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Anadromous Fish Evaluation Program

By:

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Title: **Evaluate the Impacts of Avian Predation on Salmonid Smolts from the Columbia and Snake Rivers**

Study Code: AVS-W-03

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SUMMARY

This study is designed to help determine to what extent avian predation on the Columbia River Plateau reduces survival and limits recovery of ESA-listed salmonid stocks. We will investigate the distribution, colony size, productivity, and diet of piscivorous waterbirds at breeding colonies on or near the mid-Columbia and Snake rivers, including Caspian terns (*Sterna caspia*) and double-crested cormorants (*Phalacrocorax auritus*), to determine which waterbird colonies pose the greatest risk to smolt survival. The primary objectives of this study are to determine (1) the fish species comprising the primary prey for piscivorous waterbirds nesting at selected colonies on the Columbia Plateau and, in particular, the proportion of the diet that consists of juvenile salmonids; (2) the size of each waterbird colony (number of breeding pairs); (3) nesting success at each colony (average number of young fledged per breeding pair); and (4) factors limiting the size and productivity of each colony, to the extent possible. Bioenergetics modeling and smolt PIT tag recoveries will be used to assess the relative impacts of piscivorous waterbirds on different species and stocks of juvenile salmonids from the Columbia River basin. Data will also be collected to assess the biotic and abiotic factors that account for differences in smolt vulnerability to avian predators on the Columbia Plateau. Finally, we will evaluate to what extent piscivorous waterbird management elsewhere (e.g., in the Columbia River estuary) affects the distribution and abundance of piscivorous waterbirds and their impacts on the survival of salmonid smolts on the Columbia Plateau. Data collected as part of this study will help guide managers in developing management initiatives for reducing smolt losses to avian predators along the mid-Columbia and lower Snake rivers, initiatives that are science-based, defensible, cost-effective, and have a high probability of success. These research objectives will be addressed with four years of funding; field data collection during FY07-09 and the completion of a final multi-year report in FY10. Some details of the objectives and tasks described in this proposal for continued support may need to be modified and/or adapted following subsequent field seasons as new data, techniques, and results become available.

BACKGROUND AND RATIONALE

Previous research has measured population trends, diet composition, and consumption of salmonid smolts by piscivorous waterbirds nesting at colonies along the lower and mid-Columbia River (Collis et al. 2001; Collis et al. 2002; Roby et al. 2002; Roby et al. 2003; Ryan et al. 2003; Anderson et al. 2004; Suryan et al. 2004; Antolos et al. 2005). A system-wide assessment of avian predation using the available data suggests that the most significant impact of avian predation on survival of juvenile salmonids occurs in the Columbia River estuary, followed by McNary Pool (Collis et al. 2001; Collis et al. 2004). Although the overall annual consumption of juvenile salmonids by avian predators is an order of magnitude less at bird colonies on the mid-Columbia River compared to colonies in the Columbia River estuary (*ca.* 1 million versus ca. 10 million, respectively), predation rates on some in-river migrant fish from the Snake River are as high or higher on the mid-Columbia as in the estuary (Ryan et al. 2003; Collis et al. 2004; Antolos et al.

2005; Roby et al. 2005). For example, predation rates by Caspian terns on in-river migrating, PIT-tagged smolts from the threatened Snake River Steelhead ESU were quite similar for terns nesting at the East Sand Island colony (river km 8) and those nesting at the Crescent Island colony (river km 510) (10.8% and 13.9%, respectively; averaged over 2004-2005; A. Evans, RTR, unpublished data). This result is surprising because the Crescent Island tern colony is roughly 1/20th the size of the East Sand Island tern colony in the Columbia River estuary (Roby et al. 2005). The reasons for the high vulnerability of Snake River steelhead to predation by Crescent Island terns (and perhaps other avian predators on the mid-Columbia River) is not clearly understood, and will be one of the major research tasks addressed in the next phase of this study.

Caspian terns and double-crested cormorants are the two species of piscivorous waterbirds responsible for the vast majority of losses of salmonid smolts to avian predators in the Columbia River basin (Collis et al. 2002; Collis et al. 2004; Roby et al. 2005). The Caspian tern colony on Crescent Island, just below the confluence of the Snake and Columbia rivers, is the largest of its kind on the Columbia Plateau at about 500 breeding pairs (Collis et al. 2004; Roby et al. 2005). Also near the confluence, on Foundation Island (river km 519), is the largest double-crested cormorant colony on the mid-Columbia River at more than 300 nesting pairs (Collis et al. 2004; Roby et al. 2005). Annual smolt consumption by the Crescent Island tern colony has ranged from 440,000 to 680,000 smolts during 2000-2005 (Roby et al. 2005). Annual smolt consumption by Foundation Island cormorant colony is currently unknown, but is likely to be somewhat less than for Crescent Island terns due to the smaller size of the colony and the lower percentage of salmonids in the diet (Roby et al. 2005). It should be noted, however, that unlike the Crescent Island tern colony, which has remained relatively stable in size, the Foundation Island cormorant colony has been growing steadily (20% increase over the past three years; Roby et al. 2005). The prospects for further growth in numbers of double-crested cormorants nesting along the mid-Columbia and Snake rivers is good because double-crested cormorants are not as constrained by the availability of suitable nesting habitat as are Caspian terns; cormorants commonly nest in trees, on navigational structures, on bridges, and on the ground, both on bare substrate and amidst vegetation. Furthermore, unlike terns, which migrate out of the region following the breeding season, a sizable but unknown number of cormorants spend most or part of the non-breeding season on the mid-Columbia and lower Snake rivers and the impacts of these post-breeding birds on smolt survival, particularly late migrating fall Chinook salmon, are unknown. Based on all these considerations, plus the much higher food requirements of cormorants compared to terns, it is possible that the impact of cormorant predation on smolt survival may soon eclipse that of tern predation in the region, just as has been recently observed for terns and cormorants nesting in the Columbia River estuary (Collis et al. 2004; Roby et al. 2005). Another major task of this study is to quantify the effects on salmonid smolt survival of the growing numbers of double-crested cormorants on the mid-Columbia and Snake rivers, both during and after the breeding season, and to determine what salmonid stocks are most vulnerable to cormorant predation and why.

A number of large breeding colonies of other piscivorous waterbirds (i.e., California gulls [*Larus californicus*], ring-billed gulls [*L. delawarensis*], American white pelicans

[*Pelecanus erythrorhyncus*]) currently exist along the mid-Columbia River (Roby et al. 2005). Previous research (Collis et al. 2002; B. Ryan, NOAA Fisheries, unpublished data) indicated that smolt losses to gulls and pelicans on the Columbia Plateau were insignificant compared to those caused by Caspian terns and double-crested cormorants nesting on the lower and mid-Columbia River. Recent data, however, suggest that gull and white pelican colonies along the mid-Columbia River may be growing (Collis et al. 2004; Roby et al. 2005), and that predation on juvenile salmonids may be increasing, potentially reaching levels that are of concern to fisheries managers. For example, the American white pelican colony on Badger Island (river km 511) has increased four-fold from 2001-2005 to more than 1,000 adults counted on colony in 2005. Recent evidence suggests that a second American white pelican colony may have become established along the lower Yakima River (J. Siegel, YIN, personal communication), where pelican predation on juvenile salmonids from the Columbia Basin has been documented (Major et al. 2003). As part of this study, we will determine the population trajectories and diet of other piscivorous waterbirds in order to determine the magnitude and trend for total losses of juvenile salmonids to avian predators on the mid-Columbia and lower Snake rivers.

Further management of Caspian terns to reduce predation on juvenile salmonids in the Columbia River estuary is imminent; the Caspian Tern Management Plan for the Columbia River Estuary currently has as the management goal the redistribution of approximately half of the East Sand Island colony to alternative colony sites in Oregon and California (USFWS 2005; N. Seto, USFWS, personal communication). Management to reduce or limit smolt losses to the expanding double-crested cormorant colony in the estuary is under consideration and may also involve relocation of nesting cormorants to alternative sites. We know that Caspian terns readily move between nesting colonies in the Columbia River estuary and colonies on the mid-Columbia River, based on resightings of banded individuals (Collis et al. 2004; Roby et al. 2005; Y. Suzuki, OSU, unpublished data); this is also probably true for double-crested cormorants. It is likely that at least some of the birds displaced from existing colonies in the Columbia River estuary will relocate to colonies on the Columbia Plateau. As part of this study we will assess the inter-colony movements of banded individuals to determine how bird management in the Columbia River estuary and elsewhere affects the distribution, numbers, and smolt predation rates of piscivorous waterbirds on the Columbia Plateau. These data are critical for confirming that increases in smolt survival associated with piscivorous waterbird management in the estuary and elsewhere are not offset by increased avian predation on juvenile salmonids along the mid-Columbia River.

PROGRAM FUNDING

This proposal is for funding of research, monitoring, and evaluation of avian predation on the Columbia Plateau during 2007-2010. Many of the research objectives and tasks proposed here for the Columbia Plateau are also proposed for the Columbia River estuary with funding from the Bonneville Power Administration as part of their Fish and Wildlife Program. The proposal submitted to BPA also advocates a comprehensive look at avian predation throughout the Columbia River basin during 2007-2009, in addition to the focused investigation of avian predation in the estuary. Although still under review, funding from the BPA in 2007 and beyond looks favorable; however, the recommendation by the Mainstem Systemwide Review Team is for level funding from BPA during 2006-2009, which would preclude support from BPA for RM&E along the mid-Columbia (i.e., would provide funding for estuary studies only). If the MSRT recommendation is accepted, there would be no overlap in funding of research proposed here with that proposed to BPA; as in 2004-2006, BPA would fund the estuary work and the Walla Walla District, USACE would fund the work on the mid-Columbia and lower Snake rivers. In the event that funding from BPA is significantly cut or eliminated during 2007-2009, we would like to request additional funding from the Walla Walla District, USACE as part of this contract in order to collect the necessary information to assess the impacts of avian predators in the Columbia River estuary on salmonid stocks from the Snake River (e.g., predation rates on Snake River stocks based on PIT tag recoveries on East Sand Island tern and cormorant colonies). Finally, we would like to point out that future RM&E on the Columbia Plateau will depend on results from our studies during 2004-2006, results that are not yet available in their entirety. Thus, some flexibility with regard to the details of research objectives, tasks, and funding for this project in out-years may be warranted.

OBJECTIVES AND METHODOLOGY

Objective 1. Research, monitor, and evaluate predation on salmonid smolts by Caspian terns on the Columbia Plateau.

Task 1.1. Determine colony size, habitat use, nesting success, and factors limiting colony size and nesting success of the Caspian tern colony on Crescent Island.

Prior to the arrival of breeding terns at Crescent Island, a grid will be placed on the colony to facilitate colony counts and monitoring of nesting success. Direct counts of adult terns on the colony will be conducted at frequent intervals from an observation blind at the edge of the colony and averaged over 2-week periods throughout the nesting season. Counts of incubating adult terns late in the incubation period will used to estimate the size of the Crescent Island tern colony (see Roby et al. 2002). Multiple counts will be conducted in order to calculate 95% confidence limits for the estimate of the number of breeding pairs. An aerial photo of the colony will also be taken late in the incubation period to determine habitat use and total colony area occupied by nesting terns. Colony size and habitat use will be compared with previous years and among colony sites.

Nesting success at the Crescent Island colony will be measured using ground counts of young terns near fledging age (see Roby et al. 2002). Multiple counts will be conducted in order to calculate 95% confidence limits for the estimate of the number of fledglings produced at the colony. We will determine average clutch size, hatching success, and nestling survival rate for a sample of nests on the colony. Nesting success (i.e., productivity) will be compared with previous years and among colony sites.

Data will also be collected on gull kleptoparasitism rates on terns, disturbance rates to the tern colony, predation rates on tern nests, and other causes of tern nesting failure in order to evaluate those factors that limit nesting success at the Crescent Island Caspian tern colony.

Task 1.2. Determine diet composition and consumption of juvenile salmonids by Caspian terns nesting on Crescent Island.

The taxonomic composition of the diet of Caspian terns nesting on Crescent Island will be determined by direct observation of adults as they return to the colony with fish (i.e., bill load observations). The target sample size will be 150 bill load identifications per week at Crescent Island. Prey items will be identified to the taxonomic level of family. We will identify prey to species, where possible, and salmonids will be identified as either steelhead or 'other salmonids' (i.e., Chinook salmon, coho salmon, or sockeye salmon). Steelhead will be distinguished from 'other salmonids' by the shape of the anal and caudal fins, body shape and size, coloration and speckling patterns, or a combination of these characteristics. The percentage of each prey type among the identifiable prey items in tern diets will be calculated for each 2-week period throughout the nesting season. The diet composition of terns over the entire breeding season will be based on the percentage of each prey type during each 2-week periods, adjusted for the average colony size during that 2-week period. Samples of fish transported by terns to the colony will not collected at the Crescent Island tern colony due to the potential impact of this type of sampling on such a small colony.

Estimates of annual smolt consumption for the Crescent Island Caspian tern colony will be calculated using a bioenergetics modeling approach (see Antolos et al. [2005] for a detailed description of model structure and input variables). We will use a Monte Carlo simulation procedure to calculate 95% confidence intervals for estimates of smolt consumption by terns.

Some salmonid smolts that are captured by terns and transported back to the colony are pirated by gulls; at the Crescent Island tern colony these rates of kleptoparasitism can be high. Bioenergetics models do not include estimates of these kleptoparasitized smolts. We will measure kleptoparasitism rates (i.e., stealing of fish carried in the bills of terns by gulls) at the Crescent Island tern colony. We will use focal observations of terns carrying fish to the colony and record the fate of each fish observed. Fish fate will be classified as either a kleptoparasitism, courtship feed, chick feed, self feed, gull chase/no feed, tern chase/no feed, or left colony/no feed. These data will be used to estimate the proportion of fish captured by terns that are consumed by terns relative to the proportion captured by terns that are kleptoparasitized by gulls. These data will then be used to adjust estimates of smolt consumption by terns (see above) to account for fish kleptoparasitized by gulls.

Task 1.3. Determine species and stock-specific (where feasible) predation rates on juvenile salmonids from the Snake and Columbia rivers by Caspian terns nesting on Crescent Island.

We will assess species and stock-specific predation rates using salmonid tags recovered at the Crescent Island tern colony (see Ryan et al. 2001a, 2001b; Collis et al. 2001; Glabek et al. 2003; Ryan et al. 2003; Antolos et al. 2005). Each year millions of juvenile salmonids in the Columbia River basin are implanted with passive integrated transponder (PIT) tags to gather information on downstream survival and behavior. These tags provide data on the species of fish, run of fish (when known), release date, release location, and other information. Thousands of these tagged fish are consumed annually by avian predators, and the tags deposited on nesting colonies throughout the Columbia River basin (Collis et al. 2001; Ryan et al. 2001a; Ryan et al. 2003; Antolos et al. 2005). On-colony recoveries of PIT tags, along with detections of PIT-tagged smolts migrating in-river, can be used to estimate minimum stock-specific predation rates and relative vulnerability of salmonid stocks to avian predators (Collis et al. 2001; Ryan et al. 2003; Roby et al. 2003; Glabek et al. 2003; Antolos et al. 2005).

We will measure predation rates on different salmonid species, run types, and stocks (as defined by NOAA Fisheries' Evolutionarily Significant Units or ESUs) for those groups of fish where a sufficient sample is tagged. For Caspian terns nesting on Crescent Island, stock-specific predation rates will be generated for PIT-tagged fish migrating in-river past Crescent Island (i.e., excludes all PIT-tagged smolts captured at dams on the lower Snake River and transported past Crescent Island). Predation rate estimates do not account for mortality that takes place between the fish's release location and the detection site (i.e., Crescent Island) and, as such, under-estimate tern predation rates because the numbers of smolts susceptible to tern predation are somewhat inflated.

A more direct or reach-specific measure of tern predation rates will be calculated by limiting the analysis to actively-migrating smolts that were last detected within the foraging range of Crescent Island terns. For Snake River stocks, PIT tags used in analyses will be from smolts that have been tagged and released into the river above Crescent Island and interrogated passing Lower Monumental Dam (lowest PIT tag interrogation point on the Snake River). Similarly for Upper Columbia River stocks, PIT tags will be from smolts that have been interrogated or tagged at Rock Island Dam (lowest PIT tag interrogation point on the Columbia River above Crescent Island). On-colony detection rates will be calculated by simply dividing the total number of tags detected on the Crescent Island tern colony (sorted by location, species, and stock) by the corresponding number of interrogated PIT-tagged fish. Temporal trends for reach-specific predation rates will be investigated based on the passage date of interrogated smolts.

To more accurately assess the impact of Crescent Island terns on salmonid stocks from the Snake River, tern predation rates will be corrected to account for the proportion of those stocks that were collected for transportation and bypassed the federal hydrosystem in barges or trucks (NMFS 2000). These transported fish are not available as prey for Crescent Island terns. This correction is not necessary for Upper Columbia River stocks because there is no smolt transportation program at Columbia River dams above Crescent Island (i.e., all Upper Columbia River smolts must migrate in-river past Crescent Island).

Accurate data on the abundance of smolts within a given river segment are needed to derive consumption estimates from predation rates based on PIT tag recoveries (i.e., by multiplying the total number of available smolts by the corresponding predation rate estimate); thereby calculating predation rates relative to the proportion of smolts available to Crescent Island terns. In cooperation with NOAA Fisheries (POC: Ben Sandford), we will estimate absolute abundance of smolts downstream of Lower Monumental Dam so that predation rate estimates using the PIT tag data can be used to generate consumption estimates of various salmonid species and stocks. Absolute abundance estimates will be generated by dividing daily smolt passage counts at the dam by daily PIT tag detection probabilities (see Sandford and Smith 2002), using a bootstrap method to calculate variance. We can then compare two independently-derived estimates of consumption (i.e., based on PIT tag recoveries and from bioenergetics modeling) as a way to validate our consumption estimates for Crescent Island terns.

Predation rate estimates based on PIT tag recoveries are minimums because (1) an unknown proportion of consumed tags are deposited off-colony, (2) wind and water erosion removes an unknown number of tags from the colony, and (3) on-colony detection efficiency is < 100% for various reasons (Collis et al. 2004; Roby et al. 2005; Ryan et al. 2003). To address these uncertainties, we will collect data to estimate the magnitude of these biases and these correction factors will then be used to adjust all predation rate estimates derived from PIT tags.

PIT Tag Recovery: As was previously accomplished by NOAA Fisheries, we will detect and recover PIT tags from the Crescent Island tern colony in August of each study year using previously established methods. Physical or hand removal of PIT tags will be used to minimize PIT tag collision (a phenomenon whereby high tag densities renders PIT tags unreadable using electronic equipment). We will physically remove tags from the colony site by breaking up the surface layer of soil with rakes equipped with magnets and then remove tags by rolling large sweeper magnets over the colony surface. To ensure that tags are removed efficiently, 60-cm wide transects will be spread across the colony surface and used to guide removal efforts. Each transect will be swept for tags at least twice. During hand removal of PIT tags, other fish tags (i.e., radio tags, acoustic tags, and floy tags) will also be collected from the colony site and returned to the appropriate project sponsor, if possible.

Following hand-removal efforts, we will systematically scan the Crescent Island tern colony site for PIT tags using a flat-plate detector/transceiver mounted on a four-wheel-drive vehicle, and a hand-held, pole-mounted transceiver to detect tags in areas inaccessible to the flat-plate detector (see Ryan et al. 2003 for detailed methods). All PIT tags detected/recovered using hand and electronic methods will be submitted to NOAA Fisheries and PTAGIS for integration into the regional PIT tag database.

PIT Tag Detection Efficiency: Not all smolt PIT tags that Caspian terns egest on their nesting colony are subsequently detected on-colony after the nesting season. In years past, a correction factor to convert number of detected PIT tags on-colony to number of PIT tags egested on the colony was estimated by distributing a known number of PIT tags on-colony prior to the nesting season, and then assessing detection rates of those tags using electronic equipment after the nesting season (Ryan et al. 2003). Using this single release strategy, NOAA Fisheries estimated a detection rate of only 15.0% and 44.7% at the Crescent Island tern colony in 2002 and 2003, respectively (Ryan et al. 2003). These estimates of detection efficiency were thought to be underestimates, however, because tags placed on the colony early in the nesting season are potentially subject to higher rates of loss and damage compared to PIT tags deposited on the colony later in the nesting season. In 2004, we learned that the systematic sowing of PIT tags on multiple occasions throughout the tern nesting season – as apposed to a single release prior to the nesting season – resulted in a more accurate and defensible estimate of PIT tag detection efficiency (Collis et al. 2004).

In 2007, we will repeat this systematic approach by intentionally spreading 960 PIT tags on the Crescent Island tern colony on four discrete plots on four different occasions: (1) prior to the bird’s arrival on colony, (2) during incubation, (3) during fledging, and (4) following the nesting season once the birds have left the colony. Each discrete plot will measure 5 x 10 m and plots will be located within the core colony area. Detection efficiency estimates will be calculated relative to the release date and the release plot, thereby describing both temporal and spatial variation in detection efficiency.

PIT Tag Deposition Rates: Not all smolt PIT tags consumed by terns are deposited on the nesting colony. Some proportion of the consumed PIT tags is regurgitated by terns while they are not on-colony, for example during flight or at off-colony loafing areas. Therefore, predation rate estimates based on on-colony PIT tag recoveries are still minimums, even after accounting for detection efficiency. In 2004-2006 we conducted two experiments to measure on-colony deposition rates of PIT tags ingested by terns nesting on Crescent Island. First, we allowed terns to forage on PIT-tagged fish confined to net pen enclosures and then scanned for those tag codes at the colony following the nesting season. Secondly, we captured nesting terns on colony and force fed them PIT-tagged fish and then scanned for those tag codes following the nesting season. We believe we now have sufficient data to accurately estimate PIT tag deposition rates for Crescent Island terns, and unless the pending results from this year's analysis suggest otherwise, we tentatively recommend that tern deposition studies be discontinued in 2007.

Task 1.4. Determine how various biotic and abiotic factors are associated with differences in smolt vulnerability to predation by Crescent Island terns.

Avian predation rates vary by salmonid species, run-type, stock, and rearing type (Collis et al. 2001; Ryan et al. 2003). Furthermore, predation rates for specific groups of fish can vary greatly from one year to the next (Antolos et al. 2005; Collis et al. 2004). Despite these well documented trends, limited data are available to determine what biotic and abiotic factors account for differences in smolt vulnerability to avian predators. Previous research suggested that low river flows may be associated with higher avian predation rates (Antolos et al. 2005), that high prey densities may reduce smolt susceptibility to predation (Roby et al. 2005), and that smolt origin (i.e., hatchery versus wild: Collis et al. 2001; Ryan et al. 2003) and "quality" (Mesa 1994; Schreck and Stahl 1998; Schreck et al. 2006) may be associated with differences in predation vulnerability. We will investigate the relative importance of these and other biotic and abiotic factors in explaining differences in tern predation rates on juvenile salmonids, with a focus on Snake River steelhead.

Smolt PIT Tag Data: In 2007, we propose a pilot study whereby run-of-the-river steelhead smolts encountered at the juvenile fish facility at Lower Monumental Dam (LMN) are PIT-tagged for the purpose of addressing questions related to avian predation. The intentional sampling and tagging of steelhead smolts at LMN would allow us to test hypotheses concerning how differences in smolt morphology, condition, abundance, origin, river conditions, and dam operations are associated with differences in smolt vulnerability to avian predation. Lower Monumental Dam represents the edge of the foraging range of Caspian terns nesting at Crescent Island (Collis et al. 2003), making the dam an excellent location to release study fish. Snake River steelhead were chosen for this pilot study because prior research has shown that they are the most vulnerable to predation by Crescent Island terns (Ryan et al. 2003; Antolos et al. 2005; Collis et al. 2004). For example, PIT tag recoveries on the tern colony in 2004 (a low flow year) indicated that the predation rate by Crescent Island terns on in-river Snake River steelhead smolts was 34% (based on the proportion of PIT-tagged smolts interrogated at Lower Monumental Dam that were subsequently recovered on the Crescent Island tern colony; Roby et al. 2005). The benefits of using Snake River steelhead for this study are three fold: (1) we are likely to get sufficient recoveries of PIT tags from Snake River steelhead on the Crescent Island tern colony to address a multitude of predation-related questions (more so than any other salmonid species or stock), (2) the incidence of morphological abnormalities (e.g., fungal infections, descaling, parasites, body injuries, etc.) is greater in steelhead than in other salmonid species (USACE, unpublished data), and (3) a better understanding of those factors responsible for the higher vulnerability of steelhead to avian predation will help resource managers implement measures to reduce avian predation on steelhead, if warranted and feasible.

In cooperation with the Smolt Monitoring Program (SMP), steelhead encountered in the juvenile fish facility at LMN will be sampled and PIT-tagged. Using existing protocols developed by veteran SMP staff, data will be collected on fish length, weight, origin (based on presence/absence and/or quality of fins), and morphological condition of steelhead smolts anesthetized as part of the SMP's on-going efforts at the dam. Physical condition will be scored based on external criteria, including the degree of (1) descaling, (2) head, body, and operculum injuries, (3) fungal infections, (4) bacterial infections, (5) parasite infestation, (6) predator marks (e.g., scars left from a failed predation attempt), and other abnormalities of each fish. Following inspection, each fish will be PIT-tagged (Biomark model TX1400SST) and a digital photo will be taken for later referencing and data validation. PIT-tagged smolts will then be placed in a temporary holding tank for a recovery period. Following the recovery period, the tank will be inspected for mortalities and fish released into the dam's tailrace to resume their downstream migration. An automated data collection system will be developed to assure that sampled fish are processed quickly and a database will be developed to house all information collected on each study fish (i.e., digital photos, PIT tag code, tagging date and time, fish morphometrics, and fish condition).

Steelhead will be sampled at LMN from ~1 April to 30 July (or until steelhead numbers are too low for productive sampling). The target sample size for this study will be 500 steelhead per week during the peak 12-16 week outmigration period for steelhead smolts in the lower Snake River. This proposed sampling effort is within the range of steelhead normally sampled at the juvenile fish facility at LMN in each of the last 5 years (USACE, unpublished data). For temporal trends, a sample of 500 steelhead per week

(week = Sunday to Saturday) would be adequate for statistical comparisons between various subgroups of LMN sampled steelhead (e.g., proportion of hatchery fish versus wild fish recovered) in cases where at least 6% of one subgroup is detected on-colony, with a minimum difference of 5% between subgroup proportions. All sample size calculations provide a statistical power of 80% (beta) at the 0.05 level (alpha). Ultimately, however, the sample size needed to detect a statistical difference in proportions or means within different subgroups of LMN sampled fish will depend on the magnitude of difference between the subgroups and the prevalence of the variable(s) of interest in the sample population. Because few empirical data are available to estimate potential differences in these parameters, we must rely on hypothetical scenarios until data from the first year pilot study become available.

In addition to biotic factors, we will also investigate how abiotic factors (i.e., river conditions and dam operations) account for differences in smolt vulnerability to predation by Crescent Island terns. We will investigate such abiotic factors as water temperature (ºC), inflow (kcfs), outflow (kcfs), spill levels, spill duration, and turbidity, as well as other abiotic variables measured at Lower Monumental and Ice Harbor dams. In addition to data being collected at the dams, we propose to supplement dam-specific measurements by taking similar measurements from in-river water quality monitoring stations located within a 15 Rkm radius of Crescent Island. These data will be used to assess water quality parameters in closer proximity to Crescent Island to determine if substantial differences exist between dam-specific and in-river monitoring locations. The exact location of these proposed water quality monitoring stations will dependent on access permits and further consultation with the USACE.

PIT tag recoveries at the Crescent Island tern colony will be compared within and among subgroups of PIT-tagged steelhead to investigate whether there are differences in tern predation rates relating to fish length, weight, condition, origin (hatchery vs. wild), abundance, and release date. Furthermore, differences in recovery rates of PIT-tagged steelhead will be investigated to determine relationships between tern predation rates and river flows, spill regimes, river temperatures, turbidity, and other environmental factors. Finally, the tagging and condition data collected from run-of-the-river steelhead smolts at LMN will benefit other USACE sponsored analyses in the region, such as in-river smolt and smolt-to-adult survival models annually generated by NOAA Fisheries (Ben Sandford, NOAA Fisheries, personal communication).

Smolt Telemetry Data: Data acquired from steelhead examined and PIT-tagged at LMN will not be sufficient to determine whether smolt travel times, migration behavior, and passage histories (e.g., bypass, spillway, etc) in the lower Snake River are associated with vulnerability to predation by Crescent

Island terns. Data acquired from radio-tagged fish released in the lower Snake River, however, may offer some insight into these factors. We will work collaboratively with NOAA Fisheries (POC: Gordon Axel) and USGS-Columbia River Research Laboratory (POC: Noah Adams) to utilize existing and future smolt telemetry data for these purposes. For example, over 20,000 steelhead, yearling Chinook, and sub-yearling Chinook have been radio-tagged and released upstream of Crescent Island on the lower Snake River since 2003, and each August hundreds of these radio tags are subsequently recovered on the Crescent Island tern (see above). As part of this task, we will start to compile and analyze radio telemetry data collected on the Crescent Island tern colony in years past (2003-2005), as well as facilitate telemetry data collection during the 2007 field season.

To facilitate the collection of data on smolt radio tags deposited on bird colonies in 2007, we propose to establish and maintain radio telemetry receivers on both the Crescent Island tern colony and the Foundation Island cormorant colony (see Task 2.4). Receivers will be programmed to detect fish radio-tagged by either NOAA Fisheries or USGS. Receivers will be placed on-colony prior the arrival of breeding birds on the colony and project staff will periodically download telemetry data throughout the nesting season. Data from the telemetry receivers placed on bird colonies will be used to determine the date that each tag is deposited on the colony. For each radio tag detected at colony, we will work with our collaborators to determine where that fish was depredated and look at the migration behavior and passage histories of those fish to see how those factors might be related to predation rates by terns or cormorants.

Task 1.5. Detect the formation of new Caspian tern colonies on the Columbia Plateau and investigate colony size, habitat use, nesting success, and factors limiting colony size and nesting success of incipient tern colonies.

We will conduct surveys of the distribution and size of Caspian tern colonies on the mid-Columbia River (from the The Dalles Dam to the head of Wanapum Pool) and on the lower Snake River (from the mouth of the Clearwater River to the confluence with the Columbia River), as well as at sites off the Columbia and Snake rivers but within tern foraging range. Aerial, boat, and land-based surveys will be conducted to identify all tern colony sites within the study area. Once new tern colonies have been identified, we will periodically monitor (i.e., bimonthly) the colony to determine tern colony size, productivity, and factors limiting colony size and productivity, when feasible. Once incipient tern colonies become established (i.e., >50 nesting pairs with some nesting success), we will increase our monitoring efforts at that colony in subsequent years (i.e., periodic to weekly) and collect data on diet composition.

We will continue to assist NOAA Fisheries (POC: Tom Good) with the monitoring of Caspian tern colonies on Potholes Reservoir, if warranted. We will also conduct an aerial survey of Potholes Reservoir to locate tern colonies and estimate colony size and habitat use in 2007. If warranted, we will band fledgling terns at colonies on Potholes Reservoir for tracking the dispersal of terns raised on Potholes Reservoir to other tern colonies. Finally, we will provide assistance with on-colony PIT tag removal and analysis (if amenable to NOAA Fisheries; see Task 1.3 for PIT tag recovery methods) following the nesting season. NOAA Fisheries will prepare an annual report summarizing their research findings and provide that report to the U.S. Army Corps of Engineers, Walla Walla District upon request.

Task 1.6. Assess the inter-colony movements, survival, and average age of first reproduction of Caspian terns banded at breeding colonies throughout the western United States.

Available evidence from band recoveries indicates that all Caspian tern colonies west of the Continental Divide in North America constitute one panmictic population (Suryan et al. 2004). Consequently, changes in the size and productivity of Caspian tern colonies outside the Columbia Plateau may have profound effects on the numbers of terns nesting on or within foraging distance of the mid-Columbia River and, consequently, on predation rates on juvenile salmonids from the Columbia and Snake rivers. Also, we do not currently understand some of the fundamental aspects of Caspian tern demography in the Pacific Coast population, such as sub-adult survival rates, average age at first reproduction, and minimum levels of colony productivity needed to ensure sufficient intrinsic recruitment to balance adult mortality. The latter is critical for identifying minimum levels of nesting success to assure a stable colony size in the absence of immigration and emigration.

We will continue to band cohorts of fledgling Caspian terns each year with unique plastic leg bands engraved with unique alphanumeric codes in order to collect information on sub-adult survival and dispersal, and maintain sample sizes of banded adults for measurement of adult survival to be used as input for demographic models. Re-sightings of banded terns will allow us to measure adult survivorship, average age at first reproduction, and juvenile recruitment, three essential parameters for modeling the demography and assessing the status of the tern population. The model, combined with colony size and productivity data, will allow us to reliably predict changes in population size into the future.

Re-sightings of color-banded adult terns will also be used to study dispersal patterns and recruitment of terns formerly banded at colonies in the lower Columbia River and along the coast (see Suryan et al. 2004). By monitoring the size and productivity of unmanaged Caspian tern colonies on the Columbia Plateau, we will assess the relationship between management-related changes in the size and productivity of colonies in the Columbia River estuary and changes in recruitment and reproductive success at colonies on the Columbia Plateau. This will help determine the potential for future impacts of unmanaged Columbia Plateau Caspian tern colonies on the survival of Columbia River basin salmonids.

Objective 2. Research, monitor, and evaluate predation on salmonid smolts by double-crested cormorants on the Columbia Plateau.

Task 2.1. Determine the size, habitat use, nesting success, and factors limiting colony size and nesting success of the double-crested cormorant colony on Foundation Island.

The number of double-crested cormorants breeding on Foundation Island will be estimated using aerial, ground-, and boat-based counts of occupied nests on the island. These counts are minimum estimates of the number of breeding pairs because some nests may be obscured from view by dense vegetation. A sub-sample of nests visible from a blind set up at the periphery of the colony will be monitored for nesting success throughout the nesting season. The ground beneath nesting trees will be searched for signs of nest predation and all potential nest predators observed in the vicinity of the colony will be recorded.

Task 2.2. Determine diet composition and consumption of juvenile salmonids by double-crested cormorants nesting on Foundation Island.

During the 16-week nesting period, we will collect diet samples that are spontaneously regurgitated by nesting adults and their young and by the lethal sampling of 30 adults for stomach contents analysis, if permitted by the USFWS. We will attempt to collect between 150 and 200 regurgitations from the ground underneath trees where cormorants are nesting. We will attempt the lethal collection of 10 adult cormorants with full stomachs during each of three discrete stages of the nesting cycle: (1) egg-laying and early incubation, (2) late incubation/early chick-rearing, and (3) late chick-rearing. These samples will be analyzed in our laboratory at Oregon State University to determine the diet composition of cormorants nesting on Foundation Island. These data will be used to (1) determine the proportion of the diet that consists of juvenile salmonids, (2) estimate the total number of juvenile salmonids consumed based on calculations using a bioenergetics model (see Roby et al. 2003), and (3) estimate predation rates on smolts based on numbers of juvenile salmonids available as potential prey in each migration year (in cooperation with Ben Sandford at NOAA Fisheries). Species-specific genetic markers will be used to identify salmonid smolts collected from cormorant stomach samples. Diet composition and smolt consumption will be compared with previous years and among colony sites.

Task 2.3. Determine species and stock-specific (where feasible) predation rates on juvenile salmonids from the Snake and Columbia rivers by double-crested cormorants nesting on Foundation Island.

The same methods and analytical approach used to determine species and stock-specific predation rates on juvenile salmonids by Crescent Island terns (*see* Task 1.3) will be used for Foundation Island cormorants. For example, PIT tags will be used to assess the relative vulnerability of various salmonid species, ESU's, run-types, and stocks to cormorant predation, based on the proportion of available PIT-tagged smolts subsequently recovered on the cormorant colony (see Task 1.3 for further details on general methods and analytical approach).

Similar to smolt predation rates estimated from PIT tag recoveries on tern colonies, PIT tag recoveries from cormorant colonies must also be corrected for sources of potential bias. The breeding behavior of cormorants, however, differs from that of terns; consequently, some alternative data collection techniques are needed to calibrate estimates of smolt predation rates for cormorants.

<u>*PIT Tag Recovery:*</u> We will recover PIT tags from the Foundation Island cormorant colony in August of each study year using hand-held electronic equipment (see Ryan et al. 2003 for detailed methods). Due to the thick underbrush on Foundation Island, however, it will not be possible to physically remove PIT tags after the nesting season using magnetic rakes and sweepers.

<u>*Nesting Platforms:*</u> Unlike Crescent Island Caspian terns, which nest on bare ground, Foundation Island double-crested cormorants nest in trees. This poses significant challenges for the recovery and detection of PIT tags egested by nesting cormorants on colony. To enhance our ability to detect PIT tags from the cormorant colony on Foundation Island, we will construct a nesting platform near the colony and used social attraction techniques (i.e., decoys and audio playback systems) to encourage cormorants to nest on the platform (see Roby et al 2002, 2005 for more detailed methods). We hypothesized that if we successfully attract cormorants to nest on the platform detection efficiency for smolt PIT tags would be markedly enhanced. Furthermore, by determining the number of cormorant breeding pairs nesting on the platform, we could calculate a per-capita PIT tag consumption rate for this sample of cormorants, which could be used, along with our estimate of colony size, to estimate total consumption of PIT-tagged smolts by cormorants nesting on Foundation Island.

Prior to the 2007 nesting season, we will construct an elevated platform (measuring 6 x 6 m) near the Foundation Island cormorant colony. Silt fencing material will be placed on the surface of the platform to retain PIT tags, and a 30-cm high side wall will be secured around the perimeter of the platform to prevent tags from blowing or washing off the platform during the nesting season. The platform will be top-dressed with sand and an array of 36 truck tires will be placed on the sand. Sticks will then be placed in the center of each truck tire to simulate cormorant nests, providing nest sites for up to 36 nesting pairs on the platform. Cormorant decoys and two speakers broadcasting audio playbacks of the cormorant colony will be used to attract nesting pairs to the platform. If fully successful, cormorants nesting on the platform would represent ~10% of the over-all Foundation Island cormorant population (ca. ~300 breeding pairs in 2005; Roby et al. 2005). The nesting chronology, number of breeding pairs, and nesting success of cormorants on the platform will be recorded throughout the nesting season. If the nesting platform is successful in attracting nesting cormorants in 2007, additional platforms could be installed in subsequent years.

PIT Tag Detection Efficiency: Similar to the Crescent Island tern colony, PIT tags will be systematically sowed on the Foundation Island cormorant colony to calculate detection efficiency. A total of 400 PIT tags will be distributed evenly under nesting trees at the main colony during four discrete time periods: (1) prior to the birds arriving at the colony, (2) during incubation, (3) during fledging, and (4) following the nesting season once all cormorants have left the colony.

Detection efficiency for PIT tags on the nesting platform will be measured by sowing 50 PIT tags on the platform during each of the same four discrete time periods (if this can be accomplished without severe disturbance to cormorants nesting on the platform). Detection efficiency will then be analyzed relative to release date at the main colony and on the platform. We hypothesize that detection efficiency on the main colony will be much less than on the platform colony, and the difference will be used to further calibrate predation rate estimates at each nesting location.

Task 2.4. Determine how various biotic and abiotic factors are associated with differences in smolt vulnerability to predation by Foundation Island double-crested cormorants.

The same methods and analytical approach described for the Crescent Island tern colony (see Task 1.4) will be used for the Foundation Island cormorant colony. Results from Foundation Island cormorants will be compared to those from terns to evaluate differences between these two species of avian predators, and to evaluate the combined impact of both bird colonies on survival of steelhead smolts PIT-tagged and released at LMN. Based on PIT tag recoveries from the Foundation Island cormorant colony in 2005, we anticipate fewer LMN steelhead tags will be deposited and detected on the cormorant colony compared to the tern colony (Roby et al. 2005), which may limit what questions can be addressed with the available PIT tag data from the Foundation Island colony due to sample size constraints.

Similar to Task 1.4, smolt telemetry data will also be compiled and evaluated for Foundation Island cormorants (for years when data exist) in collaboration with NOAA Fisheries (*see* Task 1.4, "Smolt Telemetry Data" for more details).

Task 2.5. Detect the formation of new double-crested cormorant colonies on the Columbia Plateau and investigate colony size, habitat use, nesting success, and factors limiting colony size and nesting success of incipient cormorant colonies.

We will conduct surveys of the distribution and size of double-crested cormorant colonies on the mid-Columbia River (from the The Dalles Dam to the head of Wanapum pool) and on the lower Snake River (from the mouth of the Clearwater River to the confluence with the Columbia River), as well as at sites off the Columbia and Snake rivers but within cormorant foraging range (see Task 1.5). Aerial, boat, and land-based surveys will be conducted to identify all colony sites within the study area. Once new cormorant colonies have been identified, we will periodically monitor (i.e., bi-monthly) the colony to estimate colony size, productivity, and factors limiting colony size and productivity. More frequent monitoring of these colonies may occur in subsequent years, if the colony becomes established, and data on diet composition will be collected.

In 2004, a relatively large nesting colony of double-crested cormorants (> 500 breeding pairs) was identified in Potholes Reservoir (located between the Snake and Columbia rivers, WA). Additional research on this colony in 2006 revealed that this colony is growing (ca. 1,200 nesting pairs in 2006), making the Potholes cormorant colony the largest known double-crested cormorant colony on the Columbia Plateau, and the second largest double-crested cormorant colony in the Pacific Northwest (second only to the world's largest on East Sand Island at the mouth of the Columbia River). Little is known about the Potholes cormorant colony (e.g., trends in colony size, diet composition of birds nesting at the colony, impact of the colony on survival of out-migrating salmonid smolts from the Columbia River). In 2007, we propose to visit this colony bi-weekly to monitor colony size, nesting success, and diet composition of the cormorants nesting at this colony. Diet composition will be based on chick regurgitations collected on-colony during the nesting season, when feasible.

Task 2.6. Determine the distribution and relative abundance of double-crested cormorants along the mid-Columbia River and lower Snake River during the post-breeding season.

We will conduct a pilot study to investigate the distribution and relative abundance of double-crested cormorants along the mid-Columbia River (from the The Dalles Dam to the head of McNary pool) and along the lower Snake River (from the confluence with the Columbia River to the mouth of the Clearwater River) to assess the potential impact of cormorant predation on out-migrating fall Chinook salmon during the post-breeding season period. In 2007, aerial surveys of the study area will be conducted four times during August - October to identify aggregations of post-breeding double-crested cormorants. Once major roost sites for cormorants during the post-breeding season have been identified, boat or land-based surveys will be used to count total numbers and assess foraging activity. If significant numbers of foraging cormorants are found at sites where fall Chinook smolts might be vulnerable to cormorant predation (e.g., dam forebays) in 2007, then in subsequent years we will attempt to lethally collect up to 10 adult or juvenile cormorants near each foraging hot spot to assess diet composition and the prevalence of fall Chinook smolts in the diet from stomach contents analysis. We would then compare results collected as part of this task with results from the breeding season to assess the impact of cormorants on survival of juvenile salmonids during the post-breeding season relative to the breeding season. Lethal sampling of cormorants to determine site-specific diet composition would be conducted if large numbers of foraging cormorants are observed at the site and permits have been obtained.

Objective 3. Research, monitor, and evaluate predation on salmonid smolts by other piscivorous waterbirds on the Columbia Plateau.

Task 3.1. Investigate the distribution and size of other piscivorous waterbird colonies on the mid-Columbia and lower Snake rivers.

We will conduct surveys to assess the distribution and approximate size of other piscivorous waterbird colonies (i.e., American white pelicans, California gulls, ring-billed gulls, Forster’s terns, great blue herons, black-crowned night-herons, great egrets) on the mid-Columbia River (from the The Dalles Dam to the head of Wanapum pool), on the lower Snake River (from the confluence with the Columbia River to the mouth of the Clearwater River), and on other bodies of water within foraging distance of the Snake and Columbia rivers (e.g., Potholes Reservoir). Aerial, boat, and land-based surveys will be conducted to identify all major colony sites within the study area. Once waterbird colonies have been identified, we will periodically (i.e., at least monthly) monitor the colony to determine the approximate colony size and to assess productivity, if feasible. More frequent monitoring of these colonies may be conducted in subsequent years, if warranted by the results.

Task 3.2. Determine species and stock-specific (where feasible) predation rates on juvenile salmonids from the Snake and Columbia rivers by other piscivorous waterbird colonies on the Columbia Plateau.

We propose to detect PIT tags at selected gull colonies on the mid-Columbia River and at the Badger Island American white pelican colony as a means to evaluate relative predation rates on juvenile salmonids. Due to the size and number of gull colonies in the region (> 40,000 breeding pairs on at least 8 different islands; Roby et al. 2005), efforts to estimate smolt predation rates by gulls will be limited to three or four selected colonies and derived from a sub-sample of breeding pairs at each colony. To capture potential spatial differences in predation rates on salmonids by gulls, gull colonies from The Dalles Pool (Miller Rocks), John Day Pool (Three Mile Canyon Island), and McNary Pool (Crescent Island and possibly Island 18, if permitted) will be investigated. Sub-sampling will be accomplished by placing several 10 x 10 m plots on-colony and then monitoring the number and general productivity of birds within the plots during the nesting season. PIT tags recovered from each plot will then be used to generate per-capita PIT tag consumption and determine species and stock specific predation rates, when adequate samples exist (see Task 1.3 for further details on general methods and analysis).

A combination of PIT tag recovery and detection efficiency studies will be used to calibrate predation rate estimates from gull and pelican colonies.

PIT Tag Recovery: Following the nesting season, we will recover PIT tags from each study plot using a combination of hand-held electronic scanners and magnets (see Task 1.3 for details).

PIT Tag Detection Efficiency: We propose to sow equal numbers of PIT tags on separate plots during four discrete time periods on each selected gull colony on the Columbia Plateau: (1) prior to the nesting season (n = 50 tags per plot), (2) during late incubation (n = 50 tags per plot), (3) during chick rearing (n = 50 tags per plot), and (4) after the nesting season (n = 50 tags per plot). Due to access limitations, however, we will not be able to sow test tags on the Badger Island pelican colony during the nesting season, but instead will sow PIT tags on the colony prior to and following the nesting season.

Task 3.3. Investigate how various biotic and abiotic factors are associated with differences in smolt vulnerability to other avian predators nesting on the Columbia Plateau.

The same methods and analytical approach described for Crescent Island terns (see Task 1.4) will be used for other species of piscivorous waterbirds (i.e., select gull colonies and the Badger Island American white pelican colony) nesting on the Columbia Plateau. It is likely, however, that the number of PIT tags recovered from these colonies will be relatively small compared to the

Crescent Island tern colony due to differences in (1) predation rates by these bird species (i.e., tern predation rates much higher than those of gulls and pelicans), (2) sampling methods (i.e., whole colony tag recovery for terns versus plot-restricted tag recovery for gulls and pelicans), and (3) detection efficiencies (i.e., detection efficiency on tern colonies higher than on gull and pelican colonies). The comparatively small numbers of PIT tags recovered from the gull and pelican colonies may limit the questions that can be addressed with the available PIT tag data (i.e., due to sample size constraints).

REPORTING

We will provide weekly updates of field activities and results (if available) directly to the Corps' appointed POC. Weekly reports will summarize laboratory and field activities, along with any general comments and suggestions associated with specific project objectives and tasks. In-season updates and results will also be made available weekly on the project's website www.columbiabirdresearch.org. We will prepare the necessary reports required by permitting agencies and give presentations to regional resource management agencies, as requested by the funding agency (e.g., Annual AFEP Review meeting).

A draft 2007 annual report describing results of this project will be submitted to the funding agency by January 31, 2007. A final annual report, which will incorporate comments from AFEP reviewers, will be submitted by March 31, 2007. Deliverables in optional years (i.e., annual reports, presentations to regional managers, etc.) of this study will follow the schedule outlined above, to include a final project completion report due one year after the completion of field work.

COLLABORATION AND COORDINATION

This project will be conducted cooperatively by the USGS-Oregon Cooperative Fish and Wildlife Research Unit at Oregon State University and Real Time Research (via a sub-contract with Oregon State University). Research methods used in this study will be similar to those used in related avian predation research in the Columbia River estuary and elsewhere (e.g., San Francisco Bay and Dungeness Spit). Data collected as part of this study will be compared and contrasted with data collected throughout the Western States to get a better understanding of the population dynamics and impacts of avian predation on a larger geographic scale. Collaborations on this project include; NOAA Fisheries (PIT tag studies, telemetry studies, and Potholes Reservoir tern studies), USGS (smolt telemetry studies), and WDFW's Smolt Monitoring Program activities at Lower Monumental Dam (PIT tag studies). Our work is closely coordinated with many resource management agencies, which includes representatives from Bonneville Power Administration (POC: Dorothy Welch); U.S. Army Corps of Engineers, Walla Walla District (POCs: Rebecca Kalamasz, Scott Dunmire); U.S. Army Corps of Engineers, Portland District (POCs: Bob Willis, Geoff Dorsey); Northwest Power and Conservation Council (POCs: Peter Paquet, Patty O'Toole, Doug Marker); NOAA Fisheries (POCs: Ben Meyer, Cathy Tortorici, John Ferguson, Ed Casillas, Tom Good, Brad Ryan, Gordon Axel, Ben Sandford); U.S. Fish and Wildlife Service (POCs: Tara Zimmerman, Nanette Seto); Oregon Department of Fish and Wildlife (POC: Charlie Bruce); Washington Department of Fish and Wildlife (POC: Rocky Beach); and the Columbia River Inter-Tribal Fish Commission (POC: Dale McCullough). We anticipate that additional collaborative and cooperative arrangements will be forged with other agencies and research organizations currently engaged in or planning work on the Columbia River.

FACILITIES AND EQUIPMENT

Fieldwork will be focused along the mid-Columbia River between The Dalles Dam and the head of the McNary Dam pool, with additional survey fieldwork on the lower Snake River, the mid-Columbia River from Hanford Reach to Rock Island Dam, and other sites on the Columbia Plateau. This work will be conducted out of a field station in the Tri-Cities area, WA. USGS-Oregon Cooperative Fish and Wildlife Research Unit will provide two skiffs capable of handling conditions encountered on the mid-Columbia River. The Unit will provide boats for use on the project in return for maintenance, repair, and/or replacement in the event of normal wear and tear, damage, or loss of these watercraft and associated equipment (outboard motors, trailers, etc.).

Since the project was initiated in 1997, it has acquired a considerable quantity of reusable field supplies and equipment that are dedicated to this project. These include several sturdy plywood blinds for colony observations, optical equipment for colony observations, computers, and a wide variety of other miscellaneous field supplies.

The Department of Fisheries and Wildlife, Oregon State University will provide lab facilities. This laboratory is fully equipped to conduct analyses of diet and proximate composition and energy content of fish prey for piscivorous birds. Through our collaborator, Dr. G. Henk Visser, at the University of Groningen in The Netherlands, we have access to all the laboratory and equipment required for analysis of biological samples for studies using the doubly labeled water technique for measuring field metabolic rates of fish-eating birds.

Much of the research associated with Task 1.4 will rely on the infrastructure and basic facilities already present at the Lower Monumental Dam Juvenile Fish Facility. The project will, however, need to purchase two new Destron PIT tag readers and may need to purchase some water quality monitoring probes (depending on the availability of USACE equipment already on-hand). Telemetry equipment (two receivers and antennas) for installation at Foundation Island and Crescent Island colonies will be supplied by the Walla Walla District, USACE. Finally, the project will need ~8,000 PIT tags for tasks 1.3, 1.4, 2.3, and 3.2.

IMPACTS

The capture and handling of juvenile steelhead at Lower Monumental Dam (Task 1.4) will not require additional ESA-permitting if research activities can be included within the existing Smolt Monitoring Program permit at the dam. The only change we are proposing to the existing smolt monitoring protocol at Lower Monumental Dam is that a sample of the collected steelhead be PIT-tagged prior to release. We will work with USACE, WDFW, and NOAA Fisheries to adjust estimated "take" to account for tagging at the dam in 2007. Other activities associated with this research project should not impact or otherwise interfere with other Corps activities in the region. Our research does, however, require permitting from the U.S. Fish and Wildlife Service and the Washington Department of Fish and Wildlife to access islands where bird colonies are located, collect birds for diet composition analysis, and to occasionally handle specimens (e.g., bird banding). We believe these activities pose minimal risk to native wildlife and vegetation.

TECHNOLOGY TRANSFER

Information obtained from this study will be made available to regional resource managers in a variety of formats. As previously mentioned, research results will be presented in annual reports to the U.S. Army Corps of Engineers (see section entitled "Reporting"), made available in weekly summary reports via the project's website (www.columbiabirdresearch.org), and presented at professional meetings throughout the Pacific Northwest and elsewhere. In 2007, we are planning on presenting results at five different meetings: AFEP Technical Studies Review Work Group meeting, the Annual AFEP Review Meeting, the Annual Meeting of the Oregon Chapter of The Wildlife Society (Corvallis, OR), the Annual Meeting of the American Ornithologists' Union, and the Annual Meeting of the Oregon Chapter of the American Fisheries Society (Corvallis, OR). The funding support of the U.S. Army Corp of Engineers, Walla Walla District will be gratefully acknowledged as part of each presentation and/or scientific paper resulting from this project.

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