This is not a final federal agency product. Rather, it is a pre-decisional document prepared by the Action Agencies that reflects present understandings of currently available information and analyses, and of the progression of discussions with the sovereigns in the collaborative process. Revisions and refinements are to be expected based on further discussions with the sovereigns over new and modified proposed federal actions upon which the action agencies will ultimately consult. Finally, the information in this product does not constitute an analysis of whether the identified measures would or would not jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. Furthermore, this document does not in any way interpret or apply the regulatory definitions of the statutory phrases "jeopardize the continued existence of" and "destruction or adverse modification."

Predator Control Proposed Action Summary

Predator Management Action Objective for All ESUs: Reduce mortality from predators of ESA-listed juvenile and adult fish.

Predator Management Strategy 1: Reduce Piscivorous Predation

Performance Standards: Maintain exploitation rates in the range of 15-19% consistent with rates observed since implementation of increased incentive measures which began in Summer 2004

Funding Source(s): Bonneville Power Administration – Direct Program

Rationale: Reducing the number of larger, predatory pikeminnow throughout the mainstem Columbia and Snake rivers directly reduces predation losses and increases the survival of outmigrationg juvenile salmon and steelhead

What's New: Focused pikeminnow removals at The Dalles and John Day dams forebay and tailrace boat restricted zones will be tested and evaluated in the 2007 field season.

Action: Northern Pikeminnow Management Program

The Action Agencies propose to continue implementation of the base management program which began in 1990. In addition to the base program a general increase in the reward structure started in the summer of 2004, and the Action Agencies propose to continue implementation of the reward increase into the future. Average exploitation rates (the percentage of the targeted size fish annually removed) in the NPMP, notwithstanding the NPMP heavy-up in 2001/2004-2005 have averaged approximately 11% for the last 16 years. The observed exploitation rate on pikeminnow since increasing the monetary incentives has averaged 18%, an over 50% improvement. This increase in exploitation rate resulted in an expansion of the modeled juvenile survival benefit.

Action: Other Predaceous Fish

Management efforts directed at other predaceous fish can not proceed without collaboration with entities with management authority over these resources. Therefore, further examination of this issue particularly with the states of Oregon and Washington is needed. The first step in this process should be the formation of a workshop to review, evaluate and develop strategies to

reduce non-indigenous pisciverous predation. The Action Agencies propose to assist in facilitation of a workshop to begin the process to address non-indigenous predation on juvenile salmonids.

Predator Management Strategy 2: Management of avian predators

Performance Standards: Caspian terns: phased reduction of Caspian tern nesting habitat on East Sand Island, from approximately 6.5 acres to 1.5 to 2 acres. Double-crested cormorants: reduce consumption rates of juvenile salmonids as determined by results of future investigations.

Funding Source(s): Corps of Engineers Columbia River Fish Mitigation Program funding. BPA – direct funding.

Rationale: Dispersing most of the Caspian tern population to locales outside of the Columbia River Basin will substantially reduce predation losses of juvenile salmonids in the Columbia River estuary and increase their escapement to the Pacific Ocean. Management efforts directed toward populations of double-crested cormorants nesting in the Columbia River estuary and in the mid-Columbia River and Caspian terns nesting in the mid-Columbia may further increase juvenile salmonid survival; further research is needed to address potential management actions for those populations of Caspian terns and double-crested cormorants.

What's New: These actions are consistent with the actions proposed in the 2004 PA.

Action: Estuary Caspian Tern Predation

The Action Agencies propose to carry out Caspian tern management actions within the western region (California and Oregon) to effect redistribution of a majority of the Caspian terns from the Columbia River estuary. Dispersion of most of the Caspian tern population to locales outside the Columbia River Basin would substantially reduce predation losses of juvenile salmonids in the Columbia River estuary and increase their escapement to the Pacific Ocean. Adult salmon returns are expected to increase concomitant with the increased escapement of juvenile salmonids to the Pacific Ocean.

Caspian tern management actions would be done in a manner consistent with the preferred alternative identified in the Final Environmental Impact Statement (FEIS), *Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary*, which issued in January 2005. The FEIS was prepared jointly by the U.S. Fish and Wildlife Service (USFWS) (lead), Corps and National Marine Fisheries Service (NMFS). The preferred alternative, which was modified during consultation with NMFS, relies on habitat management and social attraction measures at six alternate nesting locations to reduce the tern colony in the Columbia River estuary. These alternative nesting locations are located at Fern Ridge Lake (1 ac), Summer Lake (1.5 ac) and Crump Lake (1 ac) in Oregon and Brooks Island (2 ac), Hayward Regional Shorelines (~0.5 ac) and Don Edwards National Wildlife Refuge, San Francisco Bay, California (0.5-1.0 ac). All locations, except Fern Ridge Lake, are outside the Columbia River Basin.

In conjunction with this increase of suitable nesting habitat outside of the Columbia River Basin, the Corps would reduce the available nesting habitat at East Sand Island from approximately 6.5 acres to 1.5 to 2 acres. The reduction in habitat acreage at East Sand Island would be accomplished by discontinuing maintenance actions and allowing for vegetative succession to render the acreage unsuitable for nesting Caspian terns. The balance of nesting habitat at East

Sand Island would be maintained in order to continue to provide proper habitat conditions for Caspian terns. The scenario laid forth in the modified preferred alternative would reduce the Caspian tern colony in the Columbia River estuary from an average population of 9,093 nesting pairs (2000 – 2005) to 3,125 – 4,375 nesting pairs. Attainment of the original projected colony size for East Sand Island terns (2,500 – 3,125 pairs) described in the preferred alternative of the FEIS is contingent upon implementation of the modified preferred alternative plus adoption of adaptive management strategies to address the removal of the Dungeness NWR as an alternative management site.

Action: Estuary Double-Crested Cormorant Predation

Management efforts directed toward double-crested cormorants nesting in the Columbia River estuary could achieve additional gains in juvenile salmonid survival, perhaps comparable or even greater than those associated with the proposed Caspian tern management. Further research efforts are necessary to lead to an EIS developed in conjunction with USFWS that addresses potential population and habitat management actions for double-crested cormorants. Research into cormorant predation on juvenile salmonids, an evaluation of management needs, and an in-depth analysis of the regional double-crested cormorant population (range, population dynamics, and status) would support completion of the environmental review requirements for determination of future management actions, if warranted.

Action: Inland Avian Predation

Develop and implement a management plan for Corp's owned lands, including tern and cormorant colonies on Crescent and Foundation Islands, and associated shallow water habitat. The development and implementation of avian management plan(s) will be preceded by a thorough analysis of avian predator diets, predation rates, and overall effects of current avian predation on various salmonid ESUs. This will be a comprehensive plan developed in collaborative discussion with the U.S. Fish and Wildlife Service. The primary objective of this plan will be to improve ESA listed anadromous fish survival for fish rearing and migration through the Lower Snake and Columbia Rivers. Research in support of this plan will continue 2007 studies to determine the impact of avian predation on juvenile salmon under a range of system operations, with a potential for future research as needed. In addition, efforts are underway to better estimate the species/ESU-specific impacts of avian predation.

Action: Other Avian Deterrent Actions

Avian deterrent actions are ongoing at each of the dams. Continue to implement and improve avian predation deterrent programs at all Lower Snake and Columbia River dams. This program will continue to be coordinated with FPOM and included in the annual FPP.

Predator Management Strategy 3: Address Marine Mammal Predation

Performance Standards: Reduced presence of marine mammals at Bonneville Dam.

Funding Source(s): Corps of Engineers O&M and Columbia River Fish Mitigation Program funding.

Rationale: Studies estimate that between 0.5 and 2 percent of adult spring Chinook salmon have been consumed by sea lions; this consumption appears to be increasing due to increased sea lion activity/presence at Bonneville Dam.

What's New: These actions are consistent with the actions proposed in the 2004 PA.

Action: Marine Mammal Predation

Work closely with NMFS and the states of Oregon and Washington to develop a management strategy to address increased predation on adult salmon and steelhead by sea lions and other marine mammals.

The Action Agencies will:

- Provide and improve sea lion excluder devices (SLEDs) to limit ability of sea lions to enter fishways.
- Use acoustic deterrent devices to attempt to move sea lions from immediate adult ladder entrances, away from project facilities.
- Support and participate in efforts to keep sea lions away from the area immediately downstream of Bonneville Dam.
- Continue working with States to provide support for other harassment activities.

Predator Control Proposed Action

The following predator control actions will be implemented to reduce mortality and improve survival of juvenile and adult fish.

1.1 Northern Pikeminnow Management

The objective of the Northern Pikeminnow Management Program (NPMP) is to increase survival of outmigrating juvenile salmon and steelhead by reducing the number of larger, predatory pikeminnow throughout the mainstem Columbia and Snake rivers. There is a direct relationship between numbers of pikeminnow removed and reduced predation losses; similarly, there is a direct relationship among rewards, angler participation, and catch of pikeminnow.

The primary method of the NPMP for catching northern pikeminnow is a sport reward fishery. The BPA provides and pays a reward for each qualifying fish caught within the mainstem Columbia and Snake rivers. BPA annually sets the budget level for the NPMP and administers the program through a contract with the Pacific States Marine Fisheries Commission with subcontracts awarded to implement various program components to the Oregon Dept. of Fish and Wildlife and the Washington Dept. of Fish and Wildlife.

Implementation of the NPMP during the past 16 years shows that increased rewards result in increased participation by individuals endeavoring to catch this fish, increased dedication by those skilled at catching the fish and, as a result, increased catch of this predator. Increased rewards in the early years of the program and in 2001 resulted in increased participation and catch. Evaluation of the NPMP indicates that as a result of cumulative removals since program inception, a 25 percent reduction in pikeminnow predation has occurred (Friesen and Ward 1999). This has the effect of 2-4 million juvenile salmon annually surviving that would otherwise been eaten by this predator. The benefits of pikeminnow removals affect all listed and non-listed yearling and sub-yearling salmonids that use the mainstem Columbia and Snake Rivers as outmigration corridors. The benefit is largest for subyearling migrants. Additionally, biologists have not observed other fish predators compensating for the large number of pikeminnow removed, which could offset the benefit.

In 2006, the Action Agencies continued implementing a general increase in the reward structure started in the summer of 2004. Average exploitation rates (the percentage of the targeted size fish annually removed) in the NPMP, notwithstanding the NPMP heavy-up in 2001/2004-2005 have averaged approximately 11 percent for the last 16 years. The observed exploitation rate on

pikeminnow since increasing the monetary incentives has averaged 18 percent, an over 50 percent improvement. Program evaluators will model estimates of the increased exploitation rate's additional effect on reduction in predator mortality during the 2006-7 off-season. This increase above the baseline, once estimated and quantified, would be above and beyond the base benefits assumed many analytical analyses. Therefore, the marginal benefit of any increase in exploitation rate resulting from increases in program incentives should be separate and above base-period benefits.

The Action Agencies plan to implement the following activities during the duration of this agreement:

- Continue the base Northern Pikeminnow Management Program (NPMP) and continue the general increase in the reward structure in the Sport-Reward fishery similar to that of 2001, 2004-2006. This includes increasing the budget for monetary rewards for harvesting northern pikeminnow structured in a tiered fashion to increase the reward as anglers increase total seasonal catch.
- Increase number of tagged fish to enhance the estimation and evaluation of the NPMP.

1.2 Other Predaceous Fish

Management of non-indigenous species of predaceous fish has long been identified as a potential measure to increase the survival of outmigrationg juvenile salmonids. It is likely that development and implementation of non-indigenous predator management would not result in biological benefit measured on a system-wide scale. Therefore, the performance metric used to measure benefit would be specific to the local removals. Site-specific removals could have positive effect on reservoir mortality and/or passage survival, proportional to the relative density of the stock within a particular reach. For instance, smallmouth bass management in Lower Granite reservoir will have a disproportionate benefit for Snake River subyearling Chinook pool mortality but no benefit for sockeye.

The Action Agencies can not implement any non-indigenous fish program without the collaboration and approval of the states and tribes with management authority over this resource. Therefore, further examination of this issue particularly with the states of Oregon and Washington is needed. The first step in this process should be the formation of a workshop to review, evaluate and develop strategies to reduce non-indigenous piscivorous predation.

1.3 Pinniped Predation on Salmonids (Sea Lions)

The Action Agencies have developed an experimental strategy to address fish predation by pinnipeds at or near Bonneville Dam. Studies conducted by the Corps at Bonneville Dam from 2002-2005 estimate the amount of fish eaten by sea lions has increased every year since studies

were undertaken by the Corps, from 0.3 percent of the annual spring salmon run in 2002, to 1.1 percent in 2003, to 2.2 percent in 2004, and 3.4 percent in 2005 to 2.8 percent in 2006. The studies also suggest the sea lions are arriving earlier and staying later at Bonneville dam each year, with approximately 100 individuals annually being present. In addition, the sea lion efficiency in catching salmon and lamprey has increased annually and increased level of boldness has been observed with several pinnipeds entering the adult fishways and hauling out near the project.

In 2005, pinnipeds were observed inside the adult fishways causing concern for predation and potential delay of adult salmon passage. There is an increasing trend to this problem. In response the Corps designed sea lion excluder devices (SLEDs) to keep sea lions out of the fish ladders and has been working closely with NOAA Fisheries and the states to develop a management strategy including various techniques to haze sea lions in the area.

In 2006, the COE installed SLEDs at all fishway entrances at Bonneville Dam and deployed acoustic deterrents from the dam structure immediately adjacent to fish ladder entrances to give fish a potential refuge from sea lion presence at the entrances of the ladder where fish tend to pause/congregate.

The action agencies will continue actions at the projects to:

- Provide and improve SLEDs to limit ability to enter fishways.
- Use acoustic deterrent devices to attempt to move sea lions from immediate adult ladder entrances, away from project facilities, and out of the navigation lock.
- Support and participate in efforts to keep sea lions away from the area immediately downstream of Bonneville Dam.
- Continue working with the States and provide support for harassment activities downstream of Bonneville Dam.

Action Effectiveness Evaluation – The States of Oregon and Washington are pursuing federal authorization through Section 120 of the Marine Mammal Protection Act to lethally remove individual problem animals if necessary to protect ESA listed salmon. The Corps will assist in this effort by documenting activities of individually identifiable pinnipeds near Bonneville Dam and provide assistance and support for the removal of animals as authorized through the MMPA.

The action agencies will document the spatial and temporal distribution of sea lion predation attempts, estimate predation rates, and estimate overall seal lion abundance in order to assess the effects of a combination of deterrent actions (exclusion gates, acoustics, and harassment methods and locations) on spring runs of anadromous fish passing Bonneville Dam. This information will be shared with the states and NOAA in order to coordinate future plans and activities to reduce pinniped impacts to spring Chinook and steelhead.

Benefits of Action: – No specific quantifiable benefits are used in the benefits analysis derived from Pinniped actions as a result of current action described above. However, it is anticipated that specific harassment actions, installation of SLEDS, and acoustic deterrents will provide benefits to spring run anadromous fish for all ESU's as well as white sturgeon immediately below Bonneville. Pending the outcome of the states seeking federal authorization on sea lion removal through Section 120 of the MMPA, it is expected that survival improvements from 1 – 2 percent in adult spring chinook survival below Bonneville are likely. However, as this is a States action, they are not included in the federal FCRPS benefits analysis.

1.4 Avian Predation

1.4.1 Estuary Caspian Tern and Cormorant Predation

Caspian Terns

Caspian terns are a piscivorous species that have pioneered nesting colonies on islands in the Columbia River estuary. Currently, through implementation of management practices, their nesting activities have been confined to East Sand Island. The colony on East Sand Island supports approximately 2/3rds of the North American population of Caspian terns and is significantly larger than normal for the species. The Columbia River estuary population of this species has been the focus of intensive research actions to address their predation on juvenile salmonids and their habitat/population management. A Final Environmental Impact Statement (FEIS), *Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary*, was issued in January 2005. The FEIS was prepared jointly by the U.S. Fish and Wildlife Service (USFWS) (lead), Corps and National Marine Fisheries Service.

Nature of the Action: The Action Agencies proposed in the 2004 UPA to carry out Caspian tern management actions within the western region (California and Oregon) to effect redistribution of a majority of the Caspian terns from the Columbia River estuary. Dispersion of most of the Caspian tern population to locales (5/6) outside the Columbia River Basin would substantially reduce predation losses of juvenile salmonids in the Columbia River estuary and increase their escapement to the Pacific Ocean. Adult salmon returns are expected to increase concomitant with the increased escapement of juvenile salmonids to the Pacific Ocean.

Caspian tern management actions would be done in a manner consistent with the preferred alternative identified in the FEIS, with modification attributable to NMFS biological opinion. The preferred alternative has been modified by dropping Dungeness National Wildlife Refuge, Washington, from the alternative site list due to NMFS concerns over Caspian tern impacts to Puget Sound Chinook and Hood Canal Summer-run chum salmon ESU's. The modified preferred alternative would reduce Caspian tern nesting habitat on East Sand Island, Oregon from approximately 6.5 acres to 1.5 to 2 acres (versus the 1 to 1.5 acres identified in the FEIS). Adaptive management would be undertaken such that tern nesting habitat acreage on East Sand Island could be reduced to 1 to 1.5 acres per the original preferred alternative if terns initiate nesting on a suitable site in the future. The USFWS and the Corps signed separate Records of Decision (RODs) adopting the USFWS plan (modified preferred alternative) for managing

Caspian terms in the Lower Columbia River on November 20 and November 22, 2006 respectively. NMFS completed the biological opinion for the proposed action on February 16, 2006.

The modified preferred alternative relies on habitat management and social attraction measures at six alternate nesting locations to reduce the tern colony in the Columbia River estuary. These alternative nesting locations are located at Fern Ridge Lake (1 ac), Summer Lake (1.5 ac) and Crump Lake (1 ac) in Oregon and Brooks Island (2 ac), Hayward Regional Shorelines (~0.5 ac) and Don Edwards National Wildlife Refuge, San Francisco Bay, California (0.5-1.0 ac). Habitat development at these locations would entail construction of islands and/or modification of existing islands to provide a bare ground substrate suitable for nesting Caspian terns. All locations, except Fern Ridge Lake, are outside the Columbia River Basin.

In conjunction with this increase of suitable nesting habitat outside of the Columbia River Basin, the Corps would reduce the available nesting habitat at East Sand Island from approximately 6.5 acres to 1.5 to 2 acres. Alternative habitat would be developed prior to reduction of nesting habitat on East Sand Island at a ratio of 2 acres of alternative habitat developed to one acre of nesting habitat reduced. The reduction in habitat acreage at East Sand Island would be accomplished by discontinuing maintenance actions and allowing for vegetative succession to render the acreage unsuitable for nesting Caspian terns. The balance of nesting habitat at East Sand Island would be maintained in order to continue to provide proper habitat conditions for Caspian terns.

Background and Justification: Redistribution of the Columbia River Caspian tern population is predicated upon their documented impact to juvenile salmonids in the estuary. Roby et al. (2003) estimated that in 1998 Caspian terns nesting at Rice Island, river mile 21, consumed approximately 12.6 million (~13 percent) of the 96.6 million juvenile salmonids that reached the Columbia River estuary. Collis et al. (2001) reported that an analysis of over 36,000 smolt PIT tags recovered from the Rice Island tern colony in 1998 demonstrated that over 13.5 percent of all PIT-tagged steelhead smolts reaching the estuary were consumed by Caspian terns.

Research information from 1997-98 led to initial resource and action agency efforts to move the Caspian terns to East Sand Island based upon the hypothesis that a more diverse array of prey species would be present at Columbia River mile 5 where marine fish species are prevalent. By 2001, all Caspian terns nesting in the Columbia River estuary had been relocated to East Sand Island through habitat development there. Annual operation and maintenance actions (tillage; and social facilitation with tern decoys and sound systems playing recorded tern colony vocalizations) have succeeded in keeping the tern colony at East Sand Island through 2005.

Juvenile salmonids comprised 16.8 percent to 46.5 percent of the Caspian tern diet at East Sand Island during the 1999-2005 timeframe versus 72.7 percent to 89.6 percent juvenile salmonids in the diet for terns at Rice Island between 1997 and 2000 (Collis et al. 2006). Research results demonstrate that moving Caspian terns from Rice Island, where fresh water dominates, to East Sand Island where marine waters dominate, substantially reduced the number of juvenile salmonids harvested by the terns. Ocean productivity also appears to influence take of juvenile salmonids by Caspian terns at East Sand Island with good ocean productivity, and therefore

increased populations of marine fishes, resulting in a reduced harvest of juvenile salmonids by the terns.

Demonstration that habitat management and social facilitation could result in relocation of nesting Caspian terns and that management practices of this nature could have a substantial impact on prey resource utilization played an integral role in the development of the preferred alternative in the FEIS. Attainment of the original projected colony size for East Sand Island terns (2,500 – 3,125 pairs) described in the preferred alternative of the FEIS is contingent upon implementation of the modified preferred alternative plus adoption of adaptive management strategies to address the removal of the Dungeness NWR as an alternative management site. The scenario laid forth in the modified preferred alternative would reduce the Caspian tern colony in the Columbia River estuary from an average population of 9,093 nesting pairs (2000 – 2005) to 3,125 – 4,375 nesting pairs.

Double-crested Cormorant

Nature of the Action: The Columbia River estuary population of this species has been the focus of recent research actions to evaluate their predation on juvenile salmonids. The proposed action encompasses additional research, development of a conceptual management plan, NEPA clearances, implementation, if warranted, of a management plan, and research, monitoring and evaluation. Further research is required to provide a stronger foundation for the bioenergetics model used to predict general juvenile salmonid consumption. Research requirements include refinement of PIT-tag detection and loss estimates in order to address impacts on salmonids in general and for specific ESU's. Minimal research has been conducted to date on double-crested cormorant habitat/population management; more research is required before a conceptual management plan can be developed and evaluated per NEPA requirements.

Background and Justification: Double-crested cormorants are a piscivorous species that have pioneered breeding colonies into the Columbia River estuary. Since 1989, when less than 100 pairs were present on East Sand Island, the breeding population of this species has increased there to 12,500 pairs in 2004 (Collis et al. 2005), the largest colony in North America. Estimated juvenile salmonid consumption by this species in 2004 was 6.4 million fish (range 2.5 – 10.3 million), a 25 percent increase over the 2003 estimate of 5.2 million smolts (Collis et al. 2005). Their predation level, coupled with that for Caspian terns, generated an estimated loss of 10 million juvenile salmonids in the estuary for 2004 (Collis et al. 2005). Steelhead, coho, sub-yearling and yearling chinook comprised the salmonids in their diet in 2004; sub-yearling chinook represented the largest proportion of salmonids (Collis et al. 2005). ESU specific data are not available.

Conceptually, management efforts directed toward double-crested cormorants nesting in the Columbia River estuary could achieve additional gains, perhaps comparable or even greater than those associated with the proposed Caspian tern management. Further research efforts are necessary to lead to an EIS, developed in conjunction with USFWS, that addresses potential population and habitat management actions for double-crested cormorants. Research into cormorant predation on juvenile salmonids, an evaluation of management needs, and an in-depth analysis of the regional double-crested cormorant population (range, population dynamics,

status) would support completion of the environmental review requirements for determination of future management actions, if warranted.

Benefits: The double-crested cormorant nesting period begins in late April and continues to the end of August, coinciding with the principle juvenile salmonid outmigration period. Reductions in cormorant predation rates have the potential to benefit the majority of the listed and non-listed yearling salmonids as well as some subyearling salmonids that migrate through the Columbia River estuary during that time. This would include the following ESUs:

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

Double-crested cormorants nesting in the estuary have little to no effect on Columbia River chum salmon (D. Roby, personal comm.). Until further research is completed and a management alternative is selected, it is difficult to determine the potential benefit of a future action.

Literature Cited.

Roby, D. D., D. E. Lyons, D. P. Craig, K. Collis, and G. H. Visser. 2003. Quantifying the effects of predators on endangered species using a bioenergetics approach: Caspian terns and juvenile salmonids in the Columbia River estuary. Canadian Journal of Zoology. 81: 250-265.

1.4.2 Inland Avian Predation

Caspian Tern:

Of the inland Caspian tern colonies, the one on Crescent Island in the mid-Columbia River is the largest of its kind on the Columbia Plateau. Located below the confluence of the Snake and Columbia rivers, the tern colony on Crescent Island consists of approximately 500 breeding pairs and interacts with up to 10,000 gulls also found on Crescent Island.

Salmonid smolts represented about 68 percent, 70 percent, and 65 percent of the tern diet on Crescent Island in 2003, 2004, and 2005. Consumption of both Snake and Columbia River juvenile salmonids by the Crescent Island tern colony was estimated at approximately 440,000, 470,000, and 440,000 smolts in 2003, 2004, and 2005. These are minimum consumption estimates and do not include kleptoparasitism by the California gull colony surrounding the tern colony on Crescent Island. Snake River steelhead incurred the highest predation rate at 34.7

percent and 16.7 percent in 2004 and 2005 when corrected for PIT tag collision, detection efficiency, and PIT tag deposition (Collis et al. 2005). It is important to note that these are minimum predation rates based on the proportion of PIT-tagged smolts last detected at Lower Monumental Dam and subsequently recovered on the Crescent Island tern colony; Collis et al. (2005).

Because of low flow years in 2003 and 2004 it is estimated approximately 96 percent to 98 percent of the Snake River steelhead smolts above Lower Granite Dam, were transported via barge and were not available susceptible to predation from terns at Crescent Island. Thus, considering the percent of steelhead barged, the predation rates presented in the above paragraph were only on an estimated 2-4 percent of the total Snake River steelhead population.

However, recent and future expected transportation operations will have a spread the risk transport-inriver operation in which more steelhead migrate inriver. Data cited above for 2003 and 2004 reflect estimated losses when most fish were transported; it is unclear whether predation rates would significantly change relative to the proportion of juvenile salmonids left inriver to migrate past the Crescent Island tern colony.

Proposed Action: Develop and implement an avian management plan for Corp's owned lands, including avian colonies on Crescent Island, and associated shallow water habitat. The development and implementation of avian management plan(s) will be preceded by a thorough analysis of avian predator diets, predation rates, and overall effects of current avian predation on various salmonid ESU's. This will be a comprehensive plan developed in collaborative discussion with the U.S. Fish and Wildlife Service. The primary objective of this plan will be to improve ESA listed anadromous fish survival for fish rearing and migrating through the Lower Snake and Columbia rivers. Research in support of this plan will continue with 2007 studies to determine the impact of Caspian tern predation on juvenile salmon under a range of system operations, with a potential for future research as needed. In addition, efforts are underway to better estimate the species/ESU-specific impacts of tern predation.

Benefits: Until it is determined that management is warranted and a management alternative is selected, it is difficult to determine the potential benefit of this action. Reductions in tern predation rates have the potential to benefit the majority of the listed and non-listed yearling salmonids as well as some subyearling salmonids that migrate near Crescent Island during the Caspian tern nesting period, which begins in early April and continues to the end of July. This would include the following ESUs:

- Snake river Spring/summer Chinook Salmon,
- Snake River Fall Chinook Salmon,
- Upper Columbia River Spring Chinook Salmon,
- Snake River Steelhead,
- Upper Columbia River Steelhead,
- Mid-Columbia River Steelhead, and
- Snake River Sockeye Salmon

Schedule: The three-year goal is to begin development of a comprehensive management strategy for populations of avian predators on lands under the Corps management authorities.

Research will continue to provide information necessary to evaluate potential avian management alternatives (including terns on Crescent Island and other locations). Once management alternatives have been determined, and implementation of the management plan is on going, our performance metrics will be defined in the management plan.

Double-crested Cormorant

In recent years, the number of Double-crested cormorants has been increasing throughout the Mid Columbia region. The number of nesting pairs of cormorants on Foundation Island in the McNary Pool increased 14 percent from 2005 to 2006. In 2006, a small but new colony of cormorants was located on the railroad bridge on the Snake River across from Lyons Ferry Hatchery. Cormorants are now regularly observed over-wintering at all lower Snake River projects. In the spring of 2007, approximately 60-70 cormorants were observed roosting along the Snake River in Lewiston, Idaho. Monitoring of cormorants in the Potholes, Moses Lake, and Yakima River also show an increase in cormorant numbers.

In 2006, PIT tags were recovered at the Foundation Island cormorant colony in order to estimate smolt predation rates. Cormorants nest in trees on Foundation Island, making PIT detection difficult thereby, underestimating predation. A total of 3,505 PIT tags from 2006 migration were recovered on Foundation Island. Based on the limited Foundation Island PIT tag data, cormorants consumed a minimum estimated 0.89 percent of all the PIT-tagged smolts interrogated passing Lower Monumental Dam from April through 31 July. The estimated Foundation Island cormorant predation rates on hatchery Snake River steelhead smolts was 2.8 percent and PIT-tagged fall Chinook from the Yakima River 2.0 percent. These are minimum predation rates and are not corrected for the proportion of ingested PIT tags not deposited on the colony, including uncertainties regarding PIT tag detection efficiency and deposition rate.

Proposed Action: Develop and implement an avian management plan for Corp's owned lands. This will be a comprehensive plan that will include avian colonies on Foundation Island, other cormorant roosting sites, and associated shallow water habitat. Alternatives will be developed and evaluated in collaboration with the Fish and Wildlife Service. Research to determine the impact of double-crested cormorant predation on salmonids at in the Columbia River Basin is continuing in 2007 with a potential for future research as needed. In addition, efforts are underway to better estimate the species/ESU-specific impacts of cormorant predation.

Benefits: Until it is determined that cormorant management is warranted and a management alternative is selected, it is difficult to determine the potential benefit of action. The double-crested cormorant nesting period begins in late April and continues to the end of August, coinciding with the principle juvenile salmonid outmigration period. Reductions in cormorant predation rates have the potential to benefit the majority of the listed and non-listed yearling salmonids as well as some subyearling salmonids that migrate near Foundation Island during that time. This would include the following ESUs:

- Snake River spring/summer Chinook salmon,
- Snake River fall Chinook salmon,
- Upper Columbia River spring Chinook salmon,

- Snake River steelhead,
- Upper Columbia River steelhead,
- Mid-Columbia River steelhead, and
- Snake River sockeye salmon

Schedule: The three-year goal is to begin development of a comprehensive management strategy for populations of avian predators (including cormorants) on lands under the Corps management authorities. Research will continue to provide information necessary to evaluate potential avian management alternatives (including cormorants on Foundation Island and other locations). Once management alternatives have been determined, and implementation of the management plan is on going, our performance metrics will be defined in the management plan. To provide information in support of the plan, our goal is to estimate stock specific predation rates on juvenile salmonids, and determine if regional management actions are warranted. We will conduct collaborative discussions with the U.S. Fish and Wildlife Service during the research phase. If at the end of the research phase, it is determine management actions are warranted, we will begin environmental documentation associated with potential management alternatives on cormorants within the Columbia River Basin.

Literature Cited.

Roby, D. D., D. E. Lyons, D. P. Craig, K. Collis, and G. H. Visser. 2003. Quantifying the effects of predators on endangered species using a bioenergetics approach: Caspian terns and juvenile salmonids in the Columbia River estuary. Canadian Journal of Zoology. 81:250-265.

1.5 Other Avian Deterrent Actions

Avian deterrent actions are ongoing at each of the dams. Continue to implement and improve avian predation deterrent programs at all Lower Snake and Columbia River dams. This program will continue to be coordinated with FPOM and included in the annual FPP.

Effects of Actions to Reduce Tern Predation

Background

Caspian tern predation in the Lower Columbia River is a major source of mortality for ESA-listed Snake and Columbia River juvenile salmonids. The tern population has changed substantially over the base period (1980-2001). The year of first occurrence of Caspian terns in the Columbia River Estuary is known to be 1984 when they first used East Sand Island. By 1986, the bulk of the tern population was at Rice Island with a remnant colony (numbers unknown) at East Sand Island. Caspian terns nested exclusively at Rice Island from 1987-1998. Management efforts were implemented in 1999 to shift the Caspian tern colony back to East Sand Island. The split in the nesting colony for 1999 and 2000 can be seen in Table 1; data are reported separately for the islands in those years to facilitate further analysis.

Tern Consumption of Juvenile Salmonids

Caspian tern population estimates were derived and where necessary, interpolated, from known data. Research data collected by D. Roby (USGS/OSU) and associates formed the basis for these analyses. Collis et al. (1998) had documented population estimates for the Columbia River estuary (CRE) Caspian tern colony for 1984, 1986, 1987, and 1991 from Corps of Engineers and U.S. Fish and Wildlife Service biologists. Research data for 1997-2006 (K. Collis e-mail; 2/6/2007) provided Caspian tern population estimates for that time period. Population estimates for the years when data were unavailable were interpolated from estimates for the years that encompassed the time period.

Total juvenile salmonid consumption by Caspian terns is based upon research results for the period 1997-2006. Estimates of annual smolt consumption were calculated using a bioenergetics modeling approach (see Roby et al. 2003 for a detailed description of model construction and input variables). The annual consumption estimates from 1997-2006 were compiled by the researchers and forwarded to Portland District, USACE for utilization in preparation of these estimates. These data were derived from a Don Lyons e-mail (2/6/07) and populate Table 1 for the years research occurred. To calculate total juvenile salmonid consumption for years prior to 1997, these data were separated by island, e.g. Rice and East Sand. For each island, the number of juvenile salmonids consumed per tern per year was determined. Thus, for East Sand Island, data from 1999 to 2006 were evaluated to determine the average number of juvenile salmonids consumed per tern per year. For Rice Island, the average was calculated for 1997-2000. These averages were then multiplied by the estimated tern population at Rice or East Sand for the years prior to 1997 to generate total juvenile salmonids consumed for this period. .

A similar process to juvenile salmonid consumption estimates for years prior to 1997 was used to calculate the number of Chinook subyearling, Chinook yearling, and steelhead consumed by

terns per year at either East Sand or Rice Island. Juvenile salmonid consumption data, broken into the four "species" categories (Don Lyons e-mail -2/6/07) was grouped by island and the average percent composition for each island was then multiplied by the estimated juvenile salmonid composition (total) for the respective islands to provide a "species" breakdown.

Juvenile Salmonid Survival

Our analysis of tern predation on juvenile salmon and steelhead survival in the estuary divides the tern predation effects into three time periods: 1. baseline; 2. current condition; and 3. prospective (a future tern population level which is based on the 'Future 2' population objective or 3,125 breeding pairs established in the Caspian Tern Environmental Impact Statement). The analysis is further divided into 2 baseline and current condition scenarios: baseline 1 includes 1980 – 1999 (pre-tern relocation); current 1 includes 2000-2006 (post tern relocation); baseline 2 covers 1980-2001; current 2 includes 2002-2006.

To estimate the effects of tern predation on juvenile salmonid survival, we used estimates of the number of juvenile salmonids consumed (Table 1), divided by the number of juvenile salmonids estimated to arrive at Tongue Point (FPC hatchery release, transportation, and in-river migrant estimates for 1987-1999; NMFS Estimation Memos, 2000-2006; Table 2). We could find no estimates available pre-1987. Therefore we averaged 1987-1999 smolt numbers for each species and extrapolated them to those years. Estimated consumption rates for the baseline, current condition, and prospective tern population scenarios are presented in Table 3. We estimated the average consumption rates per breeding pair and extrapolated that rate to the future estimates of the tern population. Two baseline and current condition scenarios are presented: For baseline 1, we used the average tern numbers and consumption rates from 1980-1999. For baseline 2 we used average tern numbers and consumption rates from 1980-2001. For current condition 1, we used the average tern numbers and consumption rate from 2000-2006. For current condition 2, we used the average tern numbers and consumption rate from 2002-2006. To estimate the consumption rates for prospective 1 and 2, we calculated the 2000-2006 (prospective 1) and 2002-2006 (prospective 2) average proportion of smolts consumed per breeding pair, and expanded it to the future tern population objective of 3125 breeding pairs.

Baseline to Current and Prospective Survival Changes:

Relative survival changes resulting from the relocation of terns to East Sand Island (baseline to current) and additional benefits that would be expected for the future reduced tern population objective in the tern EIS (prospective) are presented in Table 4. Relative survival changes for the baseline to current condition are calculated by dividing the estimated absolute survival of the current condition by the estimated absolute survival of the baseline condition. For example, the baseline 1 to current 1 relative survival change for yearling chinook would be calculated as (1-current 1 consumption)/(1- baseline 1 consumption) = (1-0.036)/(1-0.024) = 0.987. It is assumed that these relative survival rates, which are based on the entire Columbia Basin run for each species and rearing type, are the same as they would be for the respective ESUs. For example, the 1.007 relative survival rate for all subyearling Chinook under the prospective 2 scenario would be same as that for the Snake River Fall Chinook ESU. Estimates of juvenile salmonids at Tongue point prior to 2000 assume that there is no mortality between Bonneville Dam and Tongue Point. We also assume that juvenile chum and Snake River sockeye salmon

consumption by terns is not substantial enough for there to be a survival benefit from the proposed tern population reduction (Collis et al. 2002).

Table 1. Caspian tern population estimates and estimated consumption of juvenile salmonids at Rice and East Sand Islands from 1980-2006. Bolded numbers based on research data from Dan Roby (USGS/OSU).

Year	Breeding Pairs		Estimated Consumption		
	East Sand	Rice	Yearling Chinook	Subyearling Chinook	Steelhead
1980	0	0	0	0	0
1981	0	0	0	0	0
1982	0	0	0	0	0
1983	0	0	0	0	0
1984	**1000**	0	130,126	92,529	78,179
1985	1000	0	130,126	92,529	78,179
1986		**1000**	92,392	667,590	162,506
1987	0	**1350**	124,729	901,247	219,384
1988	0	2563	236,800	1,711,033	416,504
1989	0	3776	348,871	2,520,820	613,624
1990	0	4989	460,942	3,330,607	810,744
1991	0	**6200**	572,828	4,139,058	1,007,540
1992	0	6356	587,241	4,243,202	1,032,891
1993	0	6512	601,654	4,347,346	1,058,242
1994	0	6668	616,067	4,451,490	1,083,593
1995	0	6824	630,480	4,555,634	1,108,944
1996	0	6980	644,893	4,659,778	1,134,295
1997	0	**7134**	**280,000**	**2,875,000**	**1,030,000**
1998	0	**8766**	**700,000**	**5,460,000**	**1,370,000**
1999		**8328**	**1,120,000**	**7,520,000**	**1,340,000**
1999	**588**		**70,000**	**440,000**	**70,000**
2000		**547**	**130,000**	**260,000**	**180,000**
2000	**8513**		**1,480,000**	**1,010,000**	**840,000**
2001	**8982**	**0**	**1,170,000**	**1,000,000**	**570,000**
2002	**9933**	**0**	**1,350,000**	**960,000**	**740,000**
2003	**8325**	**0**	**1,100,000**	**700,000**	**560,000**
2004	**9502**	**0**	**840,000**	**630,000**	**530,000**
2005	**8822**	**0**	**970,000**	**370,000**	**730,000**
2006	**9201**	**0**	**1,380,000**	**830,000**	**980,000**

Table 2. Estimated number of smolts arriving at Tongue Point from 1980 – 2006. Smolt numbers for 1987-1999 are estimates of transported, in-river migrants, and hatchery releases from the Fish Passage Center. Smolt estimates from 1980-1986 are extrapolated using 1987-1999 averages. Data for 2000-2006 are from NMFS estimation memorandums 2000 – 2006. T&S refers to transport with spill. Full T refers to full transport scenarios.

Year	Scenario	Yearling Chinook	Subyearling Chinook	Steelhead	Total
1980		12,798,976	69,429,653	11,301,436	93,530,066
1981		12,798,976	69,429,653	11,301,436	93,530,066
1982		12,798,976	69,429,653	11,301,436	93,530,066
1983		12,798,976	69,429,653	11,301,436	93,530,066
1984		12, 798,976	69,429,653	11,301,436	93,530,066
1985		12,798,976	69,429,653	11,301,436	93,530,066
1986		12,798,976	69,429,653	11,301,436	93,530,066
1987		10,457,444	74,372,997	8,738,765	93,569,206
1988		15,710,187	89,231,869	9,978,598	114,920,654
1989		11,083,229	90,629,260	10,979,152	112,691,641
1990		14,459,431	81,363,074	12,279,275	108,101,780
1991		11,726,399	84,080,243	13,266,512	109,073,154
1992		14,601,665	67,780,287	10,228,875	92,610,827
1993		12,320,315	73,934,735	13,084,545	99,339,595
1994		13,030,326	60,043,148	10,831,845	83,905,319
1995		14,383,917	81,437,342	11,669,565	107,490,824
1996		9,777,921	66,457,615	12,028,607	88,264,143
1997		10,676,760	56,810,074	10,320,437	77,807,271
1998		12,956,348	41,692,702	11,009,686	65,658,736
1999	T & S	15,202,744	34,752,149	12,502,812	62,457,705
2000	T & S	30,565,835	47,345,104	13,981,625	91,892,564
2001	Full T	23,704,323	38,571,680	14,923,748	77,199,751
2002	T & S	35,891,234	52,830,287	14,875,230	103,596,751
2003	T & S	38,662,026	59,463,290	15,767,097	113,892,413
2004	T & S	33,826,302	60,475,322	13,639,272	107,940,896
2005	T & S	37,104,975	81,247,508	13,692,298	132,044,781
2006	T & S	38,832,655	89,791,172	14,963,344	143,587,171

Table 3. Estimated consumption rate of juvenile salmonids by Lower Columbia River terns for the baseline, the current condition, and the proposed action (based on the tern EIS, Future 2).

Timeframe	Number of Tern Pairs	Yearling Chinook	Subyearling Chinook	Steelhead
Baseline 1 (1980-99)	4,002	0.024	0.030	0.043
Baseline 2 (1980-01)	4,458	0.027	0.031	0.046
1999 Alone	*8,916*	*0.078*	*0.229*	*0.113*
Current 1 (2000-'06)	9,118	0.036	0.015	0.051
Current 2 (2002-06)	9,157	0.030	0.011	0.049
Prospective 1	3,125	0.012	0.005	0.017
Prospective 2	3,125	0.010	0.004	0.017

Table 4. Relative juvenile salmonid survival changes attributed to tern relocation actions. Survival (S) is calculated as 1-consumption rate (Table 3).

Timeframe	Yearling Chinook	Subyearling Chinook	Steelhead
Current 1 S / Baseline 1 S	0.987	1.015	0.992
Prospective 1 S / Current 1 S	1.025	1.010	1.035
Current 2 S/ Baseline 2 S	0.996	1.021	0.997
Prospective 2 S / Current 2 S	1.021	1.007	1.034

Literature Cited:

Collis, K., D.D. Roby, D.P. Craig, S. Adamany, J. Adkins, and D.E. Lyons. 2002. Colony size and diet composition of piscivorous waterbirds on the Lower Columbia River: Implications for losses of juvenile salmonids to avian predation. Transactions of the American Fisheries Society. 131: 537-550.

Collis, K., S. Adamany, D. D. Roby, D. P. Craig, and D. E. Lyons. 1998. Avian Predation on Juvenile Salmonids in the Lower Columbia River. 1998 Annual Report for Bonneville Power Administration and U.S. Army Corps of Engineers.

NMFS. 1999-2006. Annual Memorandums for estimating the percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River Basin. National Marine Fisheries Service, Northwest Fisheries Science Center, Fish Ecology Division, 2725 Montlake Blvd. E. Seattle, Washington.

Roby, D. D., D. E. Lyons, D.P. Craig, K. Collis, and G. H. Visser. 2003. Quantifying the effects of predators on endangered species using a bioenergetics approach: Caspian terns and juvenile salmonids in the Columbia River estuary. Canadian Journal of Zoology 81:250-265.

Predator Control Action Benefits

Action Summary: The following predator control action will be implemented to reduce mortality and improve survival of juvenile salmonids migrating through the FCRPS projects in the Snake and Columbia Rivers, and in the Columbia River downstream of Bonneville Dam.

- Implement the base Northern Pikeminnow Management Program (NPMP) and continue the general increase in the reward structure in the Sport-Reward fishery similar to that of 2001, 2004-2006. This includes increasing the budget for monetary rewards for harvesting northern pikeminnow structured in a tiered fashion to increase the reward as anglers increase total seasonal catch.
- Evaluate the benefit of additional removals and resultant increase in exploitation rate's effect on reduction in predator mortality since the 2004 program incentive increase.
- Continue to evaluate if inter and intra species compensation is occurring on surviving northern pikeminnow and other pisciverous species.

Methodology: The juvenile salmon survival benefits associated with an increased incentive program can be estimated by modeling the additional removals consistent with the general assumptions and model parameters used in evaluating and estimating the cumulative benefits of the NPMP to date. The general approach employed by NPMP analysts involves applying an appropriate northern pikeminnow consumption rate on juvenile salmonids (temporally and spatially) to the number of additional northern pikeminnow removed (temporally and spatially) to determine "number of smolts" not eaten. This provides an indication of potential incremental benefit of increased removals, assuming no significant inter-or intra-specific compensation.

Specific Actions and Estimated Benefits: In 2006, the Action Agencies continued implementing a general increase in the reward structure started in the summer of 2004. Average exploitation rates (the percentage of the targeted size fish annually removed) in the NPMP, notwithstanding the NPMP heavy-up in 2001/2004-2006 have averaged approximately 11 percent for the last 16 years. The observed exploitation rate on pikeminnow since increasing the monetary incentives has averaged 18 percent, an over 50 percent improvement. Program evaluators are modeling the estimates of the increased exploitation rate's additional effect on reduction in predator mortality during the 2006-7 off-season. This increase above the baseline, once estimated and quantified, is above and beyond the base benefits assumed in the analytical

analyses at present. Therefore, the marginal benefit of any increase in exploitation rate resulting from increases in program incentives should be separate and above base-period benefits.

Preliminary results from ODFW evaluation indicate an increase in the reduction in pikeminnow predation resulting from the observed increase in annual exploitation since 2004 and improved estimates of pikeminnow over-wintering mortality on the order of 42 percent (ODFW, Tucker Jones, personal communication). This represents a 60 percent increase in the benefits compared to previous benefit estimates.

For the 2004 Summer Spill offset process, the Action Agencies developed a model to quantify the marginal impact of the additional harvest and resultant change in the exploitation rate of pikeminnows. The model was developed for juvenile fall Chinook as the focal species because impacts from elimination of spill in August primarily affected that stock. This model could be modified to consider other salmonid stocks. The model and analysis assumes average consumption rates and geographical distribution of pikeminnow removals within the Snake and Columbia based on historical data. The model accounts for juvenile fish transportation and timing of juvenile runs, and for the gradual within season removal of NPM. It also accounts for the abundance of smolts entering the FCRPS or below Bonneville Dam, and assumes that NPM feed only to satiation The Action Agencies determined that a 1-2 percent increase in the exploitation rate (20,000-40,000 increase in catch) would result in an additional savings of approximately 1,400,000-2,800,000 smolts across the lifespan of the northern pikeminnow caught. This equated at the time to a .6 percent increase in the juvenile survival of migrating salmonids. Currently, the NPMP is observing closer to 90,000 additional pikeminnow catch since 2004 relative to the average pikeminnow catch for the previous 16 years.

It appears reasonable, based mainly on the preliminary ODFW evaluation and the 2004 Summer spill analysis, to conclude that increasing the incentive in the pikeminnow removal program and resultant marginal increase in observed exploitation rate has a positive benefit in reduction in pikeminnow mortality. Pre-program estimates of northern pikemonnow predation rate on juvenile salmonid migrants in the Columbia River basin are 8 percent.(2000 FCRPS BiOp at 9-106). Before implementation of the additional incentive program in 2004, the cumulative benefit has reduced the pikeminnow related mortality rate to 6 percent (25 percent reduction, Friesen and Ward 1999). Preliminary estimates of reduction in predator mortality are now 42 percent, or an additional 1.4 percent reduction. Therefore, it is reasonable to assess the marginal benefit to outmigrating salmonids as at least 1 percent increase relative to the baseline.

Species Affected

Juvenile salmonids are the major dietary component of northern pikeminnow greater than 250mm fork length. The importance of salmonids in the diet of northern pikeminnow does vary seasonally; however all migrating salmonids receive benefit from the Northern Pikeminnow Management Program.