797 live CH1, 3,797 live STH, and 6,501 live CH0 at the John Day Dam (JDA) Smolt Monitoring Facility. Live fish were released daily along line transects across the Columbia River near Port Kelley, WA (rkm 503), the MCN tailrace (rkm 468), and Crow Butte, WA (rkm 422). Release times at each site were shifted by 12 h on alternate days and releases at successive sites downstream of MCN were synchronized to allow for mixing of fish in common tailwater reaches. Out of 3,797 live tagged CH1, 1,399 (36.8%) were released upstream of MCN near Port Kelley, WA; 1,198 (31.6%) were released in the MCN tailrace; 1,200 (31.6%) were released in the MCN tailwater near Crow Butte, WA. Out of 3,797 live tagged STH, 1,400 (36.9%) were released upstream near Port Kelley, WA; 1,199 (31.6%) were released in the MCN tailrace; 1,198 (31.6%) were released in the MCN tailwater near Crow Butte, WA. Out of 6,501 live tagged CH0, 2,524 (38.8%) were released upstream near Port Kelley, WA; 1,993 (30.7%) were released in the MCN tailrace; 1,984 (30.5%) were released in the MCN tailwater near Crow Butte, WA. A total of 50 tagged dead fish were released in the MCN spillway discharge in spring (29 CH1 and 21 STH) and summer (30 CH0) to test the assumption that tagged fish that die after release were not detected on downstream arrays. Fish detected at the MCN forebay entrance array or at the dam face were regrouped to form virtual releases of fish, and routes of passage through the dam were determined by 3D tracking as well as last detection data. Capture histories were formed from detections and non-detections of tagged fish on downstream survival arrays.

Results/Management Action: Data analyses are ongoing, but we anticipate presentation of final estimates for 2012 at the AFEP review, and the results should facilitate management decisions.

Performance Evaluation of Externally JSATS-Tagged Subyearling Chinook Salmon

Richard S. Brown, Z. Daniel Deng, Katrina V. Cook, Brett D. Pflugrath, Brad Trumbo and Martin Ahmann

ABSTRACT

Typically, internally-implanted telemetry tags are used to obtain estimates of dam passage survival in juvenile fish. However, fish that pass through turbines are exposed to rapid decreases in pressure which can cause injuries such as swim bladder rupture, exophthalmia, emboli and hemorrhaging. The presence of a telemetry tag implanted inside the coelom of a juvenile salmon increases the likelihood that the fish will be injured or die when exposed to rapid decompression. Thus an internal tag may introduce a bias in studies evaluating mortality of turbine-passed fish. This bias also increases with tag burden. A neutrally buoyant externally attached tag was developed to eliminate the bias in turbine survival studies. This new tag does not add mass or take up space in the coelom and thus has an effective tag burden of zero. This new tool was evaluated in the field relative to the internally implanted JSATS (juvenile salmon acoustic telemetry system) tag used widely for survival studies throughout the Columbia Basin. Half of the fish from each tag type were exposed to simulated turbine passage prior to release and survival to downstream locations was compared among groups.

Development of an Injectable Micro-Acoustic Transmitter for Fish Passage Evaluation

Z. Daniel Deng, Thomas J. Carlson, and M. Brad Eppard

ABSTRACT

Acoustic telemetry has been identified as a technology for observation of behavior and assessment of survival for juvenile Chinook salmon passing through the Federal Columbia River Power System. Although the transmitter mass meets current tag burden guidelines for most yearling Chinook salmon, reduction in size would reduce the possibility of adverse effects of implantation and would likely provide additional biological benefits for tagged fish. The current transmitter is too large for smaller juvenile Chinook salmon, particularly those found in the lower Columbia River and estuary that enter the river downstream of Bonneville Dam. At the request of the U.S. Army Corps of Engineers, Portland District, we started the development of a downsized transmitter that could meet weight and volume targets for implantation by injection by designing an application-specific integrated circuit and alternatives to current battery and PZT ceramics transducer. Implantation by injection instead of surgical implantation will result in significant reduction in costs of use. We will report the progress of the design process and testing results of the first generation prototype injectable transmitters.

Implantation and Bio-Effects Assessments of Injectable JSATS Acoustic Transmitters

Christa M. Woodley, Amanda Bryson, Rhonda Karls, Shon Zimmerman, Kathleen Hall, Huidong Li, Jayson Martinez, Mark A. Weiland, Thomas J. Carlson, and Z. Daniel Deng

ABSTRACT

Background As new telemetry technologies become available, studies of their effects on species of interest are imperative as is the development of implantation techniques. Researchers are working to reduced current transmitters into a less invasive design by developing a downsized acoustic micro-transmitter (DAMT). The lowest cost and least traumatic method for implantation of the DAMT in juvenile salmon has been assumed to be by injection using a needle and syringe based on regional passive integrative transponder (PIT) implantation expertise. The process of tag injection is efficient due to the reduced time for deep sedation of fish, reduced handling and implantation time of test fish, and does not require sutures to close the wound. Based on implantation efficiency and biocompatibility studies for PIT-tags, initial guidance to the JSATS AMT engineering design team was that a novel injectable DAMT should be packaged as a capsule, i.e. a cylinder with rounded ends. It was proposed that the cylindrical shape would be amenable to implantation by needle and syringe, similar to PIT-tags, and the rounded ends would be less likely to cause injury. Given this guidance, the engineering team developed three possible DAMT designs for biocompatibility testing using various injection techniques (Table 1) when possible.

Methods Test fish used in the evaluation were juvenile Chinook salmon (fork length [FL] 85-115) obtained from Priest Rapids hatchery and reared at PNNL. Three experiments were conducted using three unique DAMT transmitter designs. Transmitter designs, dates, and treatments are in the below table. Experiments herein are referred to as 3.4, 3.2, 3.0 based on the outer diameter (OD) of the transmitter design and are summarized (Table 1).

Table 1. Overview of dates, tag specifications, and surgical procedures used to implant DAMT in juvenile Chinook salmon. GA = needle gauge used.

Surgery Date	Incision Method	DAMT Size (mm)	DAMT Weight (mg)	Tag(s) Implanted	Insertion Method	Needle Insertion
March 17, 2012	Ocular Scalpel	3.4 x 15	290	AT	Hand	NA
	Ocular Scalpel	3.4 x 15	290	AT/PIT	Hand	NA
	8GA Needle	3.4 x 15	290	AT	Injection	75%
	8GA Needle	3.4 x 15	290	AT/PIT	Injection	75%
	CONTROL	NA	NA	NA	NA	NA
March 24, 2012	8GA Needle	3.2 x12.2	290	AT	Hand	30%
	8GA Needle	3.2 x 12.2	290	AT/PIT	Hand	30%
	8GA Needle	3.2 x 12.2	290	AT	Injection	50%
	8GA Needle	3.2 x 12.2	290	AT/PIT	Injection	50%
	NA	NA	NA	NA	Injection	NA
April 6, 2012	9GA Needle	3.0 x 14.2	290	AT	Hand	100%
	9GA Needle	3.0 x 14.2	290	AT/PIT	Hand	100%
	8GA Needle	3.0 x 14.2	290	AT	Injection	50%
	8GA Needle	3.0 x 14.2	290	AT/PIT	Injection	50%

Management Implications and Recommendations Overall, we recommendation that the 3.0 OD DAMT design using the 9-gauge needle be considered the most time efficient to implant thereby lessening fish handling time and further minimizing fish stress. The biocompatibility and wound healing were better in the 3.0 OD when compared to the other tag sizes. Survival and tag retention yielded no difference across DAMT designs as each was 100%. Though the length of the tag is confounded with OD, it should be noted that the length seems secondary to OD as the overall performance index decreased with tag size 3.0 OD x 14.2 < 3.2 OD x 12.5 < 3.4 OD x 15. Surgeon experience and needle sharpness could influence the results, and thus are factors that should be addressed in experimental designs. In addition, it was generally faster to load and implant one tag (regardless of PIT or DAMT) than two tags (DAMT and PIT). Protocols should be further developed to ensure that the above events and factors do not influence final results.

Determination of Initial Inflation of the Swim Bladder and Vulnerability to Barotrauma in White Sturgeon

Katrina Cook, Richard S. Brown, Latricia Rozeboom, Rachelle Johnson, Brett Pflugrath, Timothy Linley, Erin Miller, Tim White, Jason McLellan, Yong Gao, and Lee Baumgartner

ABSTRACT

During development, larval and juvenile sturgeon drift downstream with river flow and may drift hundreds of kilometers. Therefore, in the Columbia River Basin, developing sturgeon may pass multiple hydroelectric dams potentially making them vulnerable to injuries associated with passage. For example, fish passed through turbines commonly suffer from barotrauma as a result of rapid decompression. Barotrauma has been strongly associated with expansion of gasses in the swim bladder of fish. However, it is unknown at what life stage sturgeon fill their swim bladders, which would make them more susceptible to barotrauma. The purpose of this investigation was to determine at what age sturgeon first fill their swim bladders with gas in an effort to assess vulnerability to barotrauma of larvae and juveniles that may pass through turbines of hydroelectric dams. Using hyper/hypobaric pressure chambers, white sturgeon of varying life stages were exposed to pressure decreases. With an inflated swim bladder, exposure to these pressure decreases will cause the fish to become positively buoyant and float upward and possibly expel gas from their swim bladder. Alternatively, if swim bladder inflation has not yet been developed, the fish will not become positively buoyant. As an additional confirmation, x-ray examination of the fish for presence of gas bubbles in the swim bladder or other locations was done to support conclusions from the pressure testing. The first filling of the swim bladder was not noted until 11.5 weeks after hatching, well after they had grown out of the larval stage. The presence of gas in the swim bladder was documented by both fish expelling gas from their swim bladders and the presence of gas in the swim bladder visible on x-ray imagery. Work of this nature has never before been conducted on developing sturgeon and results should improve current understanding of how larval and juvenile fish are affected by hydroturbine passage at dams.

PIT-Tag Reach Survival Estimates, 2011

Steven G. Smith, James R. Faulkner, William D. Muir, Douglas M. Marsh

ABSTRACT

Background: NOAA Fisheries began using PIT-tags to conduct reach survival studies in the Snake and Columbia Rivers in 1993. The primary objective is to provide managers the information needed to assess structural and operational improvements made within the hydropower system to decrease travel time and increase juvenile survival.

Methods: Seven of the eight mainstem dams that Snake River stocks pass during their downstream migration have PIT-tag detection systems within their juvenile fish bypass systems. Additionally, in the Lower Columbia River downstream of Bonneville Dam, NOAA Fisheries operates a 2-boat trawl with a PIT-tag detector in the cod end. We construct a detection history for each tagged migrant (the record of whether or not detected each detection site), and use a statistical model for mark-recapture data ("Cormack-Jolly-Seber" model) to estimate survival probabilities of PIT-tagged juveniles through individual reaches (one reach is one reservoir and dam combination) and combined reaches. We also use PIT-tag detection data to calculate travel time statistics, estimate the proportion of fish transported from Lower Snake River dams, and other quantities, and investigate relationships among these estimates and environmental conditions and management operations.

Results/Management Action: The pattern through time of flow volume in the Snake River in 2012 was unique among the last 8 migration seasons, in that the highest peak in flow occurred in late April rather than in May, and the flow throughout May was no higher than in early April. The overall average of daily average flow volume was higher in 2012 than in the long-term series, but no other year's flow pattern had those characteristics. As a percentage of flow, spill was below the average of recent years in the first three weeks of April, jumped to near 50% during the spike in flow, and then returned to near-to-below average during May. Water temperatures were near average for most of the season, and increased relative to average during the spike in flow.

For yearling Chinook salmon in 2012, the estimated survival through the entire 750 km hydropower system (Snake River trap to Bonneville Dam tailrace) was the second highest (59.6%) we've observed in the 1999-2012 time series (higher only in 2006). For steelhead in estimated survival through the hydropower system was 59.8%, the third highest in the times series (behind 2008 and 2009), greater than the long-term average of 43.1%, and nearly identical to the 2011 estimate of 59.2%.

Estimated percentages transported from Snake River dams in 2012 were the lowest seen in twenty years of our estimates 1993-2012 (about 24% of yearling Chinook salmon and about 27% of steelhead. Collection for transportation began on 2 May at Lower Granite Dam and 2-4 days later downstream. However, a large spike in smolt passage was associated with the large spike in flow in late April. As a result, a large percentage of smolts (about 67% of yearling Chinook and 59% of steelhead) passed Lower Granite Dam before transportation began.

Recent Developments of COMPASS - a Model of Survival through the Hydrosystem and Beyond

Richard W. Zabel

ABSTRACT

The Comprehensive Passage (COMPASS) model was developed by the NOAA Fisheries in collaboration with scientists from other federal agencies, state and tribal agencies, and the University of Washington. The model predicts the effects of alternative dam and reservoir operations on salmon survival rates, expressed both within the hydropower system and through adult return. The model was designed to accommodate a range of alternative hypotheses regarding the functional form of underlying relationships. COMPASS moves cohorts of fish through the hydrosystem according to behavioral rules, and suffer mortality according to relationships that relate survival to travel time, travel distance, flow, magnitude of spill, and temperature. Relative return rates of transported and in-river-migrating fish are based on arrival timing to below Bonneville Dam. Model parameters are based on extensive datasets derived from PIT and active tag studies.

We will present several recent model developments: 1) We have recently expanded the model to the Upper Columba River to support the Columbia River Treaty negotiations; 2) The model calibration has been updated to include recent data in preparation for new FCRPS BiOp runs; 3) COMPASS has a new Monte-Carlo mode that produces uncertainty about survival estimates; 4) We are exploring methods to incorporate bird predation into the model, particularly for steelhead; and 5) We have updated post-Bonneville relationships.

Life-Cycle Models for Interior Columbia River Basin Populations

Richard W. Zabel

ABSTRACT

The 2008 FCRPS BiOp used a combination of life-cycle modeling and passage modeling to estimate how potential changes in hydrosystem survival affect long term viability metrics (productivity, mean abundance and probability of quasi-extinction) of listed ESUs. The Adaptive Management Implementation Plan (AMIP) called for the expansion life cycle models to explicitly evaluate a variety of other factors, particularly the potential benefits of actions called for in the BiOp. In addition, the expanded models can be developed to estimate the likelihood that early-warning and contingency triggers might be met under alternative scenarios of climate change and management strategies. The ongoing effort is a collaboration of state, tribal, and federal scientists, and we have focused on the following areas: 1) Relationships between freshwater habitat actions and population performance (survival and capacity); 2) Updating current models and developing models for new populations; 3) Hydro actions, including dam breach and drawdown scenarios; 4) Updating estuary and ocean survival relationships and modeling the effects of mitigation actions in the estuary; 5) Spatial interactions among populations; 6) Effects of hatchery spawners on wild spawners; and 7) Forecasts of adult returns for early warning triggers.

A Study to Determine Seasonal Effects of Transporting Fish from the Snake River to Optimize a Transportation Strategy

Steven G. Smith, Douglas M. Marsh, Robert L. Emmett, William D. Muir, and Richard W. Zabel

ABSTRACT

Background: Studies have shown that the benefit of smolt transportation varies within migration seasons. Typically, transportation has been less beneficial for earlier, smaller migrants. As a result, a later starting date for general transport from Snake River Dams was chosen in recent years, typically around 1 May at Lower Granite Dam and later at downstream sites. The objective of this study is to investigate within-season patterns in smolt-to-adult return rates (*SAR*s) of transported ("T") and in-river migrant fish (here we use "B," as bypassed fish are used, and patterns in the *SAR* ratio (T:B). The ultimate objective is to find a set of covariates related to *SAR* outcomes that can be used to make real-time, in-season decisions regarding transportation strategy.

Methods: We considered all PIT-tagged wild and hatchery yearling Chinook salmon and steelhead released upstream from Lower Granite Dam from 1998 through 2009, along with fish collected and PIT-tagged at Lower Granite Dam. To study within-season *SAR* patterns required known dates of juvenile passage. Therefore, inriver migrant groups were formed from PIT-tagged fish that were bypassed (i.e., detected and returned to the river) at Lower Granite Dam. Inference for the run-at-large requires an assumption regarding the relationship between *SAR*s for detected and never-detected fish. We adjusted standards of comparison to account for lower *SAR*s generally observed for detected fish. We used the statistical method of Poisson log-linear regression to model *SAR*s for daily groups of transported and migrant fish, and used Information Theoretic methods (e.g., AIC-based model averaging) for multi-model inference. In a set of descriptive analyses, we modeled *SAR*s strictly as a function of date. For another set of explanatory analyses, we compiled data on a large collection of freshwater and ocean factors that potentially influence *SAR*s. We selected a few variables to use as potential predictor variables in the regression models.

*Results/Management Actions***:** We observed a wide variety of patterns in *SAR*s and T:B ratios. A common pattern was that *SAR* decreased from the beginning of the season (earliest fish to arrive at LGR) until the end (latest to arrive). The latest arriving in-river fish (late May) almost always had the lowest *SAR*s of the season. For transported groups, the lowest *SAR* of the season was often for those that were transported earliest. The relationship of *SAR*s with explanatory covariates was not consistent across data sets. For about half of all data sets, models including at least one covariate were better than strictly descriptive models. For all species and rearing types, water temperature was most strongly associated with *SAR* among the covariates we investigated. Rankings among the other covariates varied between species and rearing types. Before 2006, the estimated T:B ratio almost always exceeded standards for fish that arrived at LGR on May 1 or later. Patterns did not change drastically in 2006-2009, but the earliest date on which T:B exceeded standards was more likely to be later in May (e.g., May 10), especially for steelhead. Additional years of data are required to determine the degree to which the changed transportation strategy has altered *SAR* and T:B patterns.

A Study to Compare SARs of Snake River Fall Chinook Salmon Under Alternative Transport and Dam Operational Strategies

Steven G. Smith, Douglas M. Marsh, William D. Muir, Richard W. Zabel, and William Connor

ABSTRACT

Background: We began a NOAA/USFWS-DWOR cooperative study in 2005 to compare the smolt-to-adult returns (SARs) of Snake River fall Chinook salmon under alternative transport and dam operational strategies. Beginning in 2008, the study fell under the Regional Consensus Proposal. Tagging under the Regional Consensus Proposal ended in 2012.

Methods: Under the NOAA/USFWS-DWOR cooperative study, hatchery Snake River fall Chinook salmon (surrogates) were reared at Dworshak NFH to mimic the size of natural fish, then PIT-tagged and released into the Snake and Clearwater Rivers upstream of Lower Granite Dam, matching the timing of natural fish emigrating from those rivers. There was also an effort to increase natural fall Chinook salmon tagging in the Snake River. Under the Regional Consensus Proposal, this study design was continued and supplemented with the tagging of hatchery yearling and (production) subyearling fall Chinook salmon and an increased effort in the tagging of Clearwater River natural fall Chinook salmon. Under the study design, PIT-tag codes were randomly assigned into two groups; 1) transport with in-river migration (TWI) – to be transported when guided into bypass systems; and 2) bypass with in-river migration (BWI) – to be returned to the river when guided into bypass systems, and the transportation strategy was evaluated by comparing SARs of the two groups.

Under both the NOAA/USFWS-DWOR and the Regional Consensus Proposal, the study design was based on evaluating the entire population of Snake River fall Chinook salmon. There are major differences in the behavior of natural, surrogate, and production subyearling fish released into the Snake and Clearwater Rivers and between subyearling and yearling fish. Different methods of analysis will be appropriate for different groups. Methods that require CJS estimates to estimate the number of never-bypassed fish are likely to work for yearling releases, and likely also applicable, with only small bias, to Snake River surrogate and natural releases. The degree of bias is related to the prevalence of the outmigration pattern that extends through the winter and into the spring ("reservoir-type"), particularly when passage occurs during the winter period when there is no monitoring for PIT-tags. The analysis under the NOAA/USFWS-DWOR proposal does not require CJS parameter estimates and is not compromised when subject fish hold over in reservoirs. It is appropriate for all types of fish in the study.

Results/Management Actions: While we acquired experimental fish for 2005 and reared and released them, circumstances resulted in fish that were inadequate surrogates. We use the 2005 "surrogate" data only to illustrate the NOAA/USFWS-DWOR analysis methods. For surrogates released in 2006 and 2008, TWI groups have averaged (geometric mean) a return rate 16% higher than BWI groups and the differences are significant (=0.10). Rele
have had more mixed results with TWI:BWI ratios both significantly greater than (2008 Clearwater) and less than 1.0 (2006 Snake). For yearlings in 2008 TWI fish from both rivers had a higher rates than BWI fish, but the difference was significant only for Clearwater-released fish.

Identifying Overwintering Location and Natal Origin for Snake River Fall Chinook Salmon

Richard W. Zabel

ABSTRACT

The life-history complexity of Snake River fall Chinook salmon has hindered efforts to manage the ESU. In particular, the existence of an overwintering behavior in a portion of the population has complicated our ability to estimate survival through the hydropower system and to assess the benefit of transportation. Effective management of reservoir-type fish will require an understanding of the details of their life-history, including the proportion of juveniles that exhibit the strategy, where they over-winter, when they initiate downstream migration in the spring, and estuarine residence time. The geochemical analysis of fish otoliths (inner ear balance organs) allows for the reconstruction of important migrational behaviors because the tissue preserves a record of chemical experience of individual fish. By analyzing these chemical signatures, it is possible to identify the location and duration of juvenile Chinook residences during rearing in their natal site, downstream migration from their rearing areas, migration through the hydrosystem, migration through and residence in the estuary and plume, and into the ocean. In addition, the width of daily increments is related to fish growth, and growth trajectories can be back-calculated from daily growth increments. We analyzed otoliths from adults (collected from Lyons Ferry Hatchery) to reconstruct their life histories during the juvenile stage (hatching to ocean entry) by estimating residence times in segments along the migration route. In addition, we also analyzed otoliths derived from juveniles of know origin to validate the methods. In this past year, we focused on distinguishing hatchery from wild fish and on better elucidating chemical signals in the estuary.

A Review of Adult Salmon and Steelhead Straying with an Emphasis on Columbia River Populations

Matthew L. Keefer and Christopher C. Caudill

ABSTRACT

Background: Many juvenile salmon and steelhead in the Columbia River basin are collected at dams during outmigration and are transported downstream on barges or trucks. Evidence from tagging studies indicates higher straying rates in adults that were transported as juveniles compared to those that migrated in river. To address information gaps regarding the causative mechanisms of adult straying in the Columbia basin, we recently completed a comprehensive review of adult salmonid straying and developed a predictive straying model for Snake River steelhead.

Methods: Our review of straying rates, behaviors, and mechanisms was developed from peer-reviewed research and from grey literature summaries of agency projects in the Columbia basin (e.g., Corps, BPA, ODFW, WDFW). The Snake River steelhead model is a spreadsheet-based tool designed for managers and researchers. The model can be used to estimate the number of adult steelhead strays for both donor (i.e., Snake River) and recipient (e.g., Deschutes or John Day River) populations. User-selected input data derived from recent empirical estimates include adult straying rates, smolt abundance at Lower Granite Dam, juvenile transportation rates from the Snake River, and smolt-to-adult returns (SARs) for hatchery, wild, in-river, and barged populations. The model can be used to evaluate the potential effectiveness of different management efforts to reduce straying by barged fish.

Results/Management Action: The literature review has a wide range of information for those working on and/or interested in adult salmon and steelhead straying in the FCRPS. The presentation will include summary information on adult straying rates and mechanisms (juvenile and adult), potential effects of straying on donor and recipient populations, and the likely roles of hatchery rearing and juvenile transportation on adult homing and straying behaviors. We will also demonstrate the Snake River steelhead straying model, and conclude with potential implications of adult straying (e.g., out-breeding depression, introgression, hybridization, domestication effects, reduced productivity, etc.) on recipient populations in the Columbia River basin.

Species, Life History and Population-Specific Patterns of Straying by Salmonids in the Columbia River

Peter Westley

ABSTRACT

Homing to natal sites for reproduction is a central element of salmonid biology, though some individuals stray and spawn elsewhere. Straying determined post-glacial re-colonization and influences current gene flow among populations, yet little is known about fundamental differences in the propensity of species, populations, or life history types to stray. In this talk I present the results of an analysis to test the hypothesis that species-specific rates of straying reflect differences in juvenile life history patterns associated with distinct processes of smolt transformation, imprinting, and downstream migration. We analyzed nearly 350,000 coded-wire tag recoveries from 10 populations of Pacific salmon and steelhead in the Columbia River Basin, while controlling for factors known to influence straying. Rates of straying differed significantly among Chinook and Coho salmon and steelhead, between life history types of Chinook salmon, and among populations and years.

We estimated that ocean-type Chinook salmon that undergo markedly different patterns of downstream migration and imprinting compared to other species, strayed at a higher rate (12.2%) compared to 3.8% for stream-type Chinook salmon (excluding the Umatilla River that produced exceedingly high stray rates), 0.7% for Coho salmon, and 2.6% for steelhead. Hatcheries that produced high rates of straying in one species typically did so for others as well, suggesting the role of particular practices at these hatcheries or responses by salmon to different environmental conditions across the landscape. Straying within a brood year and hatchery location was correlated between species and life history types, suggesting that environmental factors may affect the production of strays. Our results suggest that empirical or theoretical frameworks for conservation that incorporate straying rates that ignore temporal, population, species, or life history variation may be prone to failure.

Evaluation of Methods to Reduce Straying Rates of Barged Juvenile Salmonids

Andrew Dittman

ABSTRACT

The overall goal of this project is to develop methods to reduce wandering and straying of salmon that are collected and barged from the Snake River to below Bonneville Dam. Salmon and steelhead that stray and spawn in non-natal streams are a significant conservation concern because they may decrease the productivity of native populations through genetic introgression and ecological competition. This is a particular concern for mid-Columbia River steelhead populations, listed as threatened under the ESA, because steelhead that are barged downstream as juveniles tend to stray into these watersheds more than juveniles that migrate naturally in-river. At the same time, Snake River steelhead that are transported consistently have higher smolt-to-adult returns (SARs) than steelhead left to migrate in-river. Therefore, it is important to identify and develop strategies for reducing the stray rates of transported steelhead while maintaining the survival benefits associated with barging. We hypothesize that transporting juvenile salmon by barge interferes with the natural process of sequential imprinting in juveniles as they migrate seaward through the Columbia River and, therefore, results in impaired homing ability and elevated straying by adults. This study addresses this hypothesis by identifying and evaluating critical environmental parameters that contribute to successful imprinting during barge operation, and developing alternative barging strategies to reduce the stray rates of steelhead that are collected and barged to below Bonneville Dam.

The specific aims of this project are: 1) Assess imprinting of barged and in-river migrants by monitoring imprinting associated changes in physiological function and gene expression as indicators of imprinting success. 2) Identify key environmental parameters (e.g. novel tributary water) that are important for imprinting barged fish and develop barging protocols to optimize imprinting success and thereby minimize straying using a controlled laboratory study. In this presentation, I will describe the experimental design and sampling protocol for the initial year and present preliminary physiological imprinting data on barged fish, in-river migrants, and from laboratory studies.

Improving Adult Pacific Lamprey Passage at Bonneville Dam using Lamprey Passage Structures (LPS) and Refuges

Steve Corbett, Mary Moser, and Christopher C. Caudill

ABSTRACT

Efforts to increase adult Pacific lamprey passage in 2012 included structural and operational changes to improve lamprey access to and passage through lamprey passage structures (LPSs) at Bonneville Dam. We tested whether lamprey would use refuge boxes installed along the bottom of the Washington-shore Auxiliary Water Supply (AWS) channel, thereby improving lamprey retention in this area. Thirty-six of the 977 lamprey implanted with passive integrated transponders (PITs) and released downstream from Bonneville Dam were subsequently detected in the refuge boxes. Of the PIT-tagged lamprey detected exiting the Washington-shore fishway or LPS, 11.8% had previously used a refuge box. At the Cascades Island LPS, we conducted tests to determine whether reducing water volume through the lower part of this structure would improve collection efficiency and/or passage success. Lamprey use of this structure in 2012 was the highest of any previous year of operation (n = 2,472), and 10 of 977 (1%) lamprey PIT-tagged and released downstream from Bonneville Dam were detected at Cascades Island LPS antennas or recaptured at the terminal trap. Experiments to determine passage success indicated that 41 of 50 (82%) PIT-tagged fish released into the structure successfully ascended to the trap at its terminus. Thus, modifications made in 2012 to enhance the entry and retention at rest boxes appear to have improved passage success relative to 2011. Efforts to identify additional trapping locations for adult Pacific lamprey at Bonneville Dam were continued in 2012. At the Cascades Island Auxiliary Water Supply Channel, which has no direct outlet to the forebay, 268 lamprey were opportunistically captured, transported, and released upstream from Bonneville Dam. This location should be a focus of future efforts to collect lamprey for transport or research purposes.

General Migration and Upstream Passage Patterns in HD PIT-tagged Adult Pacific Lamprey

Matthew L. Keefer, Christopher C. Caudill, Eric Johnson, Tami Clabough, Michael Jepson, Steve Corbett, and Mary Moser

ABSTRACT

Background: Monitoring adult Pacific lamprey (*Entosphenus tridentatus*) migration in the Columbia River basin is an important part of understanding how dams and environmental factors affect lamprey behavior, dam passage success, and distribution among spawning areas. Results from long-term monitoring, like this half-duplex passive integrated transponder (HD PIT) tagging study, can also be used to evaluate the effects of management actions to improve lamprey passage at dams and to help prioritize limited conservation funds.

Methods: In 2012, we collected and HD PIT-tagged 898 adult lampreys at Bonneville Dam. Of these, 823 (92%) were released downstream, 50 (6%) were released into the Cascades Island LPS, and 25 (3%) were released into the Bonneville forebay. Upstream passage was monitored at the four lower Columbia River dams, the four lower Snake River dams, at Priest Rapids and Wanapum dams, and at tributary HD PIT antennas maintained by cooperating agencies. The primary objectives addressed in this presentation are: 1) to estimate lamprey escapement past the monitored sites, 2) to assess the final known distribution of tagged fish, 3) to compare 2012 results to those from previous HD PIT study years (2005-2011), and 4) to evaluate the effects of recent management efforts intended to improve lamprey passage through dam fishways.

Results/Management Action: At this writing, some lampreys tagged in 2012 were still actively migrating, monitoring sites were still deployed, and data were not yet fully processed. Preliminary results indicate that escapement from release below Bonneville Dam to top-of-ladder antennas at Bonneville Dam was 53% in 2012, approximately in the middle of the range of estimates from 2005-2011. Escapement estimates from release past The Dalles Dam (26%) and past John Day Dam (22%) in 2012 were also in the range of previous results. Notably, preliminary estimates of escapement into the Snake River (1.3%) and to Priest Rapids Dam (2.5%) are at the high end of estimates for those sites, and we expect that estimates will increase slightly when the late fall dam passage data and tributary detections are incorporated into the database.

Evaluation of Lamprey Behavior at Lower Fishway Sections of Bonneville and John Day Dams using DIDSON, 2012

Christopher C. Caudill, Eric Johnson, Peter Johnson, Matthew L. Keefer, Tami Clabough, Michael Jepson, and William Nagy

ABSTRACT

Background: Monitoring adult Pacific lamprey (*Entosphenus tridentatus*) migration behaviors at Columbia River basin dams is important for identifying areas of difficult passage. In 2011 we demonstrated that Dual-Frequency Identification Sonar (DIDSON) can be used to observe lamprey passage behavior at 1-10m spatial scales in fishway environments as part of efforts to identify sites and structural configurations needed to improve lamprey attraction, passage, and collection at dams. In summer 2012, we completed a second year of DIDSON monitoring at Bonneville Dam at the north downstrem entrace (NDE) of the Washington shore fish ladder and junciton poo to characterize the behavior and vertical and lateral distribution of adult lamprey in the junction pool, the associations between lamprey and sturgeon in the junction pool and behavior at NDE. We also evaluated lamprey passage and behavior in the lower section of the John Day north fishway, after the addition of a variable-width entrance weir and bollard field in the winter/spring 2012. Specific goals at JDA were to qualitatively evaluate behavior in relation to the bollards, quanitfy vertical, lateral, and longitudinal distribution of lamprey in the collection channel, and to qualitatively assess behavior at the transition pool.

Methods: A DIDSON camera was deployed from June 13 to August 31, 2012 at two locations at Bonneville Dam and four locations inside the John Day Dam north fishway (two locations upstream of the entrance and bollard field, near the turnpool, and downstream of the first submerged weir). Data were collected in high-frequency mode for periods of 12 to 48 hrs at each location. DIDSON imaging was collected in landscape mode to obtain the horizontal distribution of lampreys in the water column and to assess the direction of lamprey movements. Images were also collected in portrait mode to identify lamprey depth distributions within the sample volume. The camera was also periodically raised and lowered into the water column or programmed to tilt at 10-min intervals to obtain information on the direction of movement within depth strata. Lamprey data collected from DIDSON image files included number of lamprey observed, range from camera (m) and angle from center for each passage event, and locations and durations of lamprey attachment to structures. We also summarized the total number of white sturgeon (*Acipenser transmontanus*) events.

Results/Management Action: We collected 689 hrs of DIDSON imagery at Bonneville Dam and 773 hrs at John Day Dam in 2012. Stratified random sampling of the DIDSON imagery is currently underway with multiple viewers and example imagery will be presented. Preliminary qualitative findings will be presented on (1) distribution and movement patterns of lamprey near the entrance of the Washington shore fish ladder (NDE) and junction pool at Bonneville Dam (2) distribution and movement patterns inside the John Day Dam north fishway entrance area, collection channel, and transition pool, (3) behavior of lamprey that encounter the bollard field, and (4) lamprey interactions with sturgeon. Results from this study will help evaluate recent modifications, provide information on potential underlying mechanisms responsible for passage failures, and guide the design of future fishway modifications.

Development of 3-D Modeling Tools to Document Fish Passage Information and Prioritize Improvements at Lower Columbia River Dams, 2012.

Christopher C. Caudill, Hattie Zobott, Matthew L. Keefer, and Ralph Budwig

ABSTRACT

Background: Management of adult Pacific lamprey and other anadromous fishes in the Columbia Basin is intimately tied to the structure and operation of fishways. Efficient decision making by the regional fish managers requires common knowledge of a diverse set of information sources about fishway structure, configuration, operations, fish passage data, and recent modifications. In an effort facilitate efficient communication and to support prioritization of future fishway modifications for adult Pacific lamprey, we developed a three-dimensional fishway model of the Bonneville Washington Shore fishway that can serve as a "wiki" that provides rapid and spatially linked access to diverse information sets.

Methods: We evaluated the costs and benefits of several software platforms for the modeling using criteria related to cost, accessibility, and ease of use. Google/Trimble *Sketchup* was selected because the platform is adaptable, has well-developed user support, and can be easily customized for specific applications. In particular, Sketchup can readily imbed links to files within the model to allow for spatial reference to ancillary information sources (photos, videos, reports, etc).

Results: We used Sketchup to develop a base model of the 3D-geometry of the Washington Shore fishway, including PH2 entrances, overflow weir sections, and upper ladder sections. The base model was then populated with data layers including water level at low, average and high tailwater elevation, telemetry monitoring locations, photos of important structural elements, and passage data. We will present a basic orientation to the Sketchup modeling software and the base 3-D model, a demonstration of the major functionality and capabilities of the 3D fishway wiki, and identify future refinements to the model.

Using the Juvenile Salmon Acoustic Telemetry (JSATS) system to Evaluate Adult Pacific Lamprey Movements and Fate in Columbia River Reservoirs

Christopher Noyes, Christopher C. Caudill, Daniel Joosten, Tami Clabough, and Eric Johnson

ABSTRACT

Background: Substantial proportions of adult lampreys released in recent telemetry studies have failed to pass Bonneville Dam or had last records in Bonneville Reservoir. Battery life of radio transmitter tags limit their effectiveness for monitoring overwintering behavior and the detection ranges of both radio- and PIT-tag arrays are inadequate for tracking lamprey movement in reservoirs and habitats downstream of Bonneville Dam. In this study, we evaluated the effectiveness of a stationary array of acoustic JSATS receivers for monitoring the migration of JSATS-tagged adult Pacific lampreys in Bonneville Reservoir. In addition, we continued to monitor for movement of the 85 lamprey we tagged in the summer of 2011 with JSATS tags rated for 400-day tag life.

Methods We tagged 300 adult lampreys with 400-day duration JSAT tags from 5 June through 1 September 2012. All fish were trapped at Bonneville Dam (rkm 235) in either the Adult Fish Facility or the Cascade Island LPS. A total of 146 fish were released upstream of Bonneville Dam at the Stevenson, WA or Cascade Locks Marina. The remaining 154 fish were released into the Bonneville Dam tailrace. We deployed gates of one to three receivers at thirteen locations: Rooster Rock, OR (rkm 209.7), Dodson, OR (rkm 225.6), Cascade Locks Marina (rkm 239.1), Stevenson, WA (rkm 243), near the White Salmon River mouth (rkm 269.7), Hood River, OR (rkm 273), near the Klickitat River mouth (rkm 290.3), Lyle, WA (rkm 291.7), the tailrace of The Dalles Dam (rkm 304.9), downstream and upstream of Miller Island (rkm 326 and 233.7), near the Deschutes River mouth (rkm 328.2), and in the John Day River 1.2 km upstream of the mouth (rkm 352).

Results Of the 85 lamprey we tagged with JSATS transmitters in 2011, seven (8.2%) were subsequently detected in 2012. Five of these fish were last recorded in 2012 near the mouths of Bonneville Reservoir tributaries. One fish was last detected in Stevenson, WA, and another fish was last detected 6.7 km downstream from the Hamilton Island release site. Analysis of records for 2012 JSATS-tagged adults is currently underway and we will present results on migration rates to upstream sites and the distribution of tagged adults through early fall 2012.

Use of Non-Invasive Methods to Evaluate Pacific Lamprey Counts and Passage Behavior at The Dalles and John Day Dams – 2012

Christopher A. Peery, Brian McIlraith, Don Thompson, and Frank Loge

ABSTRACT

Background: Critical for any management action directed at reversing the declines of Pacific lamprey is to have reliable estimates of population size, to be able to track changes over time and to help set priorities for research and restoration efforts. Developing accurate counts of lamprey is difficult because lamprey are primarily nocturnal in their behavior and they are able to use alternate routes that bypass fish count stations. In 2011, we tested use of underwater video cameras to count adult Pacific lamprey passing fishway count stations at The Dalles and John Day dams. In 2012, we repeated this effort and added video monitoring at weirs within the fishway and tested use of DIDSON to image and document lamprey numbers.

Methods: A total of 13 video cameras were installed in the fishways at The Dalles and John Day dams to observe upstream passage of adult Pacific lamprey. Nine underwater cameras were used to observe lamprey that moved though picketed leads and thus bypass the four count station slots. Four additional cameras, two each in the north fishways at The Dalles and John Day dams, were used to observe passage at a vertical slot weir upstream of the count stations. All cameras were connected to multi-channel computer servers to record video images. The DIDSON was tested in the north fishway at The Dalles Dam, upstream of the location being monitored with video so that the two methods could be compared.

Results/Management Action: Cameras were operational 24 hrs/d from 19 July until 7 October 2012. Image quality varied significantly based on water visibility and lighting conditions. In some cases, infrared (IR) lighting had to be replaced with white light sources to make nighttime images usable. Computer servers were an effective method to record the large quantity of video generated during this work. Processing video images of this type continues to be a challenge. Video data is currently being processed. The DIDSON was operated continuously from 4 to 12 September 2012 and was effective at recording lamprey images at the location tested independent of visibility. As with video images, processing DIDSON data will need to be automated in order to be used as a routine monitoring tool.

Enumeration and Evaluation of Adult Pacific Lamprey Escapement and Behavior in Underwater Video at McNary and Ice Harbor Dams with the Application of Computerized Imaging Software (AVEDac)

Frank Loge, C. Negrea, Christopher C. Caudill, and Donald Thompson

ABSTRACT

Background: Accurately enumerating escapement is central to the managing Pacific lampreys and other anadromous fishes. Past research has demonstrated that lampreys may pass behind picketed leads (used to crowd salmonids into count windows) and thus avoid detection at the count window at some projects. To promote lamprey passage, the U.S. Army Corps of Engineers raised the picketed leads 1.5 inches off the ladder floor at all Columbia and Snake River projects in 2011, and we used non-invasive underwater video monitoring to record lamprey behavior and counts behind picketed leads at the McNary and Ice Harbor dams. In 2012, picketed lead video monitoring continued at these locations, as well as video monitoring of "lamprey orifices" in the McNary and Ice Harbor dam fishways. Lamprey orifice monitoring was used to assess whether the orifices negatively impacted or delayed salmonid runs. Collectively, these camera installations generated tens of thousands of hours of video data and led to development of automated computer processing software. This software (automated event detection and event classification, or "AVEDac") was used to reduce video annotators' workload by detecting and classifying objects of interest.

Methods: In 2012, eleven low-light video cameras and infrared lighting were installed behind the picketed leads at McNary and Ice Harbor fish ladders and operated continuously from June through mid-October, generating over 33,000 hours of video. Night video counts were also conducted at Ice Harbor for the second consecutive year. Lamprey video counts behind the picketed leads were summed with counts at the windows to enumerate lamprey escapement for both projects. Lamprey orifices were monitored during early and peak Chinook, steelhead, and sockeye runs. Improvement of the AVEDac event classifier continued and incorporated fish features specific to body contour using a mixture of body shape features and swimming motion.

Results: Through September 15 2012, 631 lampreys were observed in video swimming upstream behind picketed leads at the McNary south ladder, corresponding to 53% of the total counted at the window (1,191 lampreys) during the same period (day and night counts). This is a similar proportion to video picketed lead counts in 2011. Eighty six percent (543) lampreys passed directly upstream under the picketed lead gap. Video review of other locations (picketed leads and lamprey orifices) is ongoing and results will be presented. AVEDac software was used to process raw video from all cameras to obtain highly condensed clips for annotation by human observers. AVEDac was tested against video from count windows, picketed leads, and lamprey orifices to assess correct automatic identification of lampreys and salmonids. The results suggest that video monitoring of alternative lamprey passage routes past count windows and lamprey orifices are important for determining lamprey escapement and potential risks to salmonid runs, and result in more video data than human observers can economically or practically review without image processing software.

Application of DIDSON and Underwater Video to Evaluate Adult Pacific Lamprey Behavior and Passage Performance at the McNary Dam South Fishway Entrance

Frank Loge, Christopher C. Caudill, and Donald Thompson

ABSTRACT

Background: The U.S. Army Corps of Engineers changed the entrance slot at McNary Dam South Fishway Entrance SFE2 in 2012 to promote lamprey passage. Previous lamprey-related operations at the McNary SFE structures involved reducing the water velocity at night in both entrance channels, which reduces water velocities at the entrances and is known to have improved lamprey entrance rates at Bonneville Dam. In 2012, operators raised the SFE2 segmental gate 18" off the fishway floor to create a bottom gap with a deep-slot attraction plume, thus providing an alternative lamprey entrance lower in the water column. We used non-invasive means (optical and DIDSON sonar video) to study lampreys in the SFE under various operational schemes, both to understand the effects of structures and flow on lamprey approach and passage, and to provide supporting information for a future alternative lamprey passage structure, currently planned for installation at the McNary SFE2 in 2014.

Methods: At SFE2, two DIDSON cameras with pan-and-tilt capability were installed and operated from July 10 to September 3, recording from 21:00 to 05:00. One camera was directed upstream at the deep slot and segmented gates, and one aimed downstream at the entrance. These cameras followed a programmed sampling pattern, panning on the horizontal axis and tilting on the vertical axis to sample the channel volume, three times nightly. Additionally, six optical video cameras were mounted at SFE2 to observe lamprey passage at the deep slot and over the gates, and three optical cameras mounted at SFE1 to observe lampreys at this unmodified entrance. Optical video cameras were operated around the clock over the entire monitoring period. DIDSON data was processed using the DIDSON software's "echogram" feature to remove "dead space" prior to visual review, while optical video was processed using specialized event-detection software to perform a similar function.

Results: Over 12,000 hours of optical video and 768 hours of DIDSON video were thus processed. In the DIDSON video, lamprey targets were successfully discerned from salmonids, and their direction, depth, and heading recorded, as well as whether they passed through the deep slot or over the gates. 115 lampreys were observed in the downstream-facing camera, with 64%, 29%, and 7% detected, respectively, in the bottom, middle, and upper sections of the water column. Twelve lampreys were observed in the upstream-facing camera, with five observed passing the deep slot and five over the gates. Optical video, still under review, indicates roughly the same number of lampreys using the slot as the top of the gate to pass, with more lampreys observed at SFE2 (with a deep slot) than at SFE1 (without a slot). Initial results indicate that: given proper technique and application, DIDSON technology can reliably image lampreys; the modifications to SFE2 may attract more lampreys; and the deep slot does not impede (and may improve) entrance passage for lampreys.

Passage Bottlenecks and Prioritization Planning: Highlights from the Adult Lamprey Data Synthesis

Matthew L. Keefer, Tami Clabough, Michael Jepson, Eric Johnson, Charles Boggs, and Christopher C. Caudill

ABSTRACT

Background: The Corps Portland and Walla Walla districts have funded a variety of adult Pacific lamprey (*Entosphenus tridentatus*) research and monitoring studies since 1997. We recently completed a synthesis report that summarizes lamprey behavior and dam passage data collected in these projects and additionally presents results from lamprey passage modeling tools developed using the monitoring data. The synthesis document and associated tools are intended to facilitate deliberation on adult lamprey passage planning – as described in the Corps Pacific Lamprey Passage Improvements Implementation Plan 2008-2018 – and to help identify potential priority sites for fishway remediation projects.

Methods: This presentation presents results from two primary synthesis components: 1) data synthesis from the Corps-funded radio-telemetry (1997-2002, 2005-2010) and half-duplex PIT-tag (2005-2011) studies; and 2) results from models developed to help prioritize investments in lamprey passage improvements at individual dams ('fishway bottleneck' models) and to prioritize investments among dams (escapement models). The models were developed using passage efficiency data from the radio-telemetry and PIT-tag synthesis. They allow users to assess and compare potential benefits of fishway improvements at a variety of spatial scales.

Results/Management Action: The data synthesis results indicate that fishway entrance, fishway segment, total fishway, and dam passage efficiency estimates are consistently lowest at Bonneville and John Day dams. Lamprey performance was up to 50% higher at The Dalles and McNary dams, though still much lower than reported for adult salmonids. Lamprey samples sizes at Snake River dams precluded meaningful comparisons. We identified up to a 10-fold difference in lamprey passage efficiency estimates among fishway entrances and fishway routes used to attempt dam passage. Sites where lamprey chronically had difficulty moving upstream included fishway transition pools, collection channels and entrances. Additionally, the top-of-fishway serpentine weirs at Bonneville Dam present a significant passage problem. The bottleneck relief models indicated that serpentine weirs, the Powerhouse 2 junction pool/transition pool, and the Powerhouse 1 (A-branch) transition area may be the highest priority sites for future improvements at Bonneville Dam. At The Dalles, John Day, and McNary dams, transition areas were also identified as potential priority sites. The upriver escapement models suggest that Bonneville Dam should remain the highest priority site given the number of lamprey affected. However, incremental improvements at multiple dams were also shown to provide significant upriver escapement benefits.

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Last Name	First Name	Agency	Sub-Agency	City, State
Barrows	Marshall	US Fish & Wildlife Service	Columbia River Fisheries Program	Vancouver, WA
Borde	Amy	Pacific Northwest National Laboratory	Marine Sciences Laboratory	Sequim, WA
Bottom	Daniel	NOAA Fisheries	Northwest Fisheries Science Center	Newport, OR
Brown	Richard	Pacific Northwest National Laboratory	Ecology Group	Richland, WA
Buenau	Kate	Pacific Northwest National Laboratory	Marine Sciences Laboratory	Sequim, WA
Caudill	Christopher	University of Idaho	Fish Ecology Research Lab	Moscow, ID
Coleman	Andre	Pacific Northwest National Laboratory	Hydrology Group	Richland, WA
Colotelo	Alison	Pacific Northwest National Laboratory	Ecology Group	Richland, WA
Cook	Katrina	Pacific Northwest National Laboratory	Earth Systems Science Division	Richland, WA
Corbett	Steve	NOAA Fisheries	Northwest Fisheries Science Center	Seattle, WA
Deng	Z. Daniel	Pacific Northwest National Laboratory	Hydrology Technical Group	Richland, WA
Diefenderfer	Heida	Pacific Northwest National Laboratory	Marine Sciences Laboratory	Sequim, WA
Dittman	Andrew	NOAA Fisheries	Northwest Fisheries Science Center	Seattle, WA
Ham	Kenneth	Pacific Northwest National Laboratory	Ecology Group	Richland, WA
Harnish	Ryan	Pacific Northwest National Laboratory	Ecology Group	Richland, WA
Hughes	James	Pacific Northwest National Laboratory	Ecology Group	Richland, WA
Johnson	Gary	Pacific Northwest National Laboratory	Marine Sciences Laboratory	Sequim, WA
Keefer	Matthew	University of Idaho	Fish Ecology Research Lab	Bozeman, MT
Ledgerwood	Richard	NOAA Fisheries	Northwest Fisheries Science Center	Hammond, OR
Loge	Frank	University of California, Davis	Energy Efficiency Center	Davis, CA
McMichael	Geoffrey	Pacific Northwest National Laboratory	Ecology Group	Richland, WA
Noyes	Christopher	University of Idaho		Moscow, ID
Oldenburg	Eric	Pacific Northwest National Laboratory	Ecology Group	Richland, WA
Peery	Christopher	US Fish & Wildlife Service	Idaho Fishery Resource Office	Lewiston, ID
Roby	Daniel	USGS-Oregon Cooperative Fish & Wildlife Research Unit		Corvallis, OR
Sather	Nichole	Pacific Northwest National Laboratory	Marine Sciences Laboratory	Sequim, WA
Skalski	John	University of Washington	Columbia Basin Research	Seattle, WA
Smith	Steven	NOAA Fisheries	Northwest Fisheries Science Center	Seattle, WA
van der Leeuw	Bjorn	US Army Corps of Engineers	Portland District, Fish Field Unit	Bonneville Dam
Weiland	Mark	Pacific Northwest National Laboratory	Ecology Group	North Bonneville, WA
Westley	Peter	University of Washington	School of Aquatic & Fishery Sciences	Seattle, WA
Woodley	Christa	Pacific Northwest National Laboratory	Marine Sciences Laboratory	Sequim, WA
Zabel	Richard	NOAA Fisheries	Northwest Fisheries Science Center	Seattle, WA
Zamon	Jen	NOAA Fisheries	Northwest Fisheries Science Center	Hammond, OR
Zorich	Nathan	US Army Corps of Engineers	Portland District, Fish Field Unit	Bonneville Dam