Response to U.S. Army Corps of Engineers, Walla Walla District
Request for Proposal

by

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

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

A Research Proposal Submitted to the U.S. Army Corps of Engineers, Walla Walla District

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Project Duration: 4 years (with 2005, 2006, and 2007 as optional)

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PROJECT DESCRIPTION

Background

Published research suggests that avian predation can, under some conditions, be a substantial source of mortality for juvenile salmonids. Mace (1983) estimated that 10.4-31.7% of hatchery-released chinook smolts in the Big Qualicum River on Vancouver Island succumbed to avian predation within just 2 km of the hatchery. A subsequent study on the same river estimated that predation by merganser broods alone accounted for 24-65% of smolt production (Wood 1987). Feltham (1995) estimated that mergansers

removed 3-16% of smolt production on two Scottish rivers. In a 3-year study on the Penobscot River in Maine, predation by double-crested cormorants on hatchery-reared Atlantic salmon accounted for 7.5% to 9.2% of the run (Krohn and Blackwell 1996; Blackwell 1995). Perhaps most impressive is the estimate by Kennedy and Greer (1988) that 51–66% of smolts from a wild run in an Irish river were lost to cormorant predation.

Aggregations of piscivorous birds have been observed on the Columbia River near dams (Ruggerone 1986; Steuber et al. 1993; Jones et al. 1996), at hatchery (Schaeffer 1991; Schaeffer 1992) and barge release points (K. Collis, CRITFC, pers. obs.), and in the estuary (Bevan et al. 1994) near the large waterbird breeding colonies at Rice and East Sand islands. Predation by birds on radio-tagged chinook salmon smolts has been documented in the tailraces below The Dalles and John Day dams and in the Columbia River estuary (C. Schreck, OSU, pers. comm.). In 1995, 11.3% (11/97) of radio-tagged yearlings and 4.1% (4/71) of subyearlings fell prey to gulls below The Dalles Dam (J. Snelling, OSU, pers. comm.). In 1996 and 1997, between 10% and 30% of radio-tagged chinook yearlings migrating through the Columbia River estuary were consumed by terns or cormorants nesting in that area (C. Schreck, OSU, pers. comm.). The bioenergetics approach for estimating prey consumption yielded estimates of 5.4–14.2 million juvenile salmonids consumed by the Rice Island Caspian tern colony in both 1997 and 1998 (Roby et al. 2003). This is equivalent to 5–15% of the estimated number of outmigrating smolts to reach the estuary in those two years.

Caspian terns (*Sterna caspia*) are one of the more important predators of juvenile salmonids in the Columbia River Basin. Caspian terns are the largest tern species in the world and are strictly piscivorous. Until the 2000 breeding season, Rice Island, a dredged material disposal island in the Columbia River estuary, was home to the largest Caspian tern colony in North America (ca. 8,000 nesting pairs; Roby et al. 2002), and perhaps the world (Cuthbert and Wires 1999). Numbers of breeding adults in the Columbia River estuary have increased by more than an order of magnitude since the colony was first established in 1986 (G. Dorsey, USACE, pers. comm., Roby et al. 2002). In addition, there is another smaller Caspian tern colony above McNary Dam on Crescent Island, and terns nesting at this colony are mostly reliant on juvenile salmonids as a food source (Collis et al. 2002; Antolos et al., in review). Based on resightings of banded individuals, terns readily move between upriver and estuary nesting colonies and management of terns in the estuary could lead to some terns relocating to upriver colonies.

Double-crested cormorants (*Phalacrocorax auritus*) are a common piscivore in the mid-Columbia River and estuary. Pursuit-diving cormorants feed on fish throughout the water column; consequently, their diet composition is more varied than for terns. However, per capita fish consumption may be 3-4 times higher for cormorants than for terns due to their greater size and metabolic rate. A large cormorant colony has become established on a rock jetty at the west end of East Sand Island in the estuary. Just 16 years ago there were no double-crested cormorants nesting on East Sand Island and cormorant nesting pairs throughout the estuary numbered in the hundreds. Now East Sand Island supports the largest double-crested cormorant colony on the Pacific coast of the U.S. and Canada (Carter et al. 1995; Anderson 2002). East Sand Island, plus nearby pilings and channel markers, supported a total population of over 11,000 breeding pairs in 2003 (CBR 2003). This is consistent with continent-wide growth in double-crested cormorant populations and increasing frequency of conflicts with salmonid fisheries

(Nettleship and Duffy 1995). We estimated that cormorants nesting in the Columbia River estuary consumed between 2.2 and 9.2 million juvenile salmonids in 1998 (Collis et al. 1999).

Similar to the estuary, there is an increasing trend in the number of double-crested cormorants found along the mid-Columbia River (S. Bickford, pers. comm.). Unlike Caspian terns, double-crested cormorants are not constrained by the availability of suitable nesting habitat; they are commonly observed nesting in trees and on the ground, either on bare substrate or in vegetated areas. Currently there are 250–350 pairs of double-crested cormorants nesting on Foundation Island. Based on the recoveries of regurgitated fish, cormorants nesting on Foundation Island consumed between 0 - 40% salmonids during late May to late June, 2002. Based on studies in the Columbia River estuary (Collis et al. 2001; Ryan et al. 2003) steelhead are more vulnerable to cormorant and tern predation compared to yearling chinook. Hatchery-reared stocks were equally vulnerable to cormorant predation compared to their wild counterparts, and ESA-listed and unlisted juvenile salmonids are equally vulnerable to cormorant predation.

Management of double-crested cormorants in the Columbia River estuary may be imminent. Cormorant numbers are rapidly increasing and their current impacts on juvenile salmonids rival those of the Caspian tern colony on East Sand Island. is currently the object of An Environmental Impact Statement is currently being drafted for a Caspian Tern Management Plan to reduce tern predation rates on juvenile salmonids in the Columbia River estuary. If management of cormorants in the estuary occurs, it is unclear how it might affect the distribution and numbers of cormorants on the mid-Columbia River.

American white pelicans (*Pelecanus erythrorhynchos*) are a large piscivore that is commonly observed foraging below McNary Dam. Badger Island is home to the only active breeding colony of American white pelicans in the State of Washington (over 200 adults counted on colony in 2002); American white pelicans are listed as “endangered” by the State of Washington. Many more American white pelicans are found along the mid-Columbia River during the spring/summer smolt out-migration, and these individuals appear to be non-breeders (B. Tiller, pers. comm.). Less than 200 PIT tags from juvenile salmonids were recovered from the Badger Island pelican colony in 2001 and 2002, suggesting that their impacts to juvenile salmonids are relatively small. Continued monitoring of the Badger Island colony, however, is necessary to determine the trajectory of this population and to determine if they might pose an increasing threat to survival of juvenile salmonids in the future.

Rationale

Our 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 (Roby et al. 1998, Collis et al. 1999, CBR 2002, Collis et al. 2002). These studies indicate that avian predation on certain stocks of juvenile salmonids in the McNary Pool has increased and may have reached levels that warrant management to reduce losses of salmonid smolts to avian predators. For example, the proportion of juvenile salmonids in the diets of Caspian terns nesting at colonies on

Crescent Island (39 river km above McNary Dam) and on Three Mile Canyon Island (54 river km below McNary Dam) have rivaled that of the former colony of Caspian terns on Rice Island in the Columbia River estuary (CBR 2002; Collis et al. 2002). An estimated 465,000 and 679,000 juvenile salmonids were consumed by Caspian terns nesting on Crescent Island in 2000 and 2001, respectively (Antolos 2003; Antolos et al. in review). Non-transported steelhead may be particularly vulnerable to tern predation at Crescent Island (Ryan et al. 2001a, b), especially during low flow years. A minimum of 12.4% of in-river migrating PIT-tagged smolts from the threatened Snake River Steelhead ESU fell prey to Caspian terns nesting on Crescent Island in 2001 (Antolos et al., in prep.). Tern predation rates on the Mid-Columbia River Steelhead ESU (threatened) and the Upper Columbia River Steelhead ESU (endangered) are apparently similar. Also, increasing numbers of cormorants and white pelicans have been observed on the mid-Columbia River in recent years (S. Bickford, pers. comm.), particularly near dams (Tiller et al. 2003), and little is known concerning the impacts of these piscivores on survival of juvenile salmonids.

Studies are needed to determine the magnitude and dynamics of predation on juvenile salmonids by piscivorous birds nesting in McNary Pool. These bird populations may pose an increasing threat to salmonid recovery because (1) the distribution, number, and size of bird colonies have been increasing throughout Eastern Washington and Oregon, and (2) current and future management of piscivorous waterbirds in the Columbia River estuary, and the Columbia Basin generally, may result in large numbers of these birds relocating to colonies along the mid-Columbia River. Answers to these questions have profound short- and long-term implications for the management of salmon and birds. Current management actions have focused on relocating the Caspian tern colony at Rice Island in the upper estuary to East Sand Island, near the mouth of the Columbia River. This shift in nesting distribution has reduced consumption of juvenile salmonids by 6-8 million smolts annually (CBR 2003). Future management actions may seek to shift some of the Caspian terns nesting in the estuary to newly restored and existing colony sites along the Pacific Coast and inland as a way to further reduce their impacts on Columbia Basin salmonids. Some of these birds may relocate to colonies in inland Washington and Oregon, including sites along the lower Columbia River.

Significance to Regional Programs

A previous draft of this proposal was submitted to BPA for funding as part of their 2004 Fish and Wildlife Program. During the review process, the proposal received strong support from CBFWA, the ISRP, and NOAA Fisheries. Specifically, the ISRP ranked our proposal as “Fundable,” and agreed with CBFWA’s ranking of “Urgent.” NOAA Fisheries’ RME Group (Ocean and Estuary Subgroup) ascertained that the Avian Predation Project addressed not one, but several RPAs, including 49, 101, 102, 103, 104, 186, and 195. The review process seemingly had ranked the Avian Predation Project as having the highest priority for funding. Despite this, NPPC staff recommended not to fund the project in 2004-2006 because it was "not deemed responsibility of ratepayers” and that “COE should fund to resolve responsibility under lawsuit." As a result, BPA has decided to reduce funding for the Avian Predaion Project from $663,000 in 2003 to $300,000 in 2004, which will primarily cover work conducted in the Columbia River

estuary. This proposal is for funding of research, monitoring, and evaluation of avian predation in the mid-Columbia River from The Dalles Dam to the head of McNary Pool, work previously funded by BPA.

PROPOSED STATEMENT OF WORK

This study will help determine to what extent bird predation reduces survival and limits recovery of listed salmonid stocks in the mid-Columbia River. Data collected as part of this study will help guide managers in developing management initiatives on the mid-Columbia River that are science-based, defensible, cost-effective, and have a high probability of success. The objectives and tasks associated with this proposal are designed to collectively address the following research and management-oriented questions:

1) What is the level of avian predation on juvenile salmonids in McNary Pool?
2) What avian colonies pose the greatest risk to salmonid survival?
3) What factors account for the differences in smolt vulnerability to avian predators?
4) Does the management of avian predators in the Columbia River estuary affect the distribution and foraging behavior of avian predators in the mid-Columbia River?

Answers to these questions will be based on the research, monitoring, and evaluation of Caspian tern, double-crested cormorant, and American white pelican colonies located upstream of the The Dallas Dam. We believe it will take up to three consecutive years of field research (2004 to 2006) and one final year of analysis and writing (2007) to adequately address these questions. The objectives and tasks presented here, however, may need to be modified and/or tailored following each field season as new data and results become available.

Project Objectives

Objective 1. Research, monitor, and evaluate Caspian tern predation on salmonid smolts in the Columbia River above The Dalles Dam.

Objective 2. Research, monitor, and evaluate double-crested cormorants predation on salmonid smolts in the Columbia River above The Dalles Dam.

Objective 3. Research, monitor, and evaluate American white pelican predation on salmonid smolts in the Columbia River above The Dalles Dam.

METHODS

Objective 1. Research, monitor, and evaluate Caspian tern predation on salmonid smolts in the Columbia River above The Dalles Dam.

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

Methods: Ground counts of breeding adult terns late in the incubation period will be used to estimate breeding population size at Crescent Island (see Collis et al. 2002, Roby et al. 2002). Prior to the arrival of breeding terns at the site, a grid will be placed on the colony to facilitate colony counts and monitoring nesting success. Direct counts of incubating adult terns will be conducted from a blind located at the periphery of the Crescent island tern colony. Multiple counts will be conducted in order to calculate 95% confidence limits for the estimate of the number of breeding pairs. Colony size will be compared with previous years and among colony sites.

Nesting success at the Crescent Island colony will be measured using ground counts of 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. Nesting success will be compared with previous years and among colony sites. We will determine average clutch size, hatching success, and nestling survival rate for a sample of nests on the colony. We will also determine overall productivity for each colony in each year (number of fledglings raised per nesting pair).

Re-sightings of color-banded adults will be used to study dispersal patterns and habitat utilization of terns formerly banded at colonies in the lower Columbia River and along the coast (see Suryan et al. in review).

By monitoring size and productivity of unmanaged Caspian tern colonies up-river, we will assess the relationship between changes in the size and productivity of colonies in the Columbia River estuary and changes in recruitment and reproductive success at colonies farther up-river. This will help determine the potential for future impacts of unmanaged, up-river tern colonies on the survival of Columbia River basin salmonids.

Task 1.1. Schedule

January-March (CY04-06):	Pre-season coordination and administration
March-July (CY04-06):	Field work
April-December (CY04-06):	Data analysis/reporting
January-December (CY 07):	Final analysis/reporting

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

Methods: Diet composition will be monitored by visually identifying fish brought back to colonies in the bills of nesting adults (see Roby et al. 2002). These data will be used to assess (1) the proportion of the diet that consists of steelhead smolts and other juvenile salmonids, (2) the total number of steelhead smolts and other juvenile salmonids consumed based on calculations using a

bioenergetics model (*see* Roby et al. 2003), and (3) predation rates on smolts based on estimates of the numbers of juvenile salmonids available as potential prey in each migration year, if those data are available. Diet composition and smolt consumption will be compared among colonies and among years.

We are developing several new methods for assessing food habits of Caspian terns and other fish-eating birds. Tissue samples collected from fish-eating birds, in conjunction with tissue samples from their fish prey, can be used to determine diet composition of the predator over a more extended period than samples of stomach contents (gastric emptying is mostly complete in 2-3 hours). Tissue samples from both terns and their prey will be analyzed to determine stable isotope ratios and fatty acid signatures (Raclot et al. 1998, Surai et al. 2001). Once validated, these methods may prove extremely useful for quantifying the reliance of terns from different colonies and in different years on juvenile salmonids and other food sources, integrated over an extended period (several weeks to several months).

Task 1.2. Schedule

January-March (CY04-06):	Pre-season coordination and administration
March-July (CY04-06):	Field work
April-December (CY04-06):	Laboratory and data analysis/reporting
January-December (CY 07):	Final analysis/reporting

Task 1.3. Detect the formation of new Caspian tern colonies on other islands in the mid-Columbia River (e.g., Three Mile Canyon Island, Miller Rocks, Cabin Island).

Methods: We will conduct bi-weekly surveys of the distribution and size of Caspian tern colonies in the mid-Columbia River (from The Dalles Dam to the head on McNary Pool). Boat, aerial, and ground-based surveys will be conducted to identify all colony sites within the study area. Once new tern colonies have been identified, we will periodically monitor the colony to determine tern colony size, productivity, and diet composition.

Task 1.3. Schedule

January-March (CY04-06):	Pre-season coordination and administration
March-June (CY04-06):	Field work
April-December (CY04-06):	Data analysis/reporting
January-December (CY 07):	Final analysis/reporting

Task 1.4. Develop predictions for future population dynamics of Caspian terns nesting on Crescent Island that will allow reliable projections of predation rates on juvenile salmonids in the mid-Columbia River.

Methods: Available evidence from band recoveries indicates that all Caspian tern colonies west of the Continental Divide in North America constitute one panmictic population (see Suryan et al. in review). Consequently, changes in the size and productivity of Caspian tern colonies outside the mid-Columbia River may have profound effects on the numbers of terns nesting in the mid-Columbia River and, consequently, predation rates on Columbia River basin salmonids. 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, average age at first reproduction, and the minimum levels of colony productivity needed to insure sufficient recruitment to balance adult mortality. The latter is critical for identifying minimum levels of nesting success to assure stable population size. We will continue to band cohorts of fledgling Caspian terns each year with unique color combinations of plastic leg bands in order to collect information on sub-adult survival and maintain sample sizes of banded adults for measurement of adult survival to be used as input for demographic population models. Re-sightings of banded terns will allow us to measure adult survivorship and juvenile recruitment, two 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 accurately predict changes in colony sizes into the future.

Task 1.4. Schedule

January-March (CY04-06):	Pre-season coordination and administration
April-July (CY04-06):	Field work
April-December (CY04-06):	Data analysis/reporting
January-December (CY 07):	Final analysis/reporting

Task 1.5. Determine those factors that influence per-capita smolt consumption rates by Caspian terns nesting at Crescent Island to support reliable projections of predation rates on juvenile salmonids in the mid-Columbia River.

Methods: Assess the relative effects of colony size, colony nesting success, and gull kleptoparasitism on per-capita tern predation rates on salmonid smolts. Also assess how factors influencing the availability of juvenile salmonids as prey affects per capita tern predation rates, including smolt transportation, river flows, hatchery production, and migration timing.

Task 1.5. Schedule

January-March (CY04-06):	Pre-season coordination and administration
April-July (CY04-06):	Field work
April-December (CY04-06):	Data analysis/reporting

January-December (CY 07): Final analysis/reporting

Task 1.6. Determine the accuracy of estimated tern predation rates on salmonids based on smolt PIT tag recoveries on-colony.

Methods: The recovery of PIT tags on avian colonies has been used as a direct measure of predation rates on ESA-listed salmonid populations in the mid-Columbia river (Ryan et al. 2003b, Antolos et al. in review). Predation rates based on PIT tag recoveries are, however, underestimates; some proportion of tags consumed by terns is deposited off-colony, weather and other environmental factors (e.g., wind or rain storms) remove PIT tags that are deposited on-colony, and some PIT tags are damaged and rendered unreadable before or after egestion on the colony. Understanding the magnitude of the bias in estimates of tern predation on smolts based on PIT tag recoveries on-colony is critical for deriving ESU-specific tern predation rates. As part of this task, several pilot experiments will be used to address this key uncertainty. If successful, these studies will lead to the collection of quantifiable data on PIT tag deposition and recovery rates from the Crescent Island tern colony, data needed to calibrate ESU-specific estimates of predation rates. We propose to initiate the following studies in CY 04:

Net Pen Study - PIT tag deposition rates at the Crescent Island tern colony will be measured by tagging and stocking 1,000 juvenile rainbow trout (*O. mykiss*) in a net pen enclosure and monitoring the subsequent success rate of terns foraging at the net pen. A 6-meter circular net pen will be placed in Burbank Slough (off the Columbia River and ~8 rkm from Crescent Island) from mid April to late May. The rainbow trout stocked in the net pen will be comparable in size to that of steelhead smolts (~160 mm) and will be acquired from the Trout Lodge Hatchery, WA. The net pen will be monitored daily (8 hrs/day) and then closed to prevent terns from foraging at the net pen when observers are not present. The net pen will be monitored until the terns remove at least 60 PIT-tagged fish. The number of PIT tags that are removed from the net pen by terns and subsequently detected on the Crescent Island tern colony will be used to calculate on-colony recovery rates. Recovery rates will be a direct measure of deposition rates, minus PIT tags damaged or lost during the breeding season. All PIT tags used in this study will be submitted and queried via the Pacific States Marine Fisheries Commission's PIT tag database (PTAGIS). If successful in 2004, the net pen approach will be used in optional study years to gather quantifiable and statistically robust data on deposition rates of PIT tags consumed by Crescent Island terns.

Force-feeding Study - Another method of estimating deposition rates is to force-feed PIT-tagged fish to adult terns captured on the Crescent Island tern colony and then determine the proportion of force-fed tags deposited on-colony. Breeding adult terns will be captured on the Crescent Island colony late in the

incubation period or early in the chick-rearing period using noose-mat traps[1] and force-fed fish containing PIT tags. In total, 30 breeding adults from the Crescent Island colony will be captured and each will be force-fed a single fish, with each fish containing two PIT tags (n = 60 tags). Each fish will be 5–15 cm long and weigh approximately 10 - 30 g. All fish will be certified, disease-free triploid trout obtained from the Trout Lodge Hatchery, WA. Terns will be held for a short period to ensure that the fish has been ingested (i.e., not regurgitated after being force fed) and then released back onto the colony. Terns will also be marked to facilitate post-release observations of behavior.

Following the breeding season and after all the terns have left the colony, Crescent Island will be scanned for PIT tags by NOAA Fisheries and the proportion of force-fed tags that are detected on-colony will be determined. The detection rate of force-fed PIT tags[2] will be compared to that derived from the net pen study, thereby providing an independent measure of PIT tag detection rates that can be used in the design of subsequent studies (i.e., 2005 and 2006). Data from the force-feeding study will also be used to corroborate results from the net pen study.

PIT Tag Detection Efficiency Study – Not all PIT tags that are egested by Caspian terns on their nesting colony are subsequently detected by NOAA Fisheries after the nesting season. In years past, this correction factor was estimated by manually distributing a known number of PIT tags on the colony prior to the tern breeding season and then assessing detection efficiency of those tags when the colony was scanned after the breeding season (Ryan et al. 2003). This method is believed to underestimate detection efficiency, however, because tags placed on the colony before the breeding season are potentially subject to higher rates of loss and damage (e.g., wind and rain storms, tag damage or loss, etc.) compared to PIT tags deposited by terns. Multiple, systematic sowing of PIT tags on the Crescent Island colony throughout the tern breeding season – as apposed to a single release prior to the breeding season – will result in a more accurate and defensible estimate of PIT tag detection efficiency (Brad Ryan, NOAA Fisheries, personal communication).

Colony monitors at Crescent Island will systematically release a total of 1,000 PIT tags during four discrete time periods (200 per time period) to help NOAA Fisheries evaluate PIT tag detection efficiency. During each release period, 200 tags will be distributed into four zones, with 50 tags scattered throughout each zone. On-colony PIT tag releases will take place during the following field activities: (1) Pre-season setup (i.e., before terns arrive on Crescent Island), (2) force-feeding experiments (i.e., during the late incubation/early chick-rearing period), (3) chick banding (i.e., near the end of the chick-rearing period), and (4) post-season rap up (i.e., when all the birds have left the colony). Detection efficiency estimates will be analyzed relative to the release date and the release zone, thereby describing both temporal and spatial

[1] The ability to conduct this experiment in 2004 will depend on permitting from the USFWS and on the stability/size of the Crescent Island colony during the breeding season.
[2] The force-feeding experiment will also be conducted at East Sand Island (Columbia R. estuary) and results compared to those obtained from the Crescent Island colony.

variation. If successful, this approach will be repeated in optional study years (i.e., 2005 and 2006) to evaluate annual differences in PIT tag detection efficiency.

PIT Tag Removal on Crescent Island: An increasing number of PIT tags are accumulating on the Crescent Island tern colony and causing tag signals to collide, a phenomenon that reduces PIT tag detection efficiency. One method of minimizing collision is to remove PIT tags from the tern colony following post-season detection by NOAA Fisheries. As part of this task we propose to manually remove as many PIT tags as possible from the Crescent Island tern colony prior to tern arrival at the beginning of the 2004 breeding season (late March/early April).

A six-person crew will remove PIT tags from the Crescent Island tern colony. We will remove tags by breaking up the surface layer of soil with rakes equipped with magnetic tongs and then rolling large sweeper magnets over the colony surface to further remove PIT tags (*see* Biomark 2003). Prior research has demonstrated that the majority of PIT tags are retained within the top 7.5 cm of soil (Ryan et al. 2001b, Biomark 2003) and our removal efforts will be focused on this upper soil layer. 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.

All PIT tags removed during this endeavor will be scanned to determined functionality. Functional tag codes will be submitted to both NOAA Fisheries and PTAGIS. Based on results from a previous PIT tag removal project at Crescent Island, we anticipate that between 5,000 and 10,000 tags (Biomark 2003) will be removed during the three-day effort in 2004. Of these tags, we anticipate that the majority will be functional (~60%) and at least some previously undiscovered tags will be removed from the colony (~5%). If successful (i.e., a large number of tags are removed), we propose to repeat this effort in optional study years.

Task 1.6. Schedule

January-March (CY04-06):	Pre-season coordination and administration
March-October (CY04-06):	Field work
April-December (CY04-06):	Data analysis/reporting
January-December (CY 07):	Final analysis/reporting

Task 1.7. Determine the relative importance of factors that influence the vulnerability of juvenile salmonids, with particular emphasis on steelhead, to predation by Caspian terns nesting on Crescent Island.

Methods: PIT tag recoveries from the Crescent Island tern colony have been used in previous years to produce a single, ESU-specific point estimate of tern predation on juvenile salmonids (Ryan et al. 2003). Smolts originating upstream of Crescent Island, however, are from numerous, ecologically-unique watersheds (e.g., tributaries of the Upper Columbia, Salmon, Clearwater, Imnaha, Grande

Ronde, and numerous other rivers). Because of this high geographic and ecological diversity, the relative vulnerability of various salmonid stocks to avian predation is likely to differ, and a single point estimate can not adequately characterize predation rates on all stocks. Previous and on-going studies of smolt PIT tags recovered on tern colonies in the lower Columbia River indicate there is high variability among salmonid species in vulnerability to tern predation (Collis et al. 2001, Ryan et al. 2003). The primary purpose of this task is to work collaboratively with NOAA Fisheries to generate a more detailed, defensible, and accurate estimate of salmonid predation by Crescent Island terns.

This research task will be addressed in each year of the proposed study (i.e., 2004-2007) in cooperation with NOAA Fisheries, the agency responsible for the recovery of PIT tag codes from the Crescent Island tern colony. Over the term of our research we will use PIT tags recovered from the Crescent Island tern colony to address various research questions, including but not limited to: (1) how variable are estimates of tern predation rates among salmonid species, ESU's, stocks, and years; (2) which salmonid smolts are most vulnerable to Crescent Island terns; (3) which salmonid stocks are poorly represented by PIT tag data and how can tagging efforts be modified to better assess impacts of tern predation on these stocks; (4) how does tern foraging ecology and nesting chronology (e.g., timing of nest initiation, number of breeding pairs, peak foraging times, shifts in diet composition) affect predation rates; and (5) what is the association between smolt outmigration history (e.g., run timing, travel times, passage behavior, etc) and tern predation rates.

In 2004, we will determine the amount, quality, and suitability of data to address these questions by developing a PIT tag database that is unique to the Crescent Island tern colony. In addition, we will continue to develop and further define our collaboration with NOAA Fisheries in addressing these research questions. We plan to have regular meetings (i.e., monthly) with NOAA Fisheries staff (POC: Brad Ryan) throughout FY 2004 to identify (1) the specific research questions/tasks that will be addressed using the PIT tag data, (2) the field and analytical methods that will be employed to address each question/task, and (3) the schedule and agency responsibilities for completion of each research task. We are currently collaborating with Brad Ryan to publish a paper in Transactions of the American Fisheries Society on the impact of Crescent Island Caspian tern predation on juvenile salmonids during the 2000 and 2001 migration years.

Task 1.7. Schedule

January-March (CY04-06):	Pre-season coordination with NOAA
April-October (CY05-06):	Field work (if required)
June-December (CY04-06):	Data analysis/reporting
January-December (CY 07):	Final analysis/reporting

Objective 2. Research, monitor, and evaluate double-crested cormorants predation on salmonid smolts in the Columbia River above The Dalles Dam.

Task 2.1. Determine the size, nesting success, and factors limiting nest success (e.g., nest predation, habitat availability, food availability, weather) of the double-crested cormorant colony on Foundation Island.

Methods: The number of double-crested cormorants breeding on Foundation Island in 2004 will be estimated using boat-based counts of occupied nests from the east side of the island. These boat-based counts are considered minimum estimates of the number of breeding pairs, because some nests were not visible from the boat. In order to improve the accuracy of estimates of the size of the colony on Foundation Island, we will lay out a grid on the ground beneath the colony and mark trees that support cormorant nests. Using stratified random sampling, we will determine the number of active nests in trees within the colony. A subsample of nests visible from the water 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 2.1. Schedule

January-March (CY04-06):	Pre-season coordination and administration
March-July (CY04-06):	Field work
April-December (CY04-06):	Data analysis/reporting
January-December (CY 07):	Final analysis/reporting

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

Methods: During the 16-week nesting period, we will collect diet samples that are spontaneously regurgitated by nesting adults and their young. We will attempt to collect between 150-200 regurgitations from the ground underneath trees where cormorants are nesting. These samples will be analyzed in our laboratory at Oregon State University to determine the diet composition of cormorants nesting on Foundation Island in 2004. These data will be used to assess (1) the proportion of the diet that consists of juvenile salmonids, (2) the total number of juvenile salmonids consumed based on calculations using a bioenergetics model (see Roby et al. 2003), and (3) predation rates on smolts based on estimates of the numbers of juvenile salmonids available as potential prey in each migration year, if these data are available. Diet composition and smolt consumption will be compared among colonies and among years.

Further analysis of smolt PIT tags recovered from the Foundation Island cormorant colony will be used to assess the relative vulnerability of various stocks of salmonids to cormorant predation. Sample size permitting, different factors (colony size, year, river flow rates, colony productivity) will be examined for effects on smolt vulnerability to cormorant predation.

We are developing several new methods for assessing food habits of double-crested cormorants and other fish-eating birds. Tissue samples collected from fish-eating birds, in conjunction with tissue samples from their fish prey, can be used to determine diet composition of the predator over a more extended period than samples of stomach contents (gastric emptying is mostly complete in 2-3 hours). Tissue samples from both cormorants and their prey will be analyzed to determine stable isotope ratios and fatty acid signatures (Raclot et al. 1998, Surai et al. 2001). Once validated, these methods may prove extremely useful for quantifying the reliance of cormorants from different colonies and in different years on juvenile salmonids and other food sources, integrated over an extended period (several weeks to several months). We are also using species-specific genetic markers to identify salmonid smolts from cormorant stomachs to the species level.

Task 2.2. Schedule

January-March (CY04-06):	Pre-season coordination and administration
May-October (CY04-06):	Field work
May-December (CY04-06):	Laboratory and data analysis/reporting
January-December (CY 07):	Final analysis/reporting

Task 2.3. Survey and monitor the size, nesting success, and (where possible) the diet composition of colonies of double-crested cormorants at other sites in the mid-Columbia River.

Methods: We will conduct bi-weekly surveys of the distribution and size of double-crested cormorant colonies in the mid-Columbia River (from The Dalles Dam to the head on McNary Pool). Boat, aerial, and ground-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 the colony to determine colony size, productivity, and diet composition, if feasible.

Task 2.3. Schedule

January-March (CY04-06):	Pre-season coordination and administration
March-June (CY04-06):	Field work
April-December (CY04-06):	Data analysis/reporting
January-December (CY 07):	Final analysis/reporting

Objective 3. Research, monitor, and evaluate American white pelican predation on salmonid smolts in the Columbia River above The Dalles Dam.

Task 3.1. Determine the size, habitat use, nesting success, and factors limiting nest success (e.g., nest predation, habitat availability, food availability, flooding, weather) of the white pelican colony on Badger Island.

Methods: Colony monitoring, boat-based census, aerial photo census, and aerial photography interpretation will be used to determine the size, habitat use, and nesting success of white pelicans on Badger Island. If permitted by the USFWS, we will visit the island late in the nesting season to count nests, assess nesting success, collect diet data, and assess nesting habitat.

Task 3.1. Schedule

January-March (CY04-06):	Pre-season coordination and administration
March-August (CY04-06):	Field work
April-December (CY04-06):	Data analysis/reporting
January-December (CY 07):	Final analysis/reporting

REPORTING

We will provide monthly updates of field activities and results (if available) directly to the Corp appointed POC. Monthly 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 2004 annual report describing results of this project will be submitted to the funding agency by December 15, 2004. A final annual report, which will incorporate comments from AFEP reviewers, will be submitted by March 31, 2005. 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.

COORDINATION AND COOPERATION OF RESEARCH EFFORT

This project will be conducted cooperatively by the USGS-Oregon Cooperative Fish and Wildlife Research Unit at Oregon State University and Real Time Research. Direction for the monitoring and evaluation component of this project comes from regional resource management agencies, which includes representatives from Bonneville Power Administration (POC: Dorothy Welch), U.S. Army Corps of Engineers (POCs: Bob Willis, Geoff Dorsey, Rebecca Kalamasz, Scott Dunmire), 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), 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 (POCs: Rocky Beach, Chris Thompson), 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. This work will be conducted out of a field station in Pasco, WA. USGS-Oregon Cooperative Fish and Wildlife Research Unit will provide two skiffs capable of handling conditions encountered on the 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.). The project will need to purchase a PIT tag receiver (model No. FS2001F/ISO) to conduct research associated with Task 1.7.

Since the project "Avian Predation on Juvenile Salmonids in the Lower Columbia River" was initiated in 1997, the project has acquired a considerable quantity of reusable field supplies and equipment that are dedicated to this project. These include a net pen, several sturdy plywood blinds for colony observations, optical equipment for colony observations, 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 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.

IMPACTS

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 avian colonies and to occasionally handle specimens. 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 (see section entitled "Reporting"), made available in weekly summary reports via the project's website, and presented at professional meetings throughout the Pacific Northwest. In 2004, we are planning on presenting results at five different meetings: AFEP Technical Studies Review Work Group meeting, the Annual AFEP Review Meeting (Portland, OR), the Annual Meeting of the Oregon Chapter of The Wildlife Society (Bend, OR), the Annual Meeting of the American Ornithologists' Union (Quebec City, Quebec, Canada), and the Joint Annual Meeting of the Pacific Seabird Group and the Waterbird Society (Portland, OR). The funding support of the U.S. Army Corp of Engineers will be gratefully acknowledged as part of each presentation and/or scientific paper resulting from this project.

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