I. FINAL RESEARCH PROPOSAL (COE) (FY13)

TITLE: Measuring avian predation impacts on juvenile salmon through electronic recovery of ISO-PIT Tags from bird colonies in the Columbia River Basin

PROJECT LEADER: Jeannette E. Zamon
National Marine Fisheries Service
Northwest Fisheries Science Center
Fish Ecology Division
Point Adams Research Station
PO Box 155 / 520 Heceta Place
Hammond, OR 97121-0155
(503) 861-1818 x19

ADMIN. OFFICER: Dr. Sandra L. Downing
National Marine Fisheries Service
Northwest Fisheries Science Center
Fish Ecology Division
2725 Montlake Boulevard East
Seattle, Washington 98112-2097
(206) 860-5604

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II. PROJECT SUMMARY

Colonial nesting piscivorous birds consume millions of juvenile salmonids (*Oncorhynchus* spp.) during the smolt migration from watersheds in the Columbia River Basin, through the Columbia River Estuary, and into the ocean (Roby et al. 1998; Ryan et al. 2001). Many of the fish consumed contain Passive Integrated Transponder (PIT) tags with unique identification codes. These tag codes allow scientists to determine the origin of fish consumed and estimate ESU-specific predation rates by comparing individual tag codes with tag records contained in the basin-wide PIT Tag Information System (PTAGIS, http://www.ptagis.org).

For 2013, we propose to continue work initiated in 1998 to estimate avian predation rates on basin-wide juvenile salmon groups that have been PIT tagged. To ensure fish from protected Evolutionary Significant Units (ESUs) below Bonneville Dam are represented among PIT tagged fish, we will PIT tag select groups of Chinook, coho, or steelhead from hatcheries or streams in the Lower Columbia River. We will then use modified PIT tag detection equipment to detect and decode all PIT tags deposited on piscivorous bird colonies in the Columbia River Estuary and elsewhere in the Columbia Basin as necessary (Ryan et al. 2001). Detection efficiencies for tags deposited in 2013 will be measured by deploying known numbers of tags on selected bird colonies before, during, and after the nesting season. Predation rates calculated from PIT tag recoveries will be used to provide required information for future management decisions and current management actions intended to reduce Caspian tern (*Hydroprogne caspia)* and double-crested cormorant (*Phalacrocorax auritas)* predation on juvenile salmonids in the Columbia River Estuary. In addition, PIT tag detections will assist studies seeking to locate areas of salmonid mortality not directly attributable to operation of the hydropower system (Eppard et al.

2003), to improve hydropower system survival estimates, and to compare effects of avian predation on fish transported around the hydropower system with those migrating through the hydropower system.

We will identify Caspian tern and double-crested cormorant colonies likely to affect populations of migrating juvenile salmonids. Once birds complete the nesting season and leave the colonies, we will deploy electronic PIT tag detection equipment on each colony to detect all logistically recoverable tag codes. To estimate site-specific tag detection efficiencies, we will collaborate with Oregon State University (OSU) and Real Time Research (RTR) to place known numbers of PIT tags with known codes on the surface of selected colonies. Placement of these control tags will allow us to calculate tag detection efficiencies for each type of detection method currently in use (flat plate vs. hand-held detectors).

Given the FCRPS research, monitoring, and management needs above, the five primary objectives of our study are:

(1) to provide PIT tagged releases of Lower Columbia River ESUs below Bonneville Dam necessary to measure avian predation effects applicable to Caspian tern and double-crested cormorant management plans and actions,

(2) to survey and recover PIT tag codes from PIT tags deposited on Caspian tern and double-crested cormorant colonies on East Sand Island in the Columbia River Estuary,

(3) to estimate site- and gear-specific PIT tag detection efficiencies,

(4) to calculate and compare avian predation rates on juvenile salmon among different salmon species, rearing types, and migration/hydropower passage histories from PIT tag recovery data, and

(5) to compare avian predation rates of juvenile salmon transported around the hypdropower system to those of juvenile salmon migrating through the hydropower system.

III. BACKGROUND

Rice Island, at river kilometer thirty-four (rkm 34), is a dredge-material-disposal island in the Columbia River estuary that supported a colony of Caspian terns and double-crested cormorants between 1987 and 2001. Approximately 8,000 breeding pairs of Caspian terns inhabited Rice Island annually. The colony consumed millions of juvenile salmonids from the Columbia River (Roby et al. 1998). Because a large number of PIT tagged juvenile salmon are released into the Columbia River basin each year (e.g. over 1 million in 1999), fisheries biologists believed a significant number of PIT tags were being deposited on Rice Island bird colonies and were potentially detectable with modified PIT tag detection electronics.

In 1998, National Oceanic and Atmospheric Administration (NOAA) personnel modified PIT tag detection equipment to recover PIT tag codes from tags deposited near nest sites when fish were captured and consumed by piscivorous birds in the Columbia River Basin (Ryan et al. 2001). Tag detection electronics were then used to survey 14 bird colonies on 10 islands in the mainstem Columbia River. The colony locations ranged from East Sand Island near the mouth of the Columbia River (rkm 8) to Island 18 (rkm 549), approximately 30 km upstream from the confluence of the Snake and Columbia Rivers. Tag codes were also detected on cormorant nests located on channel markers in the estuary and Caspian tern colonies outside of the Columbia

River basin in Potholes Reservoir. To date (2012), PIT tag detection efforts resulted in the recovery of well over 1 million unique tag codes, including codes dating back to 1987, the first year PIT tags were implanted into outmigrating juvenile salmonids in the Columbia River Basin (Prentice et al. 1990).

Concern over impacts to salmon from the Caspian tern colony on Rice Island prompted managers to initiate a tern relocation experiment (Anonymous 1998). This experiment relocated a portion of the colony farther downstream in the Columbia River estuary to East Sand Island (rkm 8) near sources of alternative prey in brackish water. The relocation effort successfully attracted approximately 1,400 breeding pairs to East Sand Island in 1999 and 9,100 breeding pairs in 2000 (Collis et al. 2000), leaving approximately 600 breeding pairs on Rice Island. After 2001, all reported tern nesting activities in the Columbia River Estuary have been on East Sand Island (annual reports and documents available from http://www.birdresearchnw.org). Through 1999, the Caspian tern colony located on Rice Island had been the major tag-detection location. Beginning in 2000, the major tag detection location has been the East Sand Island tern colony (Ryan et al. 2003; Glabek et al. 2003).

While NOAA and NOAA collaborators successfully detected large numbers of PIT tags from avian colonies and estimated predation rates (Collis et al. 2001; Ryan et al. 2001; Ryan et al. 2003), these predation rates have only been available for juvenile salmonids originating upstream from Bonneville Dam because few juvenile salmonids have been PIT tagged from streams that discharge directly into the lower Columbia River below Bonneville Dam (PSMFC 1996). In 2001, we tagged several 3,000-fish groups of juvenile spring and fall Chinook salmon and steelhead from estuary streams for comparison with those PIT tagged fish upstream of Bonneville Dam. In subsequent years, we repeated and expanded lower river tagging efforts by increasing the numbers of Chinook and coho salmon released during the tern and cormorant

nesting season. These tag groups revealed high predation rates of double-crested cormorants on subyearling fall Chinook released below Bonneville Dam (Sebring et al. 2010). Results from tagged Lower Columbia River ESUs suggest there may be concern for Snake River stocks which are being transported in barges past the dams and subsequently released below Bonneville Dam. To address this concern, it will be necessary to compare avian predation rates on transported (barged) vs. non-transported (unbarged) tag groups.

IV. OBJECTIVES

Objective 1 – Tag and release PIT tagged fall Chinook, steelhead, or coho from listed ESUs below Bonneville Dam.

While salmon stocks migrating upstream of Bonneville Dam are relatively well-represented with PIT tagged fish, there is virtually no representation from Lower Columbia River fish because few, if any, of these groups are systematically PIT tagged. This lack of tagging of lower river groups was apparent during the drafting of the Caspian tern Environmental Impact Statement (EIS, USFWS 2005) when attempts were made to evaluate tern predation rates on the Lower Columbia River ESUs. The same EIS process is currently being repeated for double-crested cormorants. The EIS and draft management plan for cormorants are being modeled on the Caspian tern EIS and management plan. Estimates of predation rates by both terns and cormorants on lower river ESUs will be required. Tagging these ESUs will also provide an important comparison group for transported salmon, which bypass hydropower facilities and enter the Columbia River below Bonneville Dam during barge releases.

To provide the required tag groups, we will tag representative groups of subyearling fall Chinook salmon (*O. tshawytcha*), coho salmon (*O. kisutch*), or steelhead (*O. mykiss*) from selected streams and rivers entering the Columbia River below Bonneville Dam. We propose to

PIT tag three (3) groups of 3,000 fish from Lower Columbia River ESUs. There are no other programs we are aware of that can provide quantitative estimates of predation rates on lower river ESUs.

Which species and stocks are ultimately marked in 2013 will depend on fish availability from state hatcheries, evolving research and management priorities, available funding for tags, and whether or not tagging permits are granted. There are a limited number of hatcheries producing fall Chinook, coho, or steelhead below Bonneville. Assuming fish, tags, and permits are all available, we propose to tag Chinook from Big Creek Hatchery (OR) to allow comparison with historical tagging on this project. Tagging this group will take advantage of estuary PIT detection arrays from AFEP Project EST-P-10-1 (Contribution of tidal fluvial habitats in the Columbia River Estuary to the recovery of divers salmon ESUs). Big Creek fish have been detected by these arrays in prior years, providing information on post-release survival in the estuary prior to avian predation events. We also propose to tag Kalama Falls Hatchery (WA) Chinook for similar reasons. The third tag group will be chosen from North Toutle (Chinook), Blind Slough (coho), or Deep River (coho) hatcheries, depending upon fish availability in FY2013.

Objective 2—Survey individual sites and recover PIT tag codes from Caspian tern and double-crested cormorant colonies in the Columbia River Basin.

Previous tag detection efforts from 1998 to 2011 indicated that the primary locations of PIT tag deposition were on breeding colonies of terns and cormorants (Ryan et al. 2001; Ryan et al. 2003; Sebring et al. 2010). For this reason, we expect the primary tag detection locations in 2013 will be the tern and cormorant colonies on East Sand Island, in the Columbia River Estuary.

The focus of the NOAA PIT tag recovery will be on East Sand Island colonies because these are the largest colonies of Caspian terns and double-crested cormorants known in western North America (Lyons 2010). Tag recovery work on East Sand Island is used to derive quantitative estimates of avian predation for at least 10 salmon ESUs:

- Snake River: steelhead, sockeye, spring/summer Chinook, fall Chinook
- Upper Columbia River: steelhead, spring Chinook
- Mid-Columbia River: steelhead, spring Chinook
- Willamette River: spring Chinook
- Lower Columbia River: fall Chinook

PIT tag surveys on other bird colonies along the Columbia River (e.g. Goose Island, Crescent Island, Foundation Island, Badger Island) will be conducted by OSU and RTR collaborators. Each site will be surveyed for PIT tags using established techniques for either flat-plate or hand-held detectors (Ryan et al. 2001). Additional locations or species may be sampled if they are identified by NOAA, NOAA collaborators, or the U.S. Army Corps of Engineers (USACE) as having the potential to produce PIT tag detections as the result of avian predation.

Because tag detections from this project will be used by multiple research groups and management agencies, we shall collaborate with OSU and RTR to agree upon a common, basin-wide avian predation data set for 2013 and to ensure quality control of data collected. As an example of external applications of PIT tag detections from avian colonies, the bird predation data set has been used to separate mortality due to Snake River dams and McNary Dam from mortality not directly attributed to dam passage (Eppard et al. 2003).

Objective 3 – Estimate site- and gear-specific PIT tag detection efficiencies

Detection of PIT tags deposited in the field does not typically occur with 100% efficiency. For example, two or more tags which are deposited closely together in space can cause "tag code collisions" where individual codes are unresolved by the detector equipment, and therefore no tag codes are registered by the detection coils even though tags are present. To estimate detection efficiencies on the colony, NOAA, OSU, and RTR staff will coordinate deployment of known numbers of tags on selected bird colonies. OSU and RTR will be responsible for sowing these control tags on the colonies. Whenever possible, 100 tags with known tag codes will be deposited on the site of interest prior to, during, and after nesting season. The deployment of these control tags will allow calculation of PIT tag efficiencies, and hence allow for a more accurate measure of avian predation rates based on tag detections.

Objective 4 – Calculate, compare, and contrast avian predation rates on juvenile salmon among different species, rearing types, and migration/dam passage histories.

From the PIT tag detections collected collaboratively under Objective 2, we will compare relative predation rates on juvenile salmonids among different ESUs, species, rearing types (hatchery vs. naturally spawned), migration paths, and dam passage histories. Estimates of predation rates will make a critical contribution to ongoing evaluation of waterbird management actions in the Columbia River Estuary and elsewhere in the Columbia River Basin. For example, data generated by the proposed work will be used to evaluate the impacts on specific ESUs falling under the basin-wide Caspian tern EIS (USFWS 2005). Data for a similar EIS will most likely be required for double-crested cormorants nesting on East Sand Island before cormorant management actions can be implemented in full.

Additionally, managers are reducing the area of suitable tern nesting habitat on East Sand Island in hopes of encouraging birds to re-nest outside of the Columbia River Basin. Managers are also using dissuasion tactics (e.g. fencing, harassment) to discourage double-crested cormorants from nesting on parts of East Sand Island. To evaluate whether these management actions do, in fact, produce the desired benefit of reducing estuary avian predation on salmon, it is necessary to continue recovering PIT tags to measure predation rates from these East Sand Island colonies.

Objective 5--Compare avian predation rates on barged vs. unbarged juvenile salmon in the Federal Columbia River Power System (FCRPS).

Because recent analyses show that predation rates on subyearling fall Chinook released below Bonneville Dam are greater than those originating from above the dam (Sebring et al. 2010), there is concern that fish transported in barges around the FCRPS and released below Bonneville may also experience significant mortality from estuary avian predation. If transported fall Chinook salmon spend an increased period of time rearing in the estuary, as lower river fall Chinook are thought to do, then their exposure to avian predation may be significant. We propose to make a comparison of predation rates for both transported and non-transported Snake River fall Chinook salmon to determine whether or not transported fish experience the similar predation rates to fish which migrated through the FCRPS. This information will assist managers in making decisions about the costs and benefits of transporting Snake River fall Chinook salmon to the lower river for release below all FCRPS dams.

V. RELEVANCE

Three Reasonable and Prudent Alternative (RPA) Actions associated with the NOAA Fisheries 2008 Biological Opinion (NMFS 2008), the 2010 Supplemental Biological Opinion

(NMFS 2010), and the Adaptive Management Implementation Plan (AMIP) require FRCPS Action Agencies, including the U.S. Army Corps of Engineers (USACE), to support recovery of PIT tag codes from estuary bird colonies as well as subsequent data processing and analysis necessary to estimate avian predation on juvenile salmon from Columbia Basin ESUs. Action 45 specifies implementation of the Caspian tern management plan, which includes quantitative reduction of tern nesting habitat on East Sand Island and subsequent measurement of tern predation rates on basin-wide ESUs (including lower Columbia River ESUs) through PIT tag recoveries on East Sand Island and other tern colony sites. Action 46 specifies development and implementation of a management plan to reduce double-crested cormorant predation on salmon. The draft management plan at this time, as well as preliminary management actions being implemented on East Sand Island, requires measurement of cormorant predation rates on basin-wide ESUs (including lower Columbia River ESUs), and PIT tag recovery from East Sand Island and other cormorant nesting or roosting areas.

Finally, Action 66 specifically requires monitoring of the tern population impacts on juvenile salmon in the Columbia River Estuary. Core components of this monitoring program are the recovery of PIT tags from East Sand Island and the analysis of tern predation rates based on the tag recoveries.

VI. FIELD METHODS

PIT tag and release Chinook, coho, or steelhead below Bonneville Dam

Tagged fish will be implanted with 134.2 ISO PIT tags, the Columbia Basin standard for contemporary PIT tag work (Marvin 2012). Standard protocols will be observed for anesthetizing fish with MS-222 (tricaine methanesulfonate); implanting tags with single-use,

sterile injectors; and recovering fish from anesthesia. Hatchery fish will be released according to hatchery protocols specified at the host hatchery. Wild fish, if tagged, will be released after recovery back into the habitat from which they were taken. PIT tag codes for marked fish will be recorded on site with a portable transceiver/antenna assembly. Codes will then be uploaded to a laptop computer, checked for duplicates and errors, and then uploaded into the regional PTAGIS database.

PIT tag recovery from bird colonies

Predatory bird colonies to be surveyed will be identified in collaboration with OSU and RTR researchers during already-scheduled monitoring of bird activity in the Columbia River. Initial surveys will be based on previous research conducted by OSU, RTR, NOAA, and Columbia River Inter-Tribal Fish Commission (CRITFC) staff. After birds vacate the colonies (typically late July through early September), NOAA staff, in collaboration with OSU and RTR staff, will conduct ground surveys and determine the most appropriate method for efficient recovery of PIT tag codes, either with a flat-plate antenna or with hand-held, pole-mounted antennas (Ryan et al. 2001).

Target bird colonies will be surveyed with PIT tag detection equipment, boundaries of colonies will be documented, and transect lines established within the colonies to ensure sampling coverage is complete. We anticipate most, if not all, NOAA tag recovery efforts will be concentrated on the tern and cormorant colonies of East Sand Island (Sebring et al. 2010). The flat-plate detector will be deployed using a tractor on the East Sand Island tern colony. It will be passed one time in one direction over the entire colony. We will continue additional passes until numbers of new detections decline to <10%. For example, in 2008 the second pass

over the tern colony on East Sand Island yielded ~ 22% additional new tag detections when compared to the first pass, and the third pass yielded ~4% new tag detections; therefore, three passes was deemed sufficient to provide tag recovery data. Pole-mounted, hand-held antennas will be used on the remainder of the colonies because complex terrain prohibits use of the tractor and flat-plate detector in these areas. Where the pole mounted antennas are used, the colony will be covered by a minimum of two complete passes in opposite directions (Ryan et al. 2001; Ryan et al. 2003).

PIT tag detection efficiency

To evaluate detection efficiencies for PIT tags deposited on bird colonies, NOAA staff, along with OSU and RTR collaborators, will coordinate deployment of known numbers of tags, with known tag codes, on the surface of each colony before, during, and after the nesting season whenever this is logistically possible. Typical deployments will involve 100 tags per date per site. After tag recovery efforts have been completed, detection efficiencies can be calculated for each location, deployment date, and detection gear type.

VII. SCHEDULE

Over the past five years, the schedule for major field and data analysis tasks associated with this project roughly follows the monthly calendar below. We present the cycle in calendar year order for convenience. Actual schedules for PIT tagging and recovery efforts can be very dynamic due to unpredictability in fish availability, bird behavior, and weather. Deadlines for reports to the Anadramous Fish Evaluation Program (AFEP) are determined by USACE.

1. **Jan** – Validate prior calendar year's basin-wide PIT detection data, upload to PTAGIS, organize procurement of tag supplies for Lower Columbia River ESUs, begin writing AFEP annual report based on prior calendar year's data

2. **Feb** – Annual report writing, figures, formatting; order tag supplies
3. **Mar** – Contact hatcheries, field programs to coordinate PIT tagging schedule for Lower Columbia ESUs; prepare and test tagging equipment; coordinate detection efficiency tag deployments; internal NOAA review of AFEP report
4. **Apr** – Schedule PIT tag crews; tagging begins
5. **May** – Tagging continues; finalize AFEP annual report
6. **Jun** – Tagging continues; report tagging to PTAGIS; prepare detection vehicles, equipment; staff training
7. **Jul** – Training continues, test detection equipment; coordinate sampling with OSU, RTR; submit final report to AFEP
8. **Aug** – Caspian tern colony surveys begin
9. **Sep** – Caspian tern colony surveys
10. **Oct** – Double-crested cormorant colony surveys
11. **Nov** – Double-crested cormorant surveys; data verification, compile current year's data tables; file-sharing and data agreement with OSU/RTR, calculate preliminary detection efficiencies and predation rates, data summary/analysis, prepare and deliver AFEP preliminary results presentation
12. **Dec** – AFEP review for proposed 2014 work, clean/inventory/service/store all field gear

VIII. DATA ANALYSIS AND STATISTICS

Data analysis, calculation of avian predation rates

NOAA, OSU, and RTR will agree on a common, basin-wide, PIT tag recovery data set to use for data analysis in FY2013. NOAA will prepare summary data tables, predation rate calculations, and data analyses in a similar manner to that found in previous AFEP reports (e.g. Sebring et al. 2010).

Comparison of transported vs. non-transported juvenile salmon

We will use straightforward descriptive statistics to generate initial data summaries for avian predation rates for transported vs. non-transported juvenile salmon (e.g. distributional histograms, calculations of ranges/means/medians/quartiles). Statistical comparisons avian predation rates on different treatments (transported vs. not transported fish) and co-variates (date) will follow logistic regression techniques employed by Ryan et al. (2003). Available

comparison groups and sample sizes will depend upon the level of FY2013 tagging efforts by independent FCRPS transportation projects.

IX. EXPECTED RESULTS AND APPLICABILITY

Basin-wide results from calendar year 2011 PIT tag surveys recovered ~64,000 unique PIT tag codes from fish migrating seaward in 2011. Sixty-five percent of all recoveries were from East Sand Island in the Columbia River Estuary. If birds on East Sand Island are responding to management reductions in nesting habitat as predicted, then we expect the calendar year 2013 tag recovery effort to produce roughly 40,000 to 60,000 unique PIT tag codes from fish migrating seaward in 2013. The continued recovery of PIT tag codes is necessary to determine whether management actions are in fact producing the desired benefit of reducing predation rates on listed salmon in the estuary and in other reaches of the Columbia River. Predation rate data are also required for the U.S. Fish and Wildlife Service (USFWS) and USACE to decide what, if any, additional reductions in tern and cormorant predation will be needed in the future to generate the necessary population response in managed ESUs.

In addition to being used for predation rate calculations, 2013 detections at East Sand Island may also be used by NOAA and USACE for improving survival estimates for ESUs passing successfully through all FCRPS dams. Because actively breeding terns and cormorants have a limited foraging range from nest sites on East Sand Island (e.g. typically < 20 km, Lyons et al. 2005, 2007), birds nesting on East Sand Island are constrained to feed well below Bonneville Dam. Fish with tag codes originating above Bonneville but recovered from East Sand Island must have survived for some period in tidal freshwater, in the estuary, or in the nearshore ocean downstream of Bonneville Dam, and must have passed through the dam alive, independent

of whether or not they were detected at PIT tag monitors at Bonneville. Tag codes recovered from East Sand Island therefore represent fish that survived passage through the FCRPS system to enter tidal freshwater, the estuary, or the nearshore ocean.

X. COLLABORATIVE ARRANGEMENTS

Tagging of Lower Columbia River ESUs will require collaboration with Washington and Oregon hatchery managers and fish biologists from a subset of the following hatcheries: Big Creek, OR; Blind Slough, OR; Grays River,WA; Kalama Falls, WA; and Warrenton High School, OR. Communication with RTR, OSU, Washington Department of Fish and Wildlife (WDFW), and other biologists regarding which bird colonies need to be surveyed will occur. Coordination and collaboration for detection efficiency tag deployments, PIT tag recovery efforts, and quality control/finalization of 2013 avian predation data will take place amongst NOAA, RTR, and OSU staff. Tag detection records will be uploaded to the PTAGIS regional database (Marvin 2012), providing regional scientists and managers with access to data on avian predation.

XI. TECHNOLOGY TRANSFER

Information acquired during the proposed work will be transferred in the form of written and oral research reports as required for the AFEP process. Data from efficiency tag deployment and on-colony tag recovery will be uploaded to the PTAGIS regional database no later than two weeks after all field activities are completed. A draft report for calendar year 2013 results will be available 01 July 2014; calculations for the report cannot be completed until the majority of basin-wide PIT tag data from fish tagged in 2013 have been loaded into PTAGIS. The final report will be completed after internal NOAA and USACE review.

XII. KEY PROJECT PERSONNEL

Sandy Downing – Administrative Officer

Jeannette E. Zamon — Project Leader

Benjamin Sandford – Statistician

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