Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal Form

Section 1. General administrative information

Influence of marine-derived nutrient influx on Columbia River basin salmonid production

Bonneville project number, if an ongoing project 9136

Business name of agency, institution or organization requesting funding
U.S. Geological Survey, Biological Resources Division

Business acronym (if appropriate) USGS-BRD

Proposal contact person or principal investigator:

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Subcontractors.

Organization	Mailing Address	City, ST Zip	Contact Name

NPPC Program Measure Number(s) which this project addresses.
Sections 7.6, 7.6A, 7.6A2, all under 7.6B, 7.6C

NMFS Biological Opinion Number(s) which this project addresses.

None known.

Other planning document references.

NMFS Proposed Recovery Plan for Snake River Salmon: Task Nos. 1.1, 1.1b, 1.1b.3, 1.3,

1.3b, 1.4, 1.4a, 1.4b; Wy-Kan-Ush-Mi Wa-Kish-Wit Tribal Anadromous Fish Restoration Plan: Chapters 3 and 5; Return to the River by the Independent Scientific Group: Chapters 5 and 8A.

Subbasin.

Research to be conducted throughout the Columbia River basin.

Short description.

Establish a system-wide, coordinated, and comprehensive research effort and management strategy to document the effects of nutrient influx, especially via adult salmonid carcass decomposition, on the productivity of Columbia River basin tributaries for anadromous salmonids.

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
X	Anadromous fish		Construction	*	Watershed
	Resident fish		O & M		Biodiversity/genetics
	Wildlife		Production	*	Population dynamics
	Oceans/estuaries	X	Research	X	Ecosystems
	Climate	*	Monitoring/eval.		Flow/survival
	Other	*	Resource mgmt		Fish disease
			Planning/admin.		Supplementation
			Enforcement		Wildlife habitat en-
			Acquisitions		hancement/restoration

Other keywords.

nutrient dynamics, nutrient enrichment, salmonid ecology, stream productivity, salmonid production, stream restoration

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task

1	(Phase I--Coordination) Draft a comprehensive, systematic research plan and management strategy to investigate the effects of marine-derived nutrients on Columbia River basin tributary and salmonid productivity.	a	Assemble and coordinate a working group of interested researchers, experts, and other persons from different agencies, tribes, and the private sector.
		b	Using working group contacts, gather and summarize existing historical and recent biological data on primary and secondary productivity in tributaries of the Columbia River basin to develop relations between productivity and size and character of anadromous fish runs. This information will be used to facilitate development of the research plan. If warranted, initiate some nutrient enrichment work in selected streams.
		c	Organize and facilitate a workshop or series of meetings to develop a comprehensive strategy to establish consistent objectives, experimental designs, and methods for research and management application of nutrient enrichment to be conducted under this project.
2	(Potential Phase II--Pre-treatment) Document the productivity of selected watersheds and streams prior to nutrient enrichment. Factors to be examined would be those developed by the working group under Objective 1, but could include such factors as estimating primary productivity, invertebrate production, nutrient cycling, and aspects of fish production such as growth, biomass, density, survival, and physiology.	a	Identify candidate treatment and control streams for nutrient enrichment from a hierarchical list of potential streams formed from evaluations of biological, physical, and geomorphological characteristics.

		b	Collect and analyze pre-treatment data from selected streams.
3	(Potential Phase III -- Treatment and Monitoring) Document the effects of introducing adult salmonid carcasses or other synthetic enrichment media on stream and fish productivity in selected streams.	a	Using procedures established under Objective 1, place salmon carcasses and potentially other nutrient enrichment sources in selected streams within the basin.
		b	Monitor the response of selected aspects of fish and stream community productivity.
		c	Organize and facilitate a workshop amongst researchers, managers, and interested parties to discuss findings and to evaluate potential for establishing nutrient enrichment as a long-term management strategy to increase the productivity of anadromous salmonids in the Columbia River basin.

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	10/1998	04/2000	5
2	10/1999	09/2003	30
3	10/2001	09/2006	65

Schedule constraints.

Since implementation of objectives 2 and 3 require information derived from objective 1, scheduling could change slightly if completion of objective 1 is delayed. Also, depending on the outcome of objective 1, scheduling could change (i.e., be shorter or longer) for objectives 2 and 3.

Completion date.
FY 2006

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel	Res. Fish. Biol. GS-12/3 @ $4,116/mo. for 12 mo. Fish. Biol. GS-7/1 @ $2,175/mo. for 3 mo.	$55,917
Fringe benefits	@ 28% of personnel	$15,657
Supplies, materials, non-expendable property	Meetings, workshop, meeting supplies, computer supplies	$5,250
Operations & maintenance		$0
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		$0
PIT tags	# of tags: 0	$0
Travel	Vehicle rental, vehicle mileage, professional meeting registration, airfare, travel and expenses for some working group members	$18,023
Indirect costs	@ 38%	$36,041
Subcontracts		$0
Other		
TOTAL		$130,088

Outyear costs

(Money listed here is based on a projected need to fully complete objective 1)

Outyear costs	FY2000	FY01	FY02	FY03
Total budget	$10,537			
O&M as % of total	0%			

Section 6. Abstract

Adult salmonids (*Oncorhynchus* spp.), through excretion, gametes, and carcass decomposition, transport significant amounts of marine-derived nutrients to the freshwater ecosystem. Such nutrient input to streams is a fundamental aspect of salmonid ecology and is important to the productivity of waters in which salmon spawn. However, the decline of salmon populations in the Pacific Northwest has dramatically reduced the availability of carcasses in many tributaries of the Columbia and Snake Rivers. Diminished inputs of marine-derived nutrients can depress stream ecosystem productivity and lead to a cascade of deleterious effects such as decreased juvenile salmonid size,

reduced overwinter and marine survival, and declines of returning adults. We propose to establish and participate in a system-wide, coordinated, and comprehensive research effort to document the effects of nutrient enhancement via carcass decomposition on the productivity of Columbia River basin tributaries and anadromous salmonids. Phase I of this work, which this proposal specifically addresses, will involve development of a research plan to direct all aspects of the research, including identifying candidate streams and factors to be examined, and developing methods and analysis techniques. Phase II, which will be fully developed after completion of the first phase, will involve selection of candidate treatment and control streams and will include collection and analysis of pre-enhancement baseline data. Phase III will consist of stocking of carcasses into streams and monitoring and evaluation of the response of stream and salmonid productivity. Information derived from this project is fundamental to measures outlined in the FWP regarding coordinated salmon production and habitat. In addition, this information may be critical to the success of supplementation programs. Our results should provide sufficient scientifically valid information to assess the importance of marine-derived nutrients to salmonid production and will establish a solid foundation towards implementing nutrient enrichment as a long-term management program designed to help reverse the decline of Pacific Northwest salmonid populations.

Section 7. Project description

a. Technical and/or scientific background.

Historically, the Columbia River Basin supported overwhelming numbers of spawning salmon. Today, however, wild salmon populations in the Pacific Northwest have declined to alarming low numbers. In the Columbia River basin, one contributing factor (among several) may be a lack of marine-derived nutrients--via salmon carcasses--being transported to tributary streams where these fish spawn and juveniles rear. Increasing evidence indicates that the nutrients contained in salmon carcasses can have profound effects on stream productivity and concomitant fish production. For example, several studies have shown that decomposing fish carcasses can increase nitrogen and phosphorus concentrations in streams which, in turn, increase algal biomass and primary and secondary production (Richey et al. 1975; Kline et al. 1990; Schuldt and Hershey 1995; Bilby et al. 1996). Such changes in stream productivity can ultimately lead to substantial increases in fish production (Michael 1995; Bilby et al. 1996; Larkin and Slaney 1997). Furthermore, because many streams in the Pacific Northwest have low productivity, only modest inputs of nutrients may be necessary to increase trophic productivity (Schuldt and Hershey 1995; Larkin and Slaney 1997). In short, marine-derived nutrients may be essential for maintaining the productivity of nursery and rearing areas for future generations of salmon (Schuldt and Hershey 1995; Kline et al. 1990; Larkin and Slaney 1997).

Nutrients derived from decomposing carcasses are a fundamental aspect of salmonid and stream ecology and should be an integral component of research and management activities to meet the habitat goal, policies, and objectives of the NWPPC Fish and Wildlife Program. Although the efficacy of nutrient enrichment may vary from

stream to stream due to a variety of factors, this technique has the potential to be a relatively low-cost, long-term program to help increase salmonid production. Furthermore, the oligotrophic nature of many streams in the basin suggest that nutrient enrichment will likely be a necessary component of proposed or ongoing supplementation programs in the basin.

Given the condition of salmonid habitat and production in the Columbia River basin, the time is now to provide some focus on the potential benefits and risks of nutrient enrichment as a management technique to help reverse the decline of salmonid resources. The states of Washington and Oregon have ongoing efforts at stream nutrient enrichment via carcass introductions, which have received considerable public support and involvement. Ongoing efforts in Canada suggest that direct application of artificial chemical media may be a good substitute, especially if carcasses are scare or their use is not feasible. Despite the substantial ongoing efforts to add carcasses to streams, scant research has been conducted in the Columbia River basin to address the efficacy of these efforts and to evaluate when and where this technique is most likely to produce the desired effect.

b. Proposal objectives.

Objective 1. Draft a comprehensive, systematic research plan to investigate the effects of marine-derived nutrients on Columbia River basin tributary and salmonid productivity (FY 99-00).

(This objective does not involve hypothesis testing)

Objective 2. Document the productivity of selected watersheds and streams prior to nutrient enhancement. Factors to be examined would come from the results of objective 1, but could include such factors as estimating primary productivity, invertebrate production, nutrient cycling, and fish growth, biomass, densities, and selected aspects of fish physiology (FY 00-03).

(This objective also involves no rigorous hypothesis testing, but serves to collect baseline data prior to nutrient enhancement)

Objective 3. Document the effects of introducing adult salmonid carcasses on stream and fish productivity in selected streams (FY 02-06).

Null hypothesis: AThere is no difference in primary productivity between streams stocked with carcasses and those without≅.

Null hypothesis: AThere is no difference in secondary (invertebrate) productivity between streams stocked with carcasses and those without≅.

Null hypothesis: AThere is no difference in selected aspects of salmonid production and physiology between streams stocked with carcasses and those without≅.

Null hypothesis: AThere are no deleterious aspects of introducing carcasses to streams such as disease or deterioration of water quality≅.

c. Rationale and significance to Regional Programs.

This proposed project should be an essential component of Section 7 of the NWPPC Fish and Wildlife Program (FWP), entitled ACoordinated salmon production and habitat≅. This project clearly seeks to improve and maintain the quality and productivity of salmonid habitat on a watershed basis as stated in Section 7. Furthermore, this project has at its core the explicit use of coordinated, cooperative, and comprehensive efforts by federal, state, tribal, and private parties to undertake activities associated with this work. The FWP states that such efforts are not only needed, but are also the best approach to watershed restoration and habitat improvement projects. This project specifically addresses the habitat goal of the FWP (7.6A), to Aprotect and improve habitat conditions to ensure compatibility with the biological needs of salmon, steelhead, and other fish and wildlife species≅. This project addresses the specific objective (7.6A.2) of improving the productivity of salmon and steelhead habitat critical to the recovery of weak and other stocks. We believe this project is highly relevant to *all* the habitat policies of the FWP (7.6B) in that this work will: be cooperative in nature (7.6B.1 and 7.6.B.2), address areas of low to medium productivity (7.6.B.3), maximize the desired result per dollar spent and have a high probability of success (7.6.B.4), and encourage, involve, and promote public involvement and education (7.6.B.6). Finally, from a watershed management perspective, this research should coordinate well with other watershed improvement efforts and seeks to use a natural healing mechanism to help improve habitat quality. As previously mentioned, nutrients derived from decomposing salmon carcasses are a fundamental aspect of salmonid and stream ecology.

We recognize that there are several ongoing efforts that are introducing carcasses to streams throughout the Pacific Northwest, and we see no need to simply propose to expand these efforts in the Columbia River basin. We do see a need for a comprehensive and systematic research effort to evaluate the utility and efficiency of this management technique. Results from our proposed project will help guide future efforts by helping to define when and where the addition of carcasses or other nutrient enrichment media will be suitable, will have the highest chance of success, and will have the lowest chance of producing adverse effects.

Although the importance of marine-derived nutrients to stream and salmonid productivity may seem self-evident to those familiar with general principles of aquatic and salmonid ecology, we offer the following quote from Larkin and Slaney (1997) as timely advice for justifying nutrient enhancement work in the Columbia basin: AWithout a broad-based, integrated strategy of renewal by intensifying research on nutrient-salmon interdependence, habitat protection efforts, extensive restoration and mitigation of impacted fish habitat, and risk-averse fisheries exploitation, we are confronted with unsustainability and continued decline of weaker stocks of coastal wild anadromous salmonids...≅. We believe the same holds for Columbia River basin salmonids.

d. Project history

Not applicable.

e. Methods.

Although we have explicitly mentioned and discussed several objectives for this project, this proposal focuses only on objective 1. All methods and analysis techniques for objectives 2 and 3 will be derived from the research plan to be developed under objective 1. Therefore, no descriptions of methods to be used for Objective 2 and 3 will be discussed here; they will be discussed in detail in a subsequent outyear proposal.

To address Objective 1, we will include several persons from different agencies to participate in a working group whose goal will be to draft a comprehensive research plan. Group target size will likely be from about 12-20 persons, and will include representatives from various federal and state agencies, tribal groups, and the private sector. Our initial contacts with a number of potential candidates have been very positive, which indicates that substantial interest exists in this topic and that active participants will be readily enlisted. Once the working group is established, one primary objective will be to organize and facilitate a multi-day workshop to complete most of the work involved with development of the research and applied management strategy.

The research and management strategy will be the guiding document for all research to be conducted under this project on nutrient enhancement and will ensure that the factors examined, methods, and analysis techniques are consistent among personnel conducting the work. At a minimum, the strategic plan should contain: (1) the goals and objectives of the work; (2) a list of watersheds and specific streams to focus research effort; (3) a list of pre and post-enhancement environmental and biological factors to be examined; (4) detailed methods and experimental designs for all aspects of the research; (5) data analysis techniques and report formats; (6) a program for public education and outreach; and (7) specific criteria for measuring success. After completion of this strategic plan, we will identify agencies or groups to conduct the research in specific watersheds and begin writing a proposal for implementation of the work.

f. Facilities and equipment.

The workshop to develop the research plan will be conducted at a privately-owned facility judged to be most convenient and cost-effective for the working group. If any subsequent meetings are necessary, they will likely be conducted at government-owned facilities and these costs will be considered in-kind contributions. We anticipate that drafts of the research plan will be prepared by personnel at the USGS=s Columbia River Research Laboratory, which is well supplied with the modern office equipment and technology necessary to undertake this task.

g. References.

Bilby, R.E., B.R. Fransen, and P.A. Bisson. 1996. Incorporation of nitrogen and carbon

from spawning coho salmon into the trophic system of small streams: evidence from stable isotopes. Can. J. Fish. Aquat. Sci. 53:164-173.
Kline, T.C., J. J. Goering, O.A. Mathisen, P.H. Poe, and P.L. Parker. 1990. Recycling of elements transported upstream by runs of Pacific salmon: I. $\delta^{15}N$ and $\delta^{13}C$ evidence in Sashing Creek, Southeastern Alaska. Can. J. Fish. Aquat. Sci. 47:136-144.

Larkin, G.A., and P.A. Slaney. 1997. Implications of trends in marine-derived nutrient influx to south coastal British Columbia salmonid production. Fisheries 22:16-24.

Michael, J.H. 1995. Enhancement effects of spawning pink salmon on stream rearing juvenile coho salmon: managing one resource to benefit another. Northwest Sci. 69:228-233.

Richey, J.E., M.A. Perkins, and C.R. Goldman. 1975. Effects of kokanee salmon (*Oncorhynchus nerka*) decomposition on the ecology of a subalpine stream. J. Fish. Res. Board Can. 32:817-820.

Schuldt, J.A., and A.E. Hershey. 1995. Effect of salmon carcass decomposition on Lake Superior tributary streams. J. N. Am. Benthol. Soc. 14:259-268.

Section 8. Relationships to other projects

This project should complement any existing projects that deal with the coordinated salmon production and habitat section of the FWP. As mentioned previously, this project could be a critical adjunct to supplementation programs either proposed or ongoing in the basin. If taken to the implementation phase, this project will involve a great deal of collaboration with other agencies and organizations. In fact, the success of this project will, to a great degree, depend upon the extent of collaboration obtained, which is one purpose of the working group. In addition, there may be special permitting required from state and federal water quality agencies and perhaps certification for disease status from fish health professionals.

Section 9. Key personnel

The names, titles, and hours of key personnel are:

Matthew G. Mesa, Research Fishery Biologist, 1,040 h

Duties: To include: coordinate and facilitate meetings and workshop, write draft and final strategic research and management plan, and analyze data.

Patrick J. Connolly, Research Fishery Biologist, 1,040 h

Duties: To include: coordinate and facilitate meetings and workshop, write draft and final strategic research and management plan, and analyze data.

The resumes of these key personnel follow.

Resume for: Matthew G. Mesa

Experience

1991-Present Research Fishery Biologist, U.S. Geological Survey, Biological Resources Division, Columbia River Research Lab, Cook, WA
Current responsibilities: Team leader on research projects addressing the effects of dissolved gas supersaturation on juvenile salmonids and evaluating predator-prey relations in Columbia River fishes

1989-1991 Fishery Biologist, U.S. Fish and Wildlife Service, Seattle-NFRC, Columbia River Field Station, Cook, WA

1986-1989 Fishery Biologist/CEA Appointee, Seattle-NFRC, Oregon Cooperative Fisheries Research Unit, Oregon State University, Corvallis, OR

1984-1986 Fishery Biologist, U.S. Fish and Wildlife Service, Seattle-NFRC, Columbia River Field Station, Cook, WA

Education:

School	Degree and Date Received
California Polytechnic State Univ. at San Luis Obispo	B.S., Nat. Res. Mgt., 1984
Oregon State Univ.	M.S., Fisheries, 1989
Oregon State Univ.	Advancement to candidacy for Ph.D, 1995

Expertise: My areas of expertise include predator-prey interactions in fishes, fish behavior and performance, and general and stress physiology of fishes

Publications and Reports (five most relevant)

Mesa, M.G. and C.B. Schreck. 1989. Electrofishing mark-recapture and depletion methodologies evoke behavioral and physiological changes in cutthroat trout. Transactions of the American Fisheries Society 118:644-658.

Mesa, M.G. 1991. Variation in feeding, aggression, and position choice between hatchery and wild cutthroat trout in an artificial stream. Transactions of the American Fisheries Society 120:723-727.

Mesa, M.G. 1994. Effects of multiple acute stressors on the predator avoidance ability and physiology of juvenile chinook salmon. Transactions of the American Fisheries Society 123:786-793.

Mesa, M.G., T.P. Poe, D.M. Gadomski, and J.H. Petersen. 1994. Are all prey created equal? A review and synthesis of differential predation on prey in substandard condition. Journal of Fish Biology 45 (Supplement A):81-96.

Mesa, M.G., T.P. Poe, A.G. Maule, and C.B. Schreck. *In press*. Vulnerability to predation and physiological stress responses in juvenile chinook salmon experimentally infected with *Renibacterium salmoninarum*. Canadian Journal of Fisheries and Aquatic Sciences.

Resume for: Patrick J. Connolly

Experience

1997-Present	Research Fishery Biologist, U.S. Geological Survey, Biological Resources Division, Columbia River Research Laboratory, Cook, WA. Current responsibilities: Team leader on a research project to determine survival of summer steelhead over their first winter in the Wind River subbasin (WA).
1994-1997	Consultant to Wind River Restoration Team, WA.
1990-1996	Research Assistant, Oregon State University, Corvallis.
1988-1991	Fish Biologist--Subbasin Planner, Oregon Dept. Fish & Wildlife, Corvallis.
1987-1988	Fish Biologist--Research, Oregon Dept. Fish & Wildlife, Columbia River Research, Clackamas, OR.
1985-1987	Fish Biologist, Beak Consultants Inc., Portland, OR.
1984-1985	Fishery Biologist, U.S. Fish and Wildlife Service, National Fisheries Research Center, Columbia River Field Station, Cook, WA.
1983	Fish Habitat Surveyor, Idaho Transportation Dept., Coeur d=Alene, ID.

Education: School	Degree and Date Received
Oregon State Univ., Corvallis	Ph.D. Fisheries Science, 1996
Univ. of Idaho, Moscow	M.S. Zoology, 1983
Centre College of Kentucky, Danville	B.S. Biology, 1977

Expertise: The primary areas of my expertise include stream fish ecology and population dynamics. I have contributed to numerous studies involving anadromous resident salmonids as well as non-salmonids of the Pacific Northwest.

Publications and Reports (five most relevant)

Connolly, P.J. 1997. Influence of stream characteristics and age-class interactions on populations of coastal cutthroat trout. Pages 173-174 *in* J.D. Hall, P.A. Bisson, and R.E. Gresswell, editors. Sea-run cutthroat trout: biology, management, and future conservation. Oregon Chapter, American Fisheries Society, Corvallis.

Connolly, P.J. 1997. Status of juvenile steelhead rearing in Trout and Panther creeks of the Wind River Basin. Prepared for: Washington Trout, Duvall, WA.

Connolly, P.J. 1996. Resident cutthroat trout in the central Coast Range of Oregon: logging effects, habitat associations, and sampling protocols. Doctoral thesis, Oregon State University, Corvallis.

Connolly, P.J. 1995. Wind River steelhead restoration project: with special emphasis on the Trout Creek Basin. Prepared for: Columbia River Research Laboratory, National Biological Service, Cook, WA.

Connolly, P.J. et al. 1992. Fish management plan for the Middle Fork Willamette Subbasin. Oregon Department of Fish and Wildlife, Portland.

Section 10. Information/technology transfer

For all research activities associated with this project, we fully intend to have findings published in peer-reviewed journal articles and agency reports. An integral part of this project involves public education and outreach. In areas where carcass introductions might take place, we plan on conducting seminars for all interested parties to fully inform the public of the goals, objectives, and potential benefits of this type of work. We anticipate this project could generate considerable media interest, and will work to convey the importance of this research and management technique to the restoration of Columbia River basin salmonids.