
PART I - ADMINISTRATIVE

Section 1. General administrative information

Title of project

Avian Predation on Juvenile Salmonids in the Lower Columbia River

BPA project number: 9702400
Contract renewal date (mm/yyyy): 1/1999 **Multiple actions?**

Business name of agency, institution or organization requesting funding
Oregon State University/Columbia River Inter-Tribal Fish Commission

Business acronym (if appropriate) OSU/CRITFC

Proposal contact person or principal investigator:

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NPPC Program Measure Number(s) which this project addresses
5.7A.6, 5.7B.20, 5.7B.21, 5.7B.22, 5.7B.23

FWS/NMFS Biological Opinion Number(s) which this project addresses
1995 NMFS Hydrosystem Operations Biological Opinion: VII.A.14, XII.8, XII.9

Other planning document references

NMFS Snake River Recovery Plan: V.2.8.a.2, V.2.8.b.1; Wy Kan Ush Me Kush Wit: 5.B.Hypothesis 6; Lower Columbia Steelhead Conservation Initiative; Steelhead Supplement to the Oregon Plan; Oregon Department of Fish and Wildlife Draft Predation Action Plan: Avian Species

Short description

Monitor and evaluate the efficacy of management initiatives to reduce predation by colonial waterbirds on juvenile salmonids in the lower Columbia River. Assist resource managers in the development of a long-term avian predation management plan.

Target species

Columbia Basin salmonids, Caspian terns, double-crested cormorants, gull spp.

Section 2. Sorting and evaluation

Subbasin

Mainstem, Ocean/estuary

Evaluation Process Sort

CBFWA caucus	Special evaluation process	ISRP project type
Mark one or more caucus	If your project fits either of these processes, mark one or both	Mark one or more categories
<input checked="" type="checkbox"/> Anadromous fish <input type="checkbox"/> Resident fish <input type="checkbox"/> Wildlife	<input type="checkbox"/> Multi-year (milestone-based evaluation) <input type="checkbox"/> Watershed project evaluation	<input type="checkbox"/> Watershed councils/model watersheds <input type="checkbox"/> Information dissemination <input type="checkbox"/> Operation & maintenance <input type="checkbox"/> New construction <input checked="" type="checkbox"/> Research & monitoring <input type="checkbox"/> Implementation & management <input type="checkbox"/> Wildlife habitat acquisitions

Section 3. Relationships to other Bonneville projects

Umbrella / sub-proposal relationships. List umbrella project first.

Project #	Project title/description

Other dependent or critically-related projects

Project #	Project title/description	Nature of relationship
9008000	Columbia Basin PIT Tag Information System	Recovery of PIT tag codes from piscivorous waterbird colonies to be included in the PTAGIS database
9600800	PATH	Estimates of smolt losses to birds can be included in mainstem passage models to estimate juvenile salmonid survival

Section 4. Objectives, tasks and schedules

Past accomplishments

Year	Accomplishment	Met biological objectives?
1996	Identify the locations and population size of major piscivorous waterbird colonies on the lower Columbia River	Nine colonies were identified and the population size of each colony was estimated using aerial photography.
1996	Recover PIT tags from the Rice Island Caspian tern colony in the Columbia River Estuary	Roughly 400 tags were recovered. These data were analyzed along with tag recoveries in 1997 to estimate the total number of tags on the colony site, as well as the relative vulnerability of different salmonid species and rearing types to tern predation.
1997	Determine the population size and trajectory of nine piscivorous waterbird colonies on the lower Columbia River.	Population size was determined using aerial photography and comparisons to previous census information indicated that most

		colonies were increasing in size.
1997	Determine the diet composition of nine piscivorous waterbird colonies on the lower Columbia River.	Juvenile salmonids were an important part of the diet of some piscivorous waterbirds nesting in the estuary, most notably the Rice Island Caspian tern colony. Gulls nesting at upriver locations were far less reliant on juvenile salmonids as a food source.
1997	Recover PIT tags from the Rice Island Caspian tern colony in the Columbia River Estuary	Roughly 600 tags were recovered. These data were analyzed along with tag recoveries in 1996 to estimate the total number of tags on the colony site, as well as the relative vulnerability of different salmonid species and rearing types to tern predation.
1997	Use a bioenergetics approach to estimate the total number of juvenile salmonids consumed by the Rice Island Caspian tern colony.	Bioenergetics estimates indicated that Caspian terns consumed between 6 and 25 million juvenile salmonids in 1997.
1998	Verify estimates of predation on juvenile salmonids by Caspian terns nesting on Rice Island.	Estimates of predation in 1998 were similar to 1997, suggesting that 1997 was not an anomalous year. These data are currently being analyzed.
1998	Use a bioenergetics approach to estimate the total number of juvenile salmonids consumed by double-crested cormorants nesting in the Columbia River Estuary.	Model input variables were measured to estimate cormorant consumption on juvenile salmonids in 1998. These data are currently being analyzed.
1998	Collect information on the distribution, foraging range, and habitat utilization of Caspian terns in the Columbia River Estuary.	Road-based and aerial surveys were conducted. Most terns were observed within 5 miles of the colony location. Terns were commonly observed foraging near pile dikes and hatchery release locations in the estuary. These data are currently being analyzed.
1998	Monitor selected upriver piscivorous waterbird colonies to monitor changes in population size and diet composition.	All upriver colonies were censused using aerial photography. Three colonies were monitored to determine diet composition, including one small Caspian tern colony at Three-mile Canyon Island. Juvenile salmonids predominated in the diet of upriver terns.
1998	Test the feasibility of methods to relocate the Caspian tern colony to a new nesting location as a means to reduce their impact on survival of juvenile salmonids.	Tern decoys and an audio playback system broadcasting tern calls were used to attract several hundred terns to a site where they had not previously nested. Nesting behaviors were observed and some pairs successfully laid eggs.
1998	Recover PIT tags at the Rice Island tern and cormorant colonies and the Crescent Island Caspian tern colony.	With help from NMFS, roughly 48,000 PIT tags were detected on Rice Island and another 10,000 on Crescent and Three-Mile Canyon islands, located on the Columbia River above John Day Dam. We are currently working with NMFS to analyze these data.

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Monitor and evaluate the efficacy of management initiatives implemented to reduce avian predation on juvenile salmonids.	a	Conduct surveys to assess changes in size and productivity of managed piscivorous waterbird colonies.
		b	Determine changes in diet composition and smolt consumption rates of managed piscivorous waterbirds.
		c	Assess changes in foraging distribution, foraging range, and habitat use of managed piscivorous waterbirds.
2	Determine impacts of unmanaged piscivorous waterbird colonies on survival of juvenile salmonids.	a	Conduct surveys to estimate size and productivity of unmanaged piscivorous waterbird colonies.
		b	Determine diet composition and smolt consumption rates of unmanaged piscivorous waterbirds
		c	Assess foraging distribution, foraging range, and habitat use of unmanaged piscivorous waterbirds.
3	Assist in developing a long-term management plan to reduce avian predation on juvenile salmonids in the lower Columbia River.	a	Provide technical assistance to the Interagency Avian Predation Working Group to refine and further develop existing management initiatives (i.e., adaptive management).
		b	Test the feasibility of various management options to reduce predation on juvenile salmonids by piscivorous waterbirds in the lower Columbia River.
		c	Provide technical assistance to the Interagency Avian Predation Working Group to develop new management initiatives, as needed.
		d	Survey and inventory existing nesting habitat for piscivorous colonial waterbirds outside the Columbia Basin and provide technical assistance on restoration and conservation of critical nesting habitat.

Objective schedules and costs

Obj #	Start date mm/yyyy	End date mm/yyyy	Measureable biological objective(s)	Milestone	FY2000 Cost %
1	3/2000	12/2000	Assess the effectiveness of management initiatives implemented to reduce smolt losses to birds	1. Completion of field data collection. 2. Completion of data analysis 3. Submission of	60.00%

				draft annual report 4. Submission of final annual report	
2	3/2000	12/2000	Determine the need for further mitigation for smolt losses to birds	1. Completion of field data collection. 2. Completion of data analysis 3. Submission of draft annual report 4. Submission of final annual report	30.00%
3	1/2000	12/2000	Assist in the development of effective management alternatives to reduce unacceptable levels of predation on juvenile salmonids by piscivorous waterbirds	1. Completion of field data collection. 2. Completion of data analysis 3. Submission of draft annual report 4. Submission of final annual report 5. Provide input on out-year management.	10.00%
				Total	100.00%

Schedule constraints

The implementation of a management plan to reduce predation by piscivorous waterbirds on juvenile salmonids will depend on decisions made by the Interagency Avian Predation Working Group comprised of regional fish and wildlife managers and stakeholders.

Completion date

2002

Section 5. Budget

FY99 project budget (BPA obligated): \$515,000

FY2000 budget by line item

Item	Note	% of total	FY2000
Personnel	1 Post Doc, 2 Masters students, 5 field technicians	% 14	92,700
Fringe benefits		% 3	16,800

Supplies, materials, non-expendable property	radio tags (2 studies), switchers/antennas, doubly-labeled water	% 14	86,900
Operations & maintenance	aerial photos, vehicles, two field offices, telemetry flight time, tuition	% 14	89,600
Capital acquisitions or improvements (e.g. land, buildings, major equip.)	radio-telemetry receivers	% 9	60,000
NEPA costs		% 0	
Construction-related support		% 0	
PIT tags	# of tags:	% 0	
Travel		% 1	9,500
Indirect costs		% 11	69,900
Subcontractor	CRITFC	% 34	217,200
Other		% 0	
TOTAL BPA FY2000 BUDGET REQUEST			\$642,600

Cost sharing

Organization	Item or service provided	% total project cost (incl. BPA)	Amount (\$)
USACE	Provided funds in 1999. Obligated funds in 2000?	% 0	0
USFWS	Provided funds in 1999. Obligated funds in 2000?	% 0	0
NMFS	Provided funds in 1999. Obligated funds in 2000?	% 0	0
		% 0	
Total project cost (including BPA portion)			\$642,600

Outyear costs

	FY2001	FY02	FY03	FY04
Total budget	\$550,000	\$200,000	\$0	\$0

Section 6. References

Watershed?	Reference
<input type="checkbox"/>	Beamesderfer, R.C., and B.E. Rieman. 1991. Abundance and distribution of northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120: 439-447.
<input type="checkbox"/>	Bevan, D., J. Harville, P. Bergman, T. Bjornn, J. Crutchfield, P. Klingeman, and J. Litchfield. 1994. Snake River Salmon Recovery Team: Final Recommendations to National Marine Fisheries Service. Dated May 1994.
<input type="checkbox"/>	Blackwell, B.F. 1995. Ecology of double-crested cormorants using the Penobscot River, Maine. Unpublished Ph.D. thesis, University of Maine, Department of Wildlife and Ecology, Orono, Maine.
<input type="checkbox"/>	Carter et al. 1995. Population size, trends, and conservation problems of the double-crested cormorant on the Pacific Coast of North America. Pages 189-215 in D.N. Nettleship and D.C. Duffy, editors. Colonial Waterbirds 18 (Special Publication 1).
<input type="checkbox"/>	CRITFC (Columbia River Inter-tribal Fish Commission). 1995. Wy-Kan-Ush-Mi Wa-Kish-Wit, Spirit of the Salmon. The Columbia River anadromous fish restoration plan of the Nez

	Perce, Umatilla, Warm Springs, and Yakama tribes. Vol. 1, Final draft. Portland,
<input type="checkbox"/>	Cuthbert, F., and L. Wires. in press. Caspian Tern. In Birds of North America, No XX, A. Poole, P. Stettenheim, F. Gill, eds. Philadelphia, PA, American Ornithologists Union.
<input type="checkbox"/>	Feltham, M.J. 1995. Consumption of Atlantic salmon smolts and parr by goosanders: estimates from doubly-labeled water measurements of captive birds released on two Scottish rivers. <i>Journal of Fish Biology</i> 46:273-281.
<input type="checkbox"/>	Gill, R.E., Jr., and L.R. Mewaldt. 1983. Pacific coast Caspian terns: dynamics of an expanding population. <i>Auk</i> 100:369-381.
<input type="checkbox"/>	Greer, R.D. and D.J. O'Conner. 1994. Waterbird deterrent techniques. Technical Report Series, 94-003, Exxon Biomedical Sciences, Inc.
<input type="checkbox"/>	Jones et al. 1996. Predation by birds and effectiveness of predation control measures at Bonneville, The Dalles, and John Day dams in 1995. U.S. Army Corps of Engineers, Portland District, Operations Division, CENPP-CO-SRF. 10 pp
<input type="checkbox"/>	Kennedy, G.J.A., and J.E. Greer. 1988. Predation by cormorants, <i>Phalacrocorax carbo</i> (L.), on the salmonid populations of an Irish river. <i>Aquaculture and Fisheries Management</i> 19:159-170.
<input type="checkbox"/>	Kress, S.W. 1983. The use of decoys, sound recordings, and gull control for re-establishing a tern colony in Maine. <i>Colonial Waterbirds</i> 6:185-196.
<input type="checkbox"/>	Krohn and Blackwell. 1996. Double-crested cormorant in Maine. Part I: Concerning a study to determine whether or not this controversial Maine nester is a major predator of Atlantic salmon smolts in the Penobscot River. <i>Maine Fish and Wildlife</i> XX:8-12.
<input type="checkbox"/>	Lampman, K.P., M.E. Taylor, and H. Blokpoel. 1996. Caspian terns (<i>Sterna caspia</i>) breed successfully on a nesting raft. <i>Colonial Waterbirds</i> 19:135-138.
<input type="checkbox"/>	Li et al. 1987. Factors influencing changes in fish assemblages of Pacific Northwest streams. Pages 193-202 in W. J. Matthews and D. C. Heins, eds. <i>Community and evolutionary ecology of North American stream fishes</i> . University of Oklahoma Press, Norman.
<input type="checkbox"/>	Mace, P.M. 1983. Bird predation on juvenile salmonids in the Big Qualicum estuary, Vancouver Island. <i>Canadian Technical Report of Fisheries and Aquatic Sciences</i> 1176.
<input type="checkbox"/>	NMFS (National Marine Fisheries Service). 1995. Proposed Recovery Plan for Snake River Salmon. United States Department of Commerce. National Oceanic and Atmospheric Administration. Washington, D. C.
<input type="checkbox"/>	NPPC (Northwest Power Planning Council). 1994. Columbia River Basin Fish and Wildlife Program. Portland, OR.
<input type="checkbox"/>	Oregon Department of Fish and Wildlife. Steelhead Supplement to the Oregon Plan
<input type="checkbox"/>	Oregon Department of Fish and Wildlife. 1998. Draft Predation Action Plan: Avian Species. Portland, OR.
<input type="checkbox"/>	Rieman et al. 1991. Estimated loss of juvenile salmonids to predation by northern squawfish, walleye, and smallmouth bass in John Day Reservoir, Columbia River. <i>Transactions of the American Fisheries Society</i> 120:448-458.
<input type="checkbox"/>	Roby, D.L., D.P. Craig, K. Collis, and S.L. Adamany. 1998. Avian predation on juvenile salmonids in the lower Columbia River. 1997 Annual Report to Bonneville Power Administration and U.S. Army Corps of Engineers, Portland, OR.
<input type="checkbox"/>	Ruggerone, G.T. 1986. Consumption of migrating juvenile salmonids by gulls foraging below a Columbia River dam. <i>Transactions of the American Fisheries Society</i> 115:736-742.
<input type="checkbox"/>	Schaeffer, L. 1991. Predation study: Salmon hatchery smolts and survival. Oregon Department of Fish and Wildlife, Technical Report. 33 pp.
<input type="checkbox"/>	Schaeffer, L. 1992. Avian predators at ODFW hatcheries: Their identification and control. Oregon Department of Fish and Wildlife, Technical Report 92-1. 19 pp.
<input type="checkbox"/>	Schreck, C.B. and L.E. Davis. 1995. Evaluation of facilities for collection, bypass, and transportation of outmigrating chinook salmonid. 1995 Annual report to U.S. Army Corps of Engineers, Portland, Oregon.
<input type="checkbox"/>	Schreck, C.B. and L.E. Davis. 1996. Evaluation of migration and survival of juvenile salmonids following transportation. 1996 Annual report to U.S. Army Corps of Engineers, Portland, Oregon.
<input type="checkbox"/>	Schreck and Snelling 1995

<input type="checkbox"/>	Steuber, J.E., M.E. Pitzler, and J.G. Oldenburg. 1993. Protecting juvenile salmonids from gull predation using wire exclusion below hydroelectric dams. United States Army Corps of Engineers. United States Department of Agriculture, Animal Damage Control.
<input type="checkbox"/>	Washington Department of Fish and Wildlife Lower Columbia Steelhead Conservation Initiative
<input type="checkbox"/>	Wood, C.C. 1987. Predation of juvenile salmon by the common merganser (<i>Mergus merganser</i>) on eastern Vancouver Island. II: Predation of stream-resident juvenile salmon by merganser broods. Canadian Journal of Fisheries and Aquatic Sciences 44:950-959.
<input type="checkbox"/>	

PART II - NARRATIVE

Section 7. Abstract

As part of the 1994 Columbia Basin Fish and Wildlife Program, Bonneville Power Administration and other agencies have been charged with monitoring and assessing bird predation on juvenile salmonids in lower Columbia and Snake river reservoirs (5.7B.20) and in the Columbia River estuary (5.7B.21), and identifying non-lethal methods for control of piscivorous waterbird populations posing a problem to salmon survival (5.7B.22). This research (BPA-9702400) was initiated in FY97 to address the issue of avian predation on juvenile salmonids in the lower Columbia River. Work in FY97 and FY98 has focused on assessing the magnitude of avian predation and testing the feasibility of various non-lethal management alternatives to reduce predation by birds. In FY99 and FY00, we will assist resource managers in the development and implementation of a management plan to reduce avian predation on juvenile salmonids. We will evaluate the efficacy of management initiatives and monitor the responses in targeted populations of piscivorous waterbirds (i.e., terns, cormorants, gulls) and their diets. We will use a bioenergetics approach to monitor the numbers of juvenile salmonids consumed by managed colonies of fish-eating waterbirds in the lower Columbia River (Columbia River estuary to head of McNary Pool). We will also assess those conditions and locales where avian predation on smolts continues to be most prevalent, and test the feasibility of potential new management techniques. Finally, we will continue to monitor population size and diet composition of those fish-eating waterbirds in the lower Columbia River that could potentially contribute to significant smolt mortality. Monitoring and evaluation of the management plan can be completed in 3 more years (FY99 - FY01), unless otherwise indicated by the results, and final reports will be submitted one year following the completion of fieldwork

Section 8. Project description

a. Technical and/or scientific 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.

Available data suggest that predation is a major source of mortality for juvenile salmonids migrating through the mainstem Columbia and Snake rivers (Rieman et al. 1991; Ruggerone 1986; Bevan et al. 1994; Roby et al. 1998). 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 1995 and 1996, between 10% and 30% of radio-tagged chinook yearlings that resided in the Columbia River estuary were consumed by terns or cormorants nesting in that area (Schreck and Davis 1995, 1996). Sampling for juvenile salmonid PIT tags at the Rice Island Caspian tern colony indicated that thousands of smolt PIT tags have been deposited on the island over the past 9 years, and that millions of juvenile salmonids were consumed by Caspian terns in 1996 (Roby et al. 1998). This information prompted a study funded by the Bonneville Power Administration and the U.S. Army Corps of Engineers to investigate the impacts of piscivorous waterbirds on juvenile salmonids in the lower Columbia River and to implement management actions to reduce avian predation, if warranted by the results.

The Oregon Cooperative Fish and Wildlife Research Unit at Oregon State University (OSU) and the Columbia River Inter-Tribal Fish Commission (CRITFC) initiated a study in 1997 to assess the impacts of piscivorous waterbirds on the survival of juvenile salmonids in the lower Columbia River. The objectives of this study in 1997 and 1998 (Phase I) were to (1) estimate the size of fish-eating waterbird colonies in the lower Columbia River and determine population trends, (2) estimate the number of juvenile salmonids consumed by these populations, (3) identify the factors that influence avian predation rates on smolts, and (4) test the feasibility of different management options to reduce avian predation on smolts, if warranted by the study results.

There were nine major colonies of fish-eating birds that nested on islands in the lower Columbia river and estuary in 1997 and 1998. Most of these islands are unnatural, created by either the dumping of dredge material or rising water levels associated with mainstem dam impoundments. Population censuses indicated that the number of fish-eating colonial waterbirds totaled roughly 170,000 individuals, a substantial increase over previous estimates. Rice Island, a dredge material disposal island in the Columbia River estuary, supported the largest known Caspian tern (*Sterna caspia*) colony in North America (over 20,000 birds in 1998), which had grown by over 600% since the colony originated in 1986. This colony represents over 75% of the total Pacific Coast population, 25-30% of the continent-wide population, and perhaps 10-20% of the world-wide population of this species (Cuthbert and Wires, In press). Two colonies of double-crested cormorants (*Phalacrocorax auritus*) in the estuary were the first and second largest on the entire Pacific coast of the U.S. and Canada (Carter et al. 1995), and also appear to be growing. The nesting period for these colonies (mid-April to mid-July) generally coincided with the period of smolt out-migration. Nesting success at the Rice Island Caspian tern colony was low (ca. 5% and 38% of breeding pairs successfully raised a chick in 1997 and 1998, respectively), due mostly to predation on eggs and chicks by glaucous-winged/western gulls (*Larus glaucescens* X *L. occidentalis*). Nesting success of double-crested cormorants, in contrast, was over 50% in both years.

Diet analysis indicated that juvenile salmonids were an important part of the diet of some fish-eating waterbirds nesting in the Columbia River estuary. In 1997, Caspian terns appeared to be most dependent on salmonids (roughly 75% of the diet), followed by double-crested cormorants (roughly 24% of the diet) and glaucous-winged/western gull hybrids (roughly 11% of the diet). The large California and ring-billed gull (*Larus californicus* and *L. delawarensis*) colonies up-river relied less on juvenile salmonids as a food source compared to fish-eating waterbirds in the estuary, perhaps due in part to measures implemented at Columbia River dams to reduce bird predation. Juvenile salmonids were especially prevalent in the diets of fish-eating waterbirds in the estuary during May. Steelhead smolts were most prevalent in Caspian tern diets during April -early May, followed by coho smolts in late May - early June, and then chinook smolts in late June - late July. Diet composition data in 1998 are currently being analyzed, but the trends appear similar to 1997 results.

Over the past three years PIT tags have been recovered from bird colonies to assess the relative vulnerability of different salmonid species, stocks, and rearing types to predation by birds. In 1998, roughly 50,000 PIT tags were detected or recovered from a Caspian tern and double-crested cormorant colonies on Rice Island in the Columbia River Estuary. Another 10,000 PIT tags were recovered from two small Caspian tern colonies located on the Columbia River near Boardman, Oregon and at the mouth of the Walla Walla River. Preliminary results indicate that hatchery fish are more vulnerable to tern predation compared to wild fish. Furthermore, steelhead smolts are more prevalent in tern diets relative to their availability in the estuary. Chinook salmon, on the other hand, are underrepresented in tern diets, supporting the hypothesis that terns may be selecting prey based on size. Analysis of these data is ongoing and additional information will be presented in a subsequent report.

We estimate that 6 - 25 million juvenile salmonids were consumed by Caspian terns nesting on Rice Island in 1997, or approximately 6 - 25 % of the estimated 100 million out-migrating smolts that reach the estuary. Preliminary estimates of tern predation in 1998 were similar to 1997, suggesting that 1997 was not an anomalous year. Data are currently being analyzed to estimate smolt losses to cormorants and gulls in the estuary, but preliminary analysis suggest it is in the millions.

Various management alternatives to reduce predation by Caspian terns on juvenile salmonids have been investigated as part of the research effort. Results from the 1998 field season suggest that relocating the Caspian tern breeding colony from Rice Island to East Sand Island may be an effective method to mitigate losses of smolts to terns in the near term. East Sand Island is about 13 miles downriver from Rice Island and close to the mouth of the Columbia River. A greater diversity of forage fishes are available to fish-eating birds in the vicinity of East Sand Island compared to Rice Island. In 1998, double-crested cormorants nesting on Rice Island consumed a higher proportion of juvenile salmonids (ca. 40% of prey items) than cormorants nesting on East Sand Island (ca. 9% of prey items). Caspian terns in the estuary foraged mostly within five miles of the breeding colony at Rice Island, and 90% foraged within 13 miles of the colony. Terns returning to the Rice Island colony from upriver foraging locations had a higher proportion of juvenile salmonids in their diet (76%) as compared to terns returning from downriver (39%). Attempts in 1998 to attract Caspian terns to nest at a new site in the estuary (Miller Sands) using decoys and an audio playback system were successful. Finally, Caspian terns formerly nested on East Sand Island in the mid-1980s, and still frequently roost on the island. These research results suggest that relocating the Caspian tern colony from Rice Island to East Sand Island is a feasible short-term management option for reducing tern predation on juvenile salmonids. Longer-term management may include attracting Caspian terns to other former nesting colony locations outside the Columbia River estuary.

In 1999, a pilot study will be conducted to determine the feasibility and efficacy of relocating the Rice Island Caspian tern colony as part of a management plan for reducing predation on juvenile salmonids in the Columbia River estuary. This management plan, developed by the Interagency Avian Predation Working Group, involves a combination of efforts to attract the terns to nest on East Sand Island and dissuade them from nesting on Rice Island. The former would consist of (1) habitat modification on a portion of East Sand Island to provide the bare sand nesting habitat preferred by terns, (2) placing several hundred Caspian tern decoys on the new colony site to attract terns to land, (3) setting up several audio playback systems on the new colony site to simulate the acoustic environment of a tern colony, and (4) assure that avian predators (gulls, crows) are prevented from disrupting early attempts by terns to breed at the new site (see Kress 1983, Lampman et al. 1996 for successful use of these methods elsewhere). Efforts to dissuade terns from nesting at their current colony site on Rice Island will probably consist of vegetating a portion of the current site to reduce the availability of bare sand substrate needed for nesting. If this approach fails, additional efforts to dissuade early nesting attempts on Rice Island may consist of (1) spreading black plastic or other

suitable material on that portion of the colony where nesting is to be precluded or (2) harassing the terns as they roost on Rice Island at night, prior to the initiation of egg-laying.

In 1999 and 2000, the OSU/CRITFC research team will (1) coordinate the efforts to attract the terns to new nesting locations where their impacts on juvenile salmonid survival will be reduced, (2) conduct the monitoring and evaluation to determine the efficacy of management in reducing avian predation on smolts, (3) test the feasibility of other potential management actions to further reduce avian predation (e.g., bird deterrent devices in foraging areas), and (4) continue to monitor other avian predator populations that may be targeted for management in the near future.

b. Rationale and significance to Regional Programs

Regional plans for Snake River salmon recovery have recommended that avian predation be thoroughly investigated and managed if necessary (NPPC 1994, NMFS 1995, CRITFC 1995). Available data suggest that predation is a major source of mortality for juvenile salmonids migrating through the mainstem Columbia and Snake rivers (Rieman et al. 1991; Ruggerone 1986; Bevan et al. 1994; Roby et al. 1998). Anthropogenic perturbations to the Columbia River System have exacerbated predation-related mortality (Rieman et al. 1991; Li et al. 1987), and contributed to increases in populations of some predators (Beamesderfer and Rieman 1991; Gill and Mewaldt 1983). New islands created by dredging and impounding the Columbia River have provided safe nest sites and attracted colonial waterbirds to breed (see Cuthbert and Wires, In press). Hatchery production, structures that affect smolt out-migration (e.g., hydroelectric dams, pile dikes), and releases of barged fish all provide excellent feeding opportunities for piscivorous waterbirds, possibly contributing to recent increases in waterbird populations. The breeding season of these piscivorous birds coincides with the period of out-migration of salmon smolts, potentially resulting in intense predation pressure in the vicinity of larger bird colonies.

The 1994 Columbia Basin Fish and Wildlife Program called for the monitoring and assessment of bird predation on juvenile salmonids in Columbia and Snake river reservoirs (5.7B.20) and in the Columbia River estuary (5.7B.21), as well as identification of non-lethal methods for control of piscivorous waterbird populations that pose a significant threat to smolt survival (5.7B.22). This research (BPA-9702400) addresses the issue of avian predation on juvenile salmonids in the lower Columbia River. Work in FY97 and FY98 has focused on measuring the magnitude of predation by different piscivorous waterbird populations and testing the feasibility of various non-lethal management alternatives to reduce predation by birds. In FY99 and FY00, we propose to assist resource managers in implementing selected management options to reduce avian predation, as well as evaluate their efficacy. Furthermore, we plan to continue to monitor predation by unmanaged piscivorous waterbird populations and develop new management initiatives, as needed. This work will be part of a long-term comprehensive management plan aimed at reducing smolt losses to birds in the lower Columbia River, while not harming, or potentially benefiting, the managed bird populations.

c. Relationships to other projects

The development and implementation of a Columbia River Avian Predation Management Plan is a cooperative effort with input from many agencies and stakeholders groups. Specifically, an Interagency Avian Predation Working Group was formed in May 1998 to make management decisions to reduce smolt losses to colonial waterbirds in the Columbia Basin. The Working Group includes representatives from the U.S. Army Corps of Engineers, National Marine Fisheries Service, U.S. Fish and Wildlife Service, Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, Bonneville Power Administration, Columbia River Inter-Tribal Fish Commission, Oregon Division of State Lands, Oregon State University, and U.S. Department of Agriculture – Wildlife Services. By executive order the Working Group has been asked to (1) complete development of a short term strategy for reducing avian predation on listed salmonids in the lower Columbia River estuary, (2) develop a monitoring and evaluation plan to

determine whether the short-term goals are met, (3) complete the required environmental documentation, (4) develop budgets for the recommended actions so that cost sharing opportunities can be identified, and (5) determine future research and management needs. As researchers, OSU and the CRITFC have been asked to (1) provide technical assistance to the Working Group in the development and implementation of short and long-term management plans to reduce smolt losses to birds in the lower Columbia River, (2) test the feasibility of different management initiatives to reduce avian predation, and (3) monitor and evaluate the effectiveness of those initiatives once fully implemented.

Additional cooperators for work on colonial waterbirds in the Columbia River estuary include the U.S. Fish and Wildlife Service (POC: Al Clark, Refuge Biologist), the Oregon Cooperative Fish and Wildlife Research Unit (POC: Carl Schreck and Tom Stahl), the National Marine Fisheries Service (POC: Dick Ledgerwood, Brad Ryan), and the Clatsop County Economic Development Council (POC: Jim Hill).

For work farther up river, cooperators include the U.S. Fish and Wildlife Service (POC: Kathy Cheap, Refuge Biologist) and the U.S. Army Corps of Engineers (POC: Robert Stansell, Gretchen Starke, and other Corps biologists). Animal Damage Control (ADC) has been charged with implementing avian predation abatement measures at lower Columbia River Dams. We will work with U.S. Department of Agriculture – Wildlife Services (POC: John Urquart) and the Corps (POC: Bob Cordie) to collect birds shot as part of this program for the purpose of determining diet of adult birds foraging at the dams. If requested, birds shot for diet analysis will be provided to the U.S. Fish and Wildlife (POC: Jeremy Buck) to measure body burdens of contaminants.

PIT tags recovery efforts previous conducted by OSU/CRITFC researchers are now being conducted by the National Marine Fisheries Service (POC: Brad Ryan and Dick Ledgerwood). We will assist NMFS with their recovery efforts and will work with them to summarize the PIT tag results. A list of unique PIT tag codes will be sent to Pacific States Marine Fisheries Commission (POC: Dave Marvin and Carter Stein) for interrogation and inclusion in the PITAGIS database.

Depending on funding availability and pending research results, whole fish collected at the breeding grounds of piscivorous waterbirds will be provided to OSU (POC: Carl Schreck) to determine the incidence of BKD and other pathological conditions. We anticipate that additional collaborative and cooperative arrangements will be forged with other refuge managers and agencies currently engaged in or planning work on piscivorous birds in the lower Columbia River.

d. Project history (for ongoing projects)

In 1996, the CRITFC received a subcontract (\$20,589) from the Columbia Basin PIT-Tag Information System Project (BPA-9008000) to determine if PIT tags could be recovered from piscivorous waterbird breeding colonies. All recovered PIT tag codes were provided to PSMFC and entered into the PITAGIS database. Also in 1996, BPA directly funded a photo census (project number and costs?) of all piscivorous waterbird breeding colonies in our study area based on our recommendations and guidance. That census produced a set of high-resolution photos that were then analyzed to estimate the breeding population size at each colony. The results of the work completed in 1996 were included in a report submitted to the funding agencies (Roby et al. 1998).

In 1997, the first year of full project funding (\$119,019, not including costs for aerial photo census and survey which was funded directly by BPA), OSU/CRITFC were contracted to investigate the impacts of piscivorous waterbirds on the survival of juvenile salmonids on the lower Columbia River (BPA-55059000). Additional funds (\$110,000) were provided by the USACE to look specifically at predation by Caspian terns nesting on Rice Island in the Columbia River estuary. This work focused on determining the magnitude of avian predation on the survival of juvenile salmonids in the lower Columbia River. Of the nine piscivorous waterbird colonies studied, Caspian terns nesting on Rice Island in the Columbia River estuary posed the greatest immediate risk to smolt survival (6 - 25 million or 6 - 25% of the smolts that survived to the estuary were consumed by terns). The results from this study were included in a report submitted to the funding agencies (Roby et al. 1998).

In 1998, OSU/CRITFC continued their investigations of avian predation on juvenile salmonids with funds (\$280,000) provided by BPA (BPA- 9702400) and the USACE (\$115,000; FY98 was the last year of scheduled funding from the Corps for research activities). The focus of this work was to refine and verify estimates of predation by piscivorous waterbirds in the lower Columbia River and test the feasibility of various management options to reduce avian predation. In addition, we advised the Interagency Avian Predation Working Group on the development of short-term management options to reduce smolt losses to terns. Caspian tern predation on juvenile salmonids in 1998 was similar to the previous year and viable management options were identified (i.e., relocation of the tern colony to East Sand Island). Additional information was collected on other piscivorous waterbird populations (e.g., double-crested cormorant), which will allow us to estimate their impacts on smolt survival. The analysis of 1998 results is ongoing and will be included in a subsequent report to the funding agencies (March 1999).

In 1999, OSU/CRITFC has received funding (\$515,000) from BPA (BPA-9702400) to conduct a pilot study designed to assess the feasibility and efficacy of relocating the Rice Island Caspian tern colony as a management action for reducing tern predation on juvenile salmonids. In addition, we will continue to monitor other avian predator populations that may be targeted for management in the future. Finally, we will assist the Interagency Avian Predation Working Group in the development of existing and new management initiatives as part of a long-term management plan to reduce smolt losses to birds in the Columbia Basin. These results will be included in a subsequent report to the funding agency (March 2000)

e. Proposal objectives

The objectives of this study in FY00 are to; (1) monitor and evaluate the efficacy of management initiatives implemented to reduce avian predation on juvenile salmonids, (2) monitor affects of unmanaged piscivorous waterbird colonies on survival of juvenile salmonids, and (3) assist in developing a long-term management plan to reduce avian predation on juvenile salmonids in the lower Columbia River.

Results from our field investigations in 1999 and on-going review of the scientific literature will be provided to the Interagency Avian Predation Working Group as they develop long-term management plans for reducing avian predation on juvenile salmonids. These management plans will be specific to particular breeding colonies of piscivorous waterbirds where the magnitude of predation on juvenile salmonids has been determined to be significant by the Working Group. The emphasis will be on management options that do not involve direct destruction of the birds, their eggs, or their young. The specific long-term management initiatives that will be implemented in FY 2000 have yet to be proposed by the Working Group and will be developed based on our research results from 1999. Long-term management plans as proposed by the Interagency Avian Predation Working Group will also likely require an Environmental Impact Statement, so management initiatives may be modified during the NEPA compliance process. Possible management options include, but are not limited to; (1) relocation of the Rice Island Caspian tern colony and perhaps other colonies to East Sand Island and other former colony sites outside the Columbia River Basin, (2) deterring piscivorous birds from foraging in particular areas where smolts are especially vulnerable to avian predation (e.g., near pile dikes), and/or (3) changes in hatchery and barging practices that result in decreased susceptibility of smolts to bird predation.

We will evaluate the effectiveness of the management initiatives chosen for implementation in FY 2000. The specifics of the monitoring and evaluation plan will depend on the management plan that is implemented. Among the critical questions will likely be: (1) Was the management action successful in relocating the colony to an alternative location? (2) Did management reduce foraging activity in the area of concern? (3) Was the prevalence of juvenile salmonids in the diet of the managed population less than pre-management? (4) Did the size and productivity of the managed population change following management? and (5) How did management affect unmanaged bird populations? Answers to these questions will be used to refine and further develop management actions both within a field season and in outyears.

The impacts of other piscivorous waterbird colonies that are not managed in FY 2000 will be monitored if it is determined that (1) there is potential for the colony to have a significant effect on survival of juvenile salmonids and (2) insufficient data currently exist to estimate the magnitude of smolt losses to the colony.

f. Methods

Objective 1. Monitor and evaluate the efficacy of management initiatives implemented to reduce avian predation on juvenile salmonids.

Task 1.1. Conduct surveys to assess changes in size and productivity of managed piscivorous waterbird colonies.

Methods: Surveys of the distribution and size of managed piscivorous waterbird colonies will be conducted following (1) attempts to relocate a piscivorous waterbird colony to an alternative nesting location or (2) implementation of other management initiatives to reduce the size of breeding colonies of piscivorous birds on the lower Columbia River. Ground-based and aerial surveys will be conducted to locate new colonies and aerial photos will be taken late in the incubation period to estimate breeding population size (see FY98 Project Proposal to BPA for further details on aerial survey techniques). Population size is an important input variable in bioenergetics models used to estimate the number of juvenile salmonids consumed by piscivorous waterbirds (Tasks 1.2 and 2.2). Additionally, population census results will be compared to previous results to determine population trends and trajectories for managed bird populations as a means to predict future affects on survival of juvenile salmonids.

Once the managed population has become established at a new or existing colony site, productivity of the breeding colony will be measured (see the FY98 Project Proposal to BPA for further details on methods to measure productivity) and compared to previous measures of productivity for that population. If the colony has relocated to a new colony site, nesting success will be compared before (i.e., in previous years) and after colony relocation and to other colonies of its type within the study area (i.e., if a population is split between two or more colony sites). Additional comparisons will be made to the productivity of other established colonies (i.e., from published literature). These comparisons of productivity will be important to assess the suitability of the new or existing colony site as a permanent nesting location for the birds. Productivity measures include; clutch size, hatching success, nestling survival rate, brood size at fledging (if possible), and overall nesting success (proportion of nests that had at least one egg that produced one or more fledglings; if possible) for a sample of nests on the colony (n = 200 nests).

Task 1.2. Determine changes in diet composition and smolt consumption rates of managed piscivorous waterbirds.

Methods: Diet composition and smolt consumption rates of managed piscivorous waterbird populations will be compared before vs. after management action and to other colonies of its type within the study area (i.e., if a population is split between two or more colony sites). Diet sampling will be conducted according to methods outlined in the FY98 Project Proposal to BPA. In general, Caspian tern diet will be assessed by observation from nearby blinds of fish carried in the bills of adult terns returning to the colony (n = 1000 bill loads), supplemented by dropped fish (i.e., bill loads) and stomach contents of terns collected as they return to the colony after foraging (n = 100). Cormorant and gull diets will be assessed by collecting chick regurgitations during the chick-rearing period and by collection of adult birds as they return to the colony after foraging during other stages of the nesting cycle (n = 10/colony/week). Diet will be monitored to assess whether the implemented management had the desired affect in reducing (1) the proportion of juvenile salmonids in the diet and (2) the total number of juvenile salmonids consumed based on calculations using a bioenergetics approach (see FY98 Project Proposal to BPA for further details on the bioenergetics approach). Results from the radio telemetry study (see Tasks 1.3 below) will be used to further assess changes in diet composition associated with management. Finally,

managed piscivorous waterbird colonies will be searched for salmon PIT tags (field work to be conducted by NMFS with alternative funding) as a means to identify changes in the relative importance of different species, stocks, and rearing types in the diet of fish-eating birds.

Task 1.3. Assess changes in foraging distribution, foraging range, and habitat use of managed piscivorous waterbirds.

Methods: In FY98, a protocol for a road-based foraging bird survey was designed and implemented in order to sample the range of foraging habitats and locales utilized by piscivorous waterbirds in the Columbia River estuary (e.g., deep-water channels, shallow sloughs, sheltered bays, points of land, etc.; see FY98 Project proposal to BPA for further details on methods). Additionally, an aerial survey protocol was developed and implemented in FY98 to characterize the spatial distribution of foraging Caspian terns around the Rice Island breeding colony. These surveys provided a baseline measure of foraging distribution and habitat use for the Rice Island Caspian tern population prior to management. We will repeat these surveys in FY99 and FY00 and compare results with those collected prior to management to assess changes in foraging distribution, habitat use, and foraging behavior related to the management action. In addition, 30 birds from each managed population will be radio-tagged during early incubation. The movements of the radio-tagged birds will be tracked from the air and ground to further assess foraging distribution, foraging range and habitat use. These results will be compared to telemetry results in FY 99 to assess changes in foraging activity associated with management.

Foraging conditions can be inferred in part from parental attendance, parental exchange rates, and activity of piscivorous waterbirds at the breeding colony, as well as the distribution and numbers of birds at foraging sites. For managed and unmanaged populations, we will monitor nest attendance (% of time parents remain on or near the nest), parental exchange rates (frequency with which the two members of a pair relieve each other of nest attendance duties or deliver food to young), and activity budgets (frequency of various behaviors) from blinds (in order to minimize the risk of observer influence on bird behavior). Attendance, exchange rates, and activity patterns will be analyzed with respect to time of day, tide stage, tidal amplitude, season, weather, nearby smolt releases, river flow rates, and other environmental factors in order to assess the relative importance of these factors in influencing foraging success.

Objective 2. Measure impacts of unmanaged piscivorous waterbird colonies on survival of juvenile salmonids.

Task 2.1. Conduct surveys to estimate size and productivity of unmanaged piscivorous waterbird colonies.

Methods: The smolt consumption rates of piscivorous waterbird colonies that are targeted for management in FY00 will be monitored if it is determined that (1) there is potential for these populations to significantly affect survival of juvenile salmonids, and (2) existing data are insufficient to reliably estimate the magnitude of smolt losses to these unmanaged piscivorous birds. Aerial photos will be taken to estimate breeding population size (see FY98 Project Proposal to BPA for further details on aerial survey techniques) and results compared to population estimates in previous years to determine population trends and trajectory. In addition, productivity of the unmanaged piscivorous waterbird colonies will be monitored as described above (Task 1.1). By monitoring size and productivity of unmanaged piscivorous waterbird colonies we will also assess the relationship between implemented management actions and changes in recruitment and reproductive success at unmanaged waterbird colonies, thereby helping to determine the potential for future impacts of unmanaged piscivorous waterbird colonies on the survival of juvenile salmonids.

Task 2.2. Determine diet composition and smolt consumption rates of unmanaged piscivorous waterbirds.

Methods: Colony-based diet sampling will be conducted on selected unmanaged piscivorous waterbird populations to determine the proportion of juvenile salmonids in the diet. Specifically, diet composition and smolt consumption rates will be determined for the Caspian tern colonies on Three-Mile Canyon and Crescent Islands and for double-crested cormorants nesting in the estuary. Diet composition and smolt consumption rates will be determined as described above (Task 1.2). We will build observation blinds at both upriver Caspian tern colonies in order to identify fish transported in the bills of adults and determine the proportion of juvenile salmonids in the diet. We will use the doubly labeled water technique (see FY98 Project Proposal to BPA for further details on this technique) to measure daily energy requirements of upriver terns (n = 10 breeding adults/colony), an essential input variable in bioenergetics models used to estimate smolt consumption rates. Finally, the upriver tern colonies, and if possible the double-crested cormorant colonies in the estuary, will be searched for salmon PIT tags (field work to be conducted by NMFS with alternative funding) as a means to identify the relative importance of different species, stocks, and rearing types in the diet of fish-eating birds. The FY00 results on population trajectory (Task 2.1) and diet will be compared with results from previous years to determine if unmanaged bird populations pose an increasing risk to survival of juvenile salmonids, information that will be important in decisions regarding the necessity of future management and/or monitoring.

Task 2.3. Assess foraging distribution, foraging range, and habitat use of unmanaged piscivorous waterbirds.

Methods: In FY00, a radio-telemetry study will be initiated to characterize the foraging range and distribution of double-crested cormorants in the Columbia River estuary. Thirty double-crested cormorants will be radio-tagged during incubation and foraging behavior monitored from the air and ground-based receiving stations. Also, we will continue a road-based foraging bird survey (see task 1.3 above) to collect data on cormorant distribution and habitat use in the estuary. The combined data from these surveys will provide baseline information to assess impacts of double-crested cormorants nesting in the estuary on survival of juvenile salmonids.

Also in FY00, Caspian terns from two up-river colonies (Three-Mile Canyon and Crescent Islands) will be radio-tagged to characterize foraging behavior of these populations. Twenty birds per colony will be radio-tagged and monitored using aerial surveys and ground-based receiving stations. Foraging distribution, foraging range from the colony site, and habitat use (e.g. mainstem channel, tributaries, etc.) will be characterized. Tern foraging use of anthropogenic features (e.g. dams, hatchery smolt releases) will also be investigated. Parental attendance, parental exchange rates, and activity of piscivorous waterbirds at the breeding colony will be measured to help assess the importance of various environmental factors in influencing foraging success and ultimately the impacts of piscivorous bird predation upon juvenile salmonids (see Task 1.3 above).

Objective 3. Assist in developing a long-term management plan to reduce avian predation on juvenile salmonids in the lower Columbia River.

Task 3.1. Provide technical assistance to the Interagency Avian Predation Working Group to refine and further develop existing management initiatives (i.e., adaptive management).

Methods: As participants in the Working Group, OSU/CRITFC researchers will provide technical assistance to managers in refining and further developing existing management initiatives to reduce avian predation on juvenile salmonids in the lower Columbia River. We will provide information at regular Working Group meetings (1 or 2 meetings/month throughout the season) that will help in evaluating the effectiveness of ongoing management initiatives and thereby provide the opportunity for adaptive management both in-season and in out-years. For example, the results from our telemetry studies will tell us whether or not implemented management

initiatives reduced foraging activity in the areas of concern (e.g., near Rice Island) and, if not, additional measures may be implemented to achieve the desired reductions in that activity. We will assess the efficacy of efforts to dissuade terns from nesting at previous colony sites and suggest changes in management activities to help meet the management objectives established by the Interagency Working Group. Also, we will monitor diet of managed populations in-season to assess whether management is having the desired effect in reducing the proportion of juvenile salmonids in the diet and, if not, timely adjustments to management activities can be implemented. By providing timely information to the Interagency Avian Predation Working Group on the efficacy of implemented management, managers can make adjustments that help assure management objectives are met.

Task 3.2. Test the feasibility of various management options to reduce predation on juvenile salmonids by piscivorous waterbirds in the lower Columbia River.

Methods: Based on results from our field investigations in 1998 and 1999, the Interagency Avian Predation Working Group may decide that additional management initiatives to reduce avian predation on juvenile salmonids are necessary. We will test the feasibility of new management initiatives and, if fully implemented, evaluate their efficacy (Objective 1). For example, if the level of cormorant predation on juvenile salmonids in the estuary is deemed unacceptable by the Working Group, different methods to deter cormorants from foraging in areas where juvenile salmonids are particularly vulnerable (e.g., near pile dikes) can be tested (Greer and O'Conner 1994). If the Interagency Avian Predation Working Group decides to attempt to relocate Caspian terns nesting in the Columbia River estuary to former colony sites outside the estuary, or if the Working Group decides to attempt to relocate the double-crested cormorant colony from Rice Island to East Sand Island, we will test the feasibility of these initiatives by (1) helping to establish suitable nesting habitat on former or new colony sites, (2) providing the social attractants necessary to encourage nesting at new sites, and (3) determining the potential for nest predators (e.g., gulls, crows) to disrupt nesting by breeding adults at the new sites. Results from these feasibility tests will be used to help direct efforts to fully implement selected management initiatives, should they be deemed appropriate by the Interagency Avian Predation Working Group.

Task 3.3. Provide technical assistance to the Interagency Avian Predation Working Group to develop new management initiatives for full implementation.

Methods: Based on research results and our on-going review of literature on restoration techniques for colonial waterbirds, we will provide technical assistance to the Interagency Avian Predation Working Group and advise managers as they develop new management initiatives for implementation in 2001 or beyond. We will provide information at regular Working Group meetings (1 or 2 meetings/month throughout the season) that will help in evaluating various management options and, if deemed necessary by the Working Group, designing practical and effective management plans that have a strong likelihood of providing survival benefits to juvenile salmonids. Input to the Working Group will include, but is not limited to (1) nesting habitat requirements, (2) potential attraction techniques for establishing new breeding colonies, (3) predator control methods to enhance nesting success at new colonies, and (4) potential negative side effects of colonial waterbird management.

Task 3.4. Survey and inventory existing nesting habitat for piscivorous colonial waterbirds outside the Columbia Basin and provide technical assistance on restoration and conservation of critical nesting habitat.

Methods: Longer-term management of avian predation on juvenile salmonids in the Columbia River estuary may require restoration of piscivorous waterbird colonies along the coasts of Washington and Oregon. For example, management of Caspian tern predation may include restoring habitat at former colony sites in Willapa Bay, Grays Harbor, and Puget Sound and attracting terns back to these sites. A comprehensive survey of present and historical Caspian tern,

double-crested cormorant, and western/glaucous-wing gull breeding sites in the Pacific Northwest will be compiled from the available scientific literature, agency reports, non-governmental reports (e.g. American Birding Association, Breeding Bird Surveys), and relevant works in progress. In this review process we will include an analysis of factors that may have contributed to the decline or abandonment of current or former breeding colonies (e.g. habitat degradation, introduced predators, changes in food availability).

We will provide recommendations regarding the best sites for restoration and conservation of waterbird breeding colonies. These recommendations will be based on ranking the suitability of potential sites, as well as potential conflicts with local fisheries. Biological suitability will be evaluated by assessing available forage fish, abundance of potential predators, and habitat quality. These data will be obtained from existing sources or in collaboration with other researchers. Potential conflicts with fisheries will be determined through interviews of relevant governmental agencies (e.g. NMFS, ODFW, WDFW, etc). The survey and inventory results would assist managers in understanding the regional context of piscivorous waterbird colony restoration activities in an effort to relieve predation pressure on juvenile salmonids.

g. Facilities and equipment

This work will be conducted out of a field station in Astoria, Oregon. Lab facilities will be provided by OSU in Corvallis and Oregon Department of Fish and Wildlife in Clackamas, Oregon . Two boats capable of handling conditions encountered on the Columbia River will be needed. The Oregon Cooperative Fish and Wildlife Research Unit has a 20 ft. Boston Whaler and an 18 ft. Alumiweld that are fully equipped. The Unit will provide both 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 two watercraft and associated equipment (outboard motors, trailers, etc.).

h. Budget

Our research efforts to date (FY 97 – FY 99) have focused mostly on predation by Caspian terns in the Columbia River Estuary. Other piscivorous waterbird populations may pose an increasing risk to juvenile salmonid survival and therefore warrant more attention than they have received thus far. In particular, the two Caspian tern colonies located upriver at Three Mile Canyon and Crescent islands and the double-crested cormorant colonies in the Columbia River estuary, especially at Rice Island, are cause for concern. The increase in the proposed budget in FY 00 is largely due to increased research efforts on these other piscivorous waterbird colonies. In the estuary, we will continue our work on Caspian terns and add the new task of assessing the foraging distribution, range, and habitat utilization of double-crested cormorants using radio-telemetry. Additional research efforts upriver will focus on impacts of Caspian terns on juvenile salmonids, to include; (1) measuring colony size, productivity, and chick provisioning rates, (2) sample diets in order to measure the proportion of juvenile salmonids in the diet, (3) measure field metabolic rates of adult terns to estimate food requirements, and (4) conducting a radio-telemetry study to determine foraging distribution, range, and habitat utilization. This proposal requires that we hire additional personnel, acquire the necessary boats and vehicles, and establish a full-time field office in Umatilla, OR. Additionally, because we will have concurrent telemetry studies going in both the estuary and upriver we will need to purchase more radio-telemetry equipment (i.e., receivers, scanners, data collection computers).

Section 9. Key personnel

DANIEL D. ROBY

Current Employment:

Associate Professor, Oregon Cooperative Fish and Wildlife Research Unit and Department of Fish and Wildlife, Oregon State University, 1995-present

Project Title:

Principal Investigator (0 FTE; time not charged to the project)

Education:

Ph.D., University of Pennsylvania (Biology), 1986
M.S., University of Alaska (Wildlife Management), 1978
B.A., Antioch College (Biology), 1974

Previous Employment:

Assistant Unit Leader - Wildlife, Alaska Cooperative Fish and Wildlife Research Unit, University of Alaska Fairbanks, 1992-1995
Assistant Professor of Zoology, Southern Illinois University, 1988-1992
Director, G.C.M. Wildlife Research Center, University of Rochester, 1986-1988

Selected References:

- Roby, D. D., J. R. E. Taylor, and A. R. Place. 1997. Significance of stomach oil for reproduction in seabirds: An interspecies cross-fostering experiment. *Auk* 114:725-736.
- Roby, D.D. 1991. Diet and postnatal energetics in convergent taxa of plankton-feeding seabirds. *Auk* 108:131-146.
- Roby, D.D. 1991. A comparison of two noninvasive techniques for measuring total body lipid in live birds. *Auk* 108: 509-518.
- Roby, D.D., and R.E. Ricklefs. 1986. Energy expenditure in adult least auklets and diving petrels during the chick-rearing period. *Physiol. Zool.* 59:661-678.
- Roby, D.D., and K.L. Brink. 1986. Breeding biology of least auklets on the Pribilof Islands, Alaska. *Condor* 88: 336-346.

Qualifications:

Dan Roby has been actively conducting research on the breeding biology and nesting ecology of colonial waterbirds for the last 20 years. His research has focused on the diet composition and reproductive energetics of seabirds, and how these factors influence nesting success. He has served as principal investigator on several major research projects with budgets in excess of \$1 million, has been a PI on NSF-funded research, and is currently the PI for the Seabird Energetics component of APEX, a multi-million dollar integrated ecosystem project examining seabird-forage fish interactions in Alaska. He has published over 40 articles in peer-reviewed scientific journals, and he was the first or sole author on over half these articles. He is currently an Associate Professor of Wildlife Ecology (Courtesy) in the Department of Fisheries and Wildlife at Oregon State University, a Certified Wildlife Biologist with The Wildlife Society, and an Elected Member of the American Ornithologists' Union.

KEN COLLIS**Current Employment:**

Fisheries Scientist, Columbia River Inter-Tribal Fish Commission, 1992-present

Project Title:

Co-Principal Investigator/Project Manager (1 FTE)

Education:

M.S., University of Maryland (Behavioral Ecology), 1990
B.S., Lewis & Clark College (Biology), 1983

Previous Employment:

Environmental Biological Aid, Oregon Department of Fish and Wildlife, 1991
Bird Specialist, Victoria Forestry Commission, Queensland, Australia, 1985
Field Biologist, Point Reyes Bird Observatory, 1983-1984

Selected References:

Collis, K., R.E. Beaty, and B.R. Crain. 1995. Changes in catch rate and diet of northern squawfish associated with the release of hatchery-reared juvenile salmonids in a Columbia River reservoir. *North American Journal of Fisheries Management* 15(2): 346-357.

Authored or co-authored seven Annual Reports (re: tribal fisheries as part of the Columbia River Northern Squawfish Management Program) submitted to the Bonneville Power Administration over the past 5 years.

Collis, K. and G. Borgia. 1993. The costs of male display and delayed plumage maturation in the satin bowerbird (*Ptilonorhynchus violaceus*). *Ethology* 94: 59-71.

Collis, K. and G. Borgia. 1992. The age-related effects of testosterone, plumage, and experience on aggression and social dominance in juvenile male satin bowerbirds (*Ptilonorhynchus violaceus*). *Auk* 109: 422-434.

Borgia, G. and K. Collis. 1990. Parasites and bright male plumage in the satin bowerbird (*Ptilonorhynchus violaceus*). *American Zoologist* 30: 279-285.

Qualifications:

For the past 8 years, Ken Collis has been actively involved in predation research and management on the lower Columbia River. While working as Predation Project Leader for the CRITFC, Ken was responsible for the development, implementation, and evaluation of tribal fisheries (i.e., dam angling and site-specific gillnetting) for northern pikeminnows as part of the Columbia River Northern Pikeminnow Management Program. His work investigated the factors that influence predation rates by northern pikeminnows on juvenile salmonids and he used that information to develop effective management activities to reduce predation-related mortality. Prior to his work in fisheries, Ken worked for six years studying behavioral biology in birds. Of particular relevance was his experience measuring productivity in seabirds on the Farallon Islands. He has published five articles in peer-reviewed scientific journals, both in fisheries and behavioral ecology (in birds).

Section 10. Information/technology transfer

The Interagency Avian Predation Working Group has been charged with the development of short and long-term management plans to reduce avian predation on juvenile salmonids in the lower Columbia River. As participants in the Working Group, OSU/CRITFC researchers will provide technical assistance to assist the managers in developing these plans. Specifically, we will (1) identify those piscivorous waterbird populations that pose the greatest risk to smolt survival, (2) test the feasibility of different management initiatives to reduce avian predation on smolts, (3) monitor and evaluate the effectiveness of those initiatives once fully implemented, and (4) recommend changes to existing management plans to maximize benefits to juvenile salmonids, while minimizing the impacts on the managed bird populations. This information will be made available to the Working Group both in-season and in annual reports submitted after the completion of field season. Additionally, research results will be submitted for publication in peer reviewed scientific literature and interim results will be presented at meetings of professional societies at the regional, state, and national levels.

Congratulations!

