19.5.2

Cutthroat Trout and Dolly Varden in Prince William Sound: Restoration Project Support and Coordination

Project Number:	97174
Restoration Category:	Monitoring and Research
Proposer:	Alaska Department of Fish and Game, Sport Fish Division
Lead Trustee Agency:	ADF&G
Cooperating Agencies:	USFS
Alaska Sea Life Center:	No
Duration:	4 years
Cost FY 97:	$157,500
Cost FY 98:	$140,000
Cost FY 99:	$140,000
Cost FY 00:	$70,000
Geographic Area:	Prince William Sound
Injured Resource/Service:	Cutthroat Trout, Dolly Varden, Sport Fishing

ABSTRACT

This project is intended to achieve two primary goals: 1) to collect information necessary to support other restoration projects: and 2) to coordinate with other projects to develop and implement a cutthroat trout and Dolly Varden restoration management strategies. Cutthroat trout and Dolly Varden are listed by the *Exxon Valdez* oil spill (EVOS) Trustee Council as "Injured Resources Whose Recovery is Unknown". Restoration projects to aid recovery of this injured resources that have been previously funded by the Trustee Council include: modification of habitat for the enhancement of cutthroat trout rearing habitat; and genetic evaluation to determine the relationship between resident and anadromous populations of cutthroat trout and Dolly Varden within the same watershed and between watersheds in Prince William Sound. Each of these projects will provide information valuable for the development of both short term and long term restoration strategies. Involvement and information from the Alaska Department of Fish and Game has been requested by each of these studies; and in addition, there is currently no mechanism for coordinating these projects or integrating the results into a management plan. This project will conduct field work to collect data required to support the other Trustee Council projects and work to coordinate the development and implementation of restoration strategies.

19.5.2

Cutthroat Trout and Dolly Varden in Prince William Sound: Restoration Project Support and Coordination

Project Number:	97174
Restoration Category:	Monitoring and Research
Proposer:	Alaska Department of Fish and Game, Sport Fish Division
Lead Trustee Agency:	ADF&G
Cooperating Agencies:	USFS
Alaska Sea Life Center:	No
Duration:	4 years
Cost FY 97:	$157,500
Cost FY 98:	$140,000
Cost FY 99:	$140,000
Cost FY 00:	$70,000
Geographic Area:	Prince William Sound
Injured Resource/Service:	Cutthroat Trout, Dolly Varden, Sport Fishing

ABSTRACT

This project is intended to achieve two primary goals: 1) to collect information necessary to support other restoration projects: and 2) to coordinate with other projects to develop and implement a cutthroat trout and Dolly Varden restoration management strategies. Cutthroat trout and Dolly Varden are listed by the *Exxon Valdez* oil spill (EVOS) Trustee Council as "Injured Resources Whose Recovery is Unknown". Restoration projects to aid recovery of this injured resources that have been previously funded by the Trustee Council include: modification of habitat for the enhancement of cutthroat trout rearing habitat; and genetic evaluation to determine the relationship between resident and anadromous populations of cutthroat trout and Dolly Varden within the same watershed and between watersheds in Prince William Sound. Each of these projects will provide information valuable for the development of both short term and long term restoration strategies. Involvement and information from the Alaska Department of Fish and Game has been requested by each of these studies; and in addition, there is currently no mechanism for coordinating these projects or integrating the results into a management plan. This project will conduct field work to collect data required to support the other Trustee Council projects and work to coordinate the development and implementation of restoration strategies.

INTRODUCTION

There are currently two restoration projects that are already being funded by the Trustee Council that require information about the location, distribution and population size information for cutthroat trout and Dolly Varden in Prince William Sound. In addition these project are designed to provide information to the Alaska Department of Fish and Game for the development and implementation of restoration strategies. This project is designed to provide the information required by these other Trustee Council projects and to synthesize the information provided by these projects, as well as other agency projects, into management strategies for the recovery of cutthroat trout and Dolly Varden in Prince William Sound.

Other restoration projects to which the proposal is linked include: /145 *Cutthroat Trout and Dolly Varden: The Relation Among and Within Population of Anadromous and Resident Forms*; and, /043 *Cutthroat Trout Habitat Restoration (Monitoring)*. In addition, a USFS project is being conducted to determine population variability, estimate survival rates and document migration patterns and habitat requirements of cutthroat trout at Mile 18 Creek near Cordova. This project was submitted to the Trustees Council (project no. 96043A) but not approved for funding because it was part of an on-going agency effort.

NEED FOR THE PROJECT

A. Statement of Problem

Cutthroat trout (*Oncorhynchus clarki*) and Dolly Varden (*Salvelinus malma*) are important ecological and recreational species in Prince William Sound. Resident and anadromous forms of both species are found throughout the sound. The anadromous forms spend the marine portion of their life cycle in nearshore areas feeding on marine crustaceans, invertebrates (Dolly Varden) and fish (cutthroat trout and Dolly Varden). Hepler et al. found that cutthroat trout and Dolly Varden had slower growth rates and reduced survival in oiled area than in unoiled areas, which he attributed to chronic starvation and exposure to hydrocarbons. The rate or degree of recovery of cutthroat trout and Dolly Varden from the injury documented in the *Exxon Valdez* oil spill damage assessment studies are not known.

The Trustee Council has funded restoration projects which both require information from the department and provide information intended to be used by the department in managing the fisheries and recovery strategies for cutthroat trout and Dolly Varden. The department currently has no resources dedicated to meeting these needs. This project would provide the resources to the department for providing required support to EVOS project and synthesizing results of EVOS projects into management and restoration strategies.

B. Rationale/Link to Restoration

Information has been requested by EVOS restoration projects regarding the identification and selection of sampling sites and sample sizes for cutthroat trout and Dolly Varden in Prince William Sound. The department responded to these requests with the best available data, however specific information was often not available and conservative approaches to sampling schemes were required. This work should be done to enable the department to better respond to information requests of this nature, thus enable other restoration projects to better accomplish

their objectives. In addition this information will be valuable to non-EVOS agency projects that may require this type of information, as well as providing the department biologist information valuable to the management of these species.

Objectives of EVOS restoration projects have specifically identified the department as the managing entity for which the information obtained by the project is intended. This project would enable the department to better coordinate with these other projects and better understand the results. This coordination and research will contribute to achieving recovery by enabling the department to synthesize this information with other departmental information and provide a more comprehensive management and restoration strategy.

C. Location

The field work conducted by this project will be undertaken entirely within Prince William Sound. Specific locations will be coordinated with other EVOS restoration projects. Administrative support will come from the ADF&G, Sport Fish division office in Anchorage. All communities in PWS will benefit from the restoration efforts produced by this and related Trustee Council projects.

COMMUNITY INVOLVEMENT

All affected communities will be involved to the extent that local resources and community interest exists. Project information and study results will be presented in a non-technical format by project biologists at pre-arranged informal meetings at community centers or other places of local gathering. Traditional and local knowledge of cutthroat trout and Dolly Varden will be solicited from residents of Chenega and Tatitlek through channels to be developed with the Trustee Council's Community Coordinator. Local hire, acquisition of services and equipment as well as other resources will be afforded local communities to the extent that such items and services are available competitively

PROJECT DESIGN

A. Objectives

1. Coordinate with other agencies conducting restoration projects on cutthroat trout and Dolly Varden to identify management strategies for the protection and recovery of injured populations.
2. Inventory populations of cutthroat trout in Prince William Sound and evaluate selected populations with respect to their ability to meet the study requirements of other restoration projects.

B. Methods

Hypothesis: there is no difference between abundance indices of cutthroat trout and Dolly Varden at sites known to support harvest and sites of limited or unknown harvest.

Data needed to test this hypothesis would consist of estimates of abundance of spawning cutthroat trout and Dolly Varden in index areas of streams known to support these species.

Abundance estimates in index area will be calculated by Peterson indices. Each index area will be blocked at the upstream and downstream boundaries of the area. Fish within the index reach will be captured by repeated seine hauls. All fish will be marked with a caudal fin punch and released. Barrier seines will remain in place for 2 days to allow fish within the index area to mix. After mixing the seine hauls will be repeated and the number of marked an unmarked fish will be recorded for calculation of abundance estimates.

Study sites would consist of sites that have consistently supported sport harvests of cutthroat trout and sites for which EVOS restoration project sampling is requested. The known sport harvest locations would include, but not be limited to, Makaka Creek, Boswell Bay Creek, and Eshamy Creek. The sites for which restoration sampling is requested will be coordinated with the appropriate principal investigator. Sampling will span a three year period to assure that all sites can be visited at least two times during the limited time period for sampling.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The study sites will be coordinated with the needs of the other EVOS restoration studies currently being conducted by the US Forest Service. Field operations will be coordinated as necessary.

SCHEDULE

October 1 - January 1:	Detailed ADF&G operational plan preparation, Coordination with other Principal Investigators
January 22-25:	Attend annual restoration workshop
February 1 - April 1:	Coordinate logistics
April 15 - July 31:	Field data collection
August 1 - Sept. 30:	Data analysis, report preparation

PUBLICATIONS AND REPORTS

Annual and final reports will be submitted as scheduled. In addition, manuscripts may be submitted for publication in professional journals as appropriate. Specific journal names or manuscript titles have not be determined at this point in the development of the project.

PROFESSIONAL CONFERENCES

The Principal Investigator will attend all departmental and Trustee Council meetings appropriate to cutthroat trout and Dolly Varden. In addition presentations will be made, as appropriate, at state and national American Fisheries Society and other professional meetings.

NORMAL AGENCY MANAGEMENT

The objectives of this project are designed to enhance and support the EVOS restoration projects, however the studies will also benefit the normal ADF&G management activities. None of the

proposed activities are mandated in any Alaska statute or regulation. Prior to the oil spill no work of this nature had been conducted in Prince William Sound due to relatively low angler effort and the remote nature of the fisheries. As a result of the oil spill, closures and restriction on these fisheries caused loss of sport fishing opportunity. In addition, publicity regarding Prince William Sound as a result of the spill increased sport anglers awareness and interest in recreational opportunities in the sound in general and on the cutthroat trout and Dolly Varden resources. As a result of the documented injury, increased popularity of the sound and relatively small database regarding these fisheries ADF&G has adopted an extremely conservative approach to management of these species. Without the information from this study and the opportunity to focus development of management strategies, the department will continue to manage conservatively. This type of management may result in unnecessary reduction of opportunity, however there is also the potential for additional impact to the cutthroat trout resources in Prince William Sound. This project will result in a permanent improvement of the management of cutthroat trout and Dolly Varden resources in Prince William Sound. No departmental funding for this type of work is expected in the foreseeable future.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The Alaska Department of Fish and Game has been in contact with investigators conducting project /145 *Cutthroat Trout and Dolly Varden: The Relation Among and Within Populations of Anadromous and Resident Forms*; and, /043 *Cutthroat Trout Habitat Restoration (Monitoring)*, each funded by the EVOS Trustee council. The department has assisted and will continue to assist in areas of sample collection required by project /145 and as required by efforts of project /043 with regard to habitat monitoring. Coordination will continue with the USFS cutthroat trout study being conducted at Mile 18 Creek near Cordova.

Existing (ADF&G) vehicles, inflatable rafts, outboard motors and camp equipment will be utilized to the fullest extent. Air transportation during the field season will be coordinated with CFM&D, USFS and other agencies active within Prince William Sound to minimize costs.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

(not applicable)

PRINCIPAL INVESTIGATOR

Andrew Hoffman
ADF&G - Sport Fish Division
333 Raspberry Road
Anchorage, AK 99515

ph: 907-267-2238
fax: 907-267-2424
Email: ahoffman@fishgame.ak.us.state

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$95.8						
Travel		$7.0						
Contractual		$5.0						
Commodities		$25.0						
Equipment		$10.0						
Subtotal	$0.0	$142.8	Estimated FFY 1998	Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	
General Administration		$14.7						
Project Total	$0.0	$157.5	$140.0	$140.0	$70.0	$0.0	$0.0	
Full-time Equivalents (FTE)		1.8						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

Comments:
- no prior funding

- Project costs for:
  - NEPA Compliance 0.0 (assume Categorical Exclusion)
  - report writing 9.2 (2 months of PI costs)
  - publications 2.0
  - community involvment 5.0
  - workshop attendance 0.0 (PI in Anchorage already)

- no other funds anticipated

1997

Prepared: 3/29/96

Project Number: 97174
Project Title: Cutthroat Trout and Dolly Varden in Prince William Sound: Restoration Project Support and Coordination
Agency: ADF&G

FORM 3A
TRUSTEE
AGENCY
SUMMARY

4/12/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1997
	Fisheries Biologist II	16 C	11.0	4.6		50.6
	Fisheries Technician III	11 B	4.0	3.5	2.0	16.0
	Fisheries Technician II	9 B	3.0	3.2	2.0	11.6
	Fisheries Technician II	9 B	3.0	3.2	2.0	11.6
						0.0
	Biometrican	19 D	1.0	6.0		6.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		22.0	20.5	6.0	
					Personnel Total	$95.8

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FFY 1997
Anchorage to Cordova	0.2	15	20	0.1	5.0
Anchorage to (Fairbanks, Juneau other in state for travel to conferences)	0.2	4	12	0.1	2.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$7.0

1997

Prepared: 3/29/96

Project Number: 97174
Project Title: Cutthroat Trout and Dolly Varden in Prince William Sound: Restoration Project Support and Coordination
Agency: ADF&G

FORM 3B
Personnel
& Travel
DETAIL

4/12/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Contractual Costs:		Proposed
Description		FFY 1997
Charter to villages for community meetings 10 hrs * 2 per year * 250 per hour		5.0
When a non-trustee organization is used, the form 4A is required.	**Contractual Total**	$5.0

Commodities Costs:		Proposed
Description		FFY 1997
Food (field camps) (approximately 3months * 3 personal * 20 days per month * $36 per day)	6480	7.0
boat gas		10.0
boat maintenance		3.0
Field gear (hip boots, rain gear, gloves, etc		3.0
Sampling gear (seines, nets etc)		2.0
Miscellaneous		
	Commodities Total	$25.0

1997

Prepared: 3/29/96

Project Number: 97174
Project Title: Cutthroat Trout and Dolly Varden in Prince William Sound: Restoration Project Support and Coordination
Agency: ADF&G

FORM 3B
Contractual & Commodities DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1997
			0.0
Computer with software and accessories	1	10.0	10.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$10.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
Seasport - 22 foot boat primary transportation and sampling platform	1	ADF&G

1997

Prepared: 3/29/96

Project Number: 97174
Project Title: Cutthroat Trout and Dolly Varden in Prince William Sound: Restoration Project Support and Coordination
Agency: ADF&G

FORM 3B
Equipment
DETAIL

4/12/96

Kenai Habitat Restoration & Recreation Enhancement Project

Project Number:	97180
Restoration Category:	Habitat Improvement
Proposer:	ADNR/ADFG
Lead Trustee Agency:	ADNR/ADFG
Cooperating Agencies:	DOI/USFS
Duration:	Two Years
Cost FY 97:	621.8
Cost FY 98:	815.7
Geographic Area:	Kenai Peninsula
Injured Resource/Service:	Pink salmon, sockeye salmon, Dolly Varden, commercial fishing, subsistence, recreation & tourism.

ABSTRACT

Adverse impacts to the banks of the Kenai River total approximately 19 miles of the river's 166 mile shoreline. Included in this total are 5.4 river miles of degraded shoreline on public land. Riparian habitats have been impacted by trampling, vegetation loss and structural development. This riparian zone provides important habitat for pink salmon, sockeye salmon and Dolly Varden, species injured by the *Exxon Valdez* oil spill. The project's objectives are to restore injured fish habitat, protect fish and wildlife habitat, enhance and direct recreation and preserve the values and biophysical functions that the riparian habitat contributes to the watershed. Restoration/enhancement techniques will include revegetation, streambank restoration, elevated boardwalks, floating docks, access stairs, fencing, signs, and educational interpretive displays.

INTRODUCTION

This project is a continuation of the Kenai River Habitat Restoration and Recreation Enhancement Project that began in 1996. The objectives of this project are to:

1. Restore and protect fish habitat on the Kenai River,

2. Improve existing recreational access to the Kenai River watershed in a manner that restores and protects riparian fish and wildlife habitat,

3. Provide information to the public that promotes their understanding of the river's ecology and proper use of its resources.

Public lands on the Kenai Peninsula, including those soon to be acquired with *Exxon Valdez* oil spill joint settlement funds, contain important habitat for several species injured by the spill and provide recreation services for tens of thousands of Alaska residents and tourists. Kenai River fish support a large commercial fishery, a commercial sport fishing industry, a subsistence fishery, and a recreational sport fishery. In the aggregate, revenues generated by sportfishing, commercial fishing and river-based tourism represent a significant and growing proportion of the local economy.

The riparian zone, the transitional area that lies between the river's channel and the uplands, provides important fish and wildlife habitat and plays a major role in the hydrology of the watershed by helping to control floods and erosion. This vegetated area functions as a buffer and filter system between upland development and the river, thereby maintaining water quality by absorbing nutrients, accumulating and stabilizing sediments, and removing heavy metals and pollutants that are a result of urban development and which enter the river from surface runoff. It is also the area where a significant portion of the Kenai River's sportfishing and other recreational activities are concentrated.

Degradation of the river's streambanks, riparian vegetation and fish habitat has the potential of jeopardizing its long term productivity and degrading the quality of the recreational experience. This project proposes revegetation, streambank restoration, and public access improvements that will promote pink and sockeye salmon and Dolly Varden habitat protection and restoration, as well as enhancement of recreational services in the Kenai River watershed. The project also proposes to design and construct educational and interpretive displays that will inform the public of the proper manner in which to access and use the river's resources.

During 1996, the following project elements were accomplished:

1. Development of site assessment and nomination procedures,

2. Development of a digital database containing site assessment and nomination data,

3. Development of an evaluation and ranking process for nominated projects,

4. An Interdisciplinary Team (IDT) of biologists, resource managers and planners was selected to review evaluation procedures and nominated projects,

5. Review and evaluation, by the IDT, of 16 projects nominated by public landowners,

6. Public scoping meetings were held in Anchorage, Kenai and Sterling to discuss the project,

7. Production and publication of an Environmental Assessment (EA) document,

8. Review and response to EA comments,

9. Development of a Cooperative Agreement that will form the basis for funding projects carried out by public landowners,

10. Consummation of cooperative agreements between ADF&G/ADNR and public landowners for five projects will take place this spring.

Restoration and enhancement proposals on public lands extending from the outlet of Kenai Lake to the mouth of the Kenai River (Figure 1), were nominated by public landowners and evaluated by an Interdisciplinary Team (IDT) of biologists and resource managers using specific threshold and evaluation criteria (Table 1). The IDT designed the qualifying criteria used to evaluate and rank the proposals by considering a variety of factors, including the degree of damage at a site and the effects that each proposal will have on fish habitat, recreation, and the surrounding environment.

Conceptual restoration and enhancement plans were presented to the IDT for evaluation. Final engineered plans will be provided to ADFG/ADNR prior to construction. Choice of building materials and construction methods are the responsibility of the landowner (but subject to IDT review) and must employ restoration techniques permittable by regulatory agencies (ADFG, ADNR, and the Army Corps of Engineers).

The project was proposed to last for three years, beginning in 1996. Qualifying proposals initiated in 1996 will be completed in 1996 or 1997. The last two year's of project funding

is reserved for proposals that a) still require significant revisions in design or planning before they can be evaluated (e.g. Salamatof public easement, Sportsman's Lodge, etc.); or b) are presently on lands in private ownership that are being acquired under the EVOS habitat protection program; or c) new proposals on public lands. Monitoring of funded proposals will be carried out by ADFG/ADNR to ensure the proposals are constructed and function as designed. Monitoring will also be used to gather information regarding effectiveness of restoration techniques.

Sixteen proposals (Table 2) were evaluated and scored according to threshold and evaluation criteria. Two of the evaluated proposals, Swiftwater Park and Sportsman's Lodge (sites K10 and K16), have been temporarily withdrawn from consideration by the respective landowners and one proposal, Soldotna Visitor's Center, will be funded from another source. Five sites will be restored in 1996 using available funds. The remaining proposals will be funded in the second year. As previously stated, proposals which may be eligible for funding but have not been evaluated (i.e. Salamatof, Sportman's Lodge, and EVOS parcels) will be added to third year funding if they are in compliance with the threshold criteria and rank accordingly.

Because all proposals had to meet threshold criteria before the evaluation criteria were applied, all 13 proposals are eligible for funding. The scores are a method of ranking those proposals that best achieve the overall project's goals for habitat restoration, compatible recreation enhancement, and educational value. In an attempt to identify the most cost-effective proposals and obtain maximum benefits from available funds, it was decided to compare the relative restoration benefits of the proposals in terms of costs. To facilitate that determination, the results of the evaluation process, i.e. the scores, were plotted against the estimated costs. Figure 2 displays the relative or comparative restoration benefits of the proposals as a function of cost. The most cost-effective proposals are clustered in the lower right hand corner of the scatter diagram. These proposals all score over 200 and have estimated costs of less than $100,000.

Cooperative agreements will be negotiated and signed for five of the thirteen projects identified in the Preferred Alternative of the EA. Construction should begin on these five proposals in 1996: Endicott Drive, Kenai Beach Dunes, Airport Rotary Park, Russian River, and Caymas. Russian River and Caymas will require funding in 1997 to finish construction. The remaining proposals qualifying under this alternative (Sites KO2, KO9, KO11-15) are expected to be constructed in 1997. Salamatof, the EVOS parcels, and any revised proposals will be considered for funding in 1998, if nominated.

Work proposed for 1997 includes:

1. Oversight and monitoring of on-going projects,

2. Finalizing cooperative agreements with public landowners for projects to be constructed in 1997,

3. Review and evaluation of nominations for projects on EVOS-acquired parcels,

4. Review and evaluation of new nominations for projects on other public lands,

5. Preparation of a supplement to the EA that reflects new nominations,

6. Design and development of educational and interpretive materials,

7. Preparation of an annual report.

Table 1: Threshold and Evaluation Criteria

Threshold Criteria

1. The project will protect, restore or enhance the historic functional attributes of a site and the surrounding area.
2. The project is located on public land.
3. The managing agency agrees to endorse the project.
4. The managing agency agrees to future maintenance and management of the project in a manner that facilitates and is consistent with the restoration or enhancement endpoint (#1).
5. All elements of the project can be permitted.
6. The project is not a mitigation requirement.

Nomination must be in compliance with all Threshold Criteria.

Evaluation Criteria

1. Potential Habitat Value

What is the potential habitat value of the project? [Score_ = (20/10/5) x 3.5]

2. Potential Recreation Value

What is the potential recreation value of the project? [Score = (20/10/5) x 2.5]

3. Disturbance Level

What is the level of disturbance (human impact) in relation to habitat/recreation values?
[Score = (20/10/5) x 2.0]

4. Rate

To what extent will the project decrease the amount of time needed for riparian habitat to recover? [Score = (20/10/5) x 1.0]

5. Collateral Impacts

What is the potential for adverse impacts to natural or cultural resources or to the nearby human community resulting from this project?
[Inverse relationship: Score = (5/10/20) x 3.0]

6. Design/Effectiveness

How would you rate the project's design to its expected effectiveness?
[Score = (20/10/5) x 2.0]

7. Vulnerability

Is the protected, restored or enhanced site vulnerable to natural or human-induced degradation.
[Inverse relationship: Score = (5/10/20) x 2.0]

Table 2: 1996 Project Evaluation Summary

Project ID	Project Name	Project Score
K01	Russian River	248
K02	Rebel Run	277
K03	Endicott Drive	269
K04	Kenai Beach Dunes	217
K05	Cunningham Park	184
K06	Soldotna Airport Rotary Park	239
K07	Soldotna Airport Outfall	187
K08	Centennial Park	197
K09	Soldotna Visitor Center	288
K10	Swiftwater Park (Withdrawn by Sponsor)	248
K11	Funny River	272
K12	Torpedo Creek	221
K13	Big Eddy	260
K14	Ciechanski	254
K15	Caymas	209
K16	Sportsman's Lodge (Withdrawn by Sponsor)	252

NEED FOR THE PROJECT

A. Statement of Problem

Use of the Kenai River watershed is degrading fish habitat along the riparian zone of the mainstem and, to a lesser degree, the tributaries of the river. Streambanks that provide essential fish habitat are being trampled and denuded of vegetation leading to increasing rates of erosion and sedimentation. Both commercial and residential developments are altering shorelines, changing patterns of runoff and creating the potential for the discharge of non-point source pollutants into the river. Federal and state resource agencies have limited ability to manage these problems that have the potential of threatening the productivity and world class recreational value of this river system.

Commercial fishing, subsistence, recreation and tourism (including sport fishing) are services that were reduced or lost because of the spill. Within the Kenai River watershed, the resources that support these services that were injured by the *Exxon Valdez* oil spill include pink and sockeye salmon and Dolly Varden. Chinook and coho salmon also contribute significantly to these services. The *Exxon Valdez* Oil Spill Restoration Plan states that the Kenai River sockeye salmon population is not recovering and that: *With regard to sockeye salmon, the objective of habitat protection is to ensure maintenance of adequate water quality, riparian habitat, and intertidal habitat.*

The restoration strategy articulated in the restoration plan for recreation and tourism focuses on the: *Preservation and improvement of the recreational and tourism values of the spill area.* The Plan goes on to discuss strategies for promoting recovery of commercial fishing, recreation and tourism by: *...increasing the availability, reliability, or quality of the resource on which the service depends.*

What is needed within the Kenai River watershed is an integrated approach that protects resource habitats, restores degraded streambanks and riparian vegetation, maintains productivity and promotes appropriate, sustained human use of the river.

B. Rationale

The work proposed by this project is needed to protect and restore fishery resources. Continuing loss of habitat will exacerbate the injury caused by the spill to both resources and services and lead to diminished productivity. This, in turn, diminishes the value of the commercial, subsistence and sport fisheries and the quality of recreation on the river with significant, adverse implications for the local economy.

Based on a review of historic recreation use patterns and habitat impacts, the project will protect, restore, stabilize, or rehabilitate streambanks where resource damage is occurring; enhance or close existing access points and movement corridors; or re-direct users to other areas of the river

on a temporary or long term basis. These actions will be based on the need to facilitate human use of the river in a way that protects fish habitat and minimizes degradation of other sensitive and/or pristine habitats.

This project is designed to promote streambank stability, increase vegetative cover, and mitigate accelerated erosion and sedimentation for the benefit of pink salmon, sockeye salmon, Dolly Varden and other fish species that migrate and rear along the river's banks. Techniques used to achieve these goals may include the use of elevated, grated boardwalks, river access stairs, fishing platforms, spruce tree revetments and other riparian habitat improvement and protection techniques. These techniques will, at the same time, restore and enhance sportfishing. One example is elevated, grated boardwalks, constructed to protect revegetating streambanks, that will provide river access to anglers with a minimum of impact to the recovering habitat. Post-construction monitoring will examine the effects of the method and the amount of recreational use that occurs in the area.

The education component of the project will produce user information and interpretive displays at strategically located access points along the river. These displays will provide users with information on the natural history of the river's fish, their habitats, ecology of the river system and the best methods that they can use to maximize their recreational experience with a minimum of impact to the watershed and its resources. Signs placed adjacent to work sites will describe the on-going restoration effort and direct the public away from recovering vegetation.

Each site under consideration for a restoration, enhancement or education project will be evaluated in terms of the condition of its habitats, character of adjacent lands, and historic public use. Improvements to access will reflect patterns of use as well as on-site and adjacent upland environmental sensitivities.

C. Location

All construction, maintenance and monitoring components of the project will be located within the Kenai River watershed. Planning and coordination will be based in Anchorage. Primary ecological benefits from the project will be realized by the natural systems within the watershed. Secondary benefits will affect the economy of the communities of the Kenai Peninsula and the commercial fishing industry. Improved and enhanced recreation benefits will affect users from southcentral Alaska as well as tourists from outside of the state. Communities that may be affected by the project include: Kenai, Soldotna, Homer, Sterling, Cooper Landing, Anchorage and the unincorporated communities on the Kenai Peninsula.

COMMUNITY INVOLVEMENT

It is intended that the project be fully integrated with on-going agency recreation management, permitting and regional planning activities affecting the Kenai River watershed. This includes coordination with the Kenai Peninsula Borough, City of Kenai, Kenai City Council, City of Soldotna, Soldotna City Council, Kenai Peninsula Borough Assembly, and local interest groups.

PROJECT DESIGN

A. Objectives

1. Solicit restoration project nominations from public land managers on the Kenai River.

2. Evaluate and rank projects on the basis of their restoration benefit and cost effectiveness.

3. Review detailed design plans and develop cooperative agreements for construction of the projects.

4. Verify compliance with restoration designs and evaluate construction.

5. Implement a monitoring program to assess restoration and use of project sites.

6. Design and construct educational and interpretive signs and displays.

B. Methods

The present condition of North America's native fish fauna is attributable, in part, to the degradation of aquatic ecosystems and habitat (FEMAT Report, 1993). Loss and degradation of freshwater habitats are the most frequent factors responsible for the decline of anadromous salmonid stocks (Nehlsen, et. al. 1991). Along with habitat modification or loss, changes in water quality and quantity are often cited as causative factors for degradation of aquatic systems and declines in anadromous fish populations.

The Kenai River Cumulative Impacts Assessment of Development Impacts on Fish Habitat (Liepitz, 1994) was designed to identify and evaluate the cumulative impacts of development actions including public and private land use impacts on Kenai River fish habitat. The study documented that : 11.1 percent to 12.4 percent (18.4 to 20.6 miles) of the river's 134 miles of upland and 32 miles of island shoreline and nearshore habitats have been impacted by bank trampling, vegetation denuding, and structural development along the river's banks. Degraded public land along the Kenai River includes 5.4 miles of trampled riparian habitat and 3.5 miles of developed shoreline.

Site specific project designs will reflect site characteristics including: topography, hydrologic variables, vegetation, soils, extent and type of degradation and historic use patterns. Designs may include elements that restore or enhance specific habitat values. For example, instream structures may be used to enhance fish habitat and/or angler access. Plant propagation and streambank restoration techniques will be selected on the basis of site characteristics, constraints and cost. Revegetation designs will attempt to re-establish the native, riparian plant communities. Grasses

that have been successfully used for riparian and saltmarsh revegetation in Alaska include: bluejoint reedgrass (Calamagrostis canadensis), Bering hairgrass (Deschamsia beringensa), sloughgrass (Beckmannia syzigachne), sedges (Carex spp.) and beach wildrye (Elymus mollis).

Successful revegetation requires control of site impacts. Consequently, fences and/or signed closures may be required to protect undamaged sites from human impact or to prevent additional damage to recovering sites. Project areas will either be closed and posted during the course of revegetation, or environmental engineering techniques will be used that allow public access but protect the recovering habitat from additional adverse impacts. Habitat improvement and protection techniques to be considered include:

On-site Revegetation/Restoration	Signage
Exclosures	Elevated Grating/Boardwalks
Spruce Tree Revetments	Access Stairs Ladder
Access Trails	Floating Docks

The number of sites selected for revegetation or enhancement in a given year will be dependent upon the time necessary for completion, i.e., permitting, construction and installation, and the availability of funding.

Educational/interpretive displays will be designed, constructed and placed in strategic locations along the river. Signs will also be designed and located to prevent bank trampling in areas where revegetation efforts are occurring.

A monitoring program will be used to evaluate the degree of success of each project. The purpose of the monitoring program is to:

1. Determine if the project is in compliance with the Cooperative Agreement.

2. Evaluate whether the project was been successful in meeting the restoration goals set forth in the project description, and

3. Provide data that will help in design of future restoration projects and in the establishment of performance standards.

Monitoring parameters will be chosen that reflect site-specific restoration/enhancement objectives and may include habitat, vegetation and public use measurements. The assessment of the existing condition of each site will serve as the baseline for monitoring. Monitoring measurements will be obtained frequently early in the project and could be used to amend the design if necessary. Wherever possible, photo plots will be installed and photos taken biannually. Once the project is successfully constructed and it is determined that restoration/enhancement is proceeding on an acceptable course and rate, monitoring measurements will be taken less frequently. Projects that are initially monitored monthly during the early stages of vegetation growth and establishment will be monitored biannually thereafter. Habitat and population monitoring parameters may include: vegetation diversity and cover, fish utilization and stream stability. Public use of the sites and

impacts to adjacent areas will also be monitored. Site visitation shall be based on counts of individual people by field staff and project personnel.

Observations may be made during winter months to evaluate the effects of ice scouring. The period that a project is monitored will be based upon the amount of time required for achievement of objectives.

C. Cooperating Agencies, Contracts and Other Agency Assistance

All components of the project will be carried out by personnel from ADF&G and ADNR. Volunteers supervised by agency staff will assist in the installation of prefabricated structures and in routine maintenance. Cooperating agencies will participate in IDT evaluations and development of a supplement EA. Coordination will occur with agencies through contract administration and oversight.

SCHEDULE

A. Measurable Project Tasks for FY 97

October 1 to December 1:	Contract administration. Project monitoring. Preparation of annual report. Solicit nominations for second round of projects.
December 1 to February 1:	Review nominations and site assessments. Conduct evaluations with the IDT for second round nominations and EVOS parcels. Agency coordination on cooperative agreements. Prepare environmental compliance documents, i.e., supplemental EA. Conduct public review process.
February 1 to May 15:	Review detailed design plans. Design and produce educational materials and signs. Establish cooperative agreements with public landowners for second round and EVOS projects.
May 15 to July 15:	Management and oversight of project construction. Contract administration. Put up signs and information displays. Establish monitoring plots.

July 15 to August 15:	Inspect all project sites to check for compliance with design parameters. Monitor revegetation sites. Monitor public use of completed project and proposed sites for next year.
August 15 to Sept. 30:	Continue monitoring. Contract administration.

B. Project Milestones and Endpoints

Oct. 1--Nov.1:	Complete construction on Endicott Drive, Kenai Beach Dunes, Airport Rotary Park, Russian River (Phase I) and Caymas (Phase I) Inspect the above-listed five projects to check for compliance with design and construction parameters Close-out completed cooperative agreements
Nov. 1--Feb. 1:	Evaluate and rank second round and EVOS projects
Feb1--May 15:	Publish supplemental EA Consummate cooperative agreements with public landowners for second round and EVOS projects
May 15 to July 15:	Complete Phase II of Russian River and Caymas Begin construction of second round and EVOS projects
July 15 to Sept. 30:	Complete summer monitoring and project compliance inspections

NORMAL AGENCY MANAGEMENT

The impacts affecting the Kenai River are occurring at a rate and magnitude far in excess of the management resources that are available to mitigate or restore habitat damage. The proposed project supplements existing efforts to reverse this trend. Moreover, none of the riparian habitat on small parcels that the Trustee Council is acquiring on the Kenai River has been surveyed or evaluated for restoration work. Additional issues relevant to state agency management of the Kenai River are to be found in the following section.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Coordination will occur with agency staffs in DNR, ADF&G and the Kenai National Wildlife Refuge. Their expertise will be used in defining management objectives, developing criteria, evaluating and ranking potential project sites, conducting archaeological and historical reviews and clearances, performing design to include preparing plans and specifications, bidding construction projects, oversight of project construction, permitting, monitoring public use, and enforcing site restrictions.

The project will build upon pilot efforts that have been implemented or are being developed for the river. In 1994, boardwalks were installed near the Soldotna airport and on numerous private parcels; exclosures have been used with a high degree of success along portions of the Russian River and in units of the state park system. State permitting procedures have also resulted in numerous bank stabilization projects that maintain or enhance fish habitat by using spruce tree revetments, root wads, live willow cuttings, and other protective measures.

The state and federal governments have already committed funds to accomplish several of the objectives identified by this project. Fish and Game *Exxon Valdez* criminal settlement funds ($3 million) have been dedicated for the construction of habitat protection demonstration projects and land acquisition on the Kenai River. The U.S. Fish and Wildlife Service has provided challenge grant funding to assist the ADF&G demonstration projects. The National Marine Fisheries Service will provide the ADF&G with an additional one million dollars for streambank improvements under an appropriation requested by Senator Stevens. ADNR restitution funds ($7 million) will be used, in part, to construct boardwalks and access platforms that protect streambanks at heavily used state park units at Morgan's Landing, Bing's Landing, and Slikok Creek. Dingle-Johnson funds are being used to provide recreational access, streambank revegetation, and streambank protection structures at The Pillars project site.

The intense public use pressures and development activities on the Kenai River threaten to overwhelm the limited budgets available to resource agencies attempting to manage the river for resource protection and sustained recreational use. That is why supplementary funding is so important. The proposed project, along with those utilizing other available funds, provides a cost-effective method to protect streambanks and minimize further habitat degradation.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

The project design and schedule described in the DPD approved by the Trustee Council for FY96 are unchanged.

REFERENCES

Alaska Dept. of Fish and Game and Alaska Dept. of Natural Resources. 1986. Field Guide for Streambank Revegetation . Anchorage, AK: Alaska Dept. of Fish and Game.

Forest Ecosystem Management Team. 1993. Forest Ecosystem Management: An Ecological, Economic, and Social Assessment.. Portland, OR: U.S. Forest Service. FEMAT Report.

Kondolf, G.M. 1995. Five elements for effective evaluation of stream restoration. Restoration Ecology 3:133-136.

Liepitz, Gary S. 1994. An Assessment of the Cumulative Impacts of Development and Human Uses on Fish Habitat in the Kenai River. Anchorage, AK: Alaska Department of Fish and Game, Habitat and Restoration Division. Technical Report No. 94-6.

Schiechtl, Hugo. 1980. Bioengineering for Land Reclamation and Conservation. 404 pgs. Edmonton, Alberta: Univ. Alberta Press.

Sherman, Jensen E. and William, S, Platts. 1990. Restoration of Degraded Riverine/Riparian Habitat in the Great Basin and Snake River Regions. Wetland Creation and Restoration, p. 367-404. Kusler, Jon, A. and Mary E. Kentula ed. Washington, D.C.: Island Press.

Sowl, John H. 1990. Restoration of Riparian Wetlands Along a Channelized River: Oxbow Lakes and the Middle Missouri. Environmental Restoration, p. 294-305. Berger, John, J. ed. Washington, D.C.: Island Press.

PERSONNEL

Project Leader

Mark Kuwada - Habitat Biologist with the Alaska Department of Fish and Game for 15 years. Extensive experience in coordinating departmental policy and mitigating major project impacts; Project Manager for Federal OCS Oil and Gas Leasing Program; Susitna Hydroelectric Project; Bradley Lake Hydroelectric Project; Diamond Chuitna Coal Project; ADF&G Response Coordinator, *Exxon Valdez* oil spill. ADF&G Title 16 permitter for southcentral Alaska and the Kenai River.

Mark Kuwada, Project Leader
Division of Habitat and Restoration
AK Department of Fish & Game
333 Raspberry Road
Anchorage, AK 99518-1599
(907) 267-2277
FAX (907) 349-1723

Project Leader

TBD - DNR will appoint a project leader with the following qualifications:
B.S. and graduate degree(s) in biology, zoology and/or fisheries.
Extensive experience in field biology, permitting, design and construction of restoration projects and in coordinating departmental policy with other state and federal resource agencies. The project leader will have a working knowledge of the natural resources and human uses of the Kenai River watershed.

Marty K. Rutherford, Project Manager
Deputy Commissioner
Alaska Department of Natural Resources
3601 C Street, Suite 1210
Anchorage, AK 99503
(907)-762-2483
FAX (907) 562-4871

KENAI RIVER HABITAT RESTORATION AND RECREATION ENHANCEMENT PROJECT

Proposed Project Locations

0 2.0 4.0 miles

Federal Lands
State Lands
Borough Lands
Private Lands
Proposed Project Locations

Russian River Area Insert Map

K16 Sportsmans Lodge
K01 Russian River Anglers Trail
Sterling Highway
Kenai River
Russian River

Kenai National Wildlife Refuge

Kenai
Kenai Spur Road
Loop
Beaver
K04 Kenai Beach Dunes
K05 Cunningham Park
K14 Ciechanski
K13 Big Eddy
K02 Rebel Run
K03 Endicott Sonar Site
Soldotna
K10 Swiftwater Park
K08 Centennial Park
K09 Soldotna Visitor Center
K06 Soldotna Airport Rotary Park
K07 Soldotna Airport Outfall
Funny River Road
Cook Inlet

Sterling
Highway
Sterling
Moose River
Whisper Lake
Daubenspeck Lake
K15 Caymas
Kenai River
K11 Funny River
Funny River
Browns Lake
K12 Tornado Creek
Skilak Lake Road
Bottenintnin Lake
Skilak Lake

Kenai National Wildlife Refuge

Produced by:
Alaska Department of Natural Resources
Land Records Information Section
Date Printed: March 29, 1998

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997	PROPOSED FFY 1997 TRUSTEE AGENCIES TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
				$276.8	$329.4	$8.7	$6.9	
Personnel	$0.0	$191.5						
Travel	$0.0	$10.4						
Contractual	$0.0	$352.5						
Commodities	$0.0	$14.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$568.4	Estimated FFY 1998	Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	
General Administration	$0.0	$53.4						
Project Total	$0.0	$621.8	$815.7	$0.0	$0.0	$0.0	$0.0	$0.0
Full-time Equivalents (FTE)	0	2.5						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0

Comments:
Projects detailed under contractual section are proposed and being reviewed as part of the draft environmental assessment for this project. Project costs at this point in time are estimates and not all include line item detail. Line item detail will be available prior to Trustee Council approval of budget. Projects will be funded at an amount not to exceed the amount proposed as the project was initially evaluated. Additional projects will be nominated during the period October 1, 1996 through February 1997 and it is likely that some of these projects may require startup costs for the 1997 field season.

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Lead Agency: AK Dept. of Natural Resources

FORM 2A
MULTI-TRUSTEE AGENCY SUMMARY

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997						
Personnel		$88.5						
Travel		$4.6						
Contractual		$200.5						
Commodities		$8.5						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$302.1	Estimated FFY 1998	Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	
General Administration		$27.3						
Project Total	$0.0	$329.4	$400.0					
Full-time Equivalents (FTE)		1.1						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:
Projects detailed under contractual section are proposed and being reviewed as part of the draft environmental assessment for this project. Project costs at this point in time are estimates and not all include line item detail. Line item detail will be available prior to Trustee Council approval of budget. Projects will be funded at an amount not to exceed the amount proposed as the project was initially evaluated. Additional projects will be nominated during the period October 1, 1996 through February 1997 and it is likely that some of these projects may require startup costs for the 1997 field season.

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Agency: AK Dept. of Natural Resources

FORM 3A
TRUSTEE
AGENCY
SUMMARY

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1997
	Natural Resource Manager	20	12.0	7.0		84.0
	IDT Member	16	1.0	4.5		4.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		13.0	11.5	0.0	
					Personnel Total	$88.5

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FFY 1997
					0.0
Travel to Kenai to attend meetings, conduct site evaluations, inspections, supervise and monitor construction and revegetation.	0.1	16	20	0.15	4.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$4.6

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Agency: AK Dept. of Natural Resources

FORM 3B
Personnel
& Travel
DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Contractual Costs:			Proposed
Description			FFY 1997
Cooperative Agreements with the following entities by project:			
Funny River	DNR Division of Parks	Line Item detail will be provided by project following approval of EA and	$35.0
Big Eddy	DNR Division of Parks	completion of cooperative agreements with entity doing project	$35.0
Ciechanski	DNR Division of Parks	implementation.	$40.0
Torpedo Creek	DNR Division of Parks		$30.0
Start up costs for second tier of projects; estimates based upon remining river miles and identified parcels to be addressed and representative 1996 project implementation costs.			$35.0
Signage			$15.0
Consulting services for site evaluation, assessment and monitoring as needed.			$10.0
Printing costs for EA Supplement			$0.5
When a non-trustee organization is used, the form 4A is required.		**Contractual Total**	$200.5

Commodities Costs:	Proposed
Description	FFY 1997
Field equipment as needed, for project oversign and monitoring of restoration benefit. Every effort will be made to utilize existing supplies currently on hand with Division of Parks and other agencies working in the Kenai area.	3.0
Plant materials	5.0
Office supplies (including paper, toner cartridges, data cartridges, mailing labels, write in rain paper, etc.)	0.5
Commodities Total	$8.5

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Agency: AK Dept. of Natural Resources

FORM 3B
Contractual & Commodities DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1997
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Agency: AK Dept. of Natural Resources

FORM 3B
Equipment
DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997						
Personnel		$90.5						
Travel		$4.6						
Contractual		$152.0						
Commodities		$5.5						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$252.6	Estimated FFY 1998	Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	
General Administration		$24.2						
Project Total	$0.0	$276.8	$400.0					
Full-time Equivalents (FTE)		1.2						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Agency: AK Dept. of Fish & Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1997
						0.0
	Habitat Biologist III	18	12.0	6.5		78.0
	IDT Member	18	1.0	6.5		6.5
	Graphic Designer	16	1.0	6.0		6.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		14.0	19.0	0.0	
					Personnel Total	$90.5

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FFY 1997
					0.0
Travel to Kenai to attend meetings, conduct site evaluations, inspections, supervise and monitor construction and revegetation.	0.1	16	20	0.15	4.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$4.6

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Agency: AK Dept. of Fish & Game

FORM 3B
Personnel
& Travel
DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Contractual Costs:			Proposed
Description			FFY 1997
Storage and refrigeration unit for propagation of plant materials.			5.0
Graphic Designer for design of educational signage.			6.0
Signage			15.0
Cooperative Agreements with the following entities by project:			
Caymas	Kenai Peninsula Borough	Line Item detail will be provided by project following approval of EA and	31.5
Rebel Run	Kenai Peninsula Borough	completion of cooperative agreements with entity doing project	14.0
Russian River	USFS Seward Ranger District	implementation.	80.5
When a non-trustee organization is used, the form 4A is required.		**Contractual Total**	$152.0

Commodities Costs:	Proposed
Description	FFY 1997
Field equipment as neededfor project oversight and monitoring. Every effort will be made to utilize existing supplies currently on hand with Division of Habitat and Restoration and other agencies working in the Kenai area.	5.0
Office supplies (including paper, toner cartridges, data cartridges, mailing labels, write in rain paper, etc.)	0.5
Commodities Total	$5.5

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Agency: AK Dept. of Fish & Game

FORM 3B
Contractual & Commodities DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1997
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Agency: AK Dept. of Fish & Game

FORM 3B
Equipment
DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$7.0						
Travel		$0.6						
Contractual		$0.0						
Commodities		$0.0						
Equipment		$0.0						
Subtotal	$0.0	$7.6	Estimated FFY 1998	Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	
General Administration		$1.1						
Project Total	$0.0	$8.7	$8.7					
Full-time Equivalents (FTE)		0.1						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Agency: United States Forest Service

FORM 3A
TRUSTEE
AGENCY
SUMMARY

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1997
						0.0
	IDT Member	14	1.0	7.0		7.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.0	7.0	0.0	
					Personnel Total	$7.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FFY 1997
					0.0
Travel to attend Interdisciplinary Team Meetings (4 one day meetings alternating in Anchorage and Kenai)	0.1	2	2	0.2	0.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.6

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Agency: United States Forest Service

FORM 3B
Personnel
& Travel
DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Contractual Costs:	Proposed
Description	FFY 1997
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed
Description	FFY 1997
Commodities Total	$0.0

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Agency: United States Forest Service

FORM 3B
Contractual & Commodities DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1997
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Agency: United States Forest Service

FORM 3B
Equipment
DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997	LONG RANGE FUNDING REQUIREMENTS					
			Estimated FFY 1998	Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	
Personnel		$5.5						
Travel		$0.6						
Contractual		$0.0						
Commodities		$0.0						
Equipment		$0.0						
Subtotal	$0.0	$6.1						
General Administration		$0.8						
Project Total	$0.0	$6.9	$7.0					
Full-time Equivalents (FTE)		0.1						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Agency: DOI, US Fish & Wildlife Service

FORM 3A
TRUSTEE
AGENCY
SUMMARY

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1997
						0.0
	IDT Member	11	1.0	5.5		5.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.0	5.5	0.0	
					Personnel Total	$5.5

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FFY 1997
					0.0
Travel to attend Interdisciplinary Team Meetings (4 one day meetings alternating in Anchorage and Kenai)	0.1	2	2	0.2	0.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.6

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Agency: DOI, US Fish & Wildlife Service

FORM 3B
Personnel
& Travel
DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Contractual Costs:	Proposed
Description	FFY 1997
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed
Description	FFY 1997
Commodities Total	$0.0

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Agency: DOI, US Fish & Wildlife Service

FORM 3B
Contractual & Commodities DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1997
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

1997

Prepared:

Project Number: 97180
Project Title: Kenai Habitat Restoration and Recreation Enhancement
Agency: DOI, US Fish & Wildlife Service

FORM 3B
Equipment
DETAIL

Prince William Sound Intertidal Recovery Monitoring Submitted Under the BAA

Project Number:	97181
Restoration Category:	Monitoring
Proposer:	Pentec Environmental, Inc.
Lead Trustee Agency:	
Cooperating Agencies:	
Alaska SeaLife Center:	
Duration:	1st year, 4-year project
Cost FY 97:	$281,000
Cost FY 98:	$292,000
Cost FY 99:	$303,300
Cost FY 00:	$314,900
Cost FY 01:	
Cost FY 02:	
Geographic Area:	Prince William Sound
Injured Resource/Service:	Intertidal epibiota and infauna, mussels, hardshelled clams

ABSTRACT

By the end of FY 1996 eight years of data on the recovery of intertidal assemblages will have been gathered at various beaches in Prince William Sound under an ongoing NOAA program. This program provides significant insight into the bio-physical factors affecting recovery and has documented considerable instability in community structure on hot-water washed beaches. The proposed monitoring project will extend the sampling protocol of the NOAA program to intertidal areas sampled under the 1990-1991 Coastal Habitat Restoration (R102) program. This approach will establish the state of recovery over a broader area of Prince William Sound and increase our ability to generalize about factors affecting recovery rates and processes.

INTRODUCTION

The proposed FY 1997 monitoring program builds upon the data and results obtained from the Prince William Sound intertidal monitoring network established and sampled over the last eight years (Figure 1) for Exxon and the National Oceanic and Atmospheric Administration (NOAA). The proposed geographic expansion of the program with restoration funding through the Trustee Council (Council) will extend documentation of the recovery of epibiota and infauna in important intertidal habitats in Prince William Sound. The expanded study will compare the status of stations that have not been sampled since 1990-1991 (as part of the Coastal Habitat Restoration Program - R102) with stations from the NOAA program that have a known history of recovery. The study will compare conditions on unoiled reference shorelines (Category 1) with shorelines that were subject to two levels of disturbance: oiled but not high-pressure hot-water washed (Category 2), and oiled and cleaned with high-pressure hot-water washes (Category 3).

In 1989, sampling was conducted under contract to Exxon. From 1990 through 1996, this program has continued under contract with NOAA with contributions from the Environmental Protection Agency (EPA), Coast Guard, Minerals Management Service (MMS), the American Petroleum Institute, the Marine Spill Response Corporation, and most recently, the Restitution Fund.

The NOAA program was designed and field tested to quantify present and potential future impacts of the *Exxon Valdez* oil spill on important components of Prince William Sound's nearshore ecosystem, long-term recovery processes, and recovery following post-spill cleanup treatments.

Results of studies conducted from 1989 through 1995 on epibiotic communities at the NOAA stations suggest continuing oscillations in disturbed populations and in the balance of predator-prey relationships. In the case of infauna, continuing differences between hot-water washed stations and reference locations are suggestive of real differences in the habitat conditions at stations within the respective treatment categories.

Analysis of three data sets from shoreline treatment effects studies conducted in 1989 showed that major components of the intertidal flora and fauna inhabiting Prince William Sound survived at least 3 to 4 months on heavily oiled beaches (Lees et al. 1993). Except for a few taxa, these organisms were generally present in abundances comparable to those at unoiled beaches in Prince William Sound. Based on these 1989 studies, the short-term effects of the use of high-pressure hot-water on intertidal flora and fauna of Prince William Sound were significant; all dominant taxa except one (barnacles) suffered from 60 to 100 percent mortality from treatments of less than 3 hours duration. This background led to the decision to isolate the effects of exposure to oil and hot-water washing as separate kinds of stress in the study design.

The 1990 NOAA biological studies in Prince William Sound (Houghton et al. 1991a, b) report conditions on rocky, boulder/cobble, and mixed-soft beaches and in adjacent eelgrass beds in

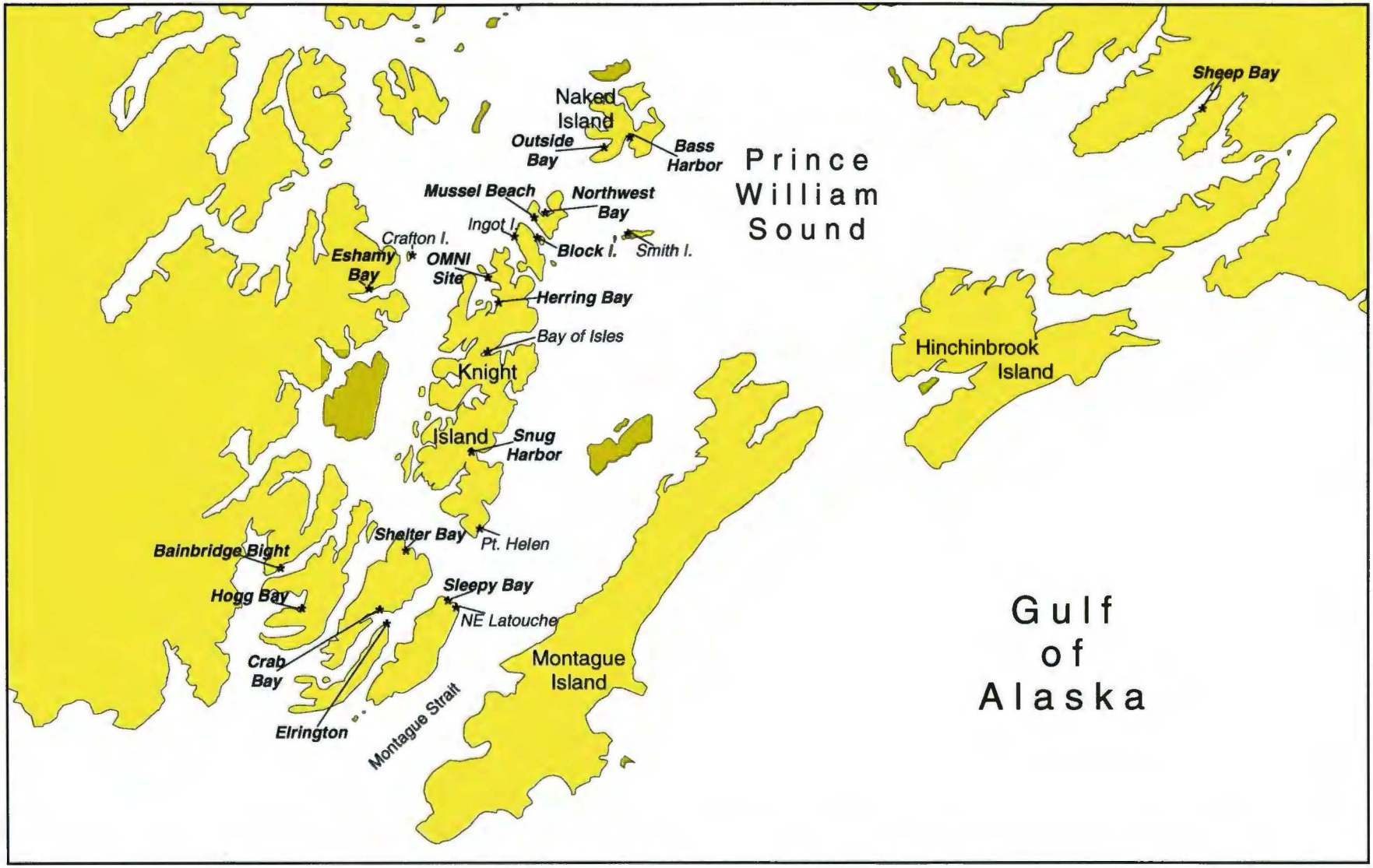


Figure 1 Prince William Sound study area and sampling locations (asterisks). 1994 biological sampling locations are shown in bold.

portions of Prince William Sound that were oiled, or oiled and high-pressure hot-water washed in 1989. Biological conditions on these beaches were compared to those on unoiled beaches of similar habitats. The conclusions were as follows:

1. The effects of high-pressure hot-water washing remained evident in the biological assemblages 16 to 18 months after the spill.

2. Oiled beaches not treated in this manner were well on their way to recovery.

Results of the 1991 and 1992 NOAA biological studies in Prince William Sound (Houghton et al. 1993a, b) showed the following:

1. Infaunal and epibiotal assemblages that were not high-pressure hot-water washed, in most respects, resembled communities on beaches that were not oiled.

2. Effects of high-pressure hot-water washing were still evident in some intertidal assemblages 40 months after the spill.

Additional conclusions in 1991 were that oiling and subsequent treatment may have altered the spawning cycle of mussels and the reproductive strategy of eelgrass. Continued bioavailability of hydrocarbons was shown in the bioaccumulation of polycyclic aromatic hydrocarbons (PAHs) in transplanted molluscs. PAH levels in mussels had declined by an order of magnitude in 1991 from those seen in 1990, however, and generally continued to decline in 1992.

By 1993, most epibiota had recovered at all oiled sites; abundances in some cases were higher on oiled sites than on unoiled sites (Houghton et al. 1995a; Figures 2 through 5). This was attributed to continued instability in populations of biological controls (grazers and predators). The infauna at hot-water washed lower intertidal stations continued to display lower density, richness, and diversity than those at reference stations and at oiled but unwashed stations (Figure 6). This continued difference raised a concern that the hot-water washed stations sampled have become fundamentally different from the other station categories as a consequence of loss of fine sediments and may not support similar infaunal communities until the sediment quality is re-established.

In 1994 there was a reduction in cover of rockweed at all three elevations sampled on oiled rocky habitats; in contrast, cover at unoiled reference sites increased somewhat (Figure 2). The reduction at oiled sites appeared to be the result of the natural culmination of the life cycle of this species; post-spill and post-treatment colonization by germlings in late 1989 and early 1990 developed to reproductive maturity in 1992 over broad areas of central Prince William Sound.

Depressed numbers of littorines and limpets allowed this development to proceed with minimal grazing pressure. By 1993 this cohort of rockweed was showing signs of senescence, and numbers of grazers had increased to the point where the decline in rockweed seen in 1994 and 1995 was inevitable.

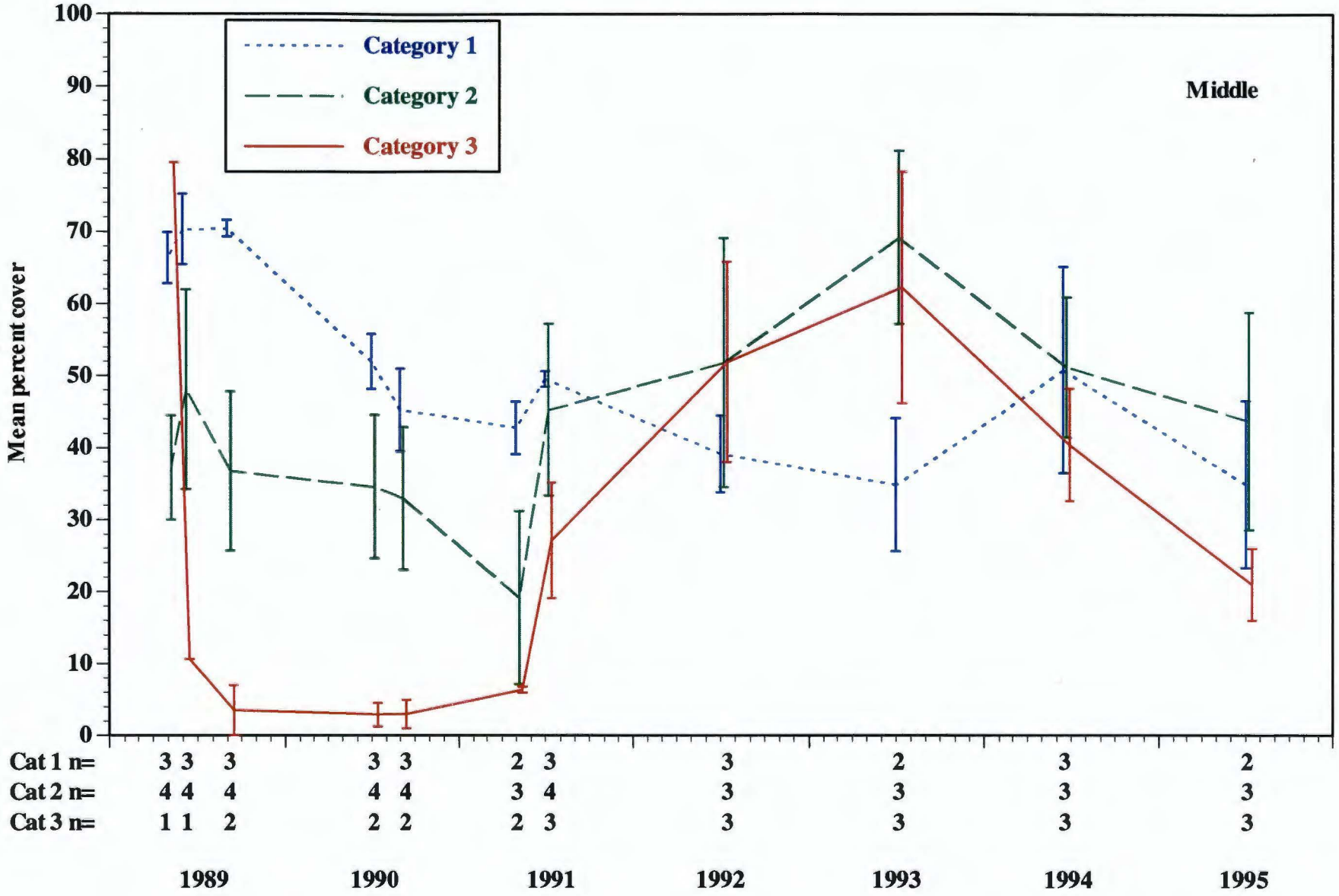


Figure 2 Mean percent cover (±1 SE) of *Fucus* from middle rocky stations, by category 1989-1995.

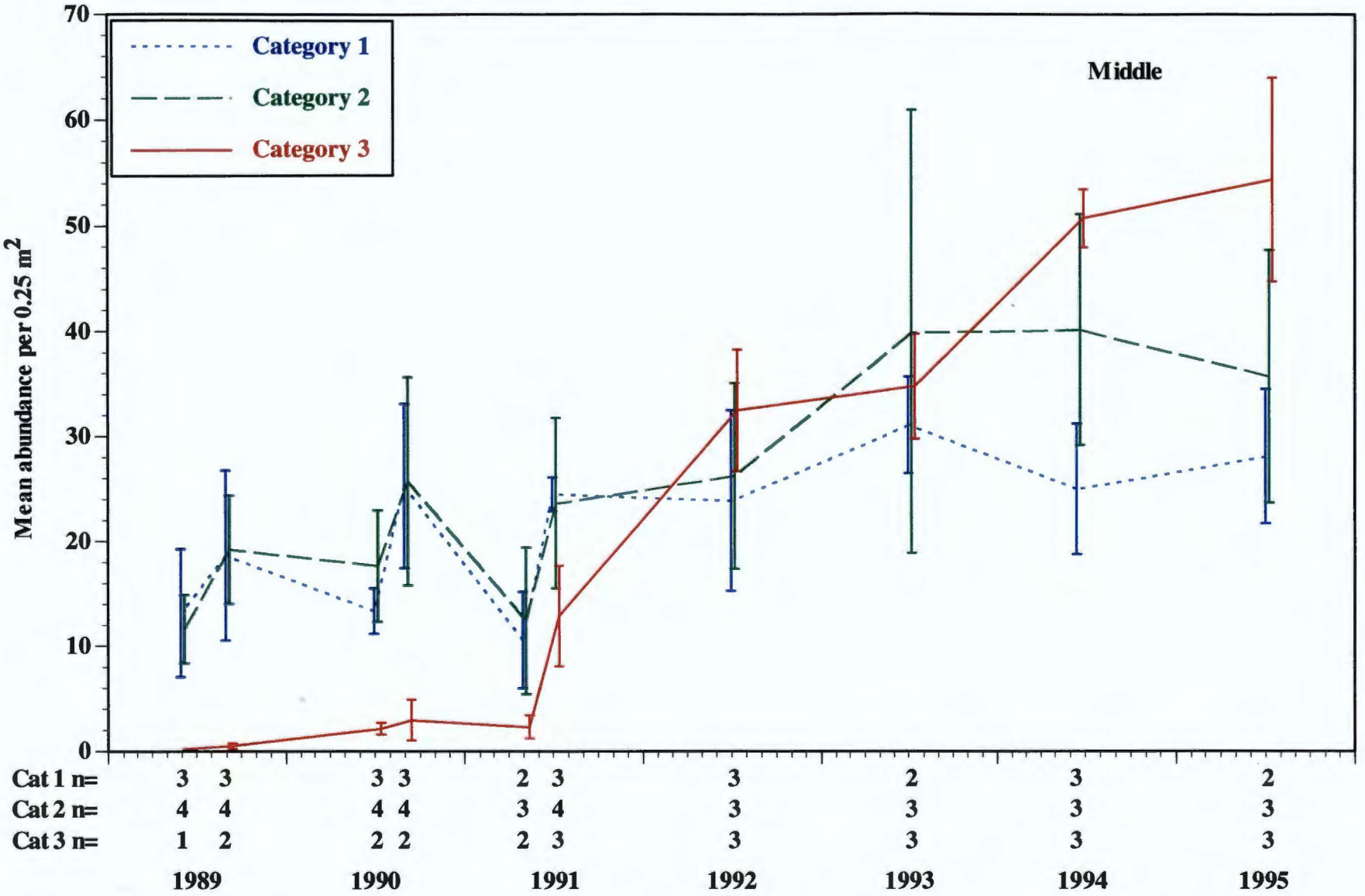


Figure 3 Mean abundance (±1 SE) of Lottidai from middle rocky stations, by category 1989-1995.

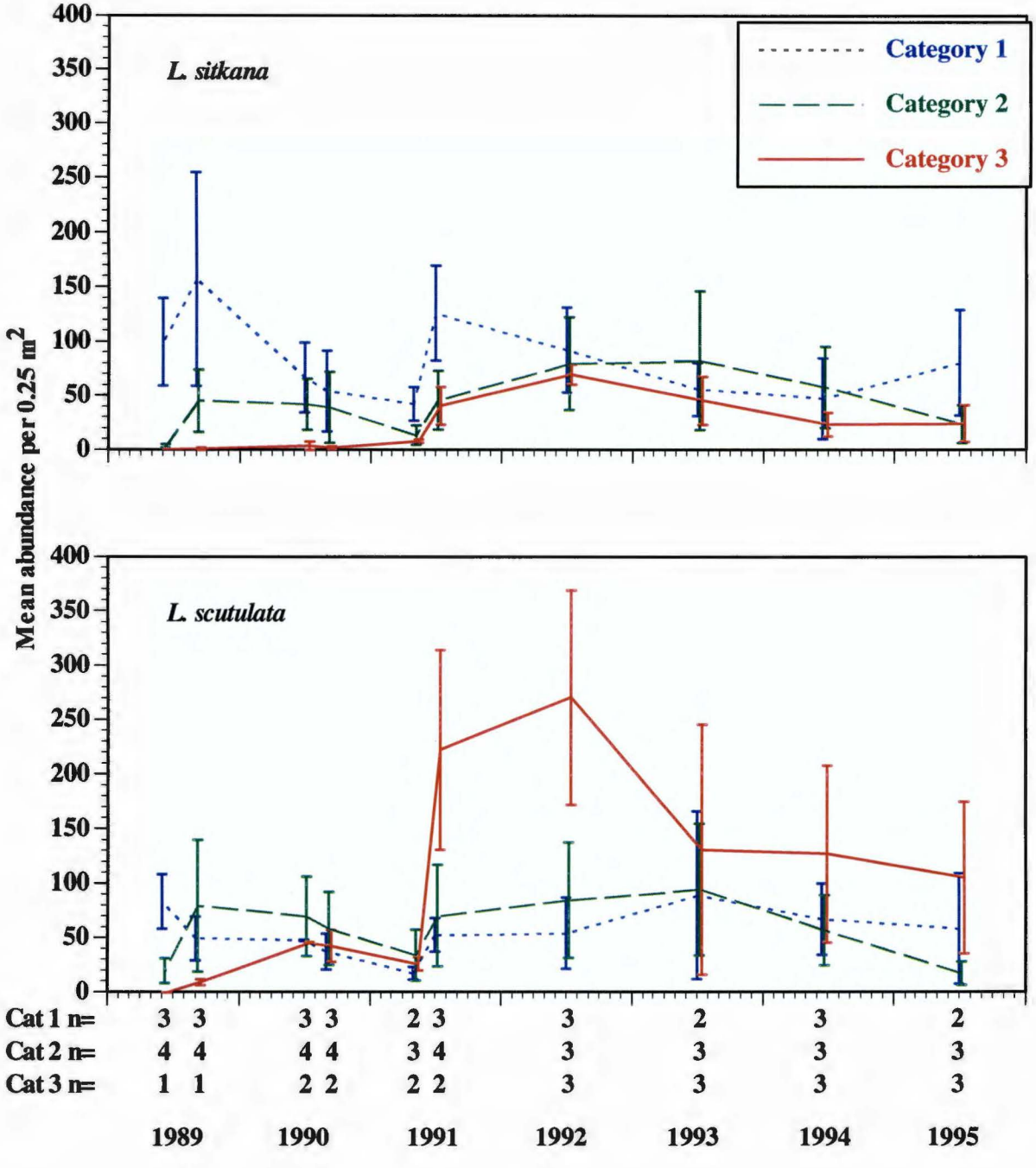


Figure 4 Mean abundance (±1 SE) of littorine snails from middle rocky stations, by category 1989-1995.

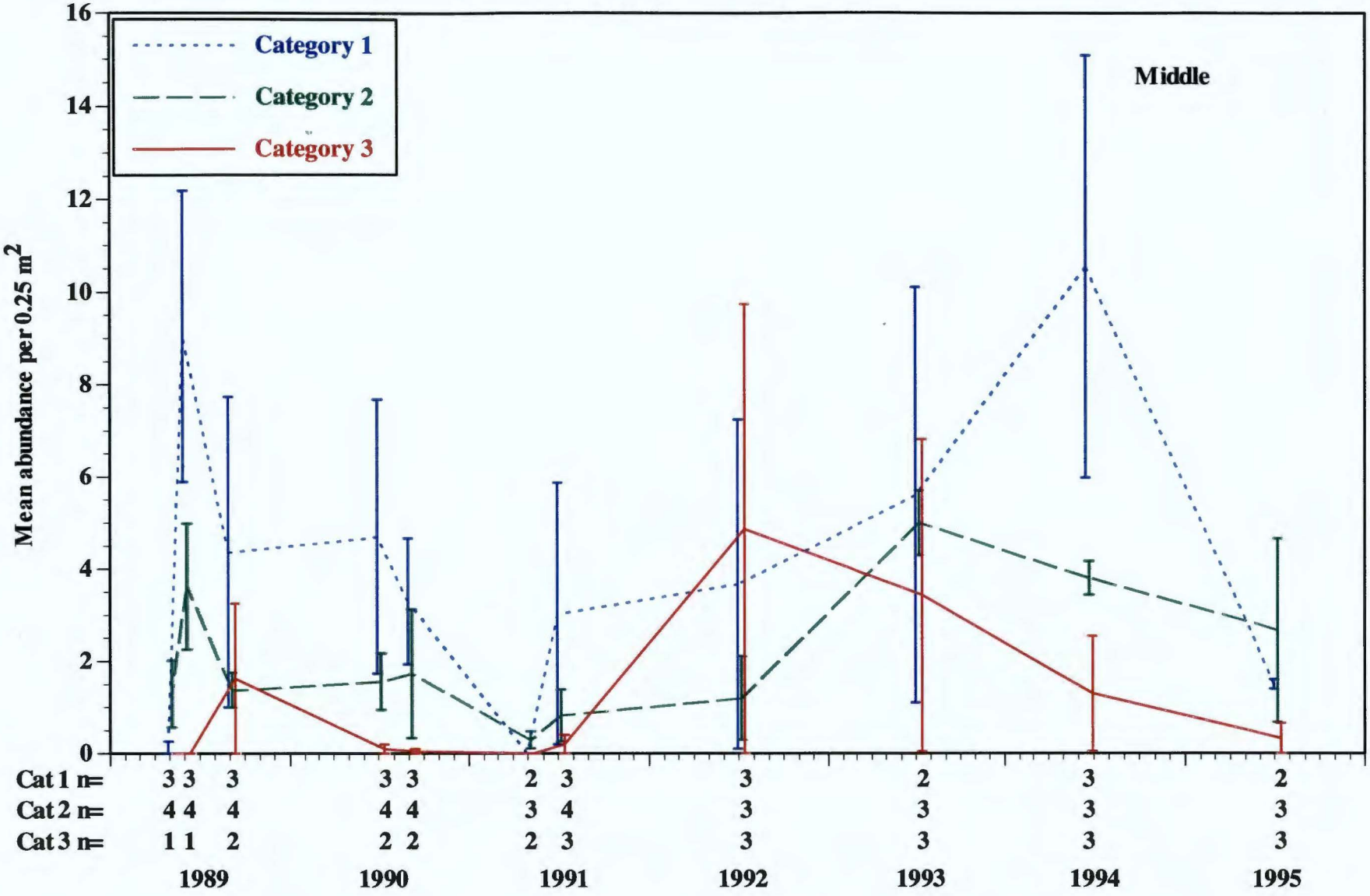


Figure 5 Mean abundance (±1SE) of *Nucella* from middle rocky stations, by category 1989-1995.

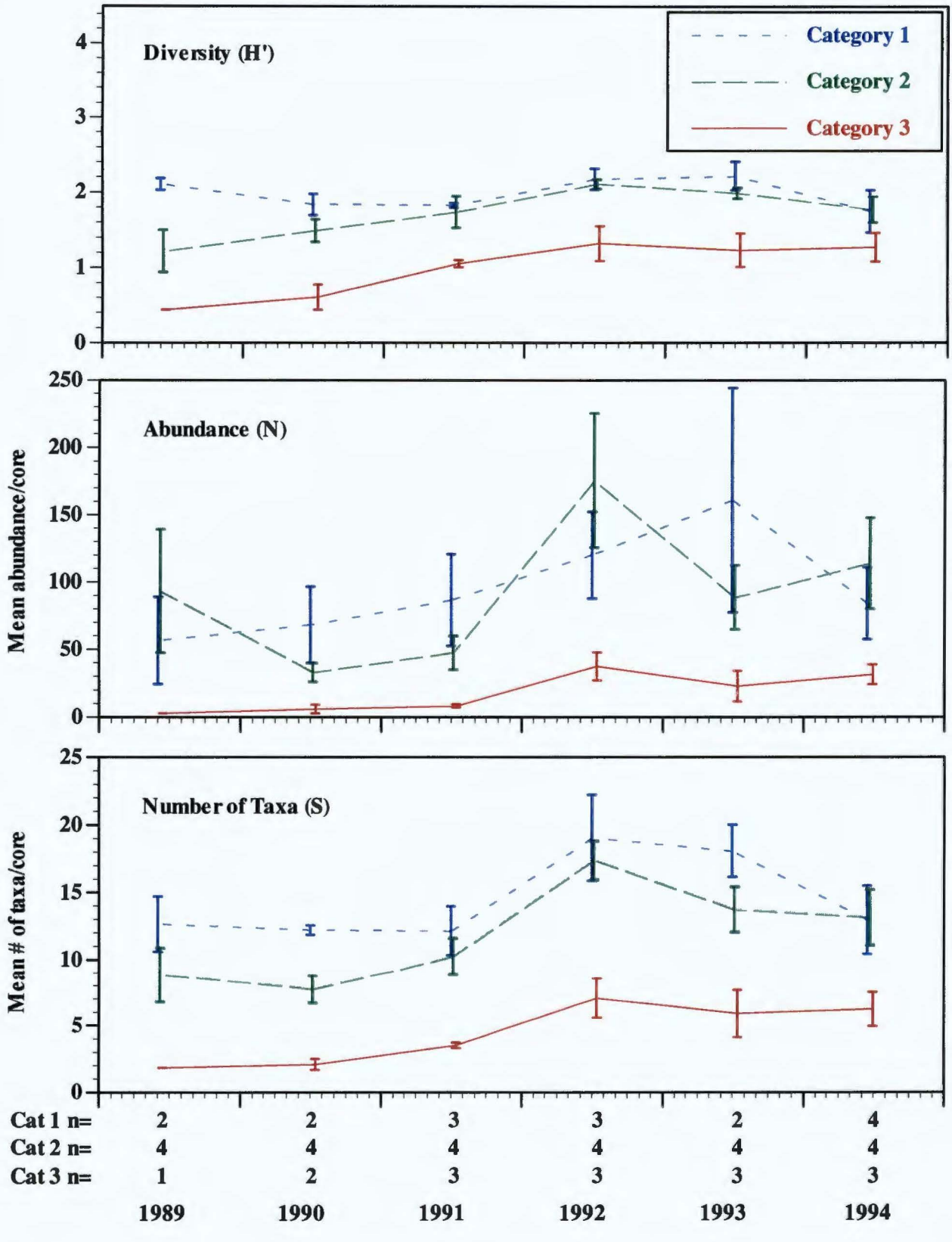


Figure 6 Selected attributes (±1 SE) of the macro-infaunal community from lower mixed-soft sites, 1989-1994. Number of stations sampled (n) for each category shown below axis.

In 1994 littorine densities at oiled (Category 2 and 3) upper and middle rocky stations converged with those at unoiled middle stations, a sign of increasing stability (Houghton et al. 1995b; Figure 4). Limpet densities increased at oiled middle stations in 1994 and 1995 (Figure 3), probably in response to the abundance of weakened rockweed plants. Future trends in populations of these grazers will depend on the extent and pattern of the die-back and recolonization of rockweed that occurs in the next few years.

Multiple null hypotheses relating to effects of hydrocarbon contamination from the Tanker/Vessel *Exxon Valdez* and to effects of subsequent shoreline treatments have been tested over the seven-year study period (1989 to 1995). Many of these null hypotheses have been rejected; these rejections indicate that significant differences existed in the condition of shorelines among three categories of sites. For the majority of the variables tested, especially in later years of the study, conditions did not differ significantly among Category 1 (unoiled) and Category 2 (oiled but not high-pressure hot-water washed) sites. At Category 3 sites (those that were high-pressure hot-water washed), some variables differed significantly from levels at other site categories, especially early in the study, and resources were not fully recovered by 1995. In other cases, patterns apparent in the field or in the data were not statistically significant, but the data have been useful in providing information on the direction of qualitative relationships among the treatment categories.

Continuation of the NOAA funded sampling program for FY96 will include the revisitation and continued monitoring of sites sampled during the previous seven years of the program. Surveys of the epibiota in the rocky intertidal zone will be conducted at selected Category 1, 2 and 3 sites. Intertidal infauna will be collected and analyzed from selected sites having mixed-soft sediments. The native littleneck and butter clam populations will be sampled and age structures of the resident populations compared between sites.

The proposed monitoring program for FY97 through FY00 would add a total of 12 new stations to the NOAA program sample design. These 12 stations would be selected from those sampled under the 1990-1991 Coastal Habitat Restoration Program (R102). The proposed monitoring program is for a duration of four years, starting in 1997, in order to be in sync with NOAA's monitoring program and would use the established NOAA sampling protocol.

NEED FOR THE PROJECT

A. Statement of Problem

One of the most dramatic results of the *Exxon Valdez* oil spill was the effect of oiling and shoreline treatments on intertidal assemblages and habitats. Despite the considerable documentation of oil spill effects on intertidal areas worldwide, the Council has not had a long-term program to monitor this important component of the nearshore ecosystem. As a result, little definitive information is shown in the summary table of the status of intertidal resources and services injured by the spill (Table 1 in the Invitation). Data on the population status of a wide variety of intertidal species are needed to supplement the work of the Nearshore Vertebrate Predator Project (\025; Page 33 in the Invitation). Data on the status of littleneck and butter clam

populations and factors influencing their recovery are also critical to planning restoration of these populations in the Chugach Region (\131).

As defined by Ganning et al. (1984) and endorsed by earlier studies (Houghton et al. 1993a), recovery will be considered to be complete when variability of measured population and assemblage parameters at oiled sites is consistently within the range of natural fluctuations at unoiled sites.

A brief summary of the status of each resource and the rate of recovery (as known at this time) follows:

Intertidal Epibiota

Despite the apparent bloom (1991-1993) and decline (1994-1995) of rockweed at oiled stations, the trend toward normal (e.g., Category 1) abundance levels for grazers and predators at middle elevation rocky stations suggest that biological controls will become increasingly influential. Because of the wide natural fluctuations in the drill/mussel-barnacle association, it may well be that these components of the intertidal assemblage can be considered to be recovered at middle rocky stations. At least through 1995, the fluctuations in the grazer/rockweed association appear to be greater at the oiled middle stations than at reference stations; thus, this component of the intertidal assemblage does not appear to have recovered. We expect a gradual damping of oscillations in abundances of dominant species at affected sites over the coming years.

Infaunal Assemblages

Protected sand and gravel beaches were severely affected by hydraulic treatments, which greatly altered beach morphology and grain size characteristics. Sands and finer gravels were flushed from upper intertidal elevations and often buried the lower beach under several centimeters of sediment that had a relatively low content of fines and organic carbon. Unusual movement of beach sediments was evident at least through 1992 as beach sediments were resorted by wave action to reestablish a stable beach profile. In 1994, significant differences remained in sediment grain size composition between Category 1 beaches compared with Category 3 beaches; the percentage of finer materials remained lower at Category 3 beaches. Category 3 beaches were also lowest in nitrogen and organic content, an important energy resource for infauna, but these differences were not significant.

In 1994 as in previous years, infauna appeared only moderately affected by the spill on Category 2 beaches with no significant differences between Category 1 and Category 2 stations (funding levels have not yet allowed analysis of 1995 infaunal samples; Figure 6). The trend of increasing diversity, abundance, and richness within the infauna assemblage at Category 3 lower stations that had been seen from 1990 through 1992 slowed substantially in 1993 and 1994. It remains uncertain if this leveling off of recovery signifies a constraint on recovery potential dictated by physical and chemical alterations resulting from treatment, or if it reflects inherent differences in the beaches represented in Category 3. Although some Category 3 beaches are somewhat more exposed on average than are Category 1 or 2 beaches, some data suggest that these differences

are, at least in part, true impacts of treatment that will simply require an extended period for recovery.

Hardshelled Clams

Within the first few weeks of the spill, toxic effects of oiling on littleneck clam (*Protothaca staminea*) populations were evident where thick oil covered their lower beach habitat. At one oiled station where sampling was possible before and after hydraulic beach washing in the spring of 1989, clams surviving the spill were reduced 95.6 percent by dislocation and burial. After that initial period of toxicity, the primary impacts to surviving clams appear to have been from the hydraulic washing.

Oiled beaches that were hydraulically washed in 1989 consistently showed lower clam recruitment through 1994 compared to that on unoiled beaches and on beaches that were oiled but not washed (Figure 7). It is hypothesized that clam (and other infaunal) recruitment was inhibited by the low level of finer sediments and low organic content remaining after washing.

Estimated clam densities in large quadrats have been variable but relatively high at oiled but unwashed beaches through 1994 (Figure 8). Thus, the flushing of beaches appears to have resulted in very high mortalities of clam populations surviving the oiling; direct evidence of this was observed in tests in 1989 (Lees et al. 1993) Flushing also degraded conditions necessary for recruitment. Given the generally slow growth and substantial longevity of pre-spill littleneck clam populations in unaffected areas of Prince William Sound (mean age of 5 to 6 years), it is expected that several more years will be required for full recovery of hardshelled clam populations on washed beaches.

B. Rationale/Link to Restoration

The NOAA *Exxon Valdez* Shoreline Monitoring Program has gathered and analyzed six years of data (1990 through 1995; 1996 studies are planned) on the recovery of intertidal organisms and assemblages at over two dozen selected sites in Prince William Sound (Figure 1). These sites represent several habitat types that were subjected to varying degrees of oiling and shoreline treatment and include unoiled reference areas. Information from these seven years of study are made even more valuable by the availability of 1989 data collected at most of the same sites by the study's principal investigators while under contract to Exxon. Major results of this program are reviewed above; detailed technical reports and scientific summary papers are available upon request.

The NOAA study has provided important descriptions of the patterns of intertidal recovery and an excellent understanding of many of the key factors influencing that recovery. Among the findings most relevant to the information needs of the Nearshore Ecosystem Projects are the following:

1. Recovery of intertidal assemblages on oiled shorelines was significantly delayed by hot-water washing and is generally not complete in those areas that were washed.

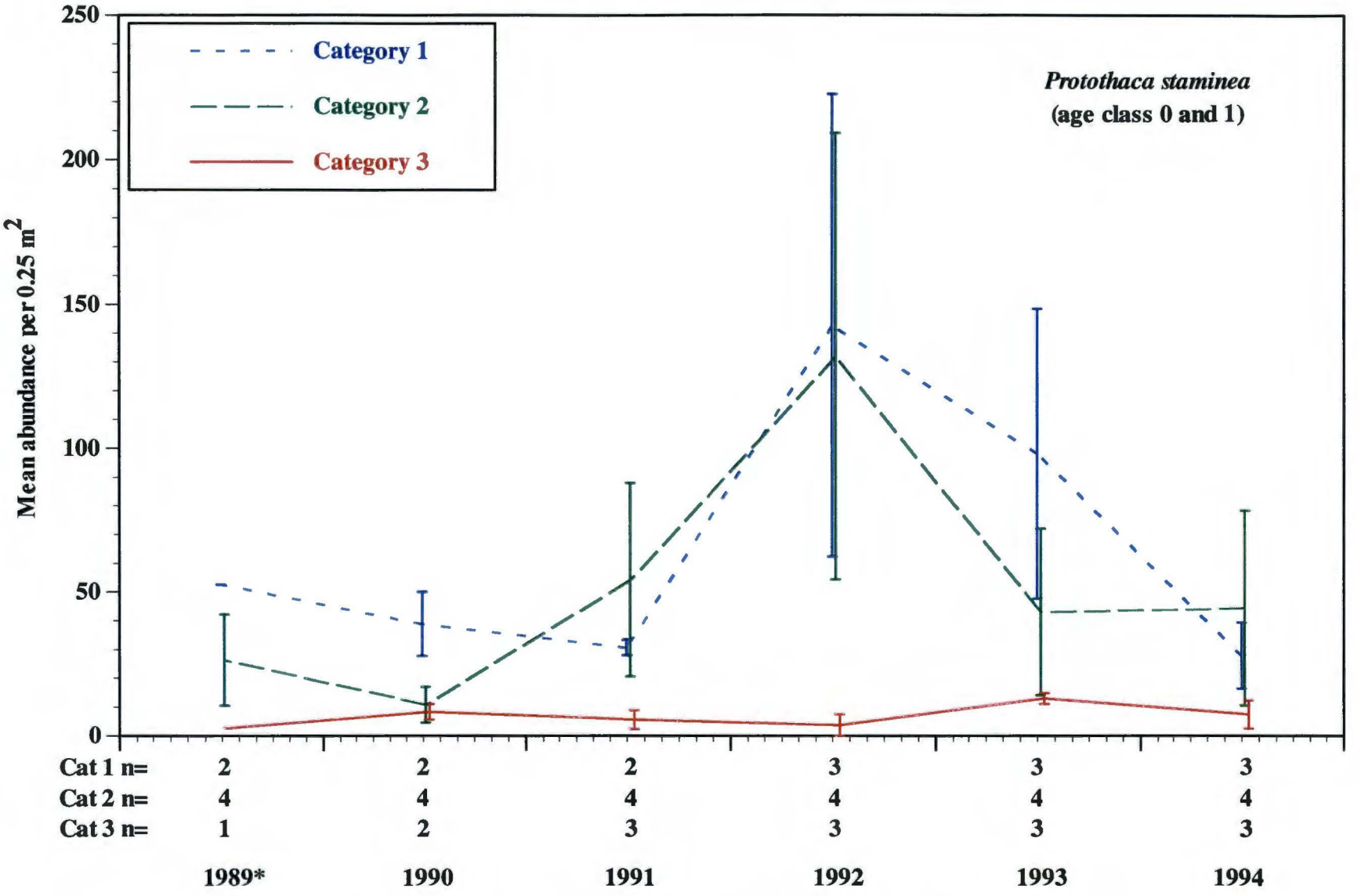


Figure 7 Mean abundance (±1 SE) of littleneck clams, age class 0 and 1, from lower mixed-soft sites, by category 1989-1994.
* 1989 densities are for clams of all ages recovered in cores.

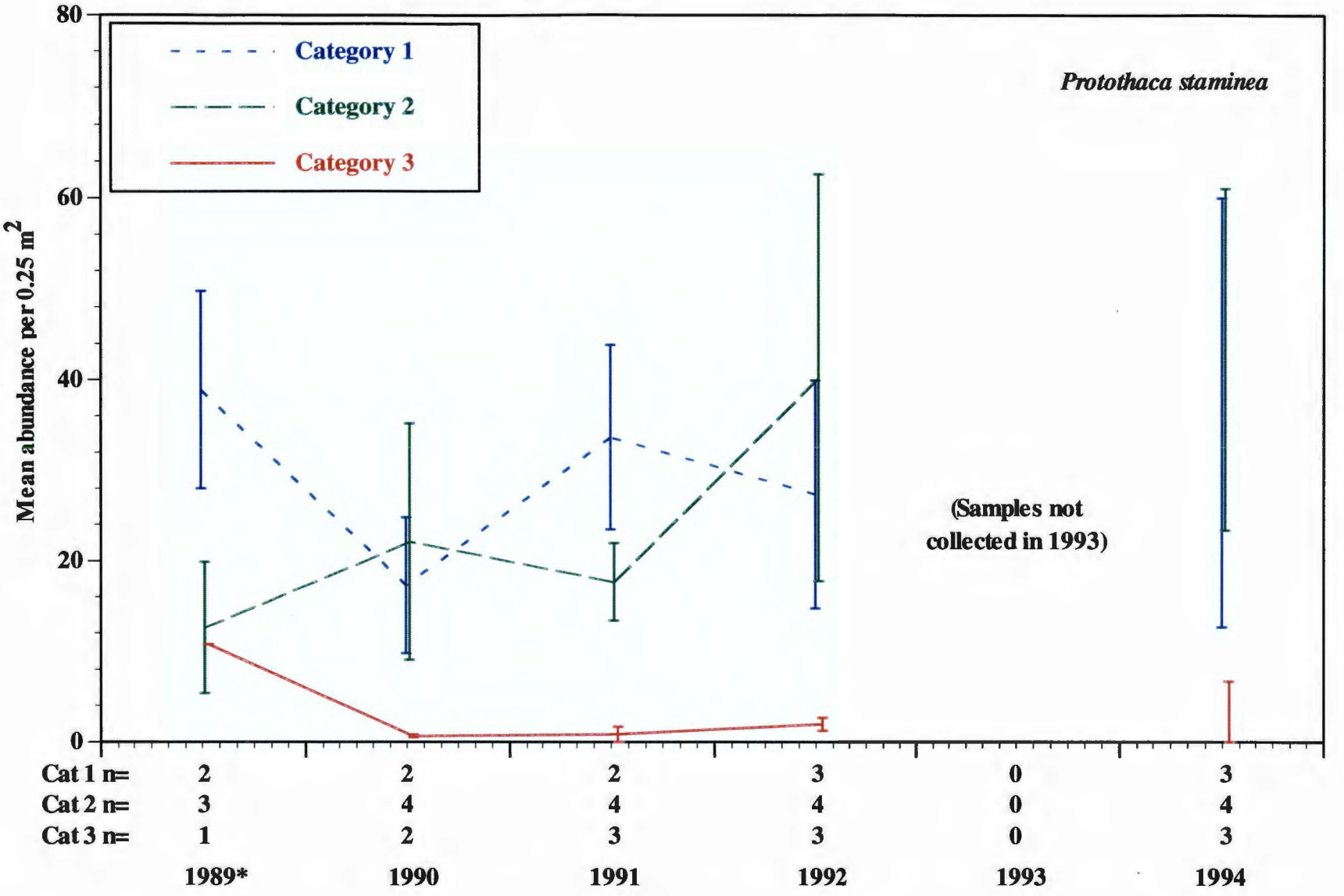


Figure 8 Mean abundance (±1 SE) of littleneck clams (≥5 mm), from lower mixed-soft sites, by category 1989-1994. * 1989 densities are for clams of all ages recovered in 0.25 m^2 excavations.

2. The appearance that recovery of dominant biota on rocky shores was well underway in 1991 and 1992 (e.g., Houghton et al. 1993) was misleading in light of indications from 1994 and 1995 that these populations are only at the beginning of what may be a lengthy period of oscillations in abundance. These oscillations were set up by hot-water wash treatments that removed the vast majority of the intertidal biota and reset the clock of ecological succession to zero over large areas of shoreline (100s of meters in length or more). (See time trend for rockweed over time at treated rocky sites; Figure 2.) As a result, the population structure of rockweed, a dominant species upon which many other taxa depend, consists largely of a single cohort same-age individuals over broad areas. The coincident senescence of this cohort led to the precipitous decline in rockweed cover at hot-water washed sites in 1995 (Figure 2). Ramifications of this decline on other species abundances may be even more evident in 1996 data (not yet available). It may take many years for the "patch size" of rockweed to break up into more normal dimensions such that in any square meter of shoreline four or five cohorts are present, as is the normal case on undisturbed rocky intertidal shorelines in Prince William Sound.

3. Populations of red algae are much slower to recover from hot-water washing than are green or brown algae; the intense set of the 1989 cohort of rockweed may have inhibited recovery of the understory red algae; this in turn reduces the habitat complexity and food availability for a variety of animals.

4. Intertidal molluscs that are prey to vertebrate predators on rocky shores have experienced a variety of patterns of recovery depending on their food base, reproductive and dispersal mechanisms, and predator abundance.

5. Hydraulic effects of washing mixed pebble/granule beaches were likely more significant on infauna (Figure 6), including important bivalves (Figures 7 and 8), than were thermal effects; recovery appears to have been slowed by changes in substrate stability and nature (loss of fines and organic materials from beach sediments) which may be especially significant to recruitment of infauna to washed beaches.

6. Presence of residual hydrocarbons in sediments can inhibit growth and survival of hardshelled clams; higher sediment hydrocarbons equate with higher tissue hydrocarbons in littleneck clams and, to a lesser degree, mussels.

7. Presence of residual hydrocarbons in sediments does not necessarily equate with a depauperate infauna assemblage or inhibit recruitment of hardshelled clams.

The usefulness of these and other results of the NOAA study is limited, however, by the limited number of sites sampled (typically 2 to 5 stations in each habitat type, treatment category, and tidal elevation) and by the fact that sites were not selected in 1989 by any statistically based randomization process (often they were selected at places where the beach could be reached by helicopter in March or April 1989!).

The proposed augmentation of the NOAA study design with additional funding from the Council's restoration program would provide the following benefits to our understanding of the status of recovery in the nearshore environment of Prince William Sound:

1. An ability to cross check the 1997 status of recovery at our hot-water washed sites with other treated sites that had reached similar points of recovery in 1991; a major question relates to the status of rockweed populations and associated epibiota.

2. A more general understanding of the nature of recovery in the two primary habitats of interest; comparison of data from the Coastal Habitat Restoration program survey in 1990, 1991 and 1997 with similar conditions at NOAA sites sampled in the intervening years may allow inference of the path of recovery of important assemblage components at the Coastal Habitat Restoration program sites.

3. An ability to extrapolate more broadly from the NOAA Shoreline Study results; if declines in rockweed similar to those seen at the NOAA sites are seen at other sites, then stronger conclusions can be reached regarding the geographic extent of the apparent oscillations in intertidal abundances seen in the NOAA results.

4. A better understanding of the generality of the effects of hot-water washing seen on lower intertidal infauna on sheltered pebble/granule beaches; the NOAA data indicate a very limited recovery of infauna, including important hard-shelled clams, at these sites. Comparable sampling at other similarly washed beaches will demonstrate the generality of this finding. Comparisons of 1991 and 1997 infauna at these sites will reveal the degree of change that has occurred for comparison with change (or absence of change) seen over the years at the NOAA sites.

C. Location

For the purposes of this proposal, we have assumed that we will initiate sampling under the NOAA protocols at three of the five sheltered rocky site pairs and three of the four "coarse textured" site pairs sampled by the Coastal Habitat Restoration program in Prince William Sound. Thus, we will be adding a total of 12 new stations to the NOAA sample design. Specific site pairs to be included under each habitat type will be chosen after a detailed review of available site oiling/treatment histories, habitat descriptions, results of data gathered in the earlier program, and location in relation to stations already included in the NOAA study design. Station pairs will be selected to complement the data already available, to maximize the information gained by the resampling, and to maximize our ability to extrapolate information to the remainder of Prince William Sound.

Sampling sites may lie in areas used by the residents of Tatitlek and Chenega Bay for commercial and subsistence harvest of intertidal organisms. Results of the proposed monitoring program would contribute to the Tatitlek and Chenega Bay communities' understanding of sustainability of food collection by giving them the knowledge and understanding of the of the current state of recovery and the factors affecting the recovery process.

There are additional benefits to be realized from the proposed project. From NOAA's perspective, it is imperative that information regarding shoreline recovery from the *Exxon Valdez* oil spill and the various treatments applied for shoreline cleanup be made available to decision makers before the next such incident occurs.

COMMUNITY INVOLVEMENT

In the past, NOAA has extended invitations to the Chenega Bay community to join a portion of our survey. We typically involve all "observers" in the daily scientific work (data recording, sample screening, etc.) with appropriate supervision and would welcome this involvement by the community. As part of the proposed monitoring program, we would contact the Council representatives from Tatitlek and Chenega Bay before finalizing field plans to inquire about potential participation. We believe that this participation would be particularly beneficial to us because local participants would have knowledge about local lore that could be very helpful to the study. Also, participation would be beneficial to the native communities involved, if participants could be found with a strong interest in science and/or in the natural history of the region, and who are interested in knowing the status of their intertidal resources.

We were privileged to work from Mr. Gary Kompkoff's vessel in April 1989 and look forward to working with him and Mr. Don Kompkoff to maximize community involvement. Our cruises are typically planned to spend at least one night in Chenega Bay. We would inquire with Gary and Don about local interest in having a 'town meeting' with our scientists at the community center or an 'open house' on the support vessel, either of which would provide an explanation of our program and its results.

Although not included in the level of funding requested, we would be very pleased to put together a lay summary of the results of our eight years of monitoring of the beaches in Prince William Sound for the information of the local communities.

PROJECT DESIGN

A. Objectives

The overall objective of this program is to broaden our knowledge and understanding of the state of recovery of intertidal epibiota and infauna from the effects of the *Exxon Valdez* oil spill. Emphasis is placed on resources of importance to the nearshore ecology of Prince William Sound and to the area's indigenous peoples. Our overall approach will be to expand the geographic coverage of the existing NOAA shoreline recovery program to sites previously sampled under the Coastal Habitat Restoration program (R102). This approach will allow us to accomplish the following specific objectives:

1. Assess the state of recovery of intertidal assemblages at the R102 sampling sites.

2. Contrast and compare status of recovery from the R102 sites with that at NOAA program sites that experienced similar oiling and treatment.

3. Determine the generality of conclusions reached based on annual (1989-1996) monitoring at the NOAA sites and the validity of extrapolations to other areas of Prince William Sound.

4. Better define the state of recovery of key intertidal resources in Prince William Sound.

For maximum efficiency and cost-effectiveness, the overall conduct of this program (logistics, field work, and reporting) will be fully integrated with continuing work on the NOAA Shoreline Recovery monitoring study.

B. Methods

The methods described below represent those used in the last eight years (1989-1996) of monitoring under the NOAA Shoreline Recovery study. Data gathered under Council funding will be fully compatible with and comparable to data from the NOAA study, thus maximizing their value to the Council.

Sampling Design

For consistency with earlier studies, a stratified random sampling design has been established to assess important intertidal assemblage and population (individual taxa) characteristics. Sampling is structured following Zeh et al. (1981) and Houghton et al. (1993) to obtain statistically reliable estimates of density or cover of macrobiota inhabiting the surface (epibiota) and, where possible, the subsurface (infauna) within important life zones and within typical habitats.

The intertidal sampling effort was initially stratified according to three habitat types important in Prince William Sound:

1. Sheltered rocky habitats—Intertidal substratum composed primarily of bedrock or very large boulders (50 cm or larger).

2. Mixed-soft or pebble/granule habitats (coarse textured in the terminology of R102)—Typically a mixture of silt, granules, and pebbles with varying amounts of cobbles (4 to 25 cm) or boulders (25 to 50 cm).

3. Boulder/cobble habitats—Exposed beaches with nearly 100 percent cover by rounded cobbles and boulders ranging from about 10 to 50 cm. Boulder sites have not been consistently sampled in recent NOAA studies and are not included in this proposal.

Sheltered (low energy) rocky and mixed-soft sites are included for two reasons:

1. Their biological productivity is high.

2. Their low energy regime reduces the rate of natural weathering of oil (Jahns et al. 1991; Michel et al. 1991).

Council-funded sampling will be conducted at six rocky sites and six mixed-soft sites; Restitution-funded NOAA sampling is also planned at an additional 12 sheltered rocky sites and 10 mixed-soft sites.

To represent important life zones (i.e., to further stratify the sampling), three elevations (stations) are typically sampled for epibiota at each site:

1. Near the upper limit of attached macrobiota.

2. In the upper portion of the broad rockweed-dominated zone

3. Along the lower edge of this rockweed zone.

These elevations are analogous to the 1, 2, and 3 meters vertical drop (MVD) stratification in the R102 study design. In the terminology of the NOAA study, a "location" can have both rocky and mixed-soft "sites," and each site can have up to three "stations" to represent different intertidal zones. Infauna is typically sampled only at lower elevation stations at mixed-soft sites. At each station, sampling is conducted at randomly selected points along a transect line laid parallel to the waterline along the beach contour.

Site Classification, Oiling, and Treatment History

About 570 km of shoreline in Prince William Sound received sufficient oiling to require some form of cleanup or treatment in 1989 (Harrison 1991). Intensive efforts will be made to verify the treatment history of each sampling site added to the NOAA study (see Appendix Table A-1 in Houghton et al. 1993a for treatment histories at existing sampling sites). Information used to document the site designations will be compiled from Exxon and State of Alaska records of treatments applied to various "beach segments" and from conversations with knowledgeable personnel in the field during 1989 (e.g., the authors, previous investigators, NOAA personnel, and field bosses for specific locations).

To the extent possible, stations sampled from the R102 program will be placed within the station category matrix of the NOAA study for direct comparisons to other stations and for purposes of statistical testing. Stations at a given site may or may not be classified in the same category depending on the site's known treatment history. New stations will be classified as Category 1, 2, or 3 based on available information regarding habitat disturbance from oiling and high-pressure hot-water treatment. Where possible, new stations will be assigned to one of the following three site categories:

1. Category 1: Unoiled in 1989—No significant oiling or treatment reported; considered reference stations.

2. Category 2: Oiled in 1989—Untreated (set aside) or treated with cool-water flushes in 1989 and/or bioremediation in 1989, 1990, or 1991.

3. Category 3: Oiled in 1989—Treated with high-pressure hot-water washes; most, if not all, were also bioremediated in 1989, 1990, and/or 1991.

To the extent possible, each of the new intertidal stations also will be classified as to the degree of oiling experienced in 1989. Because oiling was typically very uneven vertically over the intertidal zone and upper elevations were much more heavily oiled, there is little point in mandating the same oiling classification for all stations (elevations) at a site. Moreover, the width of the oiled band on a shoreline has little effect on the specific intertidal assemblage at a station; what is important is the specific degree of oiling to which the plants and animals at that station are actually exposed (cf. Page et al. 1995).

For consistency with earlier studies, the following oiling classifications will be used for all new stations in the proposed study:

1. Unoiled—No area of continuous oiling present at any time in 1989. Some sheens may have been present on adjacent waters. In 1990 no oiling was present except for possible widely scattered tar balls or spots of indeterminate origin.

2. Lightly oiled—Patches of oiling in 1989 with fresh oil, mousse, or tar; cover generally less than 50 percent, or large areas of continuous sheen present on the beach. Little if any oil was visible in 1990. All stations at a site reported to have been oiled were considered to have been at least lightly oiled, even if no evidence of oil was ever gathered from that elevation.

3. Moderately oiled—Near-continuous oiling in 1989 with fresh oil, mousse, or tar; cover often exceeding 50 percent and approaching 100 percent in some areas but with relatively thin sheens; few areas of thick deposition (i.e., several millimeters or more). Usually some oil remained in these areas in 1990 in the form of dry tar crusts on upper rock surfaces or light sheens within soft sediments.

4. Heavily oiled—Continuous oiling in 1989 with fresh oil, mousse, or tar; cover approaching or reaching 100 percent; some thick deposits (i.e., several millimeters or more). Considerable oil generally remained in these areas in 1990 in the form of dry tar crusts on upper rocks or sheens and moist tar spots within soft sediments.

Site Setup

The center of each of the R102 stations selected for inclusion in the program will be located as accurately as possible based on records from that study. If no permanent head stake or marker remains, our initial actions will be to establish a head stake, select the origins for each station within each of the desired biological zones, and measure the distances and compass bearings from the head stake. From each station origin, a tape will be laid out along the contour of the beach

and previously selected random origins for each quadrat located and permanently marked. Area photographs and sketches of the site layout will be made to allow ready relocation.

Sediment Hydrocarbon Sampling and Analysis

Sediment sampling is proposed only at the mixed-soft sites. Field sampling techniques are designed to ensure that no hydrocarbon contamination is introduced during collection. Field personnel will wear disposable surgical gloves and use new wooden or Teflon spoons to place sediment samples in new I-Chem glass jars. All equipment will be changed between samples. At most stations sediment samples will be composited from surface sediments scooped to about 3 cm deep at five randomly chosen locations along each transect. Sampling points will be located immediately adjacent to the five infaunal cores along the established mixed-soft transects. At some stations a separate sediment sample (i.e., not composited) will be collected adjacent to each of the five infaunal coring locations for direct correlation with infaunal variables. Thus, hydrocarbon samples will be collected from the same tidal levels as the biological samples. All samples will be frozen aboard the vessels and shipped frozen to the laboratory.

For maximum comparability with data from the ongoing NOAA study, sediment hydrocarbon analyses will be performed at the Institute for Environmental Studies (IES), Louisiana State University, Baton Rouge, Louisiana. Methods are modified from procedures of Krahn et al. (1988). Sediment samples will be weighed into 600-ml beakers for extraction. Approximately 100 cc of material will be extracted for each sample. The samples were dried prior to extraction by the addition of anhydrous sodium sulfate (Na2SO4). Sodium sulfate removes water as an extraction interference and also enhances the extraction of weathered oil residue from the pebbles and gravel by acting as an abrasive. Surrogate standards *d*-10-acenaphthylene, *d*-10-phenannthrene, and *d*-14-terphenyl will be added. Samples will be extracted three times using nanograde hexane solvent and a bath sonication technique. The extracts will be combined and then reduced in volume by a combination of rotary-evaporation and solvent reduction under a gentle stream of high purity nitrogen. The final volume is likely to vary between 1 ml and 150 ml depending on the degree of contamination. The extracts will be analyzed by gas chromatography/mass spectrometry (GC/MS) using a Hewlett Packard 5890 gas chromatograph equipped with a DB-5 high-resolution capillary column directly interfaced to a Hewlett Packard 5970B mass spectrometer (MS). The GC will be optimized to provide the required degree of separation (i.e., baseline resolution between *n*C-17 and pristane). The GC will be operated in the temperature program mode with an initial column temperature of 55° C for 3 minutes, then increased to 290 °C at a rate of 6 °C/minute, and held at the upper temperature for 17 minutes. The MS will be operated in the selective ion mode to enhance quantitative analyses. The injection temperature will be held constant at 250 °C, and only high temperature, low thermal bleed septa will be used. The interface to the MS will be maintained at 280 °C.

At the beginning of each analysis period, the MS will be tuned to perfluorotributylamine. Quantitative analysis will be done by an internal standard technique using authentic standards for nonalkylated PAHs with the exception of naphthobenzothiophene, which will be estimated using the response of dibenzothiophene. The alkylated homologs will be calculated using the nonalkylated parent. The following internal standards will be co-injected: *d*-8-naphthalene, *d*-10-

anthracene, *d*-12-chrysene, and *d*-12-perylene. Values reported as total PAHs will be the totals of the target analytes.

Tissue Hydrocarbons

Tissue samples for PAH analysis will be collected from populations of mussels and littleneck clams by field personnel wearing surgical gloves. The number of organisms sampled will vary according to the size of the animals, but a minimum of 10 g of wet tissue will be collected to allow for duplicate chemical analyses. For example, sample sizes for mussels is expected to range between 15 and 35 individuals based upon past experience. The entire sample of whole individuals for each species will be carefully wrapped in aluminum foil. The samples will then be placed in labeled polyethylene bags and frozen for transport to the laboratory.

Tissue aromatic hydrocarbon (AH) analyses will also be performed by IES. Methods will be modified from the procedures of Krahn et al. (1988). Tissue samples will be carefully removed from their shells, thoroughly rinsed with deionized water, and refrigerated in solvent-rinsed jars with Teflon-lined caps before further sample preparation. If delays of more than 2 to 3 days are expected, the samples will be frozen. For analysis, a small aliquot (3 to 5 g) of the homogenized tissue will be added to 40-ml precleaned and solvent-rinsed vials. The samples will be digested overnight by the addition of a single pellet of KOH. To enhance digestion, the samples will be sonicated and swirled periodically. The samples will then be spiked with the same surrogate standard suite used for sediment analyses. The samples will be dried with anhydrous sodium sulfate until they achieve the consistency of dry sand. They will then be extracted three times with dichloromethane (DCM). The extracts will then be combined into a single rotary-evaporation flask and reduced in volume to less than 4 ml. At this time the sample extract will be transferred into 4-ml vials and further reduced in volume by nitrogen blow-down. The solvent will then be exchanged into hexane and reduced to 100 ul.

Sample fractionation, or cleanup, will be required to enrich the target analytes and at the same time exclude matrix interferences. Sample fractionation will be performed using silica-gel/alumina columns. The columns will be calibrated such that the desired analytes are eluted from the column in the F-2, or aromatic, fraction. This fraction will then be eluted into conical 4-ml volumetric vials and reduced to a final extract volume of 0.1 ml before instrumental analysis. The target analytes will be quantified by an internal standard method and corrected for recovery using surrogate standards. Values reported as total PAHs will be the totals of the target analytes.

Lipid weights will be determined by preparing the sample as above except for fractionation. The weight of the solvent extract will be determined by a gravimetric analysis (oil/grease analysis). The results from these analyses are crude and subject to a variety of interferences that may overestimate the true lipid weight.
Dry weights will be determined by weighing a small amount of the homogenized tissue on a preconditioned, prenumbered, and preweighed tin. The tin will be placed into a drying oven at 90° C for 24 hours, then reweighed

Intertidal Epibiota

The abundance of epibiota will be measured at two or three elevations on rocky substrata and at two elevations at mixed-soft sites. Five or ten 0.25-m2 quadrats will be sampled on 30-m sampling lines (transects) oriented along the beach contour. Because all sampling is non-destructive, quadrats will be repositioned at the same location each sampling period with the aid of rebar stakes, spikes, or epoxy markers that will be placed during the first site visit. The position of each quadrat will be adjusted by referring to photographs taken during previous surveys. Latitude and longitude coordinates from a global positioning system (GPS) will be used to define each of the new study sites.

Prior to sampling, each quadrat will be photographed with a label showing the site, date, and quadrat number. Most taxa will be identified by biologists in the field. Project biologists have many years of experience in the taxonomy and natural history of Alaskan intertidal organisms. Problematic taxa will be collected (from outside the sample area, if possible) for cross-comparison among investigators or for identification on board the support vessel or in the laboratory. Biological variables to be measured or estimated include algae cover (percent by taxon) and numbers or percent cover of major epibenthic fauna. Relative cover estimates for biota, substratum type, and oiling will be based on visual examination of the tops, sides, and overhangs within a quadrat, but rocks fist size and larger will not be overturned. Whenever any oil is found, a subjective description of oiling in each quadrat will be recorded along with the percentage of oil cover found within the quadrat. Some qualitative observations of trends or patterns observed in the course of the field surveys will be reported without quantitative measurements or without demonstration of statistical significance.

Intertidal Infauna

At lower mixed-soft stations sampled, up to four randomly located 0.25-m^2 quadrats will be excavated and hand-sorted to remove larger bivalves. This method has been found to provide more efficient quantitative sampling of larger hardshelled clams than methods employing screens (Houghton 1973). Butter and littleneck clams (*Saxidomus giganteus* and *Protothaca staminea*) larger than 4 to 5 mm will be retained and preserved in 10 percent formalin for length and age analyses in the laboratory.

Macro infauna will be sampled with five randomly located 0.009-m^2-by-15-cm-deep cores taken adjacent to the permanently marked 0.25-m^2 quadrat locations used to sample epibiota. A different position relative to the quadrat will be sampled in each successive sampling trip to avoid resampling the same location.

All five cores will be field-sieved through a 1.0-mm screen, and residue will be preserved in a 10 percent buffered formalin solution. A sixth sample will be taken for grain size analysis, and a seventh sample will be taken for analysis of total organic carbon and total Kjeldahl nitrogen. These samples were frozen whole until laboratory analysis.

Samples will be washed in the laboratory on a 0.5-mm screen to remove formalin and transferred to 70 percent ethanol. All animals will be sorted from debris and identified to the lowest

practicable taxon under a dissecting microscope. All sorting and taxonomy will be done in the laboratories of Pentec Environmental, Inc. Twenty percent of each sample will be re-sorted for quality control. Problematic species will be identified by regional specialists.
Because erosion in the umbonal region makes identification of the first annulus difficult on older venerid clams, littleneck and butter clams will be aged using a modification of the methods and conventions of Houghton (1973). Specifically, rings less than 2.5 mm in length will not be counted as annuli, and no first annulus will be recorded as greater than 8 mm. When the first distinct ring is greater than 8 mm, we assume that this ring was the second annulus, and the first annulus is recorded as 2.5 mm. In addition, the external sculpture may be filed to aid in distinguishing true annuli from disturbance checks. Total length and lengths of the last three annuli will be measured to the nearest 0.1 mm for all clams collected from cores and from 0.25-m^2 quadrat excavations.

Statistical Analyses

Hypotheses to be Tested—The general form of hypotheses tested within this program is as follows:

Tests for spatial differences at a given time:

1. H_o: There is no difference in abundance of resource *x* among oiling/treatment categories (within a given habitat type and at a given elevation).

2. Tests for temporal differences at a given place (station):

3. H_o: There is no difference in abundance of resource *x* between time t_1 and time t_2 at station *s*.

Inferential Statistics—Various statistical analyses will be applied to quantitatively describe the data (number of species number of individuals and percent cover by species) and evaluate the significance of the findings. Parametric and nonparametric tests will be applied to evaluate the significance of differences observed between station categories. In these tests the mean of all subsamples (replicates) at a given station will be used to represent each variable; thus, n = the number of stations within that category where the variable in question was measured.

For tests of category effects and site-to-site differences in intertidal epibiota and environmental variables, a critical value (alpha) of $p = 0.1$ will be used. Eberhardt and Thomas (1991) note that the alpha of 0.05 "automatically" selected by most ecologists may be inappropriate in some cases. Use of 0.1 allows that there is a 1 in 10 chance of falsely rejecting the null hypothesis ("no difference between site categories" - Type I error). If there is a greater concern for falsely accepting a null hypothesis that is in fact false (i.e., failure to identify significant effects of oiling or treatment when they exist - Type II error), then a lower critical value may be justified.

Eberhardt and Thomas (1991) note further that a disparity commonly occurs about probability values between analysts on opposing sides of a controversial environmental issue. Those wishing to show "no effect" may ignore Type II error and opt for a critical p value of 0.05 or even 0.01;

those concerned with not missing an impact choose a higher probability value to reduce the Type II error. Therefore, the authors have considered probability levels of 0.1 or less to represent significant differences (i.e., to reject the null hypothesis) in most aspects of earlier studies. Use of the randomization approach to analysis of variance (ANOVA) and t-testing (see below) will allow computation of exact p values.

Randomization Tests—Enumeration data will first be tested for significant category effects using a randomization ANOVA and then tested for significant differences between pairs of site categories with a 2-tailed randomization t-test (Edgington 1987).

Randomization ANOVA tests performed on epibiota (middle rocky stations) data collected in 1990 indicated that, for certain dominant taxa, there were significant category effects—that is, abundance varied significantly among treatment categories. Multiple comparison tests using the 1990 data (Houghton et al. 1991a) identified significant ($p < 0.1$) differences in abundances of certain taxa between various permutation pairs of site categories. The same approach, ANOVA for category effects followed by t-tests for significance of differences between pairs of site categories, was applied in 1991 through 1995. Because a main purpose of the earlier studies (and the proposed expanded study) was to assess the degree of recovery occurring over time, it is considered important to continue to test for differences between pairs of site categories, even for taxa for which no experiment-wise category effect remain. It is recognized that such multiple comparisons have a statistical penalty in the true experiment-wise alpha (Type I error term): differences calculated to have an alpha of 0.1 in the multiple comparison randomization t-tests in fact represent differences that have a greater than 1 in 10 chance of occurring randomly.

For epibiota, detailed abundance data will be used in calculations of total algal cover and total taxa present. Certain taxa will be subsequently combined into higher taxonomic groups (e.g., all species of limpets into the Family Lottiidae) for ease of presentation and for statistical testing. A randomization ANOVA will be used to determine if a significant category effect exists and will be followed by randomization t-tests for differences among station categories for dominant taxonomic groups.

Field Quality Assurance/Quality Control

All members of the field sampling team will discuss procedures for field sampling at a mobilization meeting aboard each vessel before sampling to ensure that everyone understands the field methods to be used and that the methods will be followed consistently. This common understanding, along with the use of the same personnel will maximize consistency with procedures used in previous years.

Several checks will be made prior to any data collection in the field. Quadrats sampled at each location will be checked against a master list of stations, dates of previous sampling, and quadrats that had previously been sampled destructively and nondestructively since 1989. This check will preclude resampling an area previously sampled destructively. Notes on the orientation of the station line and any deviations in the previous samplings will also be checked.

Some of the header information required on the data sheets (including location, elevation, date, foot marker numbers of quadrats to be sampled, and sample identification (ID) will be filled out on board the support vessel prior to sampling. The sample ID numbers consist of an eight-digit designation composed of the year, month, day, and a unique sample serial number. The principal investigator will check these numbers against the computer logs to ensure that numbers are not duplicated. Members of the field team will note these numbers, along with the type of sample to which each will be assigned, in their field notebooks for reference in the field. Filling out the computer sample ID log prior to sampling will ensure that all desired sampling activities at existing and new stations will be accomplished at each location.

On the beach, data sheets will be checked to be sure header information is correct. The time sampling began will be entered, and the data recorder will check quadrat numbers against the master station list to be sure that the quadrat numbers sampled were correct for the elevation. One person will lay the tape in the appropriate direction from the station origin stake and check with the recorder to see if permanent quadrat locations are lined up with markers. Permanent stakes or markers will be placed at all new study sites. Deviations from previous samplings will be noted on the data sheet. The initials of the recorder will be placed at the top of the data sheet, and the initials of the quadrat enumerator placed at the top of each data column.

There will be frequent cross-checking of taxonomic identifications and estimates of percent cover between quadrat enumerators. At some stations, two or more observers may independently enumerate several quadrats.

Invertebrate nomenclature will follow Kozloff (1987) and algal nomenclature will follow Gabrielson et al. (1989). Problematic species and unique fauna and flora will be placed in plastic bags, labeled, and returned to the support vessel for identification or for preservation as reference or voucher specimens. When sampling is finished, the recorder will check to make sure that all header information is entered on the data sheet, and another person will also check that all information is complete. A final review of the data sheets will be made later on board the support vessel and will include checking of the sample ID numbers against those previously assigned.

C. Cooperating Agencies Contracts, and Other Agency Assistance

Funding requested for this project will be committed to private contractors except for analytical chemistry which will be performed by Louisiana State University. Pentec Environmental, Inc. will be the prime contractor and will be assisted by the same suite of subcontractors comprising the Pentec team that has performed the Exxon and NOAA studies in Prince William Sound for the past eight years.

Pentec will provide overall management and technical control of the project. Ogden Environmental and Energy Services (Ogden) will provide Mr. Dennis Lees, a marine invertebrate biologist with over 20 years experience in the littoral ecology of southcentral Alaska. Dr. Sandra Lindstrom has over 20 years experience in the taxonomy of the marine algae of southcentral Alaska. Mr. William Driskell is a marine biologist and biometrician with over 20 years of experience in fieldwork and analysis of data from marine biological studies in southcentral Alaska and elsewhere in the world. Other field staff and laboratory services will be provided by Pentec.

SCHEDULE

A. Measurable Project Tasks for FY 97 (October 1, 1996 - September 30, 1997)

October 1 - December 31:	Research background (oiling/treatment history) on stations that are candidates for inclusion in the program.
January 1- March 15:	Assemble and review 1990-1991 data from selected stations. Discuss possible community involvement with community representatives.
February 1- April 30:	Arrange field logistics.
May 15- June 15:	Mobilize for field.
June 15- July 30:	Field work (integrated with NOAA program).
July 30- September 30:	Infaunal sample analysis; epibiota data processing.
FY 1998	
Sept. 30-November 30:	Infaunal data processing; data analyses.
December 1- April 1:	Report preparation (1997 results).
April 15:	Submit 1997 report.

B. Project Milestones and Endpoints

October 1, 1996: Receive funding authorization.

April 15, 1998:

1. Complete assessment of the state of recovery of R102 stations.
2. Contrast and compare status of recovery of R102 sites with that at NOAA sites with similar oiling and treatment histories.
3. Preliminary assessment of the generality of conclusions reached based on the sites sampled in the NOAA program.
4. Define the state of recovery of key intertidal resources in Prince William Sound.

April 15, 1999:

1. Re-assess the state of recovery of R102 stations.
2. Contrast and compare status of recovery of R102 sites with that at NOAA sites with similar oiling and treatment histories.
3. Assess the generality of conclusions reached based on the sites sampled in the NOAA program.
4. Update the state of recovery of key intertidal resources in Prince William Sound.

April 15, 2000:

1. Re-assess the state of recovery of R102 stations.
2. Contrast and compare status of recovery of R102 sites with that at NOAA sites with similar oiling and treatment histories.
3. Assess the generality of conclusions reached based on the sites sampled in the NOAA program.
4. Update the state of recovery of key intertidal resources in Prince William Sound.

April 15, 2001:

1. Final assess the state of recovery of R102 stations.
2. Contrast and compare status of recovery of R102 sites with that at NOAA sites with similar oiling and treatment histories.
3. Final status of recovery of key intertidal resources in Prince William Sound.

C. Completion Date

April 15, 2001

PUBLICATIONS AND REPORTS

A quarterly progress report will be submitted to the Anchorage Restoration Office for each quarter of the proposed research program. The report will follow the format requirements provided by the Anchorage Restoration Office. The report will describe milestone accomplishments, deviations from the proposed work plan, if any, as well as any significant problems encountered during the reporting period.

A comprehensive annual report will be submitted on or before April 15th for each year following the year in which the research and monitoring activities are funded. Inasmuch as the proposed expanded project builds upon and supplements ongoing studies funded by NOAA's Hazardous Materials Response and Assessment Division, each report will be prepared to meet the reporting requirements of both the Council and NOAA.

As a component of the annual reporting requirement, the program's Principal Investigator will attend the Annual Restoration Workshop in Anchorage (tentatively scheduled for January 22-25, 1997). As a part of the workshop, an abstract of activities describing the results of work to date under the NOAA funded program will be prepared as one of the project deliverables. If requested, an oral or poster presentation summary of our results and conclusions to date and how they relate to the restoration program will be provided at the workshop.

It is anticipated that the results of ongoing as well as the proposed expanded program will be published in a peer-reviewed journal and/or under the auspices of the NOAA Technical Memorandum NOS ORCA (National Ocean Service [NOS], Office of Ocean Resources and Conservation Assessment [ORCA]) series. We anticipate publication of the results of the overall program through 1996 in appropriate journals (e.g. the Marine Pollution Bulletin) and would include work funded under this program in future publications.

It is our understanding that the Council has adopted a policy regarding an acknowledgment and disclaimer that is to be used in publishing results of restoration projects. To ensure compliance with the Council's policy, the program's Principal Investigator will contact the Anchorage Restoration Office to obtain the required information about the acknowledgment and disclaimer requirements prior to submission of any technical manuscript for publication.

PROFESSIONAL CONFERENCES

The proposed budgets for FY 1998 through 2001 include $500 to partially defray expenses of attendance at two professional conferences each year. Probable conferences where data from this study will be presented include the Society of Ecological Toxicology and Chemistry (SETAC), the Arctic Marine Oil Pollution (AMOP) conference, and the Arctic Science Conference.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This program will be fully integrated with the ongoing NOAA Shoreline Recovery study which is funded by the Restitution Fund. Each program will benefit greatly from the additional perspective of the sampling accomplished in the other. A single report will be prepared that will fully analyze the results of both programs and will identify the status of the R102 sites in the context of the recovery history documented at the NOAA stations.

Data from this combined program, and especially the increased awareness among the Restoration Program principal investigators of the results to date from the NOAA Shoreline Recovery program, will be of substantial benefit in identifying and evaluating restoration opportunities and approaches for intertidal resources.

The contract for the continuation of the NOAA Shoreline Recovery study is up for renewal for FY 1997 through 2002. The Pentec team will be making every effort to retain that contract through competitive bid.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

Not applicable.

PROPOSED PRINCIPAL INVESTIGATOR

Jonathan P. Houghton, Ph.D.
Pentec Environmental, Inc.
120 Third Avenue South, Suite 110
(206) 755-4682
(206) 778-9417
jon@pentec.wa.com

PERSONNEL

Principal Investigator—Dr. Jonathan P. Houghton, Pentec

The Principal Investigator Director for this project will be Dr. Jonathan P. Houghton, vice president and senior marine biologist with more than 25 years of experience relevant to this project. Dr. Houghton will have overall contractual and technical control of the project and will be the primary interface between Pentec and the Council, as well as with other contractors on this project.

Dr. Houghton has been working on intertidal ecological monitoring studies in the Pacific Northwest since 1969. Dr. Houghton began his scientific career in Alaska in 1971 and has concentrated his technical focus in the state since 1976. During the last 20 years he has accumulated a unique combination of field and managerial experience in monitoring effects of various perturbations on Alaska's nearshore resources.

His direct experience with southcentral Alaska ecosystems spans much of the last two decades and has included baseline data collection and analysis of ecological conditions as well as assessment of impacts of a number of different types of perturbations on marine ecosystems and coldwater fisheries. Dr. Houghton began working in Cook Inlet in 1976, at the start of a three-year baseline monitoring study of intertidal ecology of the lower inlet under the NOAA/OCSEAP program. This study, under the direction of Mr. Lees of Ogden (see below), included quantitative inventory of nearshore resources at a large number of sites on both sides of the Inlet. Pentec and Dr. Houghton have recently received funding from the Cook Inlet RCAC to revisit and resample many of the stations sampled under OCSEAP using the protocols and techniques proposed for this program and used in our NOAA Prince William Sound *Exxon Valdez* oil spill studies. This study will use the same team proposed for the Restoration Program study.

In 1977 Dr. Houghton directed biological aspects of a comprehensive evaluation of the effects of the effluents from the Lower Cook Inlet COST well on important biological resources in the inlet. This work included laboratory and *in-situ* bioassays as well as studies in the drilling fluid discharge impact area. In 1978 he directed five investigations of specific marine resources in leased areas of the inlet as a prerequisite to exploratory drilling. Also in the late 1970s, he worked on evaluations of a natural gas pipeline around the inlet from the Drift River to Nikiski. In 1983 he conducted one of the first ecological investigations of fish and benthos in Knik Arm, a dynamic glacial estuary, and described a high level of activity that had not been previously reported.

In addition to this strong, practical experience base in the southcentral region, Dr. Houghton has managed several complex interdisciplinary studies in Alaska. These include a synthesis of available information (benthos, sediments, fish) and development of recommended long-term Beaufort and Bering sea oil and gas development monitoring programs for NOAA and MMS (Houghton et al. 1984, 1987), the preparation of the Prudhoe Bay Waterflood EIS for the US Army Corps of Engineers and the Prudhoe Bay Unit (PBU) owners, and the PBU and Kuparuk Waterflood NPDES studies. In the 1970s, he was in charge of assessing marine biological

impacts of several proposed pipeline projects around and under Puget Sound. These efforts gave him a good background in early literature on oil spill effects and recovery.

The 1985 *ARCO Anchorage* spill provided an opportunity for Dr. Houghton to design and direct a two-year study of the recovery of benthic biota on an oiled and treated shoreline at Ediz Hook in the Strait of Juan de Fuca. With this background, he was asked in March of 1989 to be part of the first team of marine biologists in the field for Exxon to evaluate the effects of the *Exxon Valdez* spill. During 1989, he spent four months in Prince William Sound working on evaluations of the spill's effects on intertidal and shallow subtidal (e.g., eelgrass) communities. He also directed a Pentec study of the short-term impacts of several different shoreline treatment approaches commonly used in Prince William Sound. Field evaluations of this spill have continued through 1996 under contract with NOAA and funding from EPA, the Coast Guard, Minerals Management Service, the American Petroleum Institute, the Marine Spill Response Corporation, and the Retitution Fund. He has presented results of monitoring, showing the significant adverse impacts of certain types of shoreline cleanup activities and tracking the progress of recovery at the the Council/AFS sponsored symposium in Anchorage in winter of 1993 as well as at the last three International Oil Spill Conferences and at three meetings of the Society of Environmental Toxicology and Chemistry.

As a result of his *Exxon Valdez* work for NOAA, Dr. Houghton was asked by the NOAA Damage Assessment Team to assist in the design of monitoring studies to assess the potential effects of the recent *Tenyo Maru* spill off Washington's Olympic Peninsula. He is also currently directing Pentec's work for the Cook Inlet RCAC.

Marine Phycologist—Dr. Sandra Lindstrom

Dr. Sandra Lindstrom has specialized expertise in the systematics of the benthic marine macroalgae from Prince William Sound. A native of Alaska, Dr. Lindstrom is a recognized authority on the taxonomy, biogeography and phylogeny of the cold temperate marine benthic algal flora of the North Pacific Ocean. She is the author of more than 30 scientific papers, many on new or poorly known species of algae from Alaska. Her recent research has focused on the population genetics, biogeography and phylogeny of Alaskan algae.

Dr. Lindstrom began marine benthic monitoring studies in British Columbia in 1971, and worked on similar studies in Kachemak Bay and the Gulf of Alaska in the mid 1970's. She has worked on EVOS studies in Prince William Sound, Kodiak Island and the Alaska Peninsula, beginning in 1989, including cooperative work with Pentec and Ogden in PWS.

Dr. Lindstrom has also been a leader in the development of seaweed aquaculture in both British Columbia and Alaska, and she remains actively involved in that field at present.

Co-Principal Investigator for Marine Biology—Dennis C. Lees, Ogden

Mr. Lees has more than 26 years of experience in the study and evaluation of nearshore and intertidal biological systems ranging from California and Alaska to the Arabian Gulf. He participates in field, analytical, and reporting activities as a principal investigator or project

manager. He has assessed and predicted impacts on nearshore marine habitats of a wide variety of industrial development activities around the world, including oil development, oil spills and related cleanup and treatment activities, construction and operation of power, desalination, petrochemical, and wastewater treatment facilities, mining, and port and airport construction and operation. He has designed, supervised, and conducted field studies involving intertidal, diving, submersible, trawl, and grab sampling activities and the subsequent statistical analysis necessary to describe intertidal and nearshore benthic communities and predict and assess impacts of man's industrial development activities.

Mr. Lees currently manages the Marine Sciences Group of Ogden. In this role, he oversees the group's technical, financial, marketing, and administrative aspects. Major activities of this diverse group include studies of marine ecotoxicology, sediment and effluent toxicity, bioengineering programs aimed at biofouling control and performance monitoring in power plants and wastewater treatment facilities, as well as traditional marine ecological assessment of benthic and nearshore fish communities. In this role, Mr. Lees encounters and has acquired a firm grasp of a wide range of biological and bioengineering subjects.

Mr. Lees has participated in a wide variety of studies that assess the effects of oil and gas development in southcentral Alaska. In 1975-1976, he directed two-year baseline and detailed ecological studies of intertidal and nearshore assemblages on the outer Kenai Peninsula as part of Outer Continental Shelf studies associated with development of offshore in oil in Alaska. Studies involved assessment of undisturbed intertidal and nearshore benthic communities and establishment of baseline conditions in several important communities, including eelgrass.

In 1976, he studied shallow subtidal boulder/cobble habitats and the distinctive and unusual epibiota on the Phillips Petroleum Chinitna Bay lease site on the west side of lower Cook Inlet using underwater television and SCUBA techniques.

From 1976 through 1980, he served as principal investigator on a four-year-long study involving assessment of undisturbed intertidal and nearshore benthic communities in lower Cook Inlet and Prince William Sound. These studies examined primary production of major macrophytes and secondary production, trophic structure, and energy pathways of several impacts of petroleum development in addition to baseline conditions in coastal or offshore areas. These studies were conducted through SCUBA and intertidal sampling.

In 1978 Mr. Lees conducted benthic analyses to determine the effects of the discharge of drilling cuttings and muds in lower Cook Inlet, Alaska. In Prince William Sound, he designed and directed benthic studies on the intertidal and shallow subtidal communities in Port Valdez to assess the potential effects of harbor modification and construction and operation of a petrochemical refinery in Valdez.

In 1979-1980 he directed a year-long study of intertidal and shallow subtidal benthos, demersal and anadromous fishes, and crustacean and fish plankton around Homer Spit in Kachemak Bay. The objectives of the program were to evaluate potential effects on the target organisms of general commercial and industrial development of the spit and extensive harbor modification.

From 1981 through 1983, Mr. Lees was project manager and principal investigator on major studies related to development of a new city and large power and desalination plant by the Ministry of Electricity and Water, State of Kuwait. He directed intensive baseline studies of demersal fish, zooplankton, and benthic assemblages in Kuwait Bay and northern Kuwait. The program examined distribution and abundance of the larvae and adults of commercial and non-commercial species of fish and crustaceans over a one-year period and predicted effects of development and operation of a new city and associated power and desalination plants on the fisheries stocks.

In 1982-1983 he developed and directed studies of baseline conditions of the nearshore benthos and demersal and anadromous fish in the eastern Chukchi Sea as part of a program to assess the potential effects of Cominco Alaska's development of the Red Dog lead/zinc deposit.

In 1982-1985 Mr. Lees designed and was project manager and principal investigator on major studies related to development of a major petrochemical industrial complex, associated large power and desalination plants, and operation of a major supertanker port in Abu Dhabi, U.A.E. In this role he managed year-long baseline studies of demersal fish, epifaunal invertebrates, benthic assemblages, phytoplankton and zooplankton assemblages, and coral reefs and wetlands and a two-year study of biofouling communities. These studies determined distribution patterns of major biotic assemblages and—based on modeling, physical and chemical oceanographic studies, and projected pollutant loading—evaluated potential environmental impacts of the industrial complex and operation of a supertanker port in the study area.

From 1989 to the present Mr. Lees has been a principal investigator for Exxon and NOAA on marine biological studies in intertidal and shallow subtidal habitats of Prince William Sound after the *Exxon Valdez* oil spill. These studies have been conducted jointly with Pentec and have sought to determine the impact of the oil spill on biological assemblages in affected areas and determine recovery rates of the various assemblages in affected areas and determine recovery rates of the various assemblages. The studies have evaluated growth rates and density of kelp and eelgrass in oiled and unoiled control areas as well as areas that were oiled and subsequently treated to remove oil. Biological effects of dispersant treatment and standard cleanup treatments in oiled areas were also compared to assess the biological costs of the alternative treatment.

Data Manager—William B. Driskell

Mr. Driskell is a biological oceanographer with a strong emphasis in statistical design and data management for large marine monitoring programs. He has worked on a number of marine biological studies over the past 20 years, principally in the southcentral Alaska and the Puget Sound regions. This period was interrupted by a three-year sojourn to participate in two large multidisciplinary oceanography and marine biological studies in the Arabian Gulf. Projects included a marine biological baseline in Kuwait Bay and Port of Ruwais, Abu Dhabi, and a biofouling assessment of refinery intake and the near-shore environment at Das Island, Abu Dhabi. His expertise includes: data management and statistical monitoring design; taxonomy of North Pacific and Arabian Gulf marine invertebrates and fish; biological survey techniques including trawl, seine, diving, benthic grab, dredge and box core, underwater television and still photography; bird identification; and computer programming.

From 1976 through 1981, Mr. Driskell was a resident of Homer, Alaska, where he worked with Mr. Lees, now of Ogden, and Dr. Houghton, now of Pentec, on a series of biological studies for NOAA, National Marine Fisheries Service, and Alaska Department of Fish and Game throughout Cook Inlet and the outer Kenai Peninsula. During this time period he was involved in diving, intertidal, and bird surveys for various projects around the Homer Spit, Kachemak Bay, lower Cook Inlet, and Prince William Sound, and for an airport runway extension in Dutch Harbor, Alaska. He worked with Dr. Houghton on petroleum lease block clearance surveys in lower Cook Inlet including underwater television, still-photography, and benthic grab-sampling. In Kachemak Bay, he was the project leader on a benthic survey for ADF&G, utilizing anchor dredge, underwater television, and still photographic sampling equipment. In 1988, Mr. Driskell began a consulting business in Seattle dealing primarily with marine biological and sediment chemistry databases and data analysis. Data analyses have ranged from compiling and analyzing survey results to multivariate statistical analysis.

Since early in 1989, Mr. Driskell has worked on a Pentec/Ogden team that is evaluating marine biological impacts of the *Exxon Valdez* oil spill on the intertidal and subtidal resources of Prince William Sound. In this role, Mr. Driskell has primary responsibility for the design, management and statistical analysis of the marine biological database from the spill. In 1994, Mr. Driskell provided the primary technical support in the *Exxon Valdez* civil court trial for the plaintiffs' ecological and statistical expert witnesses. In 1995, he designed a marine monitoring program for a mining venture in Lynn Canal, Alaska. These projects have given him an excellent insight into optimizing the design of monitoring programs to document long-term trends and recovery and to maximize the statistical power to detect change. Mr. Driskell and Mr. Lees also served as technical advisers on the nationally-traveled "Darkened Waters" exhibit produced by the Pratt Museum in Homer.

LITERATURE CITED

Brooks, K.M. 1994. Histopathological examination of archived bivalves *Mytilus edulis trossulus* and *Prototheca staminea* (sic) in support of the Prince William Sound long-term monitoring. Prepared by Aquatic Environmental Sciences, Port Townsend, Washington, for Gary Shigenaka, USDOC/NOAA/ORCA/HMRAD/ORCA32, Seattle, Washington.

Eberhardt, L.L., and J.M. Thomas. 1991. Designing environmental field studies. Ecol. Mono. 61(1):53-73.

Edgington, E.S. 1987. Randomization tests. 2nd Ed. Marcel Dekker, New York, New York.

Gabrielson, P.W., R.F. Scagel, and T.B. Widdowson. 1989. Keys to the benthic marine algae and seagrasses of British Columbia, Southeast Alaska, Washington, and Oregon. University of British Columbia, Vancouver, BC, Canada.

Ganning, B.D., J. Reish, and D. Straughan. 1984. Recovery and restoration of rocky shores, sandy beaches, tidal flats, and shallow subtidal bottoms impacted by oil spill. Pages 7-35 *in* J. Cairns, Jr., and A.L. Buikema, Jr., editors. Restoration of habitats impacted by oil spills. Butterworth Publishers, Boston, Massachusetts.

Harrison, O.R. 1991. An overview of the *Exxon Valdez* oil spill: 1991 International Oil Spill Conference: Prevention, Behavior, Control, Cleanup. American Petroleum Institute, Washington, DC.

Henry, Jr., C.B., P.O. Roberts, and E.B. Overton. 1994. Summary of chemistry results: shoreline monitoring study in Prince William Sound, Alaska during the summer of 1993. Chemistry report: IES/RCAT94-28, draft. Prepared by Institute for Environmental Studies, Louisiana State University, Baton Rouge, for Hazardous Materials Response and Assessment Division, NOAA, Seattle, Washington.

Houghton, J.P., D. Erikson, and W.B. Driskell. 1990a. Biological effects of beach treatment using an Omni-barge on the nearshore zone of Herring Bay, July 1989. For Exxon Company, USA. Dames & Moore technical report series - The *Exxon Valdez* oil spill studies. Dames & Moore, Seattle, Washington.

Houghton, J.P., T.P. McKenzie, and H. Teas. 1990b. *Exxon Valdez* oil spill studies: Prince William Sound shoreline treatment effects study. Final data report. Prepared for Dames & Moore and Exxon Company, USA.

Houghton, J.P., D.C Lees, H. Teas, H. Cumberland, S. Landino, and W.B. Driskell. 1991a. Evaluation of the condition of intertidal and shallow subtidal biota in Prince William Sound following the *Exxon Valdez* oil spill and subsequent shoreline treatment. Volume 1. Prepared by Pentec Environmental, Inc., and ERCE (now Ogden) Environmental and Energy Services Co., for NOAA Hazardous Materials Section. NOAA, Seattle, Washington.

Houghton, J.P., D.C. Lees, W.B. Driskell, and A.J. Mearns. 1991b. Impacts of the *Exxon Valdez* spill and subsequent cleanup on intertidal biota1 year later. 1991 International Oil Spill Conference: Prevention, Behavior, Control, and Cleanup. American Petroleum Institute, Washington, DC.

Houghton, J.P., A.K. Fukuyama, D.C.Lees, H. Teas, III, H.L. Cumberland, P.M. Harper, T.A. Ebert, and W.B. Driskell. 1993a. Evaluation of the 1991 condition of Prince William Sound shorelines following the *Exxon Valdez* oil spill and subsequent treatment: Volume II, 1991 biological monitoring survey. NOAA Technical Memorandum NOS ORCA 67, NOAA, Hazardous Materials Response and Assessment Division, Seattle, Washington.

Houghton, J.P., A.K. Fukuyama, D.C. Lees, P.J. Hague, H.L. Cumberland, P.M. Harper, and W.B. Driskell. 1993b. Evaluation of the 1992 condition of Prince William Sound shorelines following the *Exxon Valdez* oil spill and subsequent shoreline treatment: Volume II, 1992 biological monitoring survey. NOAA Technical Memorandum NOS ORCA 73, NOAA, Hazardous Materials Response and Assessment Division, Seattle, Washington.

Houghton, J.P., R.H. Gilmour, D.C. Lees, S.C. Lindstrom, and W.B. Driskell. 1995a. Evaluation of the condition of Prince William Sound shorelines following the *Exxon Valdez* oil spill and subsequent shoreline treatment: Volume I, 1993 biological monitoring survey. NOAA Technical Memorandum NOS ORCA 82, NOAA Hazardous Materials Response and Assessment Division, Seattle, Washington.

Houghton, J.P., D.C. Lees, W.B. Driskell, and S.C. Lindstrom. 1995b. Long-term recovery (1989-1994) of Prince William Sound littoral biota following the *Exxon Valdez* oil spill and subsequent shoreline treatment. Final report of Pentec Environmental, Inc., to NOAA Hazardous Materials Response and Assessments Division, Seattle, Washington.

Jahns, H.O., J.R. Bragg, L.C. Dash, and E.O. Owens. 1991. Natural cleaning of shorelines following the *Exxon Valdez* spill and subsequent cleanup on intertidal biota—1 year later. 1991 International Oil Spill Conference: Prevention, Behavior, Control, and Cleanup. American Petroleum Institute, Washington, DC.

Kozloff, E.N. 1987. Marine invertebrates of the Pacific Northwest. University of Washington Press, Seattle.

Krahn, M.C., C.A. Wigren, R.W. Pearce, L.K. Moore, R.G. Bogar, W.D. MacLeod, Jr., S.L. Chan, and D.W. Brown. 1988. Standard analytical procedures of the NOAA National Analytical Facility, 1988. New HPLC cleanup and revised extraction procedures for organic contaminants. NOAA Technical Memorandum MNFS F/NWC-153, Seattle, Washington.

Lees, D.C., and J.P. Houghton. 1990. An evaluation of biological effects of exposure to Corexit 9580 M2 in the biota of the intertidal and shallow subtidal zones. Final Data Report for

Exxon Company, USA. Dames & Moore technical report series - The *Exxon Valdez* Oil Spill Studies. Dames & Moore, Seattle, Washington.

Lees, D.C., W.B. Driskell, and J.P. Houghton. 1993. Effects of shoreline treatment methods on intertidal biota in Prince William Sound. 1993 International Oil Spill Conference: Prevention, Preparedness, Response. US Coast Guard, American Petroleum Institute, and US Environmental Protection Agency. American Petroleum Institute, Washington, DC.

Michel, J., and M.O. Hayes 1990. Review draft: Geomorphological controls on the persistence of shoreline contamination from the *Exxon Valdez* oil spill. Prepared by Research Planning, Inc., for Hazardous Materials Response Branch, NOAA, Seattle, Washington.

Michel, J., M.O. Hayes, W.J. Sexton, J.C. Gibeaut, and C. Henry. 1991. Trends in natural removal of the *Exxon Valdez* oil spill in Prince William Sound from September 1989 to May 1990. 1991 International Oil Spill Conference: Prevention, Behavior, Control, Cleanup. American Petroleum Institute, Washington, DC.

Michel, J., and M.O. Hayes. 1991. Geomorphology controls on the persistence of shoreline contamination from the *Exxon Valdez* oil spill. Prepared by Research Planning, Inc., for Hazardous Materials Response Branch, NOAA, Seattle, Washington.

Michel, J., and M.O. Hayes. 1992. Results of geomorphological shoreline monitoring survey of the *Exxon Valdez* spill site in Prince William Sound, Alaska. August 24-30, 1991. Draft report, NOAA, Seattle, Washington.

Page, D.S., E.S. Gilfillan, P.D. Boehm, and E.J. Harner. 1993. Shoreline ecology program for Prince William Sound, Alaska, following the *Exxon Valdez* oil spill: Part 1 - Study design and methods. ASTM Symposium on Environmental Toxicology and Risk Assessment, April 25-28, 1993, Atlanta, Georgia.

Zeh, J.E. 1981. Evaluation of existing marine intertidal and shallow subtidal biologic data. Prepared by Mathematic Sciences Northwest, Inc. and Dames & Moore. Prepared for MESA Puget Sound Project, Office of Environmental Engineering and Technology, Office of Research and Development, US EPA. EPA Interagency Agreement No. D6-E693-EN. Dames & Moore, Seattle, Washington.

1997 EXXON VALDEZ TRU ⋮ COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997						
Personnel		$109.2						
Travel		$9.6						
Contractual		$80.8						
Commodities		$9.2						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$208.8	Estimated FFY 1998	Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	
Indirect		$72.5						
Project Total	$0.0	$281.3	$292.1	$303.3	$314.9	$0.0	$0.0	
Full-time Equivalents (FTE)		18.2						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

Assumptions

An eight-day field program will be conducted.
Logistics: One vessel supporting six scientists or working observers.
The budget covers three Pentec scientists, one Ogden scientist, Sandra Lindstrom, and William Driskell (five quadrat enumerators).
Thirty infaunal samples will be analyzed from FY 1997 studies.

The budget is calculated using government rates. The above "indirect" costs of $72.5 represent G&A costs and a 10% fee. Our overhead and G&A rates have been approved by the Defense Contract Audit Agency. Overhead includes all indirect costs incurred for the production of services; G&A expenses are overall costs of running the business. We do not include unallowable expenses such as interest, meals and entertainment, advertising, fines and penalties, bad debts, and charitable contributions in the indirect costs pools. The overhead allocation rate is determined by dividing the pool of our total expected overhead expenses by the base of expected total direct labor costs. The G&A allocation rate is determined by dividing the pool of our total expected G&A expenses by the base of expected total direct costs plus expected overhead (total cost input).

1997

Prepared: April 14 1996

Project Number: 97181
Project Title: Prince William Sound Intertidal Recovery Monitoring
Name: Pentec Environmental, Inc.

FORM 4A
Non-Trustee
SUMMARY

4/12/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FFY 1997
Balzer, L.	Data Manager		0.5	4.5		2.3
Brockett, K.	Field/Lab Technician		4.1	3.2		13.1
Deitz, C.	Lab Technician		0.9	4.1		3.7
Gilmour, R.	Project Biologist		6.9	5.8		40.0
Houghton, J.	Principal Investigator		3.7	11.1		41.1
Shannon, D.	Document Coordination		0.5	5.0		2.5
Unknown	Budget Coordination		0.6	2.2		1.3
Unknown	Project Assistance		0.1	5.0		0.5
Unknown	Technical Editor		0.3	6.4		1.9
Unknown	Word Processing		0.6	4.6		2.8
						0.0
						0.0
	Subtotal		18.2	51.9	0.0	
					Personnel Total	$109.2

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FFY 1997
Airfare-Seattle to Anchorage		0.8	7	20	0.2	9.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$9.6

1997

Project Number:
Project Title: Prince William Sound Intertidal Recovery Monitoring
Name: Pentec Environmental, Inc.

FORM 4B
Personnel
& Travel
DETAIL

Prepared: April 11, 1996

4/12/96

1997 EXXON VALDEZ TRU: : COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Contractual Costs:	Proposed
Description	FFY 1997
Ogden Environmental, Inc. (Dennis Lees) - Biologist Subconsultant	24.5
Dr. Sandra Lindstrom - Phycologist Subconsultant	12.3
Mr. William Driskell - Biologist Subconsultant	15.4
Research Vessel	12.6
Analytical Resources, Inc. - TOC/TKN Analyses	3.8
Louisiana State University - Hydrocarbon Analyses	9.6
Taxonomic Verification - Subconsultant	2.6
Contractual Total	$80.8

Commodities Costs:	Proposed
Description	FFY 1997
Shipping & Postage	1.6
Film & Developing	0.6
Communications	0.5
Mileage (/Mile)	0.3
Miscellaneous Supplies (rebar, preservative, glassware, buckets, coolers, gloves, markers, labels, sieves, etc.)	2.3
Computer (Office & Field; /Hour)	1.7
Field Equipment (@ government lease rates)	0.4
Lab Equipment (@ government lease rates)	0.6
Reproduction	1.2
Commodities Total	$9.2

1997

Prepared: April 11, 1996

Project Number:
Project Title: Prince William Sound Intertidal Recovery Monitoring
Name: Pentec Environmental, Inc.

FORM 4B
Contractual & Commodities DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1997
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units

1997

Project Number:
Project Title: Prince William Sound Intertidal Recovery Monitoring
Name: Pentec Environmental, Inc.

FORM 4B
Equipment
DETAIL

Prepared: April 11, 1996

4/12/96

Pentec
ENVIRONMENTAL

Prince William Sound Intertidal Recovery Monitoring
Submitted Under the BAA

Submitted to:

Anchorage Restoration Office
and
NOAA, WASC, Procurement Division, WC33

Submitted by:

Pentec Environmental, Inc.
120 Third Avenue South
Edmonds, Washington 98020
(206) 775-4682

April 15, 1996

Prince William Sound Intertidal Recovery Monitoring
Submitted Under the BAA

Submitted to:

Anchorage Restoration Office
645 Street, Suite 401
Anchorage, Alaska 99501

and

NOAA, WASC, Procurement Division, WC33
7600 Sand Point Way NE, Bin C15700
Seattle, Washington 98115

Submitted by:

Pentec Environmental, Inc.
120 Third Avenue South
Edmonds, Washington 98020
(206) 775-4682

April 15, 1996

Phenology of Kittlitz's Murrelets in Prince William Sound, Alaska "Submitted Under the BAA"

Project Number:	97182-BAA
Restoration Category:	Research
Proposer:	Pelagic Environmental Services
Lead Trustee Agency:	NOAA
Cooperating Agencies:	
Alaska SeaLife Center:	
Duration:	1st year, 1-year project
Cost FY 97:	$230,800
Cost FY 98:	
Cost FY 99:	
Cost FY 00:	
Cost FY 01:	
Cost FY 02:	
Geographic Area:	Prince William Sound
Injured Resource/Service:	Kittlitz's murrelet

ABSTRACT

Kittlitz's murrelets (*Brachyramphus brevirostris*) will be captured and radio tagged from June through August, 1997 in Prince William Sound. Radio tracking individual murrelets during the breeding season will identify the relationship between the murrelets' nesting and foraging habitats. Radio tracking after the breeding season will determine murrelet dispersal patterns out of Prince William Sound. Spatial data obtained through radio tracking will be analyzed using GIS.

INTRODUCTION

In 1995 the *Exxon Valdez* Trustee's Council added the Kittlitz's murrelet (*Brachyramphus brevirostris*) to the list of resources injured by the oil spill. The world population of Kittlitz's murrelets is estimated to be about 20,000 birds (van Vliet 1993). Van Vliet estimates that the population of Kittlitz's murrelets found from the western end of the Alaska Peninsula to Prince William Sound to be 9,000 birds. In this region the estimated mortality caused by the *Exxon Valdez* oil spill was 1,000 - 2,000 birds or 5 - 10% of the world population (van Vliet and McAllister 1994). In Prince William Sound the estimated population of 1,500 birds (van Vliet 1993) is found in the northern and northwestern regions at the heads of glaciated fiords (Isleib and Kessel 1973). At present no recovery objective has been identified by the Trustee's Council due to the lack of information on this species.

Radio telemetry can provide information on the movement patterns of murrelets so that habitat use, both inland and at sea, may be more fully understood. The feasibility of capturing and radio tagging Kittlitz's murrelets was tested in 1993 during a pilot study on the capturing and radio tagging of marbled murrelets (*B. marmoratus*) in Prince William Sound (Burns et al. 1994a). Movement patterns and breeding phenology of Kittlitz's murrelets may be related to the distribution of forage fish. Radio telemetry data will permit the study of these relationships. Data from this project can be linked to data gathered by Day et al. in 1996 (Restoration Project No. 96142-BAA) and to the ongoing APEX Project. These relationships during the breeding and post breeding season may indicate future recovery objectives for the Trustee's Council.

NEED FOR THE PROJECT

A. Statement of Problem

Lack of information on the ecology of the Kittlitz's murrelet is the greatest obstacle to implementing future restoration or protective strategies for this species. Its small world population and relatively small range make it susceptible to drastic population declines if either natural or human made catastrophes occur. The extent of the impact of the *Exxon Valdez* oil spill on this species is unknown, though it has been suggested that 5 to 10% of the world population suffered mortality as a direct result of the spill (van Vliet and McAllister 1994). Human activities such as fishing, boat traffic, or on shore development close to feeding or nesting areas may also affect the birds and limit their recovery from the effects of the oil spill. At present the status and degree of recovery of this species is unknown.

B. Rationale/Link to Restoration

Radio telemetry data can provide timely and critical information on the ecology of Kittlitz's murrelets. Locating and monitoring nest sites, determining foraging ranges of both breeding and non-breeding individuals, documenting the activities of known individuals at feeding sites, and following individuals in the post breeding season will provide a better understanding of this species. Potential conflicts with human activities within the study area may be identified and future research or restoration goals recognized.

C. Location

The capture and radio tagging of Kittlitz's murrelets will be done in Blackstone Bay, in the northwestern region of Prince William Sound, an area where relatively large numbers of this bird have been seen (D. Marks pers. comm.). Other sites identified in the 1996 surveys of Kittlitz's murrelets by Day et al. will also be considered. The capture system is portable and is not restricted by water depth. Radio telemetry flights will cover all of the northwestern region of Prince William

Sound. When murrelets are not relocated in these areas the telemetry flights will be expanded to include the western shoreline of the Kenai Peninsula and may include the Kodiak Archipelago and portions of the Alaska Peninsula.

COMMUNITY INVOLVEMENT

Aircraft services will be contracted from Cordova and the charter vessel "Alaskan Gypsy", based in Seward, will be chartered for the duration of the project. Two Alaskan field biologists will also be hired to assist with the field work.

Information about our project will be readily available to any groups or individuals who may be interested. A photographic record will be kept of the project and this record will be part of the information disseminated to interested groups.

PROJECT DESIGN

A. Objectives

1. Capture and radio tag four Kittlitz's murrelets every two weeks from June through August, 1997.
2. Determine breeding phenology of Kittlitz's murrelets in Prince William Sound.
3. Determine foraging ranges of both breeding and non-breeding Kittlitz's murrelets in Prince William Sound.
4. Determine post breeding dispersal patterns of Kittlitz's murrelets out of Prince William Sound.
5. Create a GIS coverage of the radio telemetry relocation points of radio tagged Kittlitz's murrelets to permit the analysis of the distribution of murrelets in relation to the distribution of forage fish in Prince William Sound.

B. Methods

Hypothesis #1

We speculate that foraging ranges of nesting Kittlitz's murrelets are equal to or greater than those of nesting marbled murrelets in Prince William Sound. Kuletz et al. (1995) suggested that the typical foraging range of nesting marbled murrelets was 20 - 30 km. Kittlitz's murrelets are normally found at the head of glaciated fiords. If our speculation is correct then we would expect to find radio tagged Kittlitz's murrelets captured in one fiord frequenting other fiords in Prince William Sound.

Hypothesis #2

The number of Kittlitz's murrelets in Prince William Sound decrease earlier than when decreases in the number of marbled murrelets are noted (Kuletz pers. comm.). The physical differences and differences in dispersal times from their nesting areas between these two *Brachyramphus* species suggest that they may target different prey species even though both species can be found in the same areas. We speculate that the earlier dispersal of Kittlitz's murrelets is related to the distribution of a particular prey species in the area. By following radio tagged individuals, including newly fledged chicks, on a daily basis, the timing of dispersal can be noted and dispersal routes found. Radio telemetry data can then be compared to data collected from forage fish and other studies in the Sound. We would expect to see a correlation between the abundance and movement of Kittlitz's murrelets and the abundance and distribution of certain species of prey items.

To test these hypotheses we will follow radio tagged individuals. Using floating mist nests over the water (Burns et al. 1994b) we will capture and radio tag 25 or more Kittlitz's murrelets from June through August, 1997. Kittlitz's murrelets are frequently found at the heads of glaciated fiords. Water depths in these areas can be deep (up to 400 meters) and there are often pieces of glacial ice present in these areas. Our mist netting system has worked successfully in these conditions in 1993 and 1994 in Prince William Sound (Burns et al. 1994a, Kuletz et al. 1995). In 1994 we set up 100 meters of continuous mist nets to capture marbled murrelets. Because there are fewer Kittlitz's murrelets, we will set 170 meters of continuous net. Increasing the number of nets should increase the capture rate of murrelets.

During previous radio telemetry studies on marbled murrelets in Prince William Sound average life expectancy of radio tags was 14 days (1-32 days) (Burns et al. 1994a, Kuletz et al. 1995) and we assume a similar life expectancy for the same tags on Kittlitz's murrelets. Capturing Kittlitz's murrelets on a regular schedule from June through August (approximately four birds in each two week period) will provide continuous data through the breeding season and into the post breeding season. We will have 50 radio transmitters in the event we are able to catch more birds than expected. Photographs of each captured bird will be taken along with photographs of brood patches, if present. Brood patches will be scored using criteria established by Sealy (1974).

We will document the breeding phenology of Kittlitz's murrelets by following radio tagged individuals to nesting sites, and will attempt to monitor the times of incubation shifts, timing and number of chick feeding visits, and date and timing of fledging. Where possible, nest sites will be visited and just prior to fledging the chick will be radio tagged. This procedure was successfully carried out for a marbled murrelet chick in 1994 in Prince William Sound (Kuletz et al. 1995). Foraging distances will be mapped by following birds from boat and aircraft. When possible, radio tagged murrelets will be observed to record times and length of foraging bouts, and individual behavior. This behavior will be compared to the behavior of untagged murrelets in the vicinity to determine if radio tagged birds act the same as, or differently than, birds which are not tagged. Radio tagged birds will also be followed after the fledging period to record dispersal patterns. When radio tagged individuals cannot be located in Prince William Sound we will expand our aircraft search to include the western shoreline of the Kenai Peninsula and if possible, we will fly at least one monitoring trip along the shorelines of the Kodiak Archipelago and portions of the Alaska Peninsula.

Radio telemetry data will be analyzed by Ian Parfitt using ARC/INFO GIS at the University of British Columbia.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

We will contract the "Alaskan Gypsy", a 20 meter research vessel registered in Anchorage, Alaska, for the duration of the project to provide logistical support. This vessel was used in two previous radio telemetry projects in Prince William Sound involving marbled murrelets. The vessel is well suited for this type of work. The owners provide invaluable assistance in setting and retrieving the net support system, recording data, and photographing captured birds.

Aircraft will be chartered from "Fishing and Flying" based in Cordova. This company has conducted numerous radio telemetry flights for various projects (including two marbled murrelet projects) in Prince William Sound.

SCHEDULE

A. Measurable Project Tasks for FY 97 (October 1, 1996 - September 30, 1997)

October 1 - December 31:	Apply for necessary permits to capture and radio tag Kittlitz's murrelets. Order customized radio tags. Have radio telemetry equipment serviced by manufacturer.
January 1 - March 31:	Confirm contractual arrangements for vessel and aircraft. Interview potential field assistants.
April 1 - May 23:	Hire field crew for start on May 23. Prepare vessel. Arrive Prince William Sound.
May 23 - June 1:	Select capture site.
June 1 - August 23:	Capture and radio tag 25 Kittlitz's murrelets.
August 24 - August 31:	Demobilize.
September 15 - September 30:	Begin analysis of field data.

B. Project Milestones and Endpoints

The field portion of this study will be completed by August 23, 1997. Milestones during the life of the project will be measured in biweekly increments, each increment representing the successful capture, radio tagging and tracking of at least four Kittlitz's murrelets. If these milestones are met then the objectives of determining the breeding phenology, foraging ranges and dispersal patterns of Kittlitz's murrelets should be achieved for the 1997 field season. If successful, this project should be continued for two more years to examine year to year variation of breeding phenology and dispersal patterns.

C. Completion Date

This is a one year field project ending in FY 97.

PUBLICATIONS AND REPORTS

The final report will be presented to the *Exxon Valdez* Trustees Council by April 15 in FY 98.

PROFESSIONAL CONFERENCES

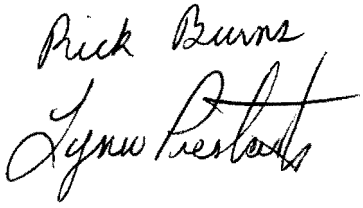
We will submit a paper on the results of this project to the annual Pacific Seabird Group conference to be held in 1997. Date and location of this conference are unknown at the present time.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Data from this project will be compiled in a GIS format that is compatible with other Agencies involved in restoration projects and will be made available to them.

PROPOSED PRINCIPAL INVESTIGATORS

Names:	Rick Burns and Lynn Prestash
Affiliation:	Pelagic Environmental Services (private organization)
Mailing address:	726 East 4th Street North Vancouver, British Columbia Canada V7L 1K2
Phone number:	(604) 987-4757
Fax number:	N/A
E-mail address:	N/A



PERSONNEL

The principal investigators, Rick Burns and Lynn Prestash, have conducted five capture and radio telemetry projects on marbled murrelets between 1991 and 1994. Two of these projects were in Prince William Sound, and three were in British Columbia. During these projects we captured a total of 94 marbled murrelets and one Kittlitz's murrelet, and radio tagged 84 of these birds. We have extensive experience radio tracking murrelets from helicopters, fixed wing aircraft, boats and on the ground.

Results of our work with murrelets have been published as technical reports by the United States Fish and Wildlife Service and the Canadian Wildlife Service, and as a paper in a peer reviewed symposium published by the Northwest Naturalist. We have presented papers and posters to the Pacific Seabird Group Conference and to the Wildlife Society Conference (Washington/British Columbia Chapter), and taught a workshop at the latter conference titled "Fixed Point Marine Surveys and Telemetry Methods". We have also given talks to local community groups and naturalist societies about our work.

Other personnel include Ian Parfitt, a GIS Analyst presently working at the University of British Columbia, and two field biologists who will be hired later if this project is funded.

LITERATURE CITED

Burns, R. A., L. M. Prestash, and K. J. Kuletz. 1994a. Pilot study on the capture and radio tagging of murrelets in Prince William Sound, Alaska, July and August, 1993. *Exxon Valdez* Oil Spill Restoration Project Final Report, Project 93051B. USDI Fish and Wildlife Service, Anchorage, Alaska.

Burns, R. A., G. W. Kaiser, and L.M. Prestash. 1994b. Use of mist nets to capture marbled murrelets over the water. In: S.K. Nelson and S.G. Sealy (eds.) Biology of Marbled Murrelets - Inland and at sea. Proc. Pacific Seabird Group Symp. Northwest Nat. 75(3).

Isleib M. E. and B. Kessel. 1973. Birds of the North Gulf Coast - Prince William Sound region, Alaska. Biol. Pap. Univ. Alaska 14: 1-149.

Kuletz, K. J., D. K. Marks, D. Flint, R. Burns, and L. Prestash. 1995. Marbled murrelet foraging patterns and a pilot productivity index for murrelets in Prince William Sound, Alaska. *Exxon Valdez* Oil Spill Restoration Project Final Report, Project 94102. USDI Fish and Wildlife Service, Anchorage, Alaska.

Sealy, S.G. 1974. Breeding phenology and clutch size in the marbled murrelet. Auk 91:10-23.

van Vliet, G. 1993. Status concerns for the "global" population of Kittlitz's murrelet: is the "glacier murrelet" receding? Pac. Seabird Group Bull. 20: 15-16.

van Vliet, G., and M. McAllister. 1994. Kittlitz's murrelet: the species most impacted by direct mortality from the *Exxon Valdez* oil spill? Pac. Seabirds 21: 5-6.

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$90.0						
Travel		$4.8						
Contractual		$125.5						
Commodities		$10.5						
Equipment		$0.0						
Subtotal	$0.0	$230.8	Estimated FFY 1998	Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	
Indirect								
Project Total	$0.0	$230.8						
Full-time Equivalents (FTE)		16.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:
Amounts included in this budget which will occur in FY 98

Report writing which will occur in FY 98 - 15.0

2 principal investigators will attend 2 workshops in Anchorage for a total of 6 days - 3.6

1997

Prepared:

Project Number: 97182-BAA
Project Title: Phenology of Kittlitz's Murrelets in Prince William Sound, Alaska "Submitted under the BAA"
Name: Pelagic Environmental Services

FORM 4A
Non-Trustee
SUMMARY

4/12/96

1997 EXXON VALDEZ TRU: : COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FFY 1997
	R. Burns	Principal Investigator	5.0	7.5		37.5
	L. Prestash	Principal Investigator	5.0	7.5		37.5
		Field Personnel	3.0	2.5		7.5
		Field Personnel	3.0	2.5		7.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	16.0	20.0	0.0	
					Personnel Total	$90.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FFY 1997
	Vancouver, Canada to Anchorage, Alaska for 2 people	0.6	6	12	0.1	4.8
	to attend 2 workshops in Anchorage					0.0
	to arrive at project site and return					0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$4.8

1997

Prepared: 4/12/96

Project Number:
Project Title: Phenology of Kittlitz's Murrelets in Prince William Sound "Submitted under the BAA"
Name: Pelagic Environmental Services

FORM 4B
Personnel
& Travel
DETAIL

1997 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Contractual Costs:	
Description	Proposed FFY 1997
Charter of research vessel "Alaskan Gypsy" - 90 days at 800.00 per day	72.0
Aircraft services from "Fishing and Flying"-Cordova - 200 hours at 230.00 per hour	46.0
Professional services - GIS analysis - Ian Parfitt - University of British Columbia - 2 months	6.0
Telemetry equipment maintenance including shipping and insurance - Telonics - Arizona	1.0
Communication and printing	0.5
Contractual Total	$125.5

Commodities Costs:	
Description	Proposed FFY 1997
Holohil radio transmitters - 50 at 200.00 each	10.0
Radio telemetry supplies - sutures, epoxies, anethetics, gloves	0.5
Commodities Total	$10.5

1997

Prepared:

Project Number:
Project Title:
Name:

FORM 4B
Contractual & Commodities DETAIL

1997 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

New Equipment Purchases:	Number of Units	Unit Price	Proposed FFY 1997
Description			
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number of Units	
Description		

1997

Prepared:

Project Number:
Project Title:
Name:

FORM 4B
Equipment
DETAIL

4/12/96

97183

HOMER SOCIETY OF NATURAL HISTORY
PRATT MUSEUM
3779 Bartlett Street
Homer, Alaska 99603
(907) 235-8635 FAX (907) 235-2764

Accredited by the American Association of Museums

APRIL 11, 1996

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
645 G STREET, SUITE 401
ANCHORAGE, ALASKA 99603

DEAR COUNCIL MEMBERS:

The Pratt Museum would like to submit the enclosed informal restoration project idea for your consideration. As you know, the Museum produced the only comprehensive exhibition on the Exxon Valdez oil spill, "Darkened Waters: Profile of an Oil Spill." The exhibition's national tour, which began in June 1991, will end in August 1997.

The Board of Directors and staff of the Pratt Museum believe that upon completion of the tour, "Darkened Waters" should be placed in an Alaskan facility where it will receive high visibility and continue to inform the public. We feel that the effort to accomplish this is a valid focus for a restoration project, and hope that the Trustee Council will agree. While the Pratt Museum is not in a position to develop this idea into a formal restoration proposal, our staff could assist the Council or its designated agent in doing so.

Please let us know if you would like to discuss this idea or if you require additional information. All of us involved in the "Darkened Waters" project appreciate the Council's past support and eagerly await your response to this restoration project idea.

Sincerely,

Michael S. O'Meara

MICHAEL S. O'MEARA
SPECIAL PROJECTS COORDINATOR/"DARKENED WATERS" CURATOR

97183

HOMER SOCIETY OF NATURAL HISTORY
PRATT MUSEUM
3779 Bartlett Street
Homer, Alaska 99603
(907) 235-8635 FAX (907) 235-2764

Accredited by the American Association of Museums

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
FY97 INFORMAL RESTORATION PROJECT IDEA

PLACEMENT OF "DARKENED WATERS: PROFILE OF AN OIL SPILL" IN A PERMANENT, ALASKAN EXHIBITION SITE

INTRODUCTION

The project would result in acquisition and placement of the traveling version of "Darkened Waters: Profile of an Oil Spill" in a permanent, Alaskan exhibition site. The effort to accomplish this is a valid focus for a restoration proposal because it would support and augment public outreach and education efforts already undertaken by the Council.

Since 1991 "Darkened Waters" has traveled to 15 venues throughout the United States, including the National Museum of Natural History at the Smithsonian Institution in Washington, D.C. More than a million Americans have seen the exhibition. Extensive visitor comments show that people are both moved and enlightened by the experience, carrying away a better grasp of the nature, extent, and significance of the Exxon Valdez oil spill, the progress of recovery, and ongoing restoration efforts.

In 1995 "Darkened Waters" was completely refurbished and updated in preparation for the Alaskan leg of the tour (November 11, 1995-April 30, 1996). The EVOS Trustee Council provided partial support ($3,000) for the 1995 update through an Alaska Department of Environmental Conservation restoration contract with the Pratt Museum. The balance of costs were met through a grant from the National Science Foundation.

"Darkened Waters" will continue its national tour through August 1997. It is therefore recommended that the first phase of the project be conducted during FY97. Work proposed for FY97 would include 1) an exhibition site search and selection process; 2) contractual negotiations with the Pratt Museum and the new exhibitor 3) purchase of the exhibition; 4) preliminary planning for storage and installation. Work proposed for FY98 would include 1) final planning, design, and fabrication of any updates or modifications; 2) installation of the exhibition.

The final exhibition site for "Darkened Waters" should be an Alaskan facility where it will receive high visibility and continue to inform the public. For example, a location such as the Alaska SeaLife Center or the University of Alaska Institute of Marine Sciences in Seward, Alaska would be ideal.

NEED FOR THE PROJECT

A. Statement of Problem

There are two places where the public can easily gain a general understanding of the Exxon Valdez oil spill, the status of recovery, and progress of restoration. One is at the Pratt Museum and the other is wherever the traveling version of "Darkened Waters" is appearing. At the end of August 1997, unless a final exhibit site is found, the traveling exhibition will no longer be available to inform ordinary people about these things.

The Exxon Valdez oil spill was a major event in Alaska's history. There were valuable lessons to be learned from that tragic experience. Not least among them is the importance of developing and maintaining strong scientific baseline study programs in marine areas which might be affected by a spill. Even with the Council's publication of yearly status reports, the general public cannot be expected to know what has been done since the spill to improve our scientific understanding of the biological resources throughout the spill area. People may not be aware that significant efforts to monitor and better understand the complex process of recovery are ongoing, as are projects designed to promote restoration.

"Darkened Waters" is a comprehensive presentation of these topics and more. It is designed to be accessible to the general public, not requiring research skills or a great commitment of time to gain a basic understanding of the Exxon Valdez spill, recovery, and restoration. This gives it a unique role as a supplement to the excellent Oil Spill Public Information Center in Anchorage and the soon to be built Alaska SeaLife Center. If the exhibition is not retained at a permanent site in Alaska this accessibility will be lost to the public.

B. Rationale/Link to Restoration

Installation of "Darkened Waters" in a permanent, Alaskan venue will support and extend the educational component of the Exxon Valdez Oil Spill Trustee Council's work. The exhibition tells not only the story of the nation's worst oil spill, but sets the stage for understanding the mission of the Council and the role

of the Alaska SeaLife Center. Only by understanding the nature and extent of the event which led to establishment of the Council and the Center, can people come to understand and appreciate the complex process of recovery and ongoing efforts toward restoration.

The Council's mission statement calls for "meaningful public participation" as one of the elements of the recovery and restoration process. The Council was an early and continuing supporter of the Pratt Museum's work in documenting and interpreting the Exxon Valdez oil spill for the public. As a result, "Darkened Waters" has brought the story, with periodic updating, to over a million Americans all across the United States. Permanent exhibition of "Darkened Waters" in Alaska will continue to assure meaningful public participation in the restoration process.

PROJECT OBJECTIVES

A. Provide a permanent, comprehensive and accessible source of information in Alaska about the Exxon Valdez oil spill, the recovery process, and restoration projects.

B. Encourage meaningful public participation in the restoration process.

C. Increase public awareness of the status of recovery throughout the Exxon Valdez spill area.

COLLABORATIVE EFFORTS

While the Pratt Museum cannot formally develop this proposal, it is prepared to provide consultation and limited staff support in the event that the Council chooses to do so. The Museum will also consider entering into whatever contractual agreements might be required for sale, planning, design, updating, modification, or installation of the exhibition at a permanent exhibition site.

In the event that the Council elects to fund purchase and installation of "Darkened Waters" at such a site, the Pratt Museum is prepared to negotiate forgiveness of a substantial portion of the exhibition's cost as an in-kind contribution to the project. The traveling version of "Darkened Waters" was produced at a cost of approximately $462,000. It is presently insured for $300,000.

DARKENED WATERS TOUR VENUE LIST
JUNE 1991 - AUGUST 1997

Oakland Museum, Oakland CA
National Museum of Natural History (Smithsonian), Washington DC
South Florida Science Museum, West Palm Beach FL
Virginia Museum of Natural History, Martinsville VA
Carnegie Science Center, Pittsburgh PA
California Museum of Science and Industry, Los Angeles CA
San Diego Natural History Museum, San Diego CA
The Children's Museum, Bettendorf IA
Museum of Science Park, Boston MA
The Museum of Scientific Discovery, Harrisburg PA
The Burke Museum, Seattle WA
The Whale Museum, Friday Harbor WA
The Alaska State Museum, Juneau AK
Anchorage MUseum of History and Art, Anchorage AK
University of Alaska Museum, Fairbanks AK
Kingman Museum of Natural History, Battle Creek MI (tentative)
Williamette Science and Technology Center, Eugene OR (tentative)
Delaware Museum of Natural History, Wilmington DE
Jenkinson's Aquarium, Point Pleasant Beach, NJ

■ U.S. apologizes
Defense Secretary William Perry told Japan the U.S. is sorry for the recent rape of a 12-year-old girl on Okinawa. Three U.S. servicemen are charged in the crime, which led to protests against the military. **Page 11**

■ Fishing boat sinks
Three crew members of a Juneau-owned fishing boat are safe after their vessel sank Tuesday west of Yakutat. The Yakutat Eagle went down after "some heavy rollers hit the stern pretty hard," said owner Jay Stevens. **Page 3**

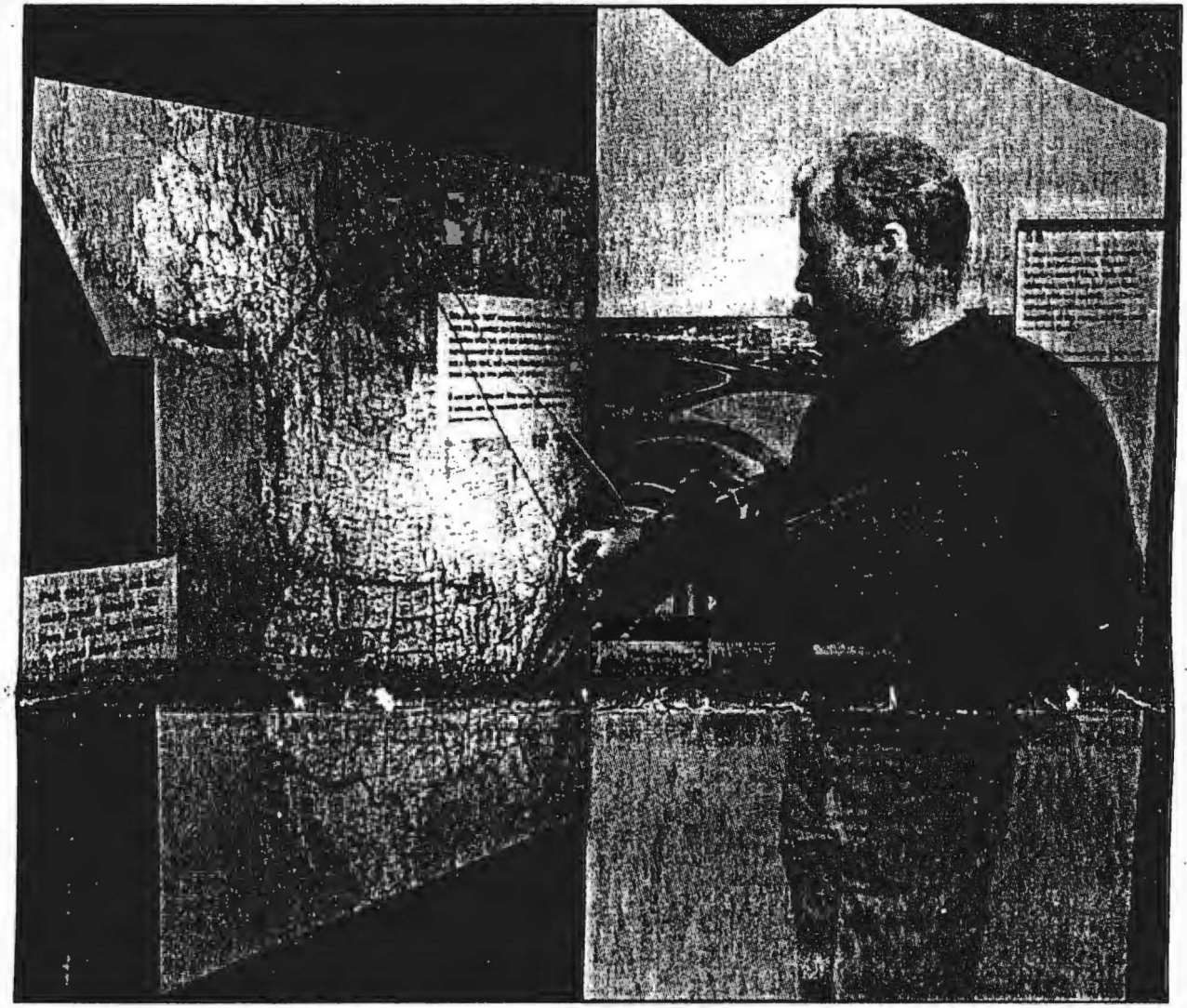
■ Echo Bay expands
Echo Bay Mines Ltd. is moving into the gold- and copper-mining business in the Philippines. The Kingking deposit is smaller than Echo Bay's Alaska-Juneau gold mine. **Page 7**

■ House battles abortion
The U.S. House moved to ban a little-used abortion procedure today in what is regarded as a first step to legislate an end to abortion rights. The bill would prohibit "partial-birth" abortions. **Page 5**

■ Vote rallies markets
Canadian financial markets rallied in the wake of the narrow defeat of a referendum allowing Quebec to leave Canada. Investors, relieved by the outcome, poured money back into Canadian investments. **Page 11**

STOCKS

How big is an oil spill?



BRIAN WALLACE / JUNEAU EMPIRE

Alaska State Museum curator Mark Daughhetee moves a plastic model representing the size of the Exxon Valdez oil spill around the Eastern seaboard portion of a map of the United States. The display is intended to give viewers the opportunity to see the size of the spill in relationship to other landmarks they are familiar with in the country, such as their hometowns. The map is part of an exhibit titled "Darkened Waters: Profile of an Oil Spill," which opens at the museum Thursday, with a reception planned from 4:30 p.m. tc 8 p.m. The exhibit remains at the museum through Dec. 2.

Rough data haunts Kensington

Straw po on Buch

■ Presidential candidate calls hin the 'true conserva

By MARK SABBATINI
THE JUNEAU EMPIRE

Alaska historically is no priority for presidential dates. There's a pittance ers, the weather's miserab the long plane trip is rath pensive.

So why is Pat Buchana has an appearance in J scheduled Friday, about come the first candidate in memory to visit the state why are at least two other candidates considering a vis

"You've got a straw January," said Buchanan Tuesday phone interview Arizona.

Buchanan said the earli usual poll increases the importance in the race si precedes the Iowa caucu New Hampshire primary, u considered the start of the paign.

The conservative comm tor for CNN's "Crossfire gram said he believes the fight is establishing who the alternative to Kansa Bob Dole, the current fr ner, and a strong showing i ka should generate media tion that will boost suppo ther south.

"I think it is going to g siderable attention," he sai

Buchanan touts himself "real conservative" in the supporting exploratory dri the Arctic National Wildli uge and increased logging

)MORROW'S
)RECAST:
ouds, showers
GH -- low40s
)W -- low 40s

) CENTS

WHAT'S BEING SAID: *"Who's being fooled, Congress or Alaska?"* — Sylvia Ward, Northern Alaska

:tal Center / Page 3

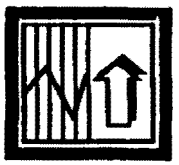
JUNEAU Empire

'The Voice of Alaska's Capital City'

OL.84 NO. 260

FRIDAY
NOV. 3, 1995

work. Page 3



today.
issues led declin-
2 to 1 on the New
change, with 1,450
nd 786 unchanged.
volume totaled
shares vs. 396.15
sday.
composite index
4.27. The Nasdaq
ex rose 6.04 to
Page 7

Exhibit takes visitors back to oil spill

By CATHY BROWN
THE JUNEAU EMPIRE

Capt. Joe Hazelwood's voice echoed in the Alaska State Museum Thursday, bringing visitors more than six years back to the spring when oil coated hundreds of miles of Alaska shoreline, and sea birds and otters struggled and died under tarred wings and oiled fur.

"It was like a war," recalled Greg Chaney, "only the enemy wasn't another army, it was the oil that was floating around Prince William Sound."

Chaney worked on the Exxon Valdez oil spill, and he and his family were among about 80 solemn-faced visitors to the exhibit "Darkened Waters: Profile of an Oil Spill," which opened Thursday night at the museum.

> "It was like a war, only the enemy wasn't another army, it was the oil that was floating around Prince William Sound."
>
> **Greg Chaney, recalling his work on the Exxon Valdez oil spill**

The exhibit, which originated at the Homer Society of Natural History's Pratt Museum, brings to Juneau the sights, sounds and even the smell of the

Please turn to Oil, Page 8

-OTHER SIDE-

Clinton signs legis
amending Native C

By BETTY MILLS
EMPIRE WASHINGTON BUREAU

WASHINGTON – President Clinton has signed into law a package of amendments to the Alaska Native Claims Settlement Act, including resolution of a longstanding dispute over ownership and removal of asbestos from the old Wrangell Institute.

The bill was signed Thursday at a White House ceremony attended by Alaska's congressional delegation and several other members of Congress.

Under
Cook Inl
lected a
that had
tute, onc
fairs bo
years
learned
hazardou
The C
sought
property
ment an
uncontai
P

Oil . . .

Continued from Page 1

1989 spill, which dumped nearly 11 million gallons of oil in Prince William Sound.

Visitors can lift a lid on an oil barrel for a whiff of crude; they can touch cleanup garb and an otter pelt; they can view photographs and documents and bumper stickers and political cartoons.

On one side of the room, a pushed button activates a recording of Exxon Valdez Capt. Hazelwood's initial, gravelly-voiced report that the tanker had "fetched up, hard aground," off Bligh Reef. On the other side of the room the voice of an Alaska Native subsistence user mourns "instead of gathering life, we're gathering death."

Bob LeResche, who was oil spill coordinator for the state, was one of the visitors to the exhibit. He said he had been curious whether it would be a "diatribe" against the oil industry or a "warm, fuzzy assurance that everything's fine."

It was neither, he said, and he was impressed. "It looks like it's designed to be educational, and it's legitimately educational. It really doesn't seem to be excessively biased either way.

"What I like about it is it sort of captures the feeling for people that weren't there," he said. "You can smell a drum of oil."

Rachel Baker, a former Illinoisan who just moved to Juneau six months ago, said the exhibit was "extremely helpful" for her. "I knew it was bad; this really puts it in perspective."

"I don't think people realize what else comes with our dependence on oil," said Wendy Campbell, a seasonal Alaska worker from New York state, who watched spill coverage from a distance six years ago.

"It's amazing," her friend, Aaron Prussian said. "This would be great if something like this could travel."

In fact, the exhibit has traveled. Mark Daughhetee, curator of exhibits at the museum, said "Darkened Waters" has been shown in Florida, Virginia, Pennsylvania, California, Louisiana, Massachusetts and Washington. After closing in Juneau Dec. 2, it will travel to Anchorage and Fairbanks.

Some Juneau exhibit visitors, like 4-year-old Connor Chaney, weren't even born when the spill happened. "What happens in an oil spill?" Connor asked his mother.

His parents remembered clearly what happens. Greg Chaney, a geomorphologist, who studied the pre-spill Prince William Sound coastline, was actually working at the state museum when the spill happened. He quit his job and immediately went to the sound to work.

"He was gone for months," his wife, Bonnie, recalls.

"I picked up a lot of those animals when they were dead," Chaney said. "That stays with you. Especially when you've seen it beforehand."

A museum exhibit can't completely capture what happened in 1989, he said. "It's like a war. It can't be contained. Everyone has their own perspective."

"It touches a lot of it, a lot of it," said former spill worker and Douglas resident Michael Dunlap. "But it just touches it."

Citizen . . .

Continued from Page 1

Hagevig say she has a balanced and thoughtful approach that helps meetings run smoothly.

"She brings a sense of warmth to a gathering that makes it kind of easy to do business," said city Community Development Director Murray Walsh, who worked with Hagevig as the planning commission debated a permit for the Alaska-Juneau gold mine. "Particularly during the mining period things were kind of intense at times and I never saw her lose her composure and behave in a way that was less than professional."

Before Hagevig was elected to the city-borough assembly she raised extra bedding plants for an annual primrose sale. Then her greenhouse was crushed by snow and she became too busy to put on the sale.

She rarely goes salmon fishing anymore either, as she used to with her husband, Bill Hagevig, who died in 1991.

"That's one of the reasons she keeps herself so busy is there's nobody at home," said Laraine Derr, who has known Hagevig since 1980. "I would do the same thing."

The
had dia
series o
came
mism.
her leg
the Do
left he
but ha
ing th
against
Fools I
dystro
"Sh
the ab
that r
them i
with li
who fi
the De
years
Hag
partm
years,
work
nating
grams
work
home
ucatio
"T
of son
her w
She

Ration . . .

Continued from Page 1

to $31 million for the current fiscal year.

Agency director Pam Varni said combining the offices of legal assistance and research will save $488,300 by eliminating a director

sponsored child-care programs to privatization of prison food services.

Staff attorneys at Legislative Legal Services draft bills and revise statutes for legislators and provide legal opinions.

The combined legislative research and legal staffs will be

man, with two ombudsman positions cut in Juneau and half a position cut in Anchorage.

Legislators also cut almost $400,000 from their own budget for salaries, travel and per diem – the amount legislators are paid while in Juneau or traveling to cover food and housing costs.

House Speaker Phillips said re-

Sign . . .

Continued from Page 1

chorage-based Native corporation has already paid $1 million to stabilize the property, and was facing an estimated $1.2 million bill to

city of
does
will
cleani
The
the In
bill.

Coded Wire Tag Recoveries From Pink Salmon in Prince William Sound

Project Number:	97186
Restoration Category:	General Restoration and Research/Monitoring
Proposer:	Alaska Department of Fish and Game
Lead Trustee Agency:	Alaska Department of Fish and Game
Cooperating Parties:	Prince William Sound Aquaculture Corporation Valdez Fisheries Development Association
Alaska SeaLife Center:	
Duration:	Ninth year, eleven year project
Cost FY 97:	$275,100
Cost FY 98:	$290,300
Cost FY 99:	$ 90,000
Cost FY 00:	$0
Cost FY 01:	$0
Cost FY 02:	$0
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pink Salmon

ABSTRACT

Pink salmon play a major role in the Prince William Sound ecosystem as well as in the economy of Cordova and other local communities. There is a growing body of evidence indicating that the *Exxon Valdez* oil spill has been at least partially responsible for weak pink salmon returns to the Sound. Pink salmon runs are dominated by hatchery populations, and efforts to restore injured wild populations through selective harvesting of hatchery fish depend upon the availability of data pertaining to the spatial and temporal abundance of wild fish in

the different fishing areas of Prince William Sound. This study will provide accurate, real-time and post-season estimates of hatchery and wild contributions to commercial harvests by date and fishing district, and also to hatchery cost-recovery harvests. This information is important for fisheries managers who must anticipate the effects of fishing strategies on injured populations. Similar analyses of coded wire tag data funded by the Natural Resource Damage Assessment and Restoration processes have been used to justify time and area fishery closures and effectively reduce exploitation on oiled pink salmon populations in portions of southwestern Prince William Sound in 1990, 1991, 1992, 1993, 1994 and 1995.

INTRODUCTION

Pink salmon play a major role in the Prince William Sound ecosystem. Migrating pink salmon fry are an important Spring food source for various fish, birds and terrestrial mammals. Marine mammals, birds, and fish also prey on the ocean life stages of pink salmon and returning adult wild salmon comprise a large portion of the summer diet of terrestrial mammals and birds such as bears, river otters, wolverines, bald eagles, gulls, and kittiwakes. Returning adult salmon also provide a pathway for the transfer of nutrients accumulated from high seas marine areas to near-shore and terrestrial ecosystems. As the principal species harvested in the Prince William Sound salmon purse seine fishery, pink salmon play a major role in the commercial fishing and fish processing industries which are the backbone of the economy in Cordova and other Prince William Sound communities. Ex-vessel values for this fishery ranged from 10 to almost 40 million through the 1980's.

Prince William Sound pink salmon returns originating from brood years subsequent to the March 24, 1989, *T/V Exxon Valdez* oil spill have been aberrant or weak, with the exception of those of 1994. Returns of wild and hatchery pink salmon in 1991 arrived late, had very compressed run timing, and the fish were small and of poor commercial quality. Returns of pink salmon in 1992 and 1993 were far fewer than expected, while those of 1994 and 1995 were more in line with expectations. The 1992 return of wild pink salmon was the fourth smallest even year return in the last 30 years and the hatchery return was less than one third of expected. The 1993 return of wild pink salmon was the third smallest in the last 30 years and the hatchery return was less than one fifth of expected. Both wild and hatchery returns of 1994 and 1995 were a significant improvement over the preceding two years.

There is a growing body of evidence which indicates that the *Exxon Valdez* oil spill was partially responsible for the weak pink salmon returns to Prince William Sound. Much of the spawning for wild pink salmon (up to 75% in some years) occurs in intertidal areas. Intertidal spawning areas are susceptible to marine contaminants and there is strong evidence the *Exxon Valdez* oil spill adversely affected spawning success and early marine survival in Prince William Sound. Mortalities of pink salmon embryos incubating in the intertidal portions of oiled streams in western Prince William Sound have been significantly higher than those which incubated in nearby unoiled streams (otherwise it sounds as if this has occurred every year since 1989) (Sharr et. al. 1994a, Bue et al. (in press)). Despite apparent reductions in the amount of observable oil in intertidal salmon spawning areas since 1990, the differences in mortality between oiled and unoiled streams persisted in 1991, 1992 and 1993 and were also observed in spawning areas upstream of oil influence (Sharr et. al. 1994b, Bue et al. (in press)). These findings may be indicative of heritable genetic damage which may have resulted in reproductive impairment among first and second generation fish originating from populations which incubated in oiled streams in 1989 and 1990.

In addition to damage incurred during the embryo stages of development, pink salmon fry and

juveniles rearing in the western portions of Prince William Sound in 1989 also exhibited reduced growth and survival (Willette and Carpenter, 1994). Because almost all wild and hatchery fry exit Prince William Sound through the straits and passages that were most heavily oiled, it is likely that at least portions of almost all pink salmon populations in Prince William Sound were damaged as rearing fry and juveniles in 1989. There are presently no data to substantiate any hypotheses regarding heritable damage to populations which traveled and fed in oiled marine waters as fry in 1989. Nevertheless, such a possibility is plausible given the findings of Sharr et al. (1994c).

Although hatchery pink salmon production in Prince William Sound began in the 1970's, the large returns associated with maximum permitted fry production did not occur until the late 1980's and early 1990's and consequently coincided with the *Exxon Valdez* oil spill era. Returns of wild salmon are dominated by the more productive hatchery populations and are therefore heavily exploited in commercial, sport, and subsistence fisheries. To sustain production from wild populations, managers must insure adequate escapements of wild fish to their natal streams, and that the escapement occurs in a smooth fashion over the season so that the genetic make-up of the populations is maintained. To achieve these goals, mixed-stock fisheries must be managed to achieve exploitation rates appropriate for the less productive wild populations throughout the season. Managers need, therefore, to be able to estimate the relative spatial and temporal abundance of wild fish in the different fishing areas of Prince William Sound.

The proposed coded wire tag study will provide accurate, real-time and post-season estimates of hatchery and wild contributions to commercial and hatchery cost-recovery harvests by date and fishing district. Such catch contribution estimates, together with real-time escapement estimates from an Alaska Department of Fish and Game aerial survey program will be used inseason by fisheries managers to reduce exploitation of wild stocks and to target effort on hatchery returns. Post season analyses of tag recovery data will be coupled with escapement data for wild populations to make estimates of total wild returns, which will in turn allow assessment of the effectiveness of various management strategies. Post season analyses will also identify time and area distribution trends for wild and hatchery fish in fisheries. This information is important for fisheries managers who must anticipate the effects of fishing strategies in future years if injured populations are to be protected. Similar analyses of coded wire tag data funded by the and Restoration processes have been used to justify time and area fishery closures and effectively reduce exploitation on oiled populations in portions of southwestern Prince William Sound in 1990, 1991, 1992, 1993, and 1994.

The results of the coded wire tag recovery project are also critical to the success of an integrated package of the Sound Ecosystem Assessment program. The Sound Ecosystem Assessment proposal has roots in a broader plan developed by the Prince William Sound Fisheries Ecosystem Research Planning Group, a bioregional coalition of Prince William Sound scientists, resource managers, resource users, aquaculture associations, and

communities, formed to "develop an ecosystem level understanding of the natural and man-caused factors influencing the production of pink salmon...in Prince William Sound". Many of the Sound Ecosystem Assessment program projects, such as those falling under the Salmon Growth Component and the Salmon Predation Component are dependent upon information provided by this coded wire tag study.

In the absence of the improved management capabilities afforded by this project, salmon stocks in western Prince William Sound which have been injured and depleted through oil impacts may be over-exploited in the commercial, sport and subsistence fisheries. Population levels of stocks may be reduced below those needed for rapid recovery and in some instances may result in elimination of impacted stocks. In the absence of the information provided by the coded wire tag program, some of the projects under the Sound Ecosystem Assessment program will also fail.

NEED FOR THE PROJECT

A. Statement of Problem

Wild pink salmon runs in Prince William Sound which were injured by the *Exxon Valdez* oil spill need to be protected from overharvest during commercial fisheries. This is difficult to accomplish since these injured wild populations migrate through fishing areas with uninjured populations as well as large hatchery runs. It is not possible to simply close these fishing areas without severely affecting local and state economies. Inseason and postseason information on the mix of the various runs in fishing areas allows fishery managers to direct fishing effort away from injured wild runs and to achieve desired spawning escapement goals.

B. Rationale/Link to Restoration

Coded-wire tag application has been the tool of choice for uniquely marking hatchery pink salmon in Prince William Sound. This technique has been used in Prince William Sound to estimate hatchery and wild stock contributions to commercial harvests since 1986, and has also been used in preliminary studies of straying. Although placement and recovery of coded wire tags is expensive and labor intensive, and effects of tags on survival and homing are not well described, this technique has been the most practical and reliable way to date in which to mark large numbers of small pink salmon fry.

C. Location

This project will be conducted in the Prince William Sound region. Pink salmon fry will be marked at the three hatcheries operated by the Prince William Sound Aquaculture Corporation (Armin F. Koerning, Wally H. Noerenberg, and Cannery Creek) and the single hatchery

operated by the Valdez Fisheries Development Association (Solomon Gulch). Sampling sites will depend upon disposition of the commercial and hatchery cost-recovery harvests and will most likely occur in various Prince William Sound communities (i.e. Cordova, Valdez, and Whittier), Seward, Anchorage, Kenai and Kodiak. Some sampling may also be done aboard processing vessels in Prince William Sound as well as at hatchery sites.

COMMUNITY INVOLVEMENT

This program is cooperatively funded by both Prince William Sound Aquaculture Corporation and the Valdez Fisheries Development Association the two private, nonprofit hatchery groups operating within Prince William Sound. These two groups are operated by a mix of individuals with ties to commercial, sport, personal use and subsistence fishing as well as by community representatives. Large scale tagging programs have been a cooperative effort between the Alaska Department of Fish and Game and these private, nonprofit aquaculture groups since the late 1980's.

Project plans and reports on results of the coded wire tag program have been reviewed by the Prince William Sound/Copper River Regional Planning Team as well as interested fishing industry groups. As part of the Trustee Council Natural Resource Damage Assessment and Restoration process, the coded wire tag recovery program has been subjected to extensive peer review and annual public review and comment. Results of the coded wire tag program were presented at the March 1993 Oil Spill Symposium sponsored by the Trustee Council, the 1993 Pink and Chum Workshop, the annual spring meeting of the Prince William Sound Aquaculture Corporation Board of Directors, the 1994 Alaska Board of Fisheries meeting and the 1996 Restoration Workshop.

The coded wire tag program is also critical to the success of the integrated package of the Sound Ecosystem Assessment studies. The Sound Ecosystem Assessment program has roots in a broader plan developed by the Prince William Sound Fisheries Ecosystem Research Planning Group. Many Sound Ecosystem Assessment program projects depend upon information provided by coded wire tags.

The project will employ local residents for data collection activities in fish processing plants located in Cordova, Valdez, Whittier, Seward, Anchorage, Kenai, and Kodiak, and at hatcheries in Prince William Sound. The project will also employ residents of Juneau for tag extraction and decoding activities performed by the Alaska Department of Fish and Game Tag Laboratory. Permanent Alaska Department of Fish and Game Biologists stationed in Cordova and biometrics staff stationed in Anchorage will complete data analyses and reports. Goods and services required by the project will be obtained from vendors in the local communities where data are collected.

PROJECT DESIGN

A. Objectives

Trustee Council funds plus those contributed by the Alaska Department of Fish and Game, the Prince William Sound Aquaculture Corporation, and the Valdez Fisheries Development Association will contribute to the completion of the following objectives for the 1997 salmon season in Prince William Sound:

1. Using undecoded-tag data, provide timely inseason estimates of the temporal and spatial contributions of tagged hatchery stocks of pink salmon to Prince William Sound commercial and hatchery harvests.

2. Assess the properties of a new, faster, but potentially less reliable inseason estimator of contributions of tagged hatchery stocks, which is based upon undecoded tags and estimates of tender loads (catches).

3. Using decoded-tag data, provide hatchery-specific estimates of the temporal and spatial contributions of tagged hatchery stocks to the commercial and cost-recovery harvests in Prince William Sound.

4. Estimate marine survival rates for each uniquely coded hatchery release group of pink salmon.

B. Methods

Personnel policy, purchasing practices, field camp operations, safety procedures, and project administration will be in compliance the Alaska Department of Fish and Game Division of Commercial Fisheries Manual of Standard Operating Procedures (SOP). Data collection and estimation procedures are similar to those used in Natural Resource Damage Assessment Fish/Shellfish Study #3. These procedures have been thoroughly reviewed by the Natural Resource Damage Assessment peer review process and approved by the Management Team.

Commercial and Cost-Recovery Harvests

Recoveries will be stratified by district, week, and processor. This stratification was chosen as a result of the findings of Peltz and Geiger (1990) who detected significant differences between the proportions of some tag codes among such strata. The differences indicate that processors tend to receive catches from only certain parts of a district and is believed to be the result of traditional tendering patterns.

Recoveries of pink salmon tags from commercial and cost-recovery harvests will be made as

fish are pumped from tenders onto conveyor belts at land-based processors located in Cordova, Valdez, Seward, Anchorage, Whittier and aboard a floating processor after each opening. Fish will be sampled by technicians standing beside the belt. Each sampled fish will be subjected to a visual and tactile examination for a missing adipose fin. It will never be possible for an observer to census all fish from a tender during the unloading process. However, on occasion, holding tanks in processing plants contain fish from only one tender. In those instances it will be possible for an observer standing on the processing line to get a census of an entire tender load which was previously sub sampled by technicians on the unloading conveyor. A Chi-square test of independence will be used to compare the rate of occurrence of adipose fin clips in the census with that observed in the random sample from the load.

Data recorded for each tender will include harvest type (i.e., commercial or cost-recovery catch), fishing district(s) from which the catch was taken, catch date, processor, and the number of fish examined. Catch data will be obtained later from fish tickets.

Heads of adipose-fin clipped fish will be excised, identified with a uniquely numbered cinch tag, and bagged. These heads will then be individually passed through a tag detector machine which produces an audible signal in the event that the head contains a coded wire tag. This procedure yields numbers of undecoded tags in the sample. Heads will then be frozen for subsequent shipment to the Alaska Department of Fish and Game coded wire tag Laboratory in Juneau (Tag Lab).

Brood Stock Harvests

Tag shedding from release to return and differential mortality between tagged and untagged fish lead to discrepancies between marking rates at release and recovery. Hatchery brood stocks will be scanned for tags in order to estimate adjustment factors which can be used to account for the loss of tags from the population. Three assumptions inherent in the use of the brood stock for this purpose are a) the brood stock consists solely of fish reared at the hatchery, b) the tendency for a tagged fish to lose a tag or to die is similar for all fish marked at the same hatchery, and c) for a specific tag code, the marking rate in the commercial fishery is the same as that in the brood stock. It is believed that the first of these assumptions is violated at all facilities except at the W.H.Noerenberg hatchery (Sharr et. al. 1994f). Consequently, a historical average adjustment factor calculated from the brood stock from the W.H.Noerenberg hatchery is considered an appropriate quantity with which to adjust for tag loss and differential mortality. With respect to the second assumption, tagging practices vary little within a facility, and it is believed that the rate of tag loss and tag-induced mortality are similar for all fish tagged within a hatchery. The third assumption relates to the possibility of tag-induced straying of hatchery fish away from the brood. Some histological evidence to this end was referenced in Sharr et al. (1994d).More direct preliminary evidence is discussed by Sharr et al. (1994f), although recent attempts to reproduce these results in a different area of

Prince William Sound have failed.

The adjustment factor for hatchery h, a_h, will be estimated as the ratio of sampled fish in the brood stock to the expanded number of fish based on tags found in the sample :

$$\hat{a}_h = \frac{s_h}{\sum_i^T \frac{x_i}{p_i}} \qquad 1$$

where,

T	=	number of tag codes released from hatchery h,
p_i	=	tagging rate at release for the ith tag code (defined as number of tagged fish released with the ith tag code divided by the total number of fish in release group i),
x_i	=	number of tags of the ith code found in s_h and,
s_h	=	number of brood stock fish examined in hatchery h.

The historical (1989-1996 for inseason, 1989-1997 for postseason) average W. H. Noerenberg adjustment factor will then be used to adjust contribution estimates (Equation 2) if it can be shown that it was significantly greater than 1.0 at the 90% level.

While only the (historical) adjustment factor associated with the W. Noerenberg facility will be used in any contribution estimation, brood stock samples will be taken during hatchery egg-take operations at each of the four Prince William Sound pink salmon hatcheries. Technicians, will examine approximately 95% of the fish through visual and tactile means for missing adipose fins. The number of fish sampled will be recorded and when adipose-clipped fish are found, the heads will be excised and shipped on a weekly basis along with sample data to the Tag Lab.

Tag Extraction, Tag Decoding, and Data Archiving

During the fishing season all sampling data and heads from adipose-clipped fish will be sent daily to the Alaska Department of Fish and Game Tag Lab. Data received at the Tag Lab will be logged and tag recovery sampling forms edited for accuracy and completeness. Samples which affect critical fisheries decisions will be processed first. Tag lab staff will locate and remove tags from heads, decode extracted tags, and enter tag code and sample data into a statewide database accessible to biologists in Cordova. Completed tag recovery data for prioritized samples will be transmitted electronically to Cordova project personnel within 36 hours of the receipt of unprocessed data at the Tag Lab. In the following 12 hours Cordova

project personnel will integrate tag recovery and catch data from the Alaska Department of Fish and Game fish ticket reporting system to estimate hatchery and wild catch contributions. Contribution estimates are used by fisheries managers to implement the inseason management actions required.

Following the fishing season, processing of all lower priority tag recovery samples will be completed by the Tag Lab. All tags recovered throughout the season will be examined a second time to insure that they have been properly decoded. All codes will be validated with a master Pacific States Marine Fisheries Commission list of codes potentially present in Pacific coast fisheries. Fully edited tag code and sampling data from all samples collected during the season will be forwarded to the Cordova office for final summarization and analyses. A complete historic database of coded wire tag information from Prince William Sound tagging and tag recovery programs will be maintained by the Alaska Department of Fish and Game Tag Lab, the Pacific States Marine Fisheries Commission and, the Cordova office of the Alaska Department of Fish and Game. The Alaska Department of Fish and Game historic fish ticket catch database is maintained at the Alaska Department of Fish and Game Juneau headquarters office and in the Cordova area office. All tagging and recovery data and all fisheries harvest data are freely available from any of these sources.

Postseason Hatchery Contributions and Survival Rates

The contribution of release group t to the sampled common property, cost-recovery, brood stock and special harvests, and escapement, C_t , will be estimated as:

$$\hat{C}_t = \sum_{i=1}^{L} x_{it} \left(\frac{N_i \, \hat{a}_h}{s_i \, p_t} \right) \qquad 2$$

where,

x_{it}	=	number of group t tags recovered in ith stratum,
N_i	=	total number of fish in ith stratum,
s_i	=	number of fish sampled from ith stratum,
p_t	=	proportion of group t tagged,
a_h	=	adjustment factor associated with hatchery h, and
L	=	number of recovery strata associated with common property, cost-recovery, broodstock, special harvests and escapement in which tag code t was found.

The contribution of release group t to unsampled strata, Cu_t, will be estimated from contribution rates associated with strata which were sampled from the same district-week openings as the unsampled strata:

$$\hat{C}_t = \sum_{i=1}^{U} \left[N_i * \left(\frac{\sum_{j=1}^{S} \hat{C}_{tj}}{\sum_{j=1}^{S} N_j} \right) \right] \qquad 3$$

where,

U	=	number of unsampled strata,
N_i	=	number of fish in ith unsampled stratum
S	=	number of strata sampled in the period in which the unsampled stratum resides,
C_{tj}	=	contribution of release coded with tag t to the sampled stratum j, and
N_j	=	number of fish in jth sampled stratum.

When a district-week opening is not sampled at all (an infrequent occurrence), the catch from that opening will be treated as unsampled catch of the subsequent opening in the same district. An estimate of the contribution of tag group t to the total Prince William Sound return for 1996 will be obtained through summation of contribution estimates for sampled and unsampled strata. An estimate of the total hatchery contribution to the Prince William Sound return will be calculated through summation of contributions over all release groups. A variance approximation for C_t , derived by Clark and Bernard (1987) and simplified by Geiger (1988) will be:

$$\hat{V}(\hat{C}_t) = \sum_{i=1}^{L} x_{it} \left[\frac{N_i \hat{a}}{s_i p_t} \right] \left[\frac{N_i \hat{a}}{s_i p_t} - 1 \right] \qquad 4$$

Assuming that covariance's between contributions of different release groups to a stratum can be ignored, summation of variance components over all tag codes will provide an estimate of the variance of the total hatchery contribution. Inspection of the formula given by Clark and Bernard (1987) for the aforementioned covariance's shows them to be negligible for large N and s, and to be consistently negative, so that when ignored, conservative estimates of variance are obtained. Variances associated with unsampled strata are believed to be small (Sharr et al., 1994d).

The survival rate of the release group coded with tag t (S_t), will be estimated as:

$$\hat{S}_t = \frac{\hat{C}_t + \hat{C}u_t}{R_t} \qquad 5$$

where,

C_t = contribution of release coded with tag t to sampled strata,
Cu_t = contribution of release group coded with tag t to unsampled strata,
R_t = total number of fish in release group coded with tag t released from hatchery.

Assuming the total release of fish associated with a tag code is known with negligible error, and that the cumulative variance contributions associated with the unsampled strata are small, a suitable variance estimate for S_t is given by:

$$\hat{V}(\hat{S}_t) = \frac{\sum_{i=1}^{L} x_{i\,t}\left[\frac{N_i\,\hat{a}}{s_i\,p_t}\right]\left[\frac{N_i\,\hat{a}}{s_i\,p_t}-1\right]}{R_t^2} \qquad 6$$

Inseason Hatchery Contributions

Inseason fisheries decisions which must be made on very short notice require rapid, real time analysis of coded wire tag data. Three inseason estimates of hatchery contributions of pink salmon will be generated for each opening. The first and most timely estimate will be calculated using knowledge of numbers of tags (undecoded) found in a sample taken from the catch and an estimate of that catch. The presence of tags in adipose-clipped fish will be discerned by passing their excised heads over a scanner identical to those used by the Tag Lab. The estimate of the catch aboard tenders will be obtained from tender captains or processor operators. In the event that catch estimates cannot be obtained, a simple unweighted average (over sampled tenders) proportion of hatchery fish in the catch will be reported. Estimation using undecoded tags requires that assumptions be made about expansion ($1/p_t$) and adjustment (a) factors (see Equation 2). For fishery openings in the western and northern portions of Prince William Sound, late-run returns from the Prince William Sound Aquaculture Corporation facilities are assumed to be the only hatchery contributors. For openings in the Southwestern district, an expansion factor which is a weighted average of all expansion factors associated with tags released at the A.F. Koernig, W.H. Noerenberg and Cannery Creek hatcheries in 1996, will be used. The weighting scheme depends upon historical contributions of hatcheries to the district in question. A similar weighting scheme for expansion factors will be used for the Coghill and Northern districts and will involve historical contributions associated with the Cannery Creek and W.H. Noerenberg hatcheries. For openings in the eastern part of Prince William Sound, returns to the Valdez Fisheries Development Association Solomon Gulch facility are assumed to be the only hatchery contributors. With respect to an appropriate expansion factor for these openings, the average of all factors

associated with tags released from the Solomon Gulch facility in 1996 will be used. An average historical (1989-1996) adjustment factor associated with the W. Noerenberg facility will be used for all inseason contribution estimates. These estimates can be made available at any stage of the unloading process, and only require that some sampling has been conducted. The precision of the estimate is, of course, increased as more of the catch is sampled. Such readily available, but less precise estimates will play a significant role in those fishery management decisions that have to be made before the more precise estimates which require exact catch figures and larger sample sizes are available. Calculations of inseason contributions will follow those used to generate post-season results (Equation 2). The second estimator will be identical to the first, except that it will be calculated only after sampling of an opening is completed and after exact tender loads have been reported. The result will be a less timely but more reliable estimate. The third estimator will be less timely still because it will rely on exact catch data and extracted and decoded tags. Use of code-specific expansion factors will, however, provide hatchery-specific contribution estimates and will mean a reduction in bias of the estimates resulting from use of average expansion factors.

Alternatives

Estimation of stock- specific contributions to large commercial fisheries requires some sort of natural or man-induced mark which is characteristic of the stock or groups of stocks to be distinguished. Any mark to be used for estimates of stock specific catch contributions for inseason fisheries management must: (1) be naturally present in all or a fixed portion of the population or easy to apply permanently to a fixed portion of the population in the early life stages before stock mixing occurs, (2) be easy to distinguish in adult returns, (3) be present or can be applied to a large enough portion of the population such that significant numbers can be recovered among adult returns in a cost-effective manner for accurate and precise estimates of catch contributions, and (4) not affect survival or behavior of fish.

Until recently, coded wire tag technology has been the only man-induced mark available which meet most of the above criteria. Although this technology has given us the opportunity to distinguish hatchery and wild fish in commercial harvests with reasonable accuracy and precision, it is not without problems. The pink salmon tagging program in Prince William Sound is the largest of its kind in the world and is pushing the limit of the technology for both application and recovery. Application in very small fish such as pink salmon may affect survival, may not be permanent (tag loss), and tagging may affect behavior. Some methods exist and are used to adjust for tag loss from differential mortality and tag shedding. The effect of tag-induced straying, though thought to be small, is, however, difficult to accommodate. On the recovery side, large and expensive sampling programs must be implemented to ensure sufficient precision of contribution estimates.

An alternative mark which circumvents the above drawbacks would be desirable. The most likely alternative to coded wire tags are thermal or chemical otolith marks. Otolith marking methods meet all of the five criteria described above. Thermal marks have been thoroughly tested in all salmon species. They are permanent, are easily applied to every individual in a hatchery population and are less expensive to apply and recover relative to coded wire tags. Because they can be applied to every individual in the population, contribution estimates based on thermal marks will be more accurate and precise than those based on coded wire tags. Differential mortality of tagged fish will no longer be a problem. Because the mark is non intrusive, permanent tag loss through shedding and straying of tagged fish will also be eliminated. A large scale otolith marking program for Prince William Sound hatchery pink salmon releases is underway. Recoveries of otolith marks from these releases will begin in 1997.

Chemical marking of otoliths has not been tested in salmon to the same degree as thermal marking, but is widely used in other species. Chemical marking requires that young fish be fed or immersed in a chemical agent which leaves a recognizable band on otoliths or skeletal structures. Tetracycline is one widely used chemical which deposits a distinctive skeletal or otolith growth band which is florescent under ultraviolet light. Because it is retained in the tissues, Food and Drug Administration permits for its use in fish destined for human consumption fish were initially difficult to obtain but permitting is now done on a routine basis for many species. The method has promise for marking wild fish where heated water is not available for thermal marks.

To date no natural markers have been discovered in Prince William Sound pink salmon which allow researchers to distinguish hatchery stocks from all wild stocks. Genetic marks are a possibility but hatchery parent stocks in Prince William Sound originated from wild stocks in the area and are shared by more than one facility, and hence are probably not distinguishable.

C. Contracts:

This is a cooperative program funded by the Trustee Council, the Alaska Department of Fish and Game, the Prince William Sound Aquaculture Corporation, and the Valdez Fisheries Development Association. The Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division will ensure that 1) pink salmon catches are scanned for pink salmon with clipped adipose fins; 2) representative samples of heads from adipose-clipped pink salmon are collected and shipped to the Juneau Tag Laboratory; 3) information obtained from this project is adequately documented and cataloged, 4) biometrics review of methods and data analysis is obtained, and 5) reports documenting results are written. The Alaska Department of Fish and Game Tag Laboratory in Juneau will extract and decode all coded-wire tags from samples of pink salmon heads sent from Prince William Sound. Funds from the Prince William Sound Aquaculture Corporation and the Valdez Fisheries Development Association for coded-wire tag recovery operations will be conveyed to the Alaska Department of Fish and Game through cooperative agreements.

SCHEDULE

A. Measurable Project Tasks for FY 97

October 1996 - June 1997:	Hire personnel; order supplies; create and test computer programs and spreadsheets; data analysis and reporting
January 22-25, 1997:	Attend Annual Restoration Workshop
March - April 1997:	Apply tags to pink salmon fry at hatcheries
April 15, 1997:	Submit annual project report for FY 96
June - Sept 1997:	Scan catches; recover tagged fish in harvests and brood stocks; recover/decode tags; provide inseason catch composition estimates by time and area
April 15, 1998:	Submit annual report for FY 97

B. Project Milestones and Endpoints

March - April 1997:	Apply tags to brood year 1996 pink salmon fry
April 15, 1997:	Annual report for FY 96
June - September 1997:	Estimate harvest stock composition for brood year 1995
April 15 1998:	Completion report for program
June - September 1998:	Estimate harvest stock composition for brood year 1996
April 15 1999:	Completion report for program

C. Completion Date

This multi-year project will be completed in FY 99. At this time, the Trustee Council has approved two years of overlap between the coded-wire tag and otolith marking programs. The 1998 season would be the last year to recover coded-wire tags and funding for final data analysis and report writing would be made available in FY 99. Peer reviewers at the 1995 Restoration Workshop unanimously recommended two years of overlap between these programs to ensure that coded-wire tags could continue to be applied and recovered in 1998 if the otolith marking program did not meet its objectives in 1997.

PUBLICATIONS AND REPORTS

An annual project report will be submitted by April 15 of each year.

PROFESSIONAL CONFERENCES

Project results should be presented at either the Alaska Chapter of the American Fisheries Society Annual meeting or the biennial Pink and Chum Salmon Workshop or both. The next

occurrence of these meetings after the data are collected and analyzed will be the fall of 1998 and spring of 1999.

NORMAL AGENCY MANAGEMENT

The *Exxon Valdez* Trustee Council has played a major role in the development of pink salmon stock identification in Prince William Sound. The Trustee Council provided support for the coded wire tag program during the damage assessment phase because the project provided essential information for evaluating injury to salmon stocks as well as invaluable data used by managers to direct harvests away from damaged wild stocks. The program has been jointly funded during the Restoration phase with the Trustee Council contributing nearly half of the funds, the remainder being contributed by the Prince William Sound Aquaculture Corporation, the Valdez Fisheries Development Association and the Alaska Department of Fish and Game. Although the coded wire tag program provided data of a sort previously unavailable to managers, shortcomings in the technique became apparent as the project evolved. The most significant related to tag expansions and were associated with the inability to mark all fish in the population. It was at this time that large-scale thermal mass marking emerged as a promising new methodology, and funds were sought from the Trustee Council to implement the program in Prince William Sound. A timeline and budget has been formulated for the near-future development of the Prince William Sound stock identification program. It consists of continued development of the thermal mass marking program, with two years of overlap with the coded wire tag program (Table 1). By FY 2000, program funding will be the responsibility of the Prince William Sound Aquaculture Corporation, the Valdez Fisheries Development Association and the Alaska Department of Fish and Game.

Table 1. Budgets for otolith marking and coded wire tagging programs for stock-identification of pink salmon in Prince William Sound (thousands of dollars).

	FY96	FY97	FY98	FY99	FY2000
CWT_a program					
	Recover BY 94 Tag BY 95	Recover BY 95 Tag BY 96	Recover BY 96	Reports	
Trustee Council	248.6	283.3	290.0	90.0	0.0
ADF&G[b]	81.6	57.6	65.0	55.0	0.0
PWSAC[c]/VFDA[d]	277.6	280.3	130.0	0.0	0.0
Total	607.8	621.2	485.0	145.0	0.0

Prepared:4/15/96 Project: 97186

Otolith program

	Mark BY 95 Sampling Experiments	Mark BY 96 Recover BY 95	Mark BY 97 Recover BY 96	Mark BY 98 Recover BY 97	Mark BY 99 Recover BY 98
Trustee Council	93.2	130.6	113.0	55.0	0.0
ADF&G	0.0	58.3	65.0	108.0	158.0
PWSAC/VFDA	0.0	64.1	75.0	205.0	155.0
Total	93.2	253.0	253.0	368.0	313.0
Total Program					
Trustee Council	341.8	413.9	403.0	145.0	0.0
ADF&G	81.6	115.9	130.0	163.0	158.0
PWSAC/VFDA	277.6	344.4	205.0	205.0	155.0
Grand Total	701.0	874.2	738.0	513.0	313.0

a Coded wire tag
b Alaska Department of Fish and Game
c Prince William Sound Aquaculture Corporation
d Valdez Fisheries Development Association

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The foundations for this project were firmly established in joint feasibility studies which were conducted by the Alaska Department of Fish and Game and non-profit aquaculture associations in Prince William Sound beginning in 1986 and extending through 1988. Results of these studies have been summarized by Peltz and Miller (1990), Peltz and Geiger (1990), and Geiger and Sharr (1990). During the damage assessment process large scale tagging and recovery projects were instituted and perfected by Natural Resources Damage Assessment Fish/Shellfish Study #3. Damage assessment funds were expended for tagging hatchery releases of pink salmon in 1989 and 1990 and wild populations of pink salmon in 1990 and 1991 (Fish/Shellfish Study #3). Tag recovery efforts for wild and hatchery pink salmon were funded by damage assessment funds in 1989, 1990, and 1991 (Fish/Shellfish Study #3) and by restoration funds in 1992 and 1993 (Restoration Studies 60A and 93067). Results of damage assessment and restoration coded wire tag studies have been reported by Sharr et. al. (1994d, 1994e and 1994f). Following the loss of funds for further tagging of hatchery stocks of pink salmon in 1990, the private non-profit aquaculture groups in Prince William Sound have continued to tag pink salmon releases at their own expense. Tags applied to pink fry from the four pink salmon hatcheries in Prince William Sound in 1996 must be recovered to provide comparative data for the otolith mark recoveries which will begin in 1997. The Prince

William Sound Aquaculture Corporation, the Valdez Fisheries Development Association, and the Alaska Department of Fish and Game have pooled their resources to come up with approximately half of the funds required to field a full fledged pink salmon tag recovery effort in 1997. The additional funds to complete tag recovery efforts and data analyses are to be provided by the Trustee Council.

The pink salmon coded-wire tag recovery program has complimented several other projects since 1989. Improved escapement estimates for Prince William Sound pink salmon from Natural Resource Damage Assessment Fish/Shellfish Study 1 and restoration Study 60B were used in conjunction with catch contribution estimates from the coded wire tag recovery projects to adjust fishery exploitation rates and achieve wild stock escapements. Growth and survival estimates from Fish/Shellfish Study #4 could not have been obtained without Fish/Shellfish Study #3 which provided tagged fish of known origin and release timing. The pink salmon coded wire tag recovery program is also integrated with several other salmon restoration projects being conducted in Prince William Sound in 1997. It will complement the Sound Ecosystem Assessment program, the multi-disciplinary program designed to develop of understanding of the mechanisms regulating ecosystem function in Prince William Sound. The Sound Ecosystem Assessment program is focused on interactions of pink salmon and herring with other components of the Prince William Sound ecosystem. Marked pink salmon provide a valuable tool for examining interactions between wild and hatchery salmon during the early marine period. The salmon growth component of the Sound Ecosystem Assessment program uses marked pink salmon to evaluate habitat overlap between wild and hatchery salmon, to examine the size composition of wild and hatchery salmon in mixed schools, and to estimate juvenile salmon mortality during the time of ocean residence. The salmon predation component of the Sound Ecosystem Assessment program uses marked pink salmon to determine whether predators select wild or hatchery salmon.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

No changes have occurred in the project design and schedule from the DPD approved in FY96 by the Trustee Council.

PROPOSED PRINCIPAL INVESTIGATOR

Timothy L. Joyce
Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division
P.O. Box 669
Cordova, Alaska 99574-669
(907) 424-3214 (phone)

Prepared:4/15/96 Project: 97186

(907) 424-3235 (FAX)
timj%fishgame@state.ak.us (E-mail)

PERSONNEL

The Principal Investigator (PI) for the project will be a permanent full-time Fisheries Biologist III (FB III) for the Alaska Department of Fish and Game. The PI will be responsible for writing project operational plans, administering project budgets, quality control of data collection, supervising data analyses and, co-authoring final reports. A Fisheries Biologist II (FB II) will supervise day to day project operations, maintain data quality, assist in data analyses, and co-author final reports. The FB II will be assisted by one permanent seasonal Fisheries Biologist I (FB I). The FB I will be in charge of supervising day to day sampling activities in Cordova and will assist the PL in supervising sampling at other ports, on floating processors, and at hatcheries. Non-permanent Fish and Wildlife Technician III's (FWT III) will be stationed in Cordova and Valdez and will assist the FB I as crew leaders. The crews in each port will be non-permanent FWT II's. Each day, two persons on each crew will scan pink salmon at each processing plant. Under the supervision of the FB I, the FWT III's will conduct daily data logging, editing and archiving activities in Cordova and Valdez.

A Biometrician I from the Alaska Department of Fish and Game Commercial Fisheries and Development Division Region II office in Anchorage will provide biometrics support for the project. The Biometrician I will assist in experimental design, inseason and post season data analyses, and report writing.

The PI, FB II or, FB I will maintain daily phone contact with project technicians stationed in ports other than Cordova or Valdez and at several remote hatchery locations. Copies of data forms from these sites will be faxed to Cordova daily and heads from sampled fish will be shipped once or twice weekly to Cordova via scheduled commercial flights or via chartered aircraft depending upon which is available. The PL, APL, or project Fisheries Biologist I's will make routine supervisory visits to each sampling port via chartered or commercial aircraft at least twice monthly for sampling quality control inspections, data collections, and industry contacts. The Biometrician I will travel to Cordova several times during the season to assist with inseason data analyses and occasionally after the season to assist with final data analyses and report writing.

TIMOTHY L. JOYCE - Fisheries Biologist III Principal Investigator

Mr. Joyce has a Bachelor of Science in Fisheries Science from Oregon State University (1973).
Mr. Joyce was appointed to the Fisheries Biologist III position in July of 1995. Prior to this appointment he worked for the State of Alaska as a hatchery manager at Kitoi Bay which was the largest multi-species salmon production facility run by the state. He did some of the initial half-length coded wire tag work on emergent pink salmon fry from 1982 through 1987. He co-authored an article titled "Retention Rates of Half-Length Coded Wire Tags Implanted in

Emergent Pink Salmon " published in the American Fisheries Society Symposium 7:253-258, 1990. He has over 17 years experience in salmon hatchery production in Alaska working with all five species of Pacific salmon, but primarily with pink salmon. Prior to his position as the hatchery manager at Kitoi Bay, Mr. Joyce worked in Sand Point, Alaska as a high school teacher instructing in Aquaculture, fish culture and biology. He was responsible for a small demonstration hatchery run by the school district with Johnson O'Malley funds where students had hands on training of salmon culture using pink and coho salmon. Mr. Joyce also has extensive experience in warm water fish culture gained while in Africa working as a Peace Corps volunteer at a UN development project under the FAO.

RENATA RIFFE - Fisheries Biologist II Research Biologist

Ms. Riffe has a Master of Science in Statistics from Colorado State University (1994), a Master of Science in Fisheries Management from the University of Alaska, Fairbanks (1987), and a Bachelor of Science in Fishery Biology from Colorado State University (1981). Since October 1994 Ms. Riffe has worked on the coded wire tag project as an FBII Research Biologist in the capacity of Assistant Project Leader. Prior to her current position, (from June 1991 - October 1994), she was employed as a biologist with the Alaska Department of Fish and Game, Sport Fish Division in Fairbanks, Alaska, and assisted in projects concerning abundance estimation and population evaluation of pike, grayling, humpback whitefish, least cisco, rainbow trout, burbot, chum salmon, and king salmon. From May 1982 - January 1991, she worked as a technician with the Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division in Juneau, Alaska. Her primary duties involved sampling commercial salmon fisheries and salmon escapements, with some report writing. She also developed discriminant function models for stock separation of Lynn Canal sockeye salmon, by scale pattern analysis, developed a computer model which simulated migratory timing of salmon escapements, and evaluated truncated escapement counts. She has authored reports for the Alaska Department of Fish and Game on estimates of abundance and survival rates of round whitefish, compilation of age and length data for rainbow trout in southwest Alaska, and migratory timing of salmon in the Situk River, Alaska.

SEAWAN GEHLBACH - Fisheries Biologist I

Ms. Gehlbach has a Bachelor of Science in biology from the University of New Hampshire (1992). Ms. Gehlbach has worked on the coded wire tag project as an FBI for the past three fishing seasons. Her responsibilities include hiring and supervising 20 Fish and Wildlife Technician II's that sample in eight ports around Prince William Sound. She has been responsible for the duties of the current APL during the change in PI. She has produced inseason data analysis for management staff and post season data analysis for the annual coded wire tag reports. Prior to her current position with the Alaska Department of Fish and Game,

she worked for Sport Fish Division in Juneau, as a short term Fish and Wildlife Technician II; her duties included collecting coded wire tag data and catch information for the sport fishery. Ms. Gehlbach has also worked for the Douglas Island Pink and Chum (DIPAC) hatchery in Juneau as a field observer, and later in the hatchery as a member of the incubation and broodstock collection crews.

DAVID EVANS - Biometrician I

Mr. Evans has a Bachelor of Science in soil science from the University of Nottingham (U.K.), a Master of Science and a Doctor of Philosophy degree in soil science from the University of Guelph (Ontario, Canada), and a Master of Science in statistics from Oregon State University. David has worked with the Alaska Department of Fish and Game since October, 1991. His primary responsibility has been analysis of coded-wire-tag data from Prince William Sound. He has designed the statistical procedures and computer spread sheets used for inseason analysis of tag recovery data, has overseen most of the post season data analyses and has co-authored interim and final reports for the 1991 Fish /Shellfish Study #3, the 1992 Restoration Study 60C, and the 1993 Restoration study 93067.

LITERATURE CITED

Bue, B.G., S. Sharr, S.D. Moffitt, and A.K. Craig. (*in press*). Effects of the Exxon Valdez oil spill on pink salmon embryos and preemergent fry. *In* Rice, S.D., R.B. Spies, D.A. Wolfe, and B.A. Wright, editors. *Exxon Valdez* Oil Spill Symposium Proceedings. American Fisheries Society Symposium.

Clark, J.E., D.R. Bernard. 1987. A compound multivariate binomial hypergeometric distribution describing coded microwire tag recovery from commercial salmon catches in southeastern Alaska. Informational Leaflet 261. Alaska Department of Fish and Game, Division of Commercial Fisheries.

Geiger, H.J. 1990. Parametric bootstrap confidence intervals for estimating contributions to fisheries from marked salmon populations. American Fisheries Society Symposium 7:667-676.

Geiger, H.J., and S. Sharr. 1990. The 1988 Tag Study of Pink Salmon From The Solomon Gulch Hatchery in Prince William Sound, Alaska. *In* Pilot Studies in Tagging Prince William Sound Hatchery Pink Salmon With Coded Wire Tags. Fisheries Research Bulletin No. 90-02. Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau, Ak.

Peltz, L., and H.J. Geiger. 1990. A Tagging Study of the Effect of Hatcheries on the 1987

Pink Salmon Fishery in Prince William Sound, Alaska. *In* Pilot Studies in Tagging Prince William Sound Hatchery Pink Salmon With Coded Wire Tags. Fisheries Research Bulletin No. 90-02. Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau, Ak.

Peltz, L., and J. Miller. 1990. Performance of half-length coded-wire tags in a pink salmon hatchery marking program. American Fisheries Society Symposium 7:244-252.

Sharr, S., B.G. Bue, S.D. Moffitt, and A.K. Craig. 1994a. Injury to salmon eggs and preemergent fry in Prince William Sound - F/S 1. State/Federal Natural Resources Damage Assessment Final Report. *Exxon Valdez* Trustee Council, Anchorage, Alaska.

Sharr, S., J.E. Seeb, B.G. Bue, S.D. Moffitt, A.K. Craig, and G.D. Miller. 1994b. Injury to salmon eggs and preemergent fry in Prince William Sound - R60C. State/Federal Natural Resources Restoration Final Report. *Exxon Valdez* Trustee Council, Anchorage, Alaska.

Sharr, S., J.E. Seeb, B.G. Bue, A.K. Craig, and G.D. Miller. 1994c. Injury to salmon eggs and preemergent fry in Prince William Sound - R93003. State/Federal Natural Resources Restoration Final Report. *Exxon Valdez* Trustee Council, Anchorage, Alaska.

Sharr, S., T.M. Willette, C.J. Peckham, D. G. Sharp, J.L. Smith, D.G. Evans, and B.G. Bue. 1994d. Coded Wire Tag Studies On Prince William Sound Pink Salmon, 1989-1991. State/Federal Natural Resources Damage Assessment Final Report. *Exxon Valdez* Trustee Council, Anchorage, Alaska.

Sharr, S., C.J. Peckham, D. G. Sharp, J.L. Smith, D.G. Evans, and B.G. Bue. 1994e. Coded Wire Tag Studies On Prince William Sound Pink Salmon, 1992. State/Federal Natural Resource Restoration Draft Report .*Exxon Valdez* Trustee Council, Anchorage, Alaska.

Sharr, S., C.J. Peckham, D. G. Sharp, D.G. Evans, and B.G. Bue. 1994f. Coded Wire Tag Recoveries From Pink Salmon in Prince William Sound Salmon Fisheries, 1993. State/Federal Natural Resource Restoration Draft Report. *Exxon Valdez* Trustee Council, Anchorage, Alaska.

Willette, T.M. and G. Carpenter. 1994. Early marine salmon injury assessment in Prince William Sound - F/S #4. State/Federal Natural Resources Damage Assessment Final Report. *Exxon Valdez* Trustee Council, Anchorage, Alaska.

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997	LONG RANGE FUNDING REQUIREMENTS					
			Estimated FFY 1998	Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	Estimated FFY 2003
Personnel	$108.2	$196.2						
Travel	$12.7	$12.7						
Contractual	$100.6	$31.7						
Commodities	$2.9	$2.9						
Equipment	$0.0	$0.0						
Subtotal	$224.4	$243.5						
General Administration	$24.2	$31.6						
Project Total	$248.6	$275.1	$290.0	$90.0	$0.0	$0.0	$0.0	$0.0
Full-time Equivalents (FTE)		4.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: This is a cooperative project between the Trustee council, Alaska Department of Fish and Game, Prince William Sound Aquaculture Corporation (PWSAC) and Valdez Fisheries Development Association (VFDA). Following is a breakout of funds provided by each entity:

Trustee Council	$275.1 k
ADF&G	$56.8 k
PWSAC	$192.0 k
VFDA	$70.0 k

1997

Project Number: 97186
Project Title: Coded Wire Tag Recoveries from Pink Salmon, PWS
Agency: Trustee Council

FORM 3A
AGENCY
PROJECT
DETAIL

Prepared: 4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Personnel Costs:			GS/Range/	Months	Monthly		Proposed
PM	Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1997
	David Evans	Biometrician I	17F	5.0	5,278	0	26.4
	Tim Joyce	FBIII	18L	3.0	6,861	0	20.6
		FTII(Valdez)	9A	3.5	2,159	4,922	12.5
		FTII(Anchorage)	9A	2.0	1,945	1,800	5.7
		FTII(Kodiak)	9A	1.0	2,120	1,580	3.7
		FTII(Kenai)	9A	2.0	1,945	1,800	5.7
		FTIII(Cordova)	9A	2.0	2,439	3,593	8.5
	Tag lab technicians	FTII (Juneau)	9A	23.0	2,864	0	65.9
	Seawan Gehlbach	FBI	14C	7.0	4,444	1,106	32.2
	Renata Riffe	FBII	16C	3.0	5,000	0	15.0
							0.0
							0.0
		Subtotal		51.5	35,055	14,801	
Those costs associated with program management should be indicated by placement of an *.						**Personnel Total**	$196.2

Travel Costs:		Ticket	Round	Total	Daily	Proposed
PM	Description	Price	Trips	Days	Per Diem	FFY 1996
*	Fishery Biologist III and II travel to Anchorage for workshops	224	3	9	150	2.0
	Supervisory trips to Whittier	224	4	8	150	2.1
	Supervisory trips to Anchorage	224	4	8	150	2.1
	Supervisory trips to Seward	224	3	6	150	1.6
	Supervisory trips to Kodiak	610	3	5	150	2.6
	Supervisory trips to Kenai	300	4	7	150	2.3
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
Those costs associated with program management should be indicated by placement of an *.					**Travel Total**	$12.7

1997

Project Number: 97186
Project Title: Coded Wire Tag Recoveries from Pink Salmon, PWS
Agency: Trustee Council

FORM 3B
Personnel
& Travel
DETAIL

4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Contractual Costs:	Proposed
Description	FFY 1996
Tag Lab Costs	10.0
Air Charters for brood stock sampling	2.0
Air Charters for Supervision and Data Transport	12.2
Dept. of Transportation Vehicle Rental	3.4
Office Costs	3.6
Maintenance Magnetic Tag Detectors	0.5
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$31.7

Commodities Costs:	Proposed
Description	FFY 1996
Rain gear, gloves, knives, sampling kits, supplies	2.9
Commodities Total	$2.9

1997

Project Number: 97186
Project Title: Coded Wire Tag Recoveries from Pink Salmon, PWS
Agency: Trustee Council

FORM 3B
Contractual & Commodities DETAIL

4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1996
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

1997

Project Number: 97186
Project Title: Coded Wire Tag Recoveries from Pink Salmon, PWS
Agency: Trustee Council

FORM 3B
Equipment
DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997						
Personnel	$81.6	$56.8						
Travel	$0.0	$0.0						
Contractual	$0.0	$0.0						
Commodities	$0.0	$0.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$81.6	$56.8	Estimated FFY 1998	Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	Estimated FFY 2003
General Administration	$0.0	$0.0						
Project Total	$81.6	$56.8	$65.0	$55.0	$0.0	$0.0	$0.0	$0.0
Full-time Equivalents (FTE)		0.9						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: This is a cooperative project between the Trustee council, Alaska Department of Fish and Game, Prince William Sound Aquaculture Corporation (PWSAC) and Valdez Fisheries Development Association (VFDA). Following is a breakout of funds provided by each entity:

Trustee Council	$275.1k
ADF&G	$56.8 k
PWSAC	$192.0 k
VFDA	$70.0 k

1997

Project Number: 97186
Project Title: Coded Wire Tag Recoveries from Pink Salmon, PWS
Agency: AK Dept. of Fish & Game

FORM 3A
AGENCY
PROJECT
DETAIL

Prepared: 4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Personnel Costs:			GS/Range/	Months	Monthly		Proposed
PM	Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1997
	Seawan Gehlbach	Fisheries Biologist I	14C	3.0	4,444	473	13.8
	Tim Joyce	FB III	18L	3.0	6,861	0	20.6
	Renata Riffe	FB II	16C	3.0	5,000	0	15.0
		FT III(Cordova)	11A	2.0	2,783	1,800	7.4
						0	0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
		Subtotal		11.0	19,088	2,273	
Those costs associated with program management should be indicated by placement of an *.						**Personnel Total**	$56.8

Travel Costs:		Ticket	Round	Total	Daily	Proposed
PM	Description	Price	Trips	Days	Per Diem	FFY 1996
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
Those costs associated with program management should be indicated by placement of an *.					**Travel Total**	$0.0

1997

Project Number: 97186
Project Title: Coded Wire Tag Recoveries from Pink Salmon, PWS
Agency: AK Dept. of Fish & Game

FORM 3B
Personnel
& Travel
DETAIL

4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Contractual Costs:	Proposed
Description	FFY 1996
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed
Description	FFY 1996
Commodities Total	$0.0

1997

Project Number: 97186
Project Title: Coded Wire Tag Recoveries from Pink Salmon, PWS
Agency: AK Dept. of Fish & Game

FORM 3B
Contractual & Commodities DETAIL
4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1996
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

1997

Project Number: 97186
Project Title: Coded Wire Tag Recoveries from Pink Salmon, PWS
Agency: AK Dept. of Fish & Game

FORM 3B
Equipment
DETAIL

4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997	LONG RANGE FUNDING REQUIREMENTS					
			Estimated FFY 1998	Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	Estimated FFY 2003
Personnel	$185.4	$195.0						
Travel	$0.0	$0.0						
Contractual	$0.0	$0.0						
Commodities	$66.0	$67.0						
Equipment	$0.0	$0.0						
Subtotal	$251.4	$262.0						
General Administration	$8.2	$13.7						
Project Total	$259.6	$275.7	$130.0	$0.0	$0.0	$0.0	$0.0	$0.0
Full-time Equivalents (FTE)		5.4						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: This is a cooperative project between the Trustee council, Alaska Department of Fish and Game, Prince William Sound Aquaculture Corporation (PWSAC) and Valdez Fisheries Development Association (VFDA). Following is a breakout of funds provided by each entity:

Trustee Council	$275.1 k
ADF&G	$56.8 k
PWSAC	$192.0 k
VFDA	$70.0 k

1997

Project Number: 97186
Project Title: Coded Wire Tag Recoveries from Pink Salmon, PWS
Agency: PWSAC & VFDA

FORM 3A
AGENCY
PROJECT
DETAIL

Prepared: 4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Personnel Costs:			GS/Range/	Months	Monthly		Proposed
PM	Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1997
		FTIII Valdez	11A	3.0	2,782	2,700	11.0
		FT II Cordova	9A	16.0	2,465	13,652	53.1
		FTII(Valdez)	9A	6.0	2,465	4,782	19.6
		FTII(Anchorage)	9A	2.0	1,945	1,800	5.7
		FTII(Kodiak)	9A	1.0	2,120	1,580	3.7
		FTII(Kenai)	9A	2.0	1,945	1,800	5.7
		FTIII(Cordova)	11A	4.0	2,782	3,604	14.7
		FT II Floating Processor	9A	2.0	2,465	3,862	8.8
		Tag lab technicians	9A	2.0	2,864	0	5.7
		Tagging personnel		26.8	2,500	0	67.0
							0.0
							0.0
		Subtotal		64.8	24,333	33,780	
Those costs associated with program management should be indicated by placement of an *.						**Personnel Total**	$195.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
PM	Description	Price	Trips	Days	Per Diem	FFY 1996
*						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
Those costs associated with program management should be indicated by placement of an *.					**Travel Total**	$0.0

1997

Project Number: 97186
Project Title: Coded Wire Tag Recoveries from Pink Salmon, PWS
Agency: PWSAC & VFDA

FORM 3B
Personnel
& Travel
DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Contractual Costs:	Proposed
Description	FFY 1996
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed
Description	FFY 1996
Coded wire tags	67.0
Commodities Total	$67.0

1997

Project Number: 97186
Project Title: Coded Wire Tag Recoveries from Pink Salmon, PWS
Agency: PWSAC & VFDA

FORM 3B
Contractual &
Commodities
DETAIL

4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1996
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

1997

Project Number: 97186
Project Title: Coded Wire Tag Recoveries from Pink Salmon, PWS
Agency: PWSAC & VFDA

FORM 3B
Equipment
DETAIL

4/15/96

Otolith Thermal Mass Marking of Hatchery Reared Pink Salmon in Prince William Sound

Project Number:	97188
Restoration Category:	General Restoration
Proposer:	Alaska Department of Fish and Game
Lead Trustee Agency:	Alaska Department of Fish and Game
Cooperating agencies:	Prince William Sound Aquaculture Corporation Valdez Fisheries Development Association
Alaska SeaLife Center:	
Duration:	Third year, five-year project
Cost FY 97:	$122,400
Cost FY 98:	$113,000
Cost FY 99:	$55,000 (Close-out)
Cost FY 00:	$0
Cost FY 01:	$0
Cost FY 02:	$0
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pink Salmon

ABSTRACT

Currently, the coded wire tag program fulfills the role of an inseason stock separation tool for Prince William Sound pink salmon. Recent questions, however, regarding the validity of some of the assumptions necessary for its successful implementation have led to the desire for a better technology. This project will develop otolith mass marking as such a technology. Otoliths are small bones in the inner ear of fish which can be visually marked through systematic changes in water temperature during embryo incubation. All hatchery-produced

salmon will be marked using this technique. Recoveries of these marks from returning adults caught in mixed-stock fisheries in Prince William Sound will allow estimation of the hatchery-wild composition of the catch. It is expected that the cost of catch-sampling will be reduced, with a concurrent increase in the precision and accuracy of inseason and postseason estimates of stock composition. Improved estimation of stock composition will enhance the fishery manager's ability to protect damaged wild pink salmon stocks in mixed-stock fisheries.

This project will be conducted cooperatively by the Alaska Department of Fish and Game, the Prince William Sound Aquaculture Corporation, and the Valdez Fisheries Development Association. In 1995, both hatchery associations installed the necessary equipment to mark the otoliths of all pink salmon embryos in the Armin F. Koernig, Wally H. Noerenberg, Cannery Creek, and Solomon Gulch hatcheries. Otolith thermal marking began after the embryos had passed the eyed stage of development in October 1995. Heated water was introduced at the hatchery head troughs allowing treatment of millions of pink salmon embryos simultaneously.

The project will be conducted over two pink salmon life cycles, marking both odd- and even-broodyear fish. Experience with two complete life cycles is needed to fully develop a program that integrates induced banding code quality, otolith processing rates and costs, and statistical designs for catch sampling. Especially important in the developmental phase are experiments to determine whether the proposed catch-sampling program can achieve unbiased samples.

When otolith marked fish return as adults in 1997 and 1998, approximately 160 pink salmon otoliths will be processed from each fishery opening to estimate the stock composition and associated confidence levels. A Bayesian approach will be used in the estimation of contribution estimates, with a dynamic sample size allocation scheme being used postseason to maximize sampling efficiency (Geiger, 1994).

Through sampling of outmigrating juveniles in the southwest passages of the Sound, growth rates and stock composition of the outmigrants may be determined. A comparison of the relative ratios of the numbers of juveniles from the different hatcheries in the sample to the ratios associated with the releases of fry will yield information pertaining to the relative fry to juvenile survival rates between facilities. By partitioning hatchery and wild juveniles, it may be possible to estimate the expected ratio of hatchery to wild pink salmon in the following year's adult return. It might also be possible after a period of time to base forecasts of pink salmon returns on the indexed number of fish captured each spring from these samples.

INTRODUCTION

Each year approximately one half billion wild pink salmon fry emerge from the streams of Prince William Sound and migrate seaward. Adult returns of wild pink salmon to Prince William Sound averaged approximately 10 million fish annually over the last two decades. The huge out-migrations of fry and subsequent adult returns of pink salmon play major roles in the Prince William Sound ecosystem. Both juveniles and adults are important sources of food for many fish, birds, and mammals. Adults returning from the high seas also convey needed nutrients and minerals from the marine ecosystem to estuaries, freshwater streams, and terrestrial ecosystems. Wild pink salmon also play a major role in the economy of Prince William Sound because of their contribution to commercial, sport, and subsistence fisheries in the area.

Up to 75% of the pink salmon spawning habitat in Prince William Sound occurs in intertidal areas. In the spring of 1989 oil from the *T/V Exxon Valdez* oil spill was deposited in layers of varying thickness in intertidal portions of many western Prince William Sound streams utilized by spawning salmon. Pink salmon embryos and fry rearing in these intertidal areas appear to have been adversely affected by the oil. Sharr et al. (1994a and 1994b) observed salmon embryo mortalities which were 67%, 51%, 96%, and 80% higher in oiled streams than in nearby comparable unoiled streams in 1989, 1990, 1991, and 1992. Wiedmer (1992) also observed a high incidence of deformities and elevated levels of cytochrome P-450 among fry in oiled streams in 1989. Willette (1993) reported reduced growth and survival of pink salmon fry and juveniles which reared in oiled marine waters of Prince William Sound in 1989. Mortality differences between oiled and unoiled streams in 1989 and 1990 were confined to intertidal spawning areas and may be attributed to direct lethal effects of oil. Large differences observed across all tide zones in 1991 and 1992 may be the consequence of damage to germ cells of the adults which originated from the 1989 and 1990 brood years when egg and larval exposures to intertidal oil were greatest. A consequence of this genetic damage may be persistent functional sterility and reduced returns per spawner for populations from oiled streams.

Prince William Sound pink salmon returns originating from brood years subsequent to the *Exxon Valdez* oil spill have been aberrant. Returns of wild and hatchery pink salmon in 1991 were only slightly below the mid-point of the pre-season forecast but arrived late and had very compressed run timing. The fish were also small and in advanced stages of sexual maturity long before reaching their natal streams. As a result, the fish were of little commercial value. Returns of pink salmon in 1992 and 1993 were far fewer than expected. The 1992 return of wild pink salmon was the fourth smallest even-year return in the last 30 years and the hatchery return was less than one third of the expected. The 1993 return of wild pink salmon was the third smallest in the last 30 years and the hatchery return was less than one fifth of the expected. The returns in 1994 and 1995 were much larger than those in 1992 and 1993, but were skewed to the eastern portion of Prince William Sound.

Although hatchery pink salmon production in Prince William Sound began in the 1970's,

returns from maximum permitted levels of fry production did not occur until the late 1980's and early 1990's and coincided with the *Exxon Valdez* oil spill era. Wild salmon populations injured by the *Exxon Valdez* oil spill are exploited in mixed stock commercial, sport, and subsistence fisheries which are dominated by returns from more productive hatchery populations. Wild pink salmon populations originate from hundreds of streams in Prince William Sound. Migratory timing and abundance of wild returns in marine fishing areas varies among populations. To sustain production from wild populations, managers must insure that adequate numbers of wild fish from all portions of the wild return escape fisheries and enter streams to spawn. To achieve this goal, mixed stock fisheries must be managed to achieve exploitation rates appropriate for less productive wild populations. To this end, managers must be able to distinguish wild from hatchery fish and estimate their relative spatial and temporal abundance in different fishing areas. The proposed otolith-marking program is designed to accomplish this task in an efficient and comprehensive manner.

NEED FOR THE PROJECT

A. Statement of the Problem

Coded wire tags have been the tool of choice for applying unique marks to hatchery pink salmon in Prince William Sound. The methodology has been used extensively to estimate hatchery and wild stock contributions to commercial harvests and has also been used in preliminary straying research. Trustee Council projects F/S3, R60C, 93067, 94320b, 95320b, and 96186 have all incorporated this technology to estimate contributions of wild and hatchery pink salmon returns to Prince William Sound since the *Exxon Valdez* oil spill. Despite its usefulness, there are drawbacks to coded wire tag technology. Approximately 1 million coded-wire tags must be applied to pink salmon fry each year to obtain catch contribution estimates for returning adults. Tagging and recovery are both very labor intensive and the number of tags applied and recovered are sometimes inadequate for the levels of accuracy and precision desired. Coded wire tags are also intrusive, tags can be shed, and tagging may affect subsequent survival. Tag loss through shedding and differential mortality of tagged individuals affects subsequent estimates of adult returns based on tag recoveries. There is also recent evidence that poor placement of coded-wire tags may cause salmon to stray (Habicht (*personal communication*; found in Appendix D of Seeb et al. 1995)). A new technology is needed to effectively separate stocks of pink salmon returning to Prince William Sound.

B. Rationale/Link to Restoration

Because of the cost and problems associated with coded-wire technology, other alternatives for marking larger portions of populations with relatively inexpensive non-intrusive methods must be investigated. This project will develop otolith mass-marking as an inseason and postseason stock-separation tool for pink salmon. By marking the otoliths of all of the fish in a population, sample sizes in the recovery phase may be much smaller without affecting the accuracy and precision of contribution estimates. The non-intrusive, permanent nature of the

otolith band eliminates concerns over mark-shedding and marking effects on survival and behavior, possible important sources of error in coded wire tag estimates. Numerous studies have documented the successful induction of pre-determined ring codes on fish otoliths by manipulation of water temperature during embryonic stages (Bergstedt et al. 1990, Brothers E.B. 1990, Munk and Smoker 1990, Volk et al. 1990). Each of these studies has provided information regarding the magnitude of temperature differences and the duration of temperature cycles needed to produce otolith rings. Recognizing the need to develop mass marking technology for pink salmon in Prince William Sound, the Alaska Department of Fish and Game and Prince William Sound Aquaculture Corporation reviewed the feasibility of otolith thermal marking at Prince William Sound hatcheries as well as otolith recovery in the commercial fisheries of Prince William Sound (Geiger et al. 1994). A commercial-level otolith marking and recovery program conducted in 1993 in S.E. Alaska (Hagen et al., 1995), identified an inseason otolith sampling and mass processing protocol potentially suitable for Prince William Sound. Additional work is needed to fully develop otolith thermal marking technology for application as an inseason commercial fisheries management tool for Prince William Sound.

In order to provide rapid information to area management biologists, recovered otoliths need to be examined and decoded by the following day. Establishing a dissecting and reading lab in Cordova in cooperation with the central processing lab in Juneau would provide the ability to give the management biologist timely information on stock composition for inseason management.

C. Location

The study will be undertaken in Prince William Sound. One of the benefits from the project will be a more sustainable local fishery, which will result in more stable local economies (fishermen, cannery employees, local retailers etc). Local tourism will also benefit. With protection of wild stocks in Prince William Sound, one of the more important driving forces of the whole Prince William Sound ecosystem will be assured, resulting in the maintenance of local ecological diversity and enhancement of the desire from the general public to visit the Sound.

COMMUNITY INVOLVEMENT

This project was developed through three months of ecosystem research planning by the Prince William Sound Fisheries Ecosystem Research Planning Group as part of the Sound EcoTsystem Assessment program. The Prince William Sound Fisheries Ecosystem Research Planning Group conducted public meetings each week in the fall of 1993. Scientists from the University of Alaska, University of Maryland, Prince William Sound Science Center, Prince William Sound Aquaculture Corporation, the Alaska Department of Fish and Game, and US Forest Service participated in the planning process. The resulting ecosystem research plan was reviewed by scientists from the United States and Canada at a public workshop held in

Cordova, Alaska in early December 1993. The methods and results of this project will continue to be reviewed by various scientists within the Program Management component of the Sound Ecosystem Assessment program.

This project is partially sponsored by the Prince William Sound Aquaculture Corporation, the regional private, non-profit (PNP) aquaculture association for Prince William Sound, and the Valdez Fisheries Development Association, a small PNP operation. Development of mass marking programs, such as the Prince William Sound coded wire tagging program, has been a cooperative effort between the Alaska Department of Fish and Game and Prince William Sound area private non-profit (PNP) aquaculture associations since the early 1980's. PNP's, operated by a broad constituency of commercial, sport, personal use, and subsistence fishers and community representatives, review coded-wire tag project plans and results annually before approving subsequent funding. Operational plans and results of mass marking projects are also reviewed periodically by the Prince William Sound/CR Regional Planning Team as well as interested fishing industry groups. As part of the Trustee Council NRDA and Restoration process the code-wire tag mass marking and recovery project has been subjected to extensive peer review and annual public review and comment. Results of coded-wire tag projects were presented at the March 1993 Oil Spill Symposium sponsored by the Trustee Council, the 1993 Pink and Chum Workshop, the annual Spring meeting of the Prince William Sound Aquaculture Corporation board of directors in 1993

and, the Alaska Board of Fisheries in 1994. The Prince William Sound Aquaculture Corporation and the Valdez Fisheries Development Association board of directors as well as the Prince William Sound/CR Regional Planning Team have endorsed development of otolith thermal mass marking of hatchery salmon in Prince William Sound.

PROJECT DESIGN

A. Objectives

A total of six major objectives will be achieved when the project is completed. Three of these will be achieved during FY 97 and all subsequent fiscal years:

1. Apply otolith thermal marks to all pink salmon embryos incubating in the Armin F. Koernig (AFK), Wally H. Noerenberg (WHN), Cannery Creek (CC), and Solomon Gulch (SG) hatcheries.

2. Evaluate the quality of otolith thermal marks applied to pink salmon embryos at AFK, WHN, CC, and SG hatcheries and collect voucher samples.

3. Estimate stock composition of commercial catches of pink salmon using otolith thermal marks.

The three remaining objectives will be achieved in FY97 and FY98:

4. Evaluate methodology for collecting samples from tender boats.

5. Evaluate quality of stock-estimation procedure.

6. Determine the feasibility of forecasting relative hatchery and wild run strength by sampling outmigrating juvenile pink salmon in the southwest passes of Prince William Sound.

B. Methods

Objective 1

Pink salmon will be marked during the eyed embryo to hatch stage at Prince William Sound hatcheries. This approach will eliminate the need to degas the incubation water, since gas saturation is not usually a problem for salmon embryos prior to hatch. Salmon embryos maintain a positive internal pressure which allows them to tolerate total dissolved gases up to 110-116%. It would be uncommon to have total dissolved gases of greater than 110% in incubation process water, but it may be possible to drive total dissolved gases this high through aggressive heating, and so total dissolved gases will be monitored during the thermal marking process. After hatching, gas-bubble disease can become a problem, and expensive degassing equipment would be required to mark the otoliths of alevins.

A unique otolith thermal mark will be used for each pink salmon hatchery in Prince William Sound. A unique hatchery mark will provide consistency in both application and recovery of the mark. The thermal mark will be applied in the eyed-embryo to hatch zone of the otolith. The eyed-embryo to hatch window occurs between September and December with an average length of 35 days. Approximately 22 days will be required to apply the thermal mark at each hatchery. The hatchery-specific codes are found in Table 1. The length of the hot and cold events may change to reflect cultural concerns at the time of marking, but the mark pattern will remain as listed. A single code for each hatchery will allow estimation of survival rate by hatchery. However, hatchery operators may also need to estimate survival rate for three treatment groups within each hatchery. In this case, a treatment-group code composed of three thermal rings can be applied in addition to the hatchery-specific base mark to distinguish among treatment groups.

Table 1. Proposed base marks for Prince William Sound pink salmon hatcheries. The thermal schedule describes the actual temperature regime. The letter "H" refers to relatively hot water, while "C" refers to relatively cold water, the difference between the two temperature levels being 4.0 degrees centigrade. The number directly before the thermal level is the number of rearing-hours at that level. Numbers in parenthesis before an "X" denote the number of repetitions.

Facility	Thermal Schedule	Banding Pattern
CC	(3X)36H:36C,(1X)72H:36C,(2X)36H:36C	III III
WHN	(8X)36H:36C	IIIIIIII
AFK	(4X)36H:36C	IIII
SG	(6X)36H:36C	IIIII

Objective 2

Evaluation of the thermal marking process will be made in two steps.

1) Characterization of the marks applied.

Determination of the banding patterns achieved by the marking process will be accomplished by formation of 'voucher sets' of otoliths representing all manifestations of a mark at a given hatchery. The size of each voucher set will be determined by the number of different patterns identified for the hatchery in question. Voucher sets will be formed for all four hatcheries producing pink salmon, and will be made available to readers assigned the task of partitioning the commercial catches of 1997 from otolith samples. Otolith preparation and assessment will be conducted at the Otolith Laboratory in Cordova, and will consist of extraction and grinding procedures to expose internal structures, followed by examination under a compound microscope. Quality control and data entry will be performed by Alaska Department of Fish and Game personnel from the statewide Otolith Laboratory in Juneau.

2) Determination of the success of the marking process.

The success of the marking process will be evaluated from the results of multiple readings of 'test sets' of otoliths originating from hatchery and wild fish. Just prior to fry swim-up, a random sample of alevins will be taken from each lot within a hatchery, preserved in 100% ethanol, and sent to the Otolith Laboratory. Sample sizes will be selected in proportion to hatchery-lot size, but a minimum of 100 alevins will be taken per lot. At least 100 alevins will also be collected from each of 20 streams during the annual pre-emergent fry survey conducted by the Alaska Department of Fish and Game, and treated similarly. A parent set of combined otoliths will then be formed by combining random subsamples of otoliths (n=150) from each hatchery sample with otoliths from 600 wild alevins, for a total of 1200 otoliths. Test sets of otoliths will then be formed by partitioning the mixed parent set into 4 sets of 300 otoliths. The test sets will then be assigned in a blind fashion to a selection of readers at the Otolith Laboratory who have studied the available voucher sets. Each reader will grade each set multiple times, and each set will be graded by all readers. The following information will be derived from the readings:

a) The within-reader variability in the estimation of the proportion of otoliths successfully assigned to the hatchery of origin.

b) The between-reader variability in the estimation of the proportion of otoliths successfully assigned to the hatchery of origin.

c) The overall readability rate associated with each facility, along with a confidence interval reflecting the within and between reader variability's, and the variability associated with sampling the original pool of otoliths.

d) The overall success of the readers' ability to partition the test sets into wild and hatchery fish, along with an appropriate confidence interval.

e) A misclassification matrix, in which the directions of misclassifications are recorded. Such a matrix will reveal situations where, for example, all otoliths of hatchery origin are distinguishable from wild otoliths, but only a portion can be assigned to a particular facility with confidence. There may consequently be more than one definition of a marking rate to consider, one related to hatchery/wild considerations, and one to hatchery-specific questions.

Voucher sets could be formed from returning adult fish, coded wire tag information being used to identify the origin of the fish, and tests similar to those above performed. As a result of the time taken to acquire representative collections of adult otoliths and the time taken for readers to acquaint themselves with new calibration sets, the adult voucher sets may only become useful towards the end of the season.

Objective 3

The composition of pink salmon catches will be estimated using otolith thermal marks in 1997

and in each subsequent year in which returning fish are marked. Technicians will sample all tender boats delivering Prince William Sound pink salmon to processors in south-central Alaska. In 1997 and 1998, the catch sampling program for recovery of otolith thermal marks will be highly integrated with the existing coded-wire tag recovery program. Technicians will employ a tender boat-sampling methodology developed during the 1996 season. It is currently envisioned that regardless of load, 100 heads will be sampled from each tender at each processor receiving fish, each selection of heads being stored separately. Once the total catch from the fishery opening is known, heads will be sampled from each 100-head collection in proportion to the load on the associated tender so that 160 heads are ultimately chosen from the fishery opening for mark analysis. The unselected heads will be stored and possibly sampled postseason during the dynamic sampling allocation phase (see below). Such an inseason sampling rate should yield estimates of the proportion of hatchery fish in the catch which are approximately +/- 8% of the true proportion 95% of the time. In the likely scenario where the hatchery proportion deviates from 50%, the precision will be greater. The precision of the season-end estimate of the proportion of the catch that is of hatchery origin will depend upon the actual sizes of the catches in the different openings. An analysis of a previous year's catch indicates that the precision of the estimate of the season-end proportion of hatchery fish will be approximately +/-2% of the true proportion 95% of the time, and greater than 95% of the time when the proportion of hatchery fish in some or all of the fishery openings deviates from 50%. Inseason mass-processing of otoliths will be conducted at the Alaska Department of Fish and Game otolith laboratory in Cordova with the aid of personnel from the Juneau statewide laboratory.

Inseason estimation of hatchery contributions will be made using the Bayesian approach of Geiger (1994), in which information pertaining to a preceding fishery in the same area can be incorporated into the estimate of the hatchery population proportion (p) in the current fishery. The idea is that the proportion of hatchery fish in a series of openings are likely to be positively correlated, and that incorporation of information from one fishery to the next can improve the estimation procedure. The weighting given to such prior information is flexible, and can reflect the wisdom of an experienced fishery manager. The beta probability density function will be used to model the prior information on p of the previous opening. Combination of data from samples from the fishery at hand (number of hatchery fish detected in sample is binomially distributed) with the prior beta density yields a beta posterior distribution of p for the current fishery. The estimate given to the fishery manager will be some measure of central tendency of this posterior distribution, probably the mean. The process then repeats itself for the next opening, in that the posterior beta distribution of p from the previous opening becomes the prior beta density for the next opening. Another important aspect of the Bayesian approach is that the measure of uncertainty associated with a given estimate of stock composition is given in terms of a distribution of p, in the form of 'credibility intervals'. Such intervals are more easily understood than the classical confidence interval, which is often misinterpreted. As discussed by Geiger (1994), the statistical functions contained in modern spreadsheets programs are sophisticated enough to allow the above manipulations to be conducted with ease.

Since the sample data enter the estimation procedure only via the likelihood function, postseason conditional sampling of otoliths (dynamic sampling allocation) to improve precision may be accomplished without the complex statistical considerations necessary in non-Bayesian schemes. Heuristically, additional otoliths will be taken from those strata for which the decrease in variability in the estimated hatchery proportion per additional otolith decoded is greatest.

Objective 4

The ability of the catch-sampling program to obtain unbiased samples is pivotal to the success of the stock-estimation aspect of the program. This project component will focus on development of a methodology for collecting unbiased representative samples from tender boats unloading salmon onto conveyor belts at processing plants. Once a methodology has been identified, twenty sampling experiments invoking the proposed methodology will be performed during the 1997 fishery to gauge its success. During each experiment, Alaska Department of Fish and Game technicians will monitor the total number of salmon loaded on a tender, and then add 2,000 externally marked salmon (e.g. with clipped pectoral fins) to the load. The placement of marked salmon in the load would be varied for different experiments. Fish will be sampled from the processor conveyor belt for each of the 20 sampling experiments. Confidence intervals (95%) regarding the portion of marks present in the tender will then be calculated. If the sampling methodology is appropriate, i.e. it yields unbiased representative samples, then 19 out of the 20 95% confidence intervals will be expected to incorporate the true proportion of marks aboard the tender. If the sampling design fails to meet this criterion, modifications will be made and further tests performed in 1998.

Objective 5

The adequacy of the sampling effort will be evaluated through examination of sizes of credibility intervals associated with the proportion of hatchery fish in the catch.

Objective 6

The proposed juvenile salmon sampling program will capture outmigrating pink salmon exceeding 60mm in size in the island passages in southwest Prince William Sound. The boundaries of the migration corridors will be defined by attempted capture of juveniles in areas near, but thought outside of the migration corridor. A stratified-random sampling design will be used to estimate the proportion of otolith marked juveniles from each pink salmon hatchery, along with the mean lengths of juveniles associated with each facility.

Upon collection of data over a number of years, an attempt will be made to correlate the size of the outmigrating juvenile populations of hatchery and wild fish (number of fish per unit of sampling effort) with sizes if corresponding adult returns. If a significant relationship is detected, further studies will be undertaken to develop the relationship into a forecasting tool.

Comparisons of otoliths recovered from captured coded wire tagged fish with those taken as voucher specimens earlier in the year will supplement the attempt to satisfy Objective 2, above.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The Alaska Department of Fish and Game Commercial Fisheries Management and Development Division will ensure (1) that information obtained from this project is adequately documented and catalogued, and (2) that biometrics review of project methods and data analyses is obtained. The Alaska Department of Fish and Game Otolith Laboratory will assist in processing all otolith samples collected during this project. Since this project is a cooperative study conducted jointly by the Alaska Department of Fish and Game, the Prince William Sound Aquaculture Corporation, and the Valdez Fisheries Development Association, contractual service agreements will be needed for application and recovery of thermal marks from each private non-profit agency..

SCHEDULE

A. Measurable Project Tasks for FY 97

This project will be conducted over one pink salmon life cycle for both the odd- and even-broodyear populations. Embryos will be otolith marked in the fall of 1995 and 1996. Salmon from the 1995 and 1996 brood years will return to Prince William Sound as adults in the summers of 1997 and 1998. The following tasks will be accomplished in FY 97:

October to December:	Apply thermal marks to BY 96 embryos at four pink salmon hatcheries
November-January:	Develop FY 98 DPD
February-March:	Collect samples from incubators to evaluate thermal mark quality
March-June:	Process and evaluate otoliths
April 15:	Submit annual project report for FY 1996
June-September:	Collect otoliths, process otoliths, analyze data, make recommendations
April 1998:	Submit annual project report for FY 1997

B. Project Milestones and Endpoints

The following milestones and endpoints will be achieved from FY 97 onward.

December 1996:	Objective 1 - Apply thermal marks to brood year 1996 embryos
June 1997:	Objective 2 - Evaluate thermal mark quality for brood year 1996
September 1997:	Objective 4 - Evaluate processor sampling methodology
February 1998:	Objective 3 - Estimate harvest stock composition for brood year 1995

February 1998:	Objective 5 - Evaluate quality of estimation procedure for brood year 1995
February 1999:	Objective 3 - Estimate harvest stock composition for brood year 1996
February 1999	Objective 5 - Evaluate quality of estimation procedure for brood year 1996

An endpoint for Objective 6 will occur when sufficient data points have been collected to assess the relationship between outmigrating juveniles and returning adults, and will occur beyond the current project timeline.

C Completion Date

All objectives of this multi-year project are expected to be met by FY99. At that time, support for a fully developed inseason stock separation program will likely be shared by the Alaska Department of Fish and Game and the private sector.

PUBLICATIONS AND REPORTS

An annual project report will be submitted by April 15 of each year.

PROFESSIONAL CONFERENCES

Project results should be presented at either the Alaska Chapter of the American Fisheries Society Annual meeting or the biennial Pink and Chum Salmon Workshop or both. The next occurrence of these meetings after the data are collected and analyzed will be the fall of 1998 and spring of 1999.

NORMAL AGENCY MANAGEMENT NOTE

The *Exxon Valdez* Trustee Council has played a major role in the development of pink salmon stock identification in Prince William Sound. The Trustee Council provided support for the coded wire tag program during the damage assessment phase because the project provided essential information for evaluating injury to salmon stocks as well as invaluable data used by managers to direct harvests away from damaged wild stocks. The program has been jointly funded during the Restoration phase with the Trustee Council contributing nearly half of the funds, the remainder being contributed by the Prince William Sound Aquaculture Corporation, the Valdez Fisheries Development Association and the Alaska Department of Fish and Game. Although the coded wire tag program provided data of a sort previously unavailable to managers, shortcomings in the technique became apparent as the project evolved. The most significant related to tag expansions and were associated with the inability to mark all fish in

the population. It was at this time that large-scale thermal mass marking emerged as a promising new methodology, and funds were sought from the Trustee Council to implement the program in Prince William Sound. A timeline and budget has been formulated for the near-future development of the Prince William Sound stock identification program. It consists of continued development of the thermal mass marking program, with two years of overlap with the coded wire tag program (Table 2). By FY 2000, program funding will be the responsibility of the Prince William Sound Aquaculture Corporation, the Valdez Fisheries Development Association and the Alaska Department of Fish and Game.

Table 2. Budgets for otolith marking and coded wire tagging programs for stock-identification of pink salmon in Prince William Sound (thousands of dollars).

	FY96	FY97	FY98	FY99	FY2000
CWT_a program					
	Recover BY 94 Tag BY 95	Recover BY 95 Tag BY 96	Recover BY 96	Reports	
Trustee Council	248.6	283.3	290.0	90.0	0.0
ADF&G[b]	81.6	57.6	65.0	55.0	0.0
PWSAC[c]/VFDA[d]	277.6	280.3	130.0	0.0	0.0
Total	607.8	621.2	485.0	145.0	0.0
Otolith program					
	Mark BY 95 Sampling Experiments	Mark BY 96 Recover BY 95	Mark BY 97 Recover BY 96	Mark BY 98 Recover BY 97	Mark BY 99 Recover BY 98
Trustee Council	93.2	130.6	113.0	55.0	0.0
ADF&G	0.0	58.3	65.0	108.0	158.0
PWSAC/VFDA	0.0	64.1	75.0	205.0	155.0

Total	93.2	253.0	253.0	368.0	313.0
Total Program					
Trustee Council	341.8	413.9	403.0	145.0	0.0
ADF&G	81.6	115.9	130.0	163.0	158.0
PWSAC/VFDA	277.6	344.4	205.0	205.0	155.0
Grand Total	701.0	874.2	738.0	513.0	313.0

a Coded wire tag
b Alaska Department of Fish and Game
c Prince William Sound Aquaculture Corporation
d Valdez Fisheries Development Association

COORDINATION AND INTEGRATION OF RESEARCH EFFORT

The Otolith Mass Marking Project (97188) is integrated with several other salmon restoration projects in Prince William Sound. This project will complement the Sound Ecosystem Assessment program (Project 97320). The Sound Ecosystem Assessment program is a multi-disciplinary program designed to develop an understanding of the mechanisms regulating ecosystem function in Prince William Sound. The Sound Ecosystem Assessment program is focused on interactions of pink salmon and herring with other components of the Prince William Sound ecosystem. Otolith marked salmon will provide a valuable tool for examining interactions between wild and hatchery salmon during the early marine period. The salmon growth component of the Sound Ecosystem Assessment program will utilize otolith marked juvenile pink salmon to (1) evaluate habitat overlap between wild and hatchery salmon, (2) examine size composition of wild and hatchery salmon in mixed schools, and (3) develop a tagging program to estimate juvenile salmon mortality within Prince William Sound and the Gulf of Alaska. The salmon predation component of the Sound Ecosystem Assessment program will utilize otolith marked juvenile salmon to determine if predators select wild or hatchery salmon.

Project 94192, Hatchery Salmon Straying, was deferred to 1997 to allow development of otolith thermal marking technologies in Prince William Sound Any straying study conducted in 1997 concerning hatchery pink salmon will undoubtedly have at its core a sampling program designed to collect otoliths from Prince William Sound streams. Such a study is therefore inextricably linked to this otolith thermal marking study. The existing Alaska Department of Fish and Game fishery management program in Prince William Sound will provide salmon catch data needed to complete this project. An Alaska Department of Fish and Game pre-

emergent fry program would provide otolith samples from wild salmon stocks in Prince William Sound. However, this program is not in the agency base budget and may not be operated in 1997. The Alaska Department of Fish and Game permanent staff of biologists and biometricians will write operational plans and provide overall supervision for this project. The Prince William Sound Aquaculture Corporation and the Valdez Fisheries Development Association used thermal mass marking to place unique marks on the otoliths of all pink salmon fry released from their facilities in brood year 1995. The Alaska Department of Fish and Game Otolith Laboratory in Juneau will assist in the processing of all otoliths recovered from experiments and recovery operations.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

Objective #6 was added to the FY 97 DPD to determine the feasibility of forecasting relative hatchery and wild run strength by sampling outmigrating juvenile pink salmon in the southwest passes of Prince William Sound.

PROPOSED PRINCIPAL INVESTIGATOR

Timothy L. Joyce
Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division
P.O. Box 669
Cordova, Alaska 99574-669
(907) 424-3214 (phone)
(907) 424-3235 (FAX)
timj%fishgame@state.ak.us (E-mail)

PERSONNEL

The Principal Investigator (PI) for the project will be a permanent full-time Fisheries Biologist III (FB III) working for the Alaska Department of Fish and Game. The PI will be responsible for writing project operational plans, administering project budgets, quality control of data collection, supervising data analyses and, co-authoring final reports. A Fisheries Biologist II (FB II) will supervise day to day project operations, maintain data quality, assist in data analyses, and co-author final reports. The FB II will be assisted by one permanent seasonal Fisheries Biologist I (FB I). The FB I will be in charge of supervising day to day sampling activities in Cordova and will assist the PL in supervising sampling at other ports, on floating processors, and at hatcheries. Non-permanent Fish and Wildlife Technician III's (FWT III) will be stationed in Cordova and Valdez and will assist the FB I as crew leaders. The crews in each port will be non-permanent FWT II's. Under the supervision of the FB I, the FWT III's will conduct daily data logging, editing and archiving activities in Cordova and Valdez.

A Biometrician I from the Alaska Department of Fish and Game Commercial Fisheries and Development Division Region II office in Anchorage will provide biometrics support for the project. The Biometrician I will assist in experimental design, inseason and post season data analyses, and report writing.

The PI, FB II or, FB I will maintain daily phone contact with project technicians stationed in ports other than Cordova or Valdez and at several remote hatchery locations. Copies of data forms from these sites will be faxed to Cordova daily and heads from sampled fish will be shipped once or twice weekly to Cordova via scheduled commercial flights or via chartered aircraft depending upon which is available. The PL, APL, or project Fisheries Biologist I's will make routine supervisory visits to each sampling port via chartered or commercial aircraft at least twice monthly for sampling quality control inspections, data collections, and industry contacts. The Biometrician I will travel to Cordova several times during the season to assist with inseason data analyses and occasionally after the season to assist with final data analyses and report writing.

TIMOTHY L. JOYCE - Fisheries Biologist III, Principal Investigator
Alaska Department of Fish and Game; Commercial Fisheries Management and Development
P.O.Box 669, Cordova, Alaska 99574
Ph. (907) 424-3212

EMPLOYMENT:

Mr. Joyce was appointed to the Fisheries Biologist III position in July of 1995. Prior to this appointment he worked for the State of Alaska as a hatchery manager at Kitoi Bay which was the largest multi-species salmon production facility run by the state. He did some of the initial half-length coded wire tagging work on emergent pink salmon fry from 1982 through 1987. He co-authored an article titled "Retention Rates of Half-Length Coded Wire Tags Implanted in Emergent Pink Salmon" published in 1990 in the American Fisheries Society Symposium 7:253- 258. He has over 17 years

experience in salmon hatchery production in Alaska working with all five species of Pacific salmon, but primarily with pink salmon. Prior to his position as the hatchery manager at Kitoi Bay, Mr. Joyce worked in Sand Point, Alaska as a high school teacher instructing in Aquaculture, fish culture and biology. He was responsible for a small demonstration hatchery run by the school district with Johnson O'Malley funds where students had hands on training of salmon culture using pink and coho salmon. Mr. Joyce also has extensive experience in warm water fish culture gained while in Africa working as a Peace Corps volunteer at a UN development project under the FAO.

OTHER EXPERIENCE:

Commercial herring spotter pilot, 1985 -1994
Research aid, Oak Creek Laboratory, Corvallis, OR. 11/71 - 6/73
Construction, 1964 - 1971

EDUCATION:

1973: Bachelor of Science , Fisheries Science, Oregon State University.

RENATA RIFFE - Fisheries Biologist II, Research Biologist
Alaska Department of Fish and Game; Commercial Fisheries Management and Development
P.O.Box 669, Cordova, Alaska 99574
Ph. (907) 424-3212

EMPLOYMENT:

Since October 1994 Ms. Riffe has worked on the coded wire tag project as an FBII Research Biologist in the capacity of Assistant Project Leader. Prior to her current position, (from June 1991 - October 1994), she was employed as a biologist with the Alaska Department of Fish and Game, Sport Fish Division in Fairbanks, Alaska, and assisted in projects concerning abundance estimation and population evaluation of pike, grayling, humpback whitefish, least cisco, rainbow trout, burbot, chum salmon, and king salmon. From May 1982 - January 1991, she worked as a technician with the Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division in Juneau, Alaska. Her primary duties involved sampling commercial salmon fisheries and salmon escapements, with some report writing. She also developed discriminant function models for stock separation of Lynn Canal sockeye salmon, by scale pattern analysis, developed a computer model which simulated migratory timing of salmon escapements, and evaluated truncated escapement counts. She has authored reports for the Alaska Department of Fish and Game on estimates of abundance and survival rates of round whitefish, compilation of age and length data for rainbow trout in southwest Alaska, and migratory timing of salmon in the Situk River, Alaska.

EDUCATION:

1994: Master of Science , Statistics, Colorado State University.
1987: Master of Science, Fisheries Management, University of Alaska, Fairbanks.
1981: Bachelor of Science, Fish Biology, Colorado State University.

SEAWAN GEHLBACH - Fisheries Biologist I

EMPLOYMENT:

Ms. Gehlbach has worked on the coded wire tag project as an FBI since the 1993 fishing season. Her responsibilities include hiring and supervising 20 Fish and Wildlife Technician II's that sample in eight ports around Prince William Sound. She was responsible for the duties of the current APL during the change in PI. She has produced inseason data analysis for management staff and post season data analysis for the annual coded wire tag reports. Prior to her current position with the Alaska Department of Fish and Game, she worked for Sport Fish Division in Juneau, as a short term Fish and Wildlife Technician II; her duties included collecting coded wire tag data and catch information for the sport fishery. Ms. Gehlbach has also worked for the Douglas Island Pink and Chum (DIPAC) hatchery in Juneau as a field observer, and later in the hatchery as a member of the incubation and broodstock collection crews.

EDUCATION:

1992: Bachelor of Science, Biology, University of New Hampshire.

PETER HAGEN - Cooperating Investigator (Otolith Laboratory Director)
Department of Fish and Game, Commercial Fisheries Management and Development Division
P.O. Box 20
Douglas, Alaska, 99824-0020

EMPLOYMENT:

August 1991 - Present: Director of the Alaska Department of Fish and Game Otolith Aging Laboratory. This laboratory was established to extract information from calcified tissues to aid in the management of the State of Alaska's fisheries resources. Responsibilities include implementing a program for mass marking hatchery reared salmon by imposing patterns on their otolith microstructure through temperature manipulation in the egg and alevin stages. The laboratory recovers the patterns from the otoliths of adult salmon to determine the proportion of hatchery fish in mixed stock fisheries. The laboratory is also charged with aging groundfish using otoliths and other hard structures. The aging information is used to determine the status of stocks and is incorporated into age-structured population models. Responsibilities

include developing research and project operation plans, instigating new cooperative studies, supervising laboratory personnel, budget management, coordinating activities with outside agencies, and other Fish and Game divisions.

September 1987 - 1991: Co-principal investigator of a joint Alaska Sea Grant - International Pacific Halibut Commission project investigating annuli and microstructure patterns in otoliths of Pacific halibut. This project is being used to complete a Ph.D. in Fisheries. It involves innovative use of image processing, x-ray microscopy, and statistical methodology to describe the process of otolith growth and quantify pattern variation. The research includes an analysis of the historical collection of otoliths maintained by the International Pacific Halibut Commission. The otolith collection provides a unique opportunity to develop a long-term record of otolith growth. This research is directed toward determining which quantifiable features of the otolith (both patterns and elemental composition) can be used to investigate mechanisms responsible for long-term changes in population structure. Published results include identifying a long-term response of juvenile halibut growth to temperature changes. Additional work investigates the potential for identifying sub-stocks of halibut through trace elements incorporate into the otolith microstructure.

OTHER EXPERIENCE:

Fisheries Biologist, National Marine Fisheries Service, Auke Bay 6/86 - 9/87.
Research Fellowship, International Pacific Halibut Commission, Seattle WA. 1/84 - 5/86
Fisheries Consultant, 5/83- 9/84,
Commercial Fisherman, 4/83
Fisheries Biologist, International Pacific Halibut Commission, Seattle WA. 6/80 - 9/82

EDUCATION:

1994 Doctor of Philosophy (Candidate) Fisheries, University of Alaska, Fairbanks
1986 Master of Science, Fisheries, University of Alaska, Juneau
1981 Bachelor of Science, Fisheries Science, University of Washington

KRISTEN M. MUNK - Cooperating Investigator (Otolith Laboratory Biologist)
Alaska Dept of Fish & Game, Commercial Fisheries Management and Development Division
PO Box 240020
Douglas, AK 99824

EMPLOYMENT:

Fisheries Biologist responsible for developing mass-processing techniques for recovery of otolith thermal marks, coordinating and conducting age analyses of groundfish structures, and supervising production of otolith processing and age structure information in the Alaska Department of Fish and Game-CFMD Otolith Lab.

1976 - present: Field experience includes gillnet test fishing in Lower Cook Inlet; commercial catch sampling of ship- and land-based processors in Cook Inlet and Prince William Sound; remote-site escapement sampling along the Kenai Peninsula, Prince William Sound and Southeastern Alaska; abundance surveys of sablefish using long lines; creel censusing of sport fishers in the Susitna drainage and Juneau marine waters; assisting in crab index surveys; flying aerial surveys for salmon; assisting in installation, operation, and maintenance of MTS and Bendix sonar; collecting habitat assessment data on numerous Juneau area creeks and rivers; enforcing fishing regulations; supervising field crews; conducting data analyses, under supervision, of commercial catch age data; aging scales; collecting fish using various trapping methods. Hatchery and weir experience includes installing, operating, and maintaining weirs; collecting data and keeping records; tagging and fin-clipping juvenile salmon; supervising tagging and weir crews; sampling tissue used for genetic stock identification studies; spawning salmon for aquaculture operations; transporting and placing eggs in incubators; monitoring incubation of salmon eggs; administering prophylactics; monitoring, maintaining, and releasing pen-reared salmon. Lab experience includes recovering and identifying aquatic insects and salmon fry stomach contents; preparing and aging otoliths, shark spines, and lingcod fin spines; designing, implementing, coordinating otolith sampling programs; sampling , preparing and analyzing otolith samples; reporting on thermal mass marking projects and technology.

EDUCATION:

1989 Bachelor of Science, Zoology, University of Hawaii

DAVID EVANS - Cooperating Investigator (Biometrician)
Department of Fish and Game, Commercial Fisheries Management and Development Division

333 Raspberry Rd.
Anchorage, Alaska 99518

EMPLOYMENT:

October, 1991 - present: Biometrician I with the Alaska Department of Fish and Game. Primary responsibility has been analysis of coded-wire-tag data from Prince William Sound. Design of the statistical procedures and computer spread sheets used for inseason analysis of tag recovery data. Oversight of most of the post season data analyses and co-author of interim and final reports for the 1991 NRDA F/S Study #3, the 1992 Restoration Study 60C, and 1993 Restoration studies 93137 and 93184.

EDUCATION:

1991 Master of Science, Statistics, Oregon State University
1988 Doctor of Philosophy, Soil Science, University of Guelph (Ontario, Canada)
1984 Master of Science, Soil Science, University of Guelph (Ontario, Canada)
1981 Bachelor of Science, Soil Science, University of Nottingham (U.K.)

LITERATURE CITED

Bergstedt, R.A., R.L. Eshenroder, C. Bowen, J.G. Seelye, and J.C. Locke. 1990. Mass-marking of otoliths of Lake Trout sac fry by temperature manipulation. In: Fish-Marking Techniques: Proceedings of the International Symposium and Educational Workshop on Fish-Marking Techniques, N. Parker, et al. (eds.), University of Washington, Seattle, Washington.

Bernard, D.R. 1983. Variance and bias of catch allocations that use the age composition of escapements. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet No. 227. Juneau, Alaska.

Brothers, E.B. 1990. Otolith Marking. In: Fish-Marking Techniques: Proceedings of the International Symposium and Educational Workshop on Fish-Marking Techniques, N. Parker, et al. (eds.), University of Washington, Seattle, Washington.

Cochran, W.G. 1977. Sampling Techniques. Third edition, John Wiley & Sons, Inc. New York, New York.

Cross, B.A. and B.L. Stratton. 1991. Origins of sockeye salmon in east side Bristol Bay fisheries in 1988 based on linear discrimination function analysis of scale patterns. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Fishery Report No. 91-09. Juneau, Alaska.

Dabrowski, K. and K. Tsukamoto. 1986. tetracycline tagging in coregonid embryos and larvae. Journal of Fish Biology 29:691-698.

Fournier, D.A., T.D. Beacham, B.E. Riddell, and C.A. Busack. 1984. Estimating stock composition in mixed stock fisheries using morphometric, meristic, and electrophoretic characteristics. Can. J. Fish. Aquat. Sci. 41: 400-408.

Geiger, H.J. 1990. Pilot studies in tagging Prince William Sound hatchery pink salmon with coded-wire tags. Alaska Department of Fish and Game, Division of Commercial Fisheries, Fishery Research Bulletin No. 90-02.

Geiger, H.J. 1994. A Bayesian approach for estimating hatchery contribution in a series of salmon fisheries. Alaska Fishery Research Bulletin 1 (1): 66-73.

Geiger, H.J., K. Munk, B.G. Bue, M. Willette. 1994. Technical issues and costs of otolith marking Prince William Sound hatchery pink salmon for fisheries management. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Regional Informational Report No. 5J94-07, Juneau.

Habicht, C., S.Sharr, and J.E. Seeb. 1995. Coded wire tag placement affects homing precision of pink salmon. (*in press*).

Hagan, P., K. Munk, B. Van Allen, and B. White. 1995. Thermal technology for inseason fisheries management: A case study. Alaska Fishery Research Bulletin 2:143-155.

Hettler, W.F. 1984. marking otoliths by immersion of marine fish larvae in tetracycline. Transactions of the American Fisheries Society 113:370-373.

Munk, K.M. and W.W. Smoker. 1990. Temperature-induced marks in otoliths of pink salmon embryos. Juneau School of Fisheries and Ocean Sciences Report 90-01. University of Alaska, Juneau, Alaska.

Munk, K.M, W.W. Smoker, D.R. Beard, R.W. Mattson, 1993. A hatchery water-heating system and its application to 100% thermal marking of incubating salmon. Progressive Fish-culturist 55:284-288

Peltz, Larry and Jack Miller. 1990. Performance of half-length coded wire tags in a pink salmon hatchery marking program. Fish Marking Techniques. American Fisheries Society Symposium 7:244-252.

Secor, D.H., M.G. White, and J.M. Dean. 1991. Immersion marking of larval and juvenile hatchery-produced striped bass with oxytetracycline. Transactions of the American Fisheries Society 120:261-266.

Seeb, J.E., B.G. Bue, A.K. Craig, C. Habicht, G.D. Miller, S. Sharr. 1995. Injury to salmon embryos and preemergent fry in Prince William Sound - Restoration Project 94191. Report to the *Exxon Valdez* Trustee Council, Anchorage.

Sharr, S., B.G. Bue, S.D. Moffitt, and A. Craig. 1994a. Injury to salmon eggs and pre-emergent fry in Prince William Sound. Federal/State Natural Resources Damage Assessment Fish/Shellfish Study Number 2 Final Report, Alaska Department of Fish and Game, Cordova.

Sharr, S., B.G. Bue, S.D. Moffitt, A. Craig, and G.D. Miller. 1994b. Injury to salmon eggs and pre-emergent fry in Prince William Sound. Federal/State Natural Resources Restoration Study Number 60A Final Report, Alaska Department of Fish and Game, Cordova, Alaska.

Sharr, S., C.J. Peckham, D.G. Sharp, L. Peltz, J.L Smith, M.T. Willette, D.G. Evans, and B.G. Bue. 1994c. Coded Wire Tag Studies on Prince William Sound Salmon. Federal/State Natural Resources Damage Assessment Fish/Shellfish Study Number 3 Final Report, Alaska Department of Fish and Game, Cordova, Alaska.

Thompson, Steven K. 1992. Sampling. Wiley-Interscience. New York. 344 pp.

Volk, Eric, Steven L.Schroder, and Kurk L. Fresh. 1990. Inducement of unique banding patterns as a practical means to mass-mark juvenile Pacific salmon. Fish Marking Techniques. American Fisheries Society Symposium 7:203-215.

Wiedmer, M. 1992. Cytochrome P-450 induction of pink salmon (*Oncorhyncus gorbuscha*) eggs and larvae in Prince William Sound, Alaska: Effects of the *Exxon Valdez* oil spill, Alaska Department of Fish and Game, Habitat Division, Technical Report No. 92-3, Juneau, Alaska.

Willette, T.M. 1993. Early marine salmon injury assessment in Prince William Sound. Federal/State Natural Resources Damage Assessment, Fish/Shellfish Study Number 4 Final Report, Alaska Department of Fish and Game, Cordova, Alaska.

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997	LONG RANGE FUNDING REQUIREMENTS					
			Estimated FFY 1998	Estimated FFY 1999	Estimated 2000	Estimated FFY 2001	Estimated FFY 2002	Estimated FFY 2003
Personnel	$57.5	$70.8						
Travel	$2.4	$3.2						
Contractual	$16.9	$16.9						
Commodities	$1.6	$1.6						
Equipment	$5.0	$18.1						
Subtotal	$83.4	$110.6						
General Administration	$9.8	$11.8						
Project Total	$93.2	$122.4	$113.0	$55.0	$0.0	$0.0	$0.0	$0.0
Full-time Equivalents (FTE)	0.9	1.2						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: This project is a cooperative effort between the EVOS Trustee Council, Alaska Department of Fish & Game (ADF&G), Prince William Sound Aquaculture Corporation (PWSAC) and Valdez Fisheries Development Association (VFDA) as it is in project 97186.
The agency contributions are listed below:

Trustee Council: $122.4
ADF&G: $57.5
PWSAC : $52.6
VFDA: $11.5

1997

Project Number: 97188
Project Title: Otolith Mass Marking of Hatchery Pink Salmon in Prince William Sound
Agency: Trustee Council

FORM 3A AGENCY PROJECT DETAIL

Prepared: 4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Personnel Costs:			GS/Range/	Months	Monthly		Proposed
PM	Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1996
	Tim Joyce	Fishery Biologist III	18L	3.0	6,861	0	20.6
	Kris Munk	Fishery Biologist I	14E	2.0	4,226	0	8.5
	Vacant	Fish & Wildlife Technician III	11A	3.0	3,509	400	10.9
	D. Evans	Biometrician	17F	3.0	5,278	0	15.8
	Renata Riffe	Fishery Biologist II	16C	3.0	5,000	0	15.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
		Subtotal		14.0	24,874	400	
Those costs associated with program management should be indicated by placement of an *.						Personnel Total	$70.8

Travel Costs:		Ticket	Round	Total	Daily	Proposed
PM	Description	Price	Trips	Days	Per Diem	FFY 1996
						0.0
	Cordova-Anch. to attend annual EVOS workshop	200	1	4	95	0.6
	Anch. - Cordova for biometrics support on catch sampling	200	2	6	95	1.0
	Juneau - Cordova for training of lab staff in otolith recovery	300	1	30	42	1.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
Those costs associated with program management should be indicated by placement of an *.					Travel Total	$3.2

1997

Project Number: 97188
Project Title: Otolith Mass Marking of Hatchery Pink Salmon in Prince William Sound
Agency: Trustee Council

FORM 3B
Personnel
& Travel
DETAIL

4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Contractual Costs:	Proposed
Description	FFY 1996
Air charter for training at hatcheries (5 hrs. @ 275 per hr)	1.4
Fuel for otolith thermal mark application at Solomon Gulch Hatchery (5200 gals. @ $1.0 per gal.)	5.2
Fuel for otolith thermal mark application at three PWSAC hatcheries (10300 gals. @ $1.0 per gal.)	10.3
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$16.9

Commodities Costs:	Proposed
Description	FFY 1996
Cell culture trays	0.1
Acetate compression plate	0.1
Grinding paper	0.2
Glass slides - regular	0.2
Glass slides - petrographic	0.3
Slide boxes	0.3
vials, storage alcohol	0.2
Misc. forceps and gloves	0.2
Commodities Total	$1.6

1997

Project Number: 97188
Project Title: Otolith Mass Marking of Hatchery Pink Salmon in Prince William Sound
Agency: Trustee Council

FORM 3B
Contractual & Commodities DETAIL

4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1996
			0.0
Stereomicroscope (Wild MZ6, 1.0X apo objective)	1	4,500	4.5
Dissecting microscope (DMLS)	2	3,300	6.6
Otolith grinders	2	3,500	7.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$18.1

Existing Equipment Usage: Description	Number of Units	Inventory Agency
Boiler module (Temp. inc. 21 deg. F and 200 gpm)	1	VFDA
Boiler modules (Temp. inc. 21 deg. F and 200 gpm)	2	PWSAC
Boiler module (Temp. inc. 21 deg. F and 200 gpm)	1	ADFG
MZ6 stereomicroscope	1	ADFG

1997

Project Number: 97188
Project Title: Otolith Mass Marking of Hatchery Pink Salmon in Prince William Sound
Agency: Trustee Council

FORM 3B
Equipment
DETAIL

4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997	LONG RANGE FUNDING REQUIREMENTS					
			Estimated FFY 1998	Estimated FFY 1999	Estimated 2000	Estimated FFY 2001	Estimated FFY 2002	Estimated FFY 2003
Personnel	$0.0	$57.5						
Travel	$0.0	$0.0						
Contractual	$0.0	$0.0						
Commodities	$0.0	$0.0						
Equipment	$0.0	$0.0						
Subtotal	$0.0	$57.5						
General Administration	$0.0	$0.0						
Project Total	$0.0	$57.5	$65.0	$108.0	$158.0	$160.0	$162.0	$164.0
Full-time Equivalents (FTE)	0.0	1.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: This project is a cooperative effort between the EVOS Trustee Council, Alaska Department of Fish & Game (ADF&G), Prince William Sound Aquaculture Corporation (PWSAC) and Valdez Fisheries Development Association (VFDA) as it is in project 97186.
The agency contributions are listed below:

Trustee Council: $122.4
ADF&G: $57.5
PWSAC : $52.6
VFDA: $11.5

1997

Project Number: 97188
Project Title: Otolith Mass Marking of Hatchery Pink Salmon in Prince William Sound
Agency: AK Dept. of Fish & Game

FORM 3A AGENCY PROJECT DETAIL

Prepared: 4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Personnel Costs:			GS/Range/	Months	Monthly		Proposed
PM	Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1996
	Tim Joyce	Fishery Biologist III	18L	3.0	6,861	0	20.6
	Seawan Gelhbach	Fishery Biologist I	14C	2.0	4,444	316	9.2
		FT III	11A	4.0	2,782	1,600	12.7
	Renata Riffe	Fishery Biologist II	16C	3.0	5,000	0	15.0
						0	0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
		Subtotal		12.0	19,087	1,916	
Those costs associated with program management should be indicated by placement of an *.						**Personnel Total**	$57.5

Travel Costs:		Ticket	Round	Total	Daily	Proposed
PM	Description	Price	Trips	Days	Per Diem	FFY 1996
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
Those costs associated with program management should be indicated by placement of an *.					**Travel Total**	$0.0

1997

Project Number: 97188
Project Title: Otolith Mass Marking of Hatchery Pink Salmon in Prince William Sound
Agency: AK Dept. of Fish & Game

FORM 3B
Personnel
& Travel
DETAIL

4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Contractual Costs:	Proposed FFY 1996
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FFY 1996
Description	
Commodities Total	$0.0

1997

Project Number: 97188
Project Title: Otolith Mass Marking of Hatchery Pink Salmon in Prince William Sound
Agency: AK Dept. of Fish & Game

FORM 3B
Contractual & Commodities DETAIL
4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1996
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

1997

Project Number: 97188
Project Title: Otolith Mass Marking of Hatchery Pink Salmon in Prince William Sound
Agency: AK Dept. of Fish & Game

FORM 3B
Equipment
DETAIL

4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997	LONG RANGE FUNDING REQUIREMENTS					
			Estimated FFY 1998	Estimated FFY 1999	Estimated 2000	Estimated FFY 2001	Estimated FFY 2002	Estimated FFY 2003
Personnel	$0.0	$57.1						
Travel	$0.0	$0.0						
Contractual	$0.0	$2.0						
Commodities	$0.0	$5.0						
Equipment	$0.0	$0.0						
Subtotal	$0.0	$64.1						
General Administration	$0.0	$0.0						
Project Total	$0.0	$64.1	$75.0	$180.0	$180.0	$182.0	$184.0	$186.0
Full-time Equivalents (FTE)	0.9	1.7						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: This project is a cooperative effort between the EVOS Trustee Council, Alaska Department of Fish & Game (ADF&G), Prince William Sound Aquaculture Corporation (PWSAC) and Valdez Fisheries Development Association (VFDA) as it is in project 97186.
The agency contributions are listed below:

Trustee Council: $122.4
ADF&G: $57.5
PWSAC : $52.6
VFDA: $11.5

1997

Project Number: 97188
Project Title: Otolith Mass Marking of Hatchery Pink Salmon in Prince William Sound
Agency: PWSAC & VFDA

FORM 3A AGENCY PROJECT DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Personnel Costs:			GS/Range/	Months	Monthly		Proposed
PM	Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1996
		FT II A	9A	16.0	2,465	4,800	44.2
		FT III A	11A	4.0	2,782	1,800	12.9
							0.0
						0	0.0
						0	0.0
						0	0.0
							0.0
							0.0
							0.0
							0.0
							0.0
		Subtotal		20.0	5,247	6,600	
Those costs associated with program management should be indicated by placement of an *.						Personnel Total	$57.1

Travel Costs:		Ticket	Round	Total	Daily	Proposed
PM	Description	Price	Trips	Days	Per Diem	FFY 1996
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
Those costs associated with program management should be indicated by placement of an *.					Travel Total	$0.0

1997

Project Number: 97188
Project Title: Otolith Mass Marking of Hatchery Pink Salmon in Prince William Sound
Agency: PWSAC & VFDA

FORM 3B
Personnel
& Travel
DETAIL

4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Contractual Costs:			Proposed
Description	Mo Budgeted	Mo. Cost	FFY 1996
Lab space rental for otolith extraction and reading	4	$0.4	$2
When a non-trustee organization is used, the form 4A is required.		**Contractual Total**	$2.0

Commodities Costs:	Proposed
Description	FFY 1996
Fuel for heating water to otolith mark pink embryos	5.0
Commodities Total	$5.0

1997

Project Number: 97188
Project Title: Otolith Mass Marking of Hatchery Pink Salmon in Prince William Sound
Agency: PWSAC & VFDA

FORM 3B
Contractual & Commodities DETAIL
4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1996
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

1997

Project Number: 97188
Project Title: Otolith Mass Marking of Hatchery Pink Salmon in Prince William Sound
Agency: PWSAC & VFDA

FORM 3B
Equipment
DETAIL

4/15/96

Construction of a Linkage Map for the Pink Salmon Genome

Project Number:	97190
Restoration Category:	Research
Proposer:	Fred W. Allendorf University of Montana
Lead Trustee Agency:	ADF&G
Alaska SeaLife Center:	yes
Duration:	2nd year, 5-year project
Cost FY 97:	$267,500
Cost FY 98:	$267,5000
Cost FY 99:	$267,500
Cost FY 00:	$267,500
Geographic Area:	Prince William Sound
Injured Resource:	Pink salmon

ABSTRACT

We propose to construct a detailed genetic linkage map for pink salmon by analyzing the genetic transmission of several hundred DNA polymorphisms. The ability to genetically map the location of oil induced lesions will allow the thorough identification, description, and understanding of oil induced genetic damage. This research will also aid other recovery efforts with pink salmon, including estimation of straying rates, description of stock structure, and testing if marine survival has a genetic basis.

INTRODUCTION

We propose to construct a genetic linkage map for the pink salmon genome. Such a map would provide the necessary platform for identifying genetic damage in pink salmon inhabiting oiled streams following the March 1989 *Exxon Valdez* oil spill (EVOS). A detailed genetic map would also aid other recovery efforts with pink salmon, including estimation of straying rates, description of stock structure, and testing if marine survival has a genetic basis.

Genetic linkage maps have provided the necessary information for understanding genetic variation in species since the rediscovery of Mendel's principles early in this century. A genetic map plays a similar role for a geneticist that a geographical map plays for the explorer of new territories. For many years, genetic maps could only be constructed in a very few model species that were suitable for extensive genetic manipulation (e.g., Drosophila and mice). Recent advances in molecular genetics now make it possible to uncover enough genetic markers to construct a detailed genetic linkage map in almost any species (Postlethwait et al. 1994).

This work will have important significance for ongoing work with pink salmon under the project Oil-Related Embryo Mortalities (Restoration Study 95191A). That project proposes to identify germline mutations in pink salmon exposed to oil. As explained in the FY95 Detailed Project Description (95191A), genetic damage induced by oil may either be small changes in nucleotide sequence (microlesions) or large-scale changes in chromosome structure (macrolesions). Restoration Study 95191A proposes to screen pink salmon DNA in order to detect such lesions.
A detailed genetic map for pink salmon would be invaluable for interpreting the results of Restoration Study 95191A in several ways. First, it will be possible by following the inheritance of any DNA lesions to determine if they are micro- or macro-lesions. Second, these lesions can be mapped to determine if they are randomly spread throughout the genome or if they occur at mutational "hot spots" that are susceptible to oil induced damage.

The construction of a detailed linkage map will also serve as a basis for understanding genetic aspects of pink salmon restoration and supplementation. This work will be performed on both odd- and even-year pink salmon because of the known genetic differences between these fish. In addition, the outbreeding depression found in hybrids suggests that there are chromosomal differences between odd- and even-year fish (Gharrett and Smoker 1991).

This project began in FY 96. However, we did not receive authorization to proceed until 5 March 1996. We have begun the initial tasks. We have obtained families created in 1996 from Prince William Sound pink salmon from our collaborator, Dr. James E. Seeb, ADF&G. We have begun the initial screening for DNA polymorphisms of the parents, and have begun testing for Mendelian inheritance. Other work to be completed in FY 96 is described in this DPD.

NEED FOR THE PROJECT

A. Statement of Problem

Elevated embryo mortalities were detected in populations of pink salmon (*Oncorhynchus gorbuscha*) inhabiting oiled streams following the March 1989 *Exxon Valdez* oil spill (EVOS). These increased rates of mortality persisted through the 1993 field season, three generations after the oil spill, suggesting that genetic damage may have occurred as a result of exposure to oil during early developmental life-stages. The consequences of the putative genetic damage include impaired physiological function of individuals and reduced reproductive capacity of pink salmon populations.

The aggregate of evidence from the field studies and incubation experiment suggests that the embryos exposed to oil in 1989 and 1990 accumulated deleterious mutations in the germline (reviewed in Detailed Project Description of Project 95191A). This hypothesis of genetic damage is consistent with previous field observations and laboratory experiments on the effects of crude oil on early life stages of fish. Long term intra-gravel oil exposures (7-8 months) to freshly fertilized eggs provide embryos sufficient time to accumulate polynuclear aromatic hydrocarbons (PAH's) from very low aqueous concentrations of crude oil. PAH's are abundant in crude oil and are potent clastogens (i.e. capable of breaking chromosomes).

Mironov (1969) observed reduced survival of fish embryos and larvae exposed to very low aqueous doses (1 ul oil/l seawater) of oil. Longwell (1977) reported genetic damage in pelagic embryos affected by the ArgoMerchant oil spill. Moles et al. (1987) confirmed that pink salmon embryos take up PAH's and demonstrated that the uptake was much greater in an intertidal environment than in strictly freshwater conditions. Biggs et al. (1991) found greater numbers of chromosome aberrations in larval herring which incubated in oiled areas than in non-oiled areas. It is likely that the same type of damage may have occurred in pink salmon, and this damage could have affected the germline of exposed individuals (Malkin 1994).

B. Rationale

The recovery objective for pink salmon is healthy and productive populations that exist at prespill levels or levels in unoiled areas. An indication of recovery is when egg mortality in oiled areas match prespill or levels in unoiled areas. The genetic map we propose to construct will be essential for detecting and understanding causes of reduced egg and embryo survival in oiled areas.

The genetic damage caused by exposure to oil may persist longer in populations of pink salmon than in other vertebrates because of the tetraploid nature of the salmonid genome. Salmonid fishes went through a tetraploid event some 25 million years ago that duplicated their entire genome (Allendorf and Thorgaard 1984). The extra genes in pink salmon may mask the effects of mutational damage caused by recessive deleterious alleles. The effects of these deleterious mutations may be uncovered in subsequent generations.

This fundamental genetic information would be of great assistance for three of the four Components of the Pink Salmon Restoration Program:

Toxic Effect of Oil on Pink Salmon: genetic mapping is essential for identifying genetic lesions induced by exposure to oil.

Stock Separation and Management: the genetic markers identified in the course of this study

will provide greatly increased power and resolution to identify stocks of pink salmon on a very fine scale.

Supplementation: the genetic markers will also be of great value in genetically identifying fish from supplementation programs and detecting their ecological and genetic interactions with wild fish.

Information gained from this study will provide resource managers with insight into the magnitude and persistence of damages sustained by wild pink salmon due to EVOS. Efforts to restore damaged pink salmon populations depend upon the ability of fishery managers to identify sources of reduced survival and to monitor their persistence. The potential of long term oil exposures to cause genetic damage needs to be understood so that spawning escapement goals can be adjusted if necessary. In addition, verification of the genetic hypothesis would provide the first evidence that the germline of fish exposed to chronic or acute sources of oil pollution can be affected.

Our results may have relevance for other fish species as well (e.g., Pacific herring, *Clupea pallasi*). Comparative gene mapping has shown that the linkage groups in a wide variety of vertebrates have been conserved. If we find that certain loci in pink salmon are mutational "hotspots" for oil induced damage, it would be possible to look for similar hotspots in Pacific herring or other fish species (e.g., rockfish, *Sebastes*).

C. Location

Gametes for the inheritance studies will be collected from Prince William Sound in collaboration with the project Oil-Related Embryo Mortalities (Restoration Study 95191A). Embryo incubation will take place at the Armin F. Koernig hatchery in Prince William Sound and at the Genetics Lab facilities of ADF&G. The initial laboratory phases of the project will be done at the University of Montana.

We propose to use the Alaska SeaLife Center Research Facilities at Seward when it is available for rearing fish and laboratory analyses. This facility will greatly strengthen genetic investigations with pink salmon by allowing multigenerational studies and testing for effects of specific genotypes on phenotypes of importance (marine survival, run timing, etc.). We anticipate that much of the laboratory analysis will be performed at this facility when it is available.

COMMUNITY INVOLVEMENT

This is a specialized project that will not benefit directly from the knowledge of local/traditional people. We will hire local residents when possible for assistance (e.g., maintaining of fish). In addition, as an professional educator in a university I am very committed to educational efforts. These will include informational meetings in the communities of Prince William Sound, including the Alaska SeaLife Center in Seward, and articles in the Trustee Council newsletter.

PROJECT DESIGN

A. Objectives

Our primary objective is to construct a detailed genetic linkage map for pink salmon by analyzing the genetic transmission of several hundred DNA polymorphisms. Pink salmon have 26 pairs of chromosomes (2N=52; Allendorf and Thorgaard 1984), and, therefore, should have a total of 27 linkage-groups (LG's): 25 autosomes, an X-chromosome, and a Y-chromosome. We plan to map enough variable markers so that a new marker, such as a putative lesion identified in Restoration Study 95191A, can be assigned with high probability to one of the 27 LG's. It is impossible to know how many markers this will require because we do not know the total length of the pink salmon linkage map. The linkage map of the zebrafish (*Danio rerio*) has been estimated to be 2317 centimorgans (cM; Postlethwait et al. 1994). We expect the pink salmon map in females will be longer than this because of the polyploid ancestry of salmonids. However, the linkage map in males will be shorter than in females because of the reduced recombination rate in male salmonids (Johnson et al. 1987). We anticipate that it will be necessary to map approximately 500 markers to insure that new markers can be assigned to an existing LG with high probability (Van der Beek and Van Arendonk 1993). For example, 99% of all loci in the zebrafish are estimated to be located within 20 cM of a marker on the map based upon 414 markers.

This project has the following specific objectives:

1. Develop several hundred variable DNA markers in pink salmon and test them for Mendelian inheritance.

2. Construct a linkage map based upon joint segregation patterns of the DNA polymorphisms detected in previous objective.

3. Map putative lesions identified in Restoration Study 95191A.

4. Test for Mendelian inheritance of markers throughout the genome in progeny of fish exposed to oil. Regions that show aberrant segregation ratios in progeny of fish exposed to oil and normal 1:1 ratios in fish not exposed to oil would be candidates for oil-induced lesions.

5. Test for regions of the genome that are associated with traits of adaptive significance (e.g., marine mortality or run-timing).

6. Test if protein markers (allozymes) are under natural selection such that they may not provide accurate information about the genetic structure and amount of gene flow among populations.

B. Methods

Linkage Map (Objectives 1 & 2)

A useful genetic map should contain genetic markers that are abundant, randomly distributed throughout the genome, highly polymorphic, and readily detectable in many laboratories (Jacob et al.

1995). A map of random amplified polymorphic DNA's (RAPD's) markers fits these criteria (Postlethwait et al. 1994). Our work has found that a polymerase chain reaction (PCR) with genomic DNA from fish of the genus *Oncorhynchus* as a template and a single, 10-nucleotide-long primer of arbitrary sequence generally amplifies 5-10 DNA fragments. We have found differences in the fragment patterns between individuals (scored as presence or absence of fragments) that are inherited as simple Mendelian markers in rainbow trout (*O. mykiss*) and cutthroat trout (*O. clarki*). A dominant allele amplifies the DNA fragment with a specific primer, whereas a recessive allele results in the absence of that fragment.

We will avoid difficulties of dominance with these markers by using haploid progeny in which recessive alleles are not obscured by their dominant alternatives (Lie et al. 1994). Stanley (1983) reported that haploid embryos of Atlantic salmon (*Salmo salar*) will develop until just prior to the stage of hatching if development of the eggs is activated by sperm in which the DNA has been inactivated by UV-radiation. We have used this technique routinely with fishes of the genus *Oncorhynchus* (Forbes et al. 1994). This will allow us to follow the segregation and linkage relationships in haploid progeny from females.

Differences in meiosis between male and female salmonids have been found in all species that have been examined (Allendorf and Thorgaard 1984; Johnson et al. 1987). There generally is greater recombination in females than in males (Johnson et al. 1987; Allendorf et al. 1994). In addition, only disomic inheritance has been reported in females. However, in males some loci show patterns of segregation that approach those expected with tetrasomic inheritance (Allendorf and Thorgaard 1984). We will have to test for segregation and linkage in males as well as females because of these sex-specific differences.

There are three possible approaches to test for segregation and recombination in males. One is genotyping in diploid progeny from parents that have been chosen so that presence or absence of a RAPD allele can be determined unambiguously. A second approach is the typing of haploid progeny from males by PCR based genotyping of single sperm; this has been carried out successfully with human sperm (Schmitt et al. 1994). Individual sperm from a single male are sorted into microtiter plates by flow cytometry, and then a PCR reaction carried out. We will perform pilot studies to determine if the latter method is feasible with pink salmon. A third possibility is to examine joint segregation in androgenetic haploids which are produced by treating eggs with radiation before fertilization with normal sperm (Scheerer et al. 1986). This treatment would be carried out in collaboration with Restoration Study 95191A in their use of androgenesis to test for elevated occurrence of harmful recessive mutations in haploid-androgens of oil-exposed ancestry.

The completion of a full linkage map is a large task. We will try to use and develop as many time and labor saving procedures as possible (Lincoln and Lander 1992; Taylor et al. 1994; Perlin et al. 1994; Archibald 1994). Our initial linkage map will be based upon progeny from females, and will be constructed by computer assisted analysis (Lander et al. 1987). We will compare the recombination rates based upon this map to rates of selected pairs of loci in males. The reduced recombination rates in salmonid males means that it will be easier to assign new markers to a LG using male parents. We will test joint segregation of individual markers from different LG's in females to determine if some of these separate LG's in females are linked in males and are therefore syntenic (on the same chromosome).

Identification and Location of Oil-Induced Lesions (Objectives 3 & 4)

This work will be done in collaboration with efforts to detect oil-induced genetic damage under Component 3 of Restoration Study 95191A. Lesions identified in that study through DNA assays of introns, microsatellite loci, or mutational hot spot regions will be tested for joint-segregation with several hundred DNA markers to identify the location of such lesions in the pink salmon genome. A recent paper has found that microsatellite loci show genetic hypermutability because of defects in DNA mismatch repair (Parsons et al. 1995).

Perhaps a more promising approach, however, is to test for regions of the genome associated with non-random survival in haploid progeny. Restoration Study 95191A will test for decreased survival in haploid androgens of oil-exposed ancestry. Examining the segregation of markers throughout the genome in these androgens would provide a more powerful test for lesions. Regions of the genome that depart from the expected 1:1 Mendelian ratio would be candidates for lesions. We will also compare Mendelian ratios in haploid gynogens in a similar manner to haploid androgens. The examination of segregation in gynogenetic and androgenetic haploids will also allow testing for oil-induced chromosomal rearrangements (e.g., inversions and deletions).

Phenotypic Effects and Fitness (Objectives 5 & 6)

The completion of a genome map for pink salmon will allow us to address important genetic issues related to two other Components of the Pink Salmon Restoration Program. The numerous genetic markers identified in the course of this study will provide greatly increased power and resolution to identify stocks of pink salmon on a very fine scale (Stock Separation and Management). The genetic map will allow us to test for the presence of genes having major effects on phenotypes of importance for the management of pink salmon, and to test for phenotypes associated with specific combinations of multilocus genotypes (Lander and Schork 1994).

This aspect of the research will be performed at the Alaska SeaLife Center Research Facilities in the latter years of the study. Large numbers of marked fish will be released and then collected when they return to the facility at sexual maturity. A large sample of the fish will be collected at release so that the genetic characteristics of the fish can be described prior to the marine phase of the life cycle. We will test for genetic effects on phenotypes of special importance by comparing the released and returning fish. This will allow us to test for genes having a major effect on marine survival.

In addition, previous work has demonstrated genetic differences between early and late run fish, and that differences in run-timing has a genetic basis (Smoker et al. in press). We will compare the genotypes of fish returning to the facility at different times to test for genes having a major effect on run timing. We will use a suite of genetic markers spread uniformly throughout the genome. Regions of the genome that show major associations with run-timing can then be examined in more detail by comparing additional markers within that region. A similar approach using only 10 protein markers in hatchery rainbow trout revealed several regions of genome associated with time of spawning (Leary et al. 1989)

Karl and Avise (1992) reported concordant patterns of genetic differentiation for mitochondrial DNA and four nuclear DNA loci in the American oyster (*Crassostrea virginica*) along the east coast of North America. In contrast, previous allozyme studies had not detected these genetic differences among these same populations. Karl and Avise concluded that the pattern observed for the DNA markers reflected the historical patterns of isolation and gene flow among these populations while this pattern is obscured in the allozymes because of "balancing selection" at the allozyme loci. Similar results have been reported recently in the Atlantic cod (Pogson et al. 1995). These results provide an important challenge to the generally accepted utility of allozyme markers for describing historical patterns and amounts of gene flow between populations. That is, if allozymes are under strong natural selection then they may not provide accurate information about the genetic structure and amount of gene flow among populations.

Pink salmon that are more heterozygous at allozyme loci have greater viability and growth rates than more homozygous individuals (Altukhov et al. 1991; Zhivotovsky et al. 1987). Similar results have been reported in other salmonid species for many phenotypes of evolutionary importance (e.g., developmental rate, egg size, and disease resistance; reviewed by Ferguson 1992). Positive associations between heterozygosity at allozyme loci and important phenotypic characters, such as growth rate, survival, fertility, disease resistance, developmental rate, and developmental stability, have been described in many organisms (reviewed by Zouros and Foltz 1986; Allendorf and Leary 1986).

The mechanism underlying these associations remains unknown. The possible explanations most often considered are either the associations are be the consequence of heterozygosity at the loci examined, or the loci examined may be in linkage disequilibrium with other loci that affect the traits being studied (Leary et al. 1987). It has been argued that these relationships between multiple locus heterozygosity and phenotypes have been found with allozymes because these loci are important in ATP production and protein catabolism (Koehn et al. 1988). We propose to distinguish between these hypotheses by comparing the effects on marine survival of DNA markers and protein polymorphisms. If the enzyme loci themselves are responsible for this effect, then we would expect to find an association between enzyme genotypes and survival, but not between genotypes at DNA markers spread throughout the nuclear genome.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

None anticipated at this time.

SCHEDULE

A. Measurable Project Tasks for FY 97 (1 Oct 96 - 30 Sep 97)

1 Oct 96 - 30 Sep 97:	Continued screening of DNA polymorphisms to test for Mendelian inheritance and joint segregation in 1995 brood-year progeny.

1 Oct 96 - 31 Dec 96:	Screening of DNA polymorphisms in 1996 brood-year parents and progeny to confirm haploid families.
1 Jan 97 - 30 Sep 97	Screen DNA polymorphisms to test for Mendelian inheritance and joint segregation in 1996 brood-year progeny.

B. Project Milestones and Endpoints

Objective 1: This objective will be completed by in the middle of year 2 (FY 97).

Objective 2: This objective will be completed in middle of year 4 (December 99).

Objective 3: This objective will be completed by the end of year 5.

Objective 4: This objective will be completed by the end of year 5.

Objective 5: This objective will be completed by the end of year 5.

Objective 6: This objective will be completed by the end of year 5.

C. Completion Date

We propose to continue this work for five years. This will allow us to complete multigenerational studies of inheritance with pink salmon. New genetic markers will be developed in the first year of the study. However, it will take several years to map the markers in both males and females in both odd- and even-year fish. Different objectives will be met throughout the course of the research. This project would be carried out in collaboration with Dr. James E. Seeb, Alaska Department of Fish and Game. The primary laboratory aspects of this research would be carried out at the University of Montana. We propose to use the Alaska SeaLife Center Research Facilities at Seward when they are available. Such a facility will greatly strengthen genetic investigations with pink salmon by allowing multigenerational studies. We cannot estimate budget costs after the first two years without knowing the cost structure of using the Alaska SeaLife facility.

PUBLICATIONS AND REPORTS

We cannot anticipate what manuscripts will be submitted in FY 97 because we have just begun work on the project. Nevertheless, we anticipate submitting manuscripts describing the polymorphic DNA markers and their inheritance to appropriate journals in FY 97.

PROFESSIONAL CONFERENCES

We anticipate presenting our results at professional and scientific meetings based on our results. We do not know at present the specifics of these presentations.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This work is being done in collaboration with James E. Seeb, Principal Geneticist, ADFG. The inheritance experiments will be in coordination with the project Oil-Related Embryo Mortalities (Restoration Study 96191A). Dr. Seeb and I are also coordinating plans to use the Alaska SeaLife Center Research Facilities at Seward when they are available. Where possible we will share fish samples, gametes, laboratory equipment, and fish rearing facilities.

This work is related to my ongoing genetic research with salmonid fishes that has been supported by the National Science Foundation since 1980. Many of the techniques and approaches proposed here are based upon the results of that research. I also intend to continue seeking support from NSF that will complement the research proposed here. A genetic map for pink salmon will allow us to address a number of fundamental questions in the conservation and genetics of pink salmon and other *Oncorhynchus* species.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

The PROJECT DESIGN in this DPD does not differ from that approved by the Trustee Council in FY 96. The SCHEDULE described in this DPD has been modified to reflect our actual start of March 1996 rather than October 1995.

PRINCIPAL INVESTIGATOR

Fred W. Allendorf
Division of Biological Sciences
University of Montana
Missoula, MT 59812

Phone: (406) 243-5503
Fax: (406) 243-4184
E-mail: darwin@selway.umt.edu

PERSONNEL

FRED W. ALLENDORF: Principal Investigator

BIRTH: 29 April 1947; Philadelphia, Pennsylvania

MILITARY SERVICE: U.S. Army, 1965-1968 (Vietnam, 1966-1967)

EDUCATION:
B.S., Zoology, Pennsylvania State University, 1971
M.S., Fisheries, University of Washington, 1973
Ph.D., Genetics and Fisheries, University of Washington, 1975 (co-directors, Joe Felsenstein and Fred Utter)

POSITIONS:

1975-1976 Lektor, Department of Genetics and Ecology, Aarhus University, Denmark
1976-1979 Assistant Professor of Zoology, University of Montana
1978-1979 NATO Fellow, Genetics Research Unit, University of Nottingham, England
1979-1984 Associate Professor of Zoology, University of Montana
1983-1984 Visiting Scientist, Department of Genetics, Univ. of California, Davis
1984-1989 Professor of Zoology, University of Montana
1989-1990 Program Director, Population Biology and Physiological Ecology, National Science Foundation (NSF)
1992-1993 Visiting Professor, University of Oregon
1990- Professor of Biology, University of Montana
1993- Director, Organismal Biology and Ecology Graduate Program, University of Montana

HONORS:
NATO/NSF Postdoctoral Fellowship, University of Nottingham, 1978-1979
European Molecular Biology Organisation (EMBO), Fellowship, University of Stockholm, 1979
Distinguished Scholar Award, University of Montana, June 1985
Burlington Northern Faculty Achievement Award for Research, University of Montana, June 1987
Elected Fellow, American Association for the Advancement of Science (AAAS), February 1987
Burlington Northern Faculty Achievement Award for Research, University of Montana, May 1991
Elected Member, AAAS Council (Biological Sciences Division)

MAJOR GRANTS:

National Science Foundation Research Grant, EPSCR, 1980-1983, $70,000
National Science Foundation Research Grant, Population Biology, 1980-1982, $60,000

National Science Foundation Research Grant, 1983-1986, $121,000
National Science Foundation, Faculty Research Opportunity Award, 1986, $10,000
United States Department of Agriculture Grant, Aquaculture, 1983-1985, $43,000
National Science Foundation Research Grant, 1986-1989, $148,000
National Science Foundation, Dissertation Research Grant, 1988-1990, $9,850
National Science Foundation Research Grant, 1989-1993, $150,000
National Science Foundation Research Grant, Conservation and Restoration Biology, 1993-1996, $250,000

ASSOCIATE EDITORSHIPS:
Evolution (1987-1990)
Journal of Heredity (1986-1989)
Progressive Fish Culturist (1986-1989)
Molecular Biology and Evolution (1994-)

EDITORIAL BOARDS:
Molecular Biology and Evolution (1983-1989)
Conservation Biology (1990-1993)
Molecular Ecology (1991-present)

PROFESSIONAL SERVICE:

Panel Member, Population Biology and Physiological Ecology, NSF (1987-1989)
Panel Member, International Program, National Science Foundation (1987)
Panel Member, Conservation and Restoration Biology, NSF (1991-1992; 1995)
Council Member, The American Genetic Association (1986-1989)
Genetics Nomenclature Committee, American Fisheries Society (1986-present)
Member, Committee on the Protection and Management of Pacific Northwest Anadromous Salmonids, National Research Council (1992-present)
Chair, Committee of Visitors, Systematic and Population Biology Programs, NSF (1993)

PROFESSIONAL SOCIETIES:
Society for the Study of Evolution
American Society of Naturalists
Genetics Society of America
Society for Conservation Biology
American Association for the Advancement of Science
American Society of Ichthyologists and Herpetologists
American Fisheries Society
American Genetic Association
Desert Fishes Council
Ecological Society of America
Montana Native Plant Society
Society of Systematic Biologists
Society for Molecular Biology and Evolution

BOOK CHAPTERS:

Utter, F.M., H.O. Hodgins, F.W. Allendorf, A.G. Johnson, and J.L. Mighell. 1973. Biochemical variants in Pacific salmon and rainbow trout: their inheritance and application in population studies. In: Genetics and Mutagenesis of Fish, pp. 329-339. Springer-Verlag, Berlin.

Utter, F.M., H.O. Hodgins, and F.W. Allendorf. 1974. Biochemical genetic studies of fishes: potentialities and limitations. In: Biochemical and Biophysical Perspectives in Marine Biology, Vol. l, pp. 213-238.

Allendorf, F.W., F.M. Utter, and B.P. May. 1975. Gene duplication in the family Salmonidae: II. Detection and determination of the genetic control of duplicate loci through inheritance studies and the examination of populations. In: Isozymes IV: Genetics and Evolution, pp. 415-432. Clement L. Markert, editor. Academic Press, New York.

Allendorf, F.W., and F.M. Utter. 1979. Population genetics. In: Fish Physiology, Volume 8, pp. 407-454. W.S. Hoar, D.J. Randall, and J.R. Brett, editors. Academic Press, New York.

Allendorf, F.W., R.F. Leary, and K.L. Knudsen. 1983. Structural and regulatory variation of phosphoglucomutase in rainbow trout. In: Isozymes: Current Topics in Biological and Medical Research, Vol. 9, pp. 123-142. Alan R. Liss Publ. Co., N.Y.

Allendorf, F.W. 1983. Isolation, gene flow, and genetic differentiation among populations. In: Genetics and Conservation, edited by C. Schonewald-Cox, et al. Benjamin/Cummings. pp. 51-65.

Allendorf, F.W., and G. Thorgaard. 1984. Tetraploidy and the evolution of salmonid fishes. In: The Evolutionary Genetics of Fishes, B.J. Turner, ed., Plenum Press, pp. 1-53.

Allendorf, F.W., and R.F. Leary. 1986. Heterozygosity and fitness in natural populations of animals. In: Conservation Biology: The Science of Scarcity and Diversity. M. Soule', editor. Sinauer Assoc. pp. 57-76.

Allendorf, F.W., N. Ryman, and F.M. Utter. 1987. Genetics and fishery management: Past, present, and future. In: Population Genetics and Fisheries Management, edited by N. Ryman and F.M. Utter. University of Washington Press, pp. 1-19.

Allendorf, F.W., and N. Ryman. 1987. Genetic management of hatchery stocks. In: Population Genetics and Fisheries Management, edited by N. Ryman and F.M. Utter. University of Washington Press, pp. 141-159.

Thorgaard, G.H., and F. W. Allendorf. 1988. Developmental genetics of fishes. In: Developmental Genetics of Animals and Plants, edited by G. M. Malacinski. Macmillan Publishing Company, pp. 363-391.

Powers, D.A., F.W. Allendorf, and T. Chen. 1990. Application of molecular techniques to the study of marine recruitment problems. In: Large Marine Ecosystems: Patterns, Processes, and Yields, ed. by K. Sherman, L.M. Alexander, and B.D. Gold. Amer. Assoc. Advancement Sci., pp. 104-121.

Allendorf, F.W., and M.M. Ferguson. 1990. Genetics. In: Methods for Fish Biology, edited by C.B. Schreck and P.B. Moyle. Amer. Fish. Soc., Bethesda, Maryland, pp. 35-63.

Ferguson, M.M., and F.W. Allendorf. 1991. Evolution of the fish genome. In: Biochemistry and Molecular Biology of Fishes, edited by P.W. Hochachka and T.P. Mommsen. Elsevier. pp. 25-42.

Allendorf, F.W. 1994. Genetics and demography of grizzly bear populations. In: Principles of Conservation Biology by G.K. Meffe and C.R. Carroll. Sinauer Associates. pp. 155-156.

Allendorf, F.W., and R.S. Waples. In press. Conservation genetics of salmonid fishes. In: Conservation Genetics, edited by J.C. Avise and J.L. Hamrick. Chapman & Hall.

ARTICLES:

Heckman, J.R., F.W. Allendorf, and J.E. Wright, Jr. 1971. Trout leukocytes: growth in oxygenated cultures. Science 173:246-247.

Allendorf, F.W., and F.M. Utter. 1973. Gene duplication in the family Salmonidae: disomic inheritance of two loci reported to be tetrasomic in rainbow trout. Genetics 74:647-654.

Utter, F.M., F.W. Allendorf, H.O. Hodgins, and A.G. Johnson. 1973. Genetic basis of tetrazolium oxidase phenotypes in rainbow trout. Genetics 73:159.

Utter, F.M., F.W. Allendorf, and H.O. Hodgins. 1973. Genetic variability and relationships in Pacific salmon and related trout based on protein variations. Syst. Zool. 22:257-270.

Allendorf, F.W., F.M. Utter, and B.P. May. 1975. Gene duplication in the family Salmonidae: II. Detection and determination of the genetic control of populations. In Isozymes IV: Genetics and Evolution, pp. 415-432. C. L. Markert, editor. Academic Press, New York.

May, B.P., F.M. Utter, and F.W. Allendorf. 1975. Biochemical genetic variation in pink and chum salmon: inheritance of intraspecies variation and apparent absence of interspecies introgression following massive hybridization of hatchery stocks. J. of Heredity 66:227-232.

Allendorf, F.W., and F.M. Utter. 1976. Gene duplication in the family Salmonidae: III. Linkage between two duplicated loci coding for aspartate aminotransferase in the cutthroat trout. Hereditas 82:19-24.

Allendorf, F.W., N. Ryman, A. Stenneck, and G. Stahl. 1976. Genetic variation in Scandinavian

populations of brown trout: evidence of distinct sympatric populations. Hereditas 83:73-82.

Utter, F.M., F.W. Allendorf, and B.P. May. 1976. The use of protein variation in the management of salmonid populations. Trans. 1st North American Wildlife and Natural Resources Conference. pp. 373-384.

Utter, F.M., F.W. Allendorf, and B.P. May. 1976. Genetic delineation of salmonid populations. In: Salmonid Genetics: Status and Role in Aquaculture. T. Nosho and W. Hershberger, editors. University of Washington Sea Grant Publication.

Allendorf, F.W., N.J. Mitchell, N. Ryman, and G. Stahl. 1977. Isozyme loci in brown trout (*Salmo trutta*): Detection and interpretation from population data. Hereditas 86:179-190.

Allendorf, F.W. 1977. Genetic variation in populations of fish. In: Fish Genetics-Fundamentals and Implications to Fish Management, pp. 35-39. C.M. Fetterholf, editor. Great Lakes Fishery Commission, Ann Arbor, Mich.

Utter, F.M., and F.W. Allendorf. 1977. Determination of the breeding structure of steelhead trout (*Salmo gairdneri*) populations through gene frequency analysis. Calif. Coop. Fish. Res. Unit Special Report 77-1:44-54.

Allendorf, F.W. 1977. Electromorphs or alleles? Genetics 87:821-822.

Allendorf, F.W. 1978. Electrophoretic distinction of rainbow trout (*Salmo gairdneri*) and cutthroat trout (*S. clarki*). Letter to the editor. J. Fisheries Res. Bd. Canada 35:483.

Allendorf, F.W. 1978. Protein polymorphism and the rate of loss of duplicate gene expression. Nature 272:76-78.

Utter, F.M., F.W. Allendorf, and B. May. 1979. Genetic basis of creatine kinase isozymes in skeletal muscle of salmonid fishes. Biochem. Genet. 17:1079-1091.

Ryman, N., F.W. Allendorf, and G. Stahl. 1979. Reproductive isolation with little genetic divergence in sympatric populations of brown trout (*Salmo trutta*). Genetics 92:247-262.

O'Malley, D.M., F.W. Allendorf, and G.M. Blake. 1979. Inheritance of isozyme variation and heterozygosity in *Pinus ponderosa*. Biochem. Genet. 17:233-250.

Clarke, B., and F.W. Allendorf. 1979. Frequency-dependent selection due to kinetic differences between allozymes. Nature 279:732-734.

Allendorf, F.W., F.B. Christiansen, T. Dobson, W.F. Eanes, and O. Frydenberg. 1979. Electrophoretic variation in large mammals. I. The polar bear, *Thalarctos maritimus*. Hereditas 91:19-22.

Allendorf, F.W. 1979. Rapid loss of duplicate gene expression by natural selection. Heredity 43:247-259.

Allendorf, F.W. 1979. Protein polymorphism and the rate of loss of duplicate gene expression, a reply. Nature 279:456.

Allendorf, F.W., D.M. Espeland, D.T. Scow, and S. Phelps. 1980. Coexistence of native and introduced rainbow trout in the Kootenai River drainage. Proc. Montana Acad. Sciences 39:28-36.

Allendorf, F.W., and S. Phelps. 1980. Loss of genetic variation in a hatchery stock of cutthroat trout. Trans. Amer. Fish. Soc. 109: 537-543.

Allendorf, F.W., and S.R. Phelps. 1981. Use of allelic frequencies to describe population structure. Canadian Journal of Fisheries and Aquatic Sciences 38: 1507-1514.

Krueger, C.C., A. Gharrett, T.R. Dehring, and F.W. Allendorf. 981. Genetic aspects of fisheries rehabilitation programs. Canadian Journal of Fisheries and Aquatic Sciences 38: 1877-1881.

Allendorf, F.W., and S.R. Phelps. 1982. Isozymes and the preservation of genetic variation in salmonid fishes. Ecological Bulletin (Stockholm) 34: 37-52.

Allendorf, F.W., K.L. Knudsen, and G.M. Blake. 1982. Frequencies of null alleles at enzyme loci in natural populations of ponderosa and red pine. Genetics 100: 497-504.

Phelps, S.R., and F.W. Allendorf. 1982. Genetic comparison of upper Missouri River cutthroat trout to other *Salmo clarki lewisi* populations. Proc. Mont. Acad. Sci. 41: 14-22.

Allendorf, F.W., K.L. Knudsen, and S.R. Phelps. 1982. Identification of a gene regulating the tissue expression of a phosphoglucomutase locus in rainbow trout. Genetics 102: 259-268.

Simonsen, V., F.W. Allendorf, W.F. Eanes, and F.O. Kapel. 1982. Electrophoretic variation in large mammals: III. The ringed seal, the harp seal, and the hooded seal. Hereditas 97:87-90.

Phelps, S.R., and F.W. Allendorf. 1983. Genetic identity of pallid and shovelnose sturgeon (*Scaphirhynchus albus* and *S. platorynchus*). Copeia 1983(3):696-700.

Allendorf, F.W. 1983. Linkage disequilibrium generated by selection against null alleles at duplicate loci. American Naturalist 121:588-592.

Daugherty, C.H., F.W. Allendorf, W.W. Dunlap, and K.L. Knudsen. 1983. Systematic implications of geographic patterns of genetic variation in the genus *Dicamptodon*. Copeia 1983(3):679-691.

Woods, J.H., G.M. Blake, and F.W. Allendorf. 1983. Amount and distribution of isozyme variation in ponderosa pine from eastern Montana. Silvae Genetica 32:151-157.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1983. Developmental stability and enzyme heterozygosity in rainbow trout. Nature 101:71-72.

Thorgaard, G.H., F.W. Allendorf, and K.L. Knudsen. 1983. Gene-centromere mapping in rainbow trout: High interference over long map distances. Genetics 103:771-783.

Allendorf, F.W., K.L. Knudsen, and R.F. Leary. 1983. Adaptive significance of differences in the tissue-specific expression of a phosphoglucomutase gene in rainbow trout. Proc. Nat. Acad. Sci. USA 80:1397-1400.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1983. Consistently high meristic counts in natural hybrids between brook trout and bull trout. Syst. Zool. 32: 369-376.

Allendorf, F.W., G. Stahl, and N. Ryman. 1984. Silencing of duplicate genes: Evidence for a common null allele polymorphism for lactate dehydrogenase in brown trout (*Salmo trutta*). Molecular Biology and Evolution 1:238-248.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1984. Major morphological effects of a regulatory gene: Pgm1-t in rainbow trout. Molecular Biology and Evolution 1:183-194.

Leary, R.F., F.W. Allendorf, S.R. Phelps, and K.L. Knudsen. 1984. Introgression between westslope cutthroat and rainbow trout in the Clark Fork River drainage, Montana. Proc. Montana Acad. Sci. 43:1-18.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1984. Superior developmental stability of enzyme heterozygotes in salmonid fishes. American Naturalist 124:540-551.

Allendorf, F.W., and R.F. Leary. 1984. Heterozygosity in gynogenetic diploids and triploids estimated by gene-centromere recombination rates. Aquaculture 43:413-420.

Woods, J.H., G.M. Blake, and F.W. Allendorf. 1984. Using isozyme analysis to aid in selecting ponderosa pine for coal mine spoil reclamation. Northwest Science 58:262-268.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1985. Developmental instability as an indicator of reduced genetic variation in hatchery trout. Trans. Amer. Fish. Soc. 114:230-235.

Leary, R.F., F.W. Allendorf, K.L. Knudsen, and G.H. Thorgaard. 1985. Heterozygosity and developmental stability in gynogenetic diploid and triploid rainbow trout. Heredity 54:219-225.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1985. Inheritance of meristic variation and the evolution of developmental stability in rainbow trout. Evolution 39:308-314.

Danzmann, R.G., M.M. Ferguson, and F.W. Allendorf. 1985. Allelic differences in initial expression of paternal alleles at an isocitrate dehydrogenase locus in rainbow trout. Developmental Genetics 5:117-127.

Ferguson, M.M., R.G. Danzmann, and F.W. Allendorf. 1985. Developmental divergence among hatchery strains of rainbow trout (*Salmo gairdneri*). I. Pure strains. Can. J. Genet. and Cytol. 27:289-297.

Ferguson, M.M., R.G. Danzmann, and F.W. Allendorf. 1985. Developmental divergence among hatchery strains of rainbow trout (*Salmo gairdneri*). II. Hybrids. Can. J. Genet. and Cytol. 27:298-307.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1985. Developmental instability and high meristic counts in interspecific hybrids of salmonid fishes. Evolution 39:1318-1326.

Gyllensten, U., R.F. Leary, F.W. Allendorf, and A.C. Wilson. 1985. Introgression between two cutthroat trout subspecies with substantial karyotypic, nuclear, and mitochondrial genomic divergence. Genetics 111:905-915.

Ferguson, M.M., R.G. Danzmann, and F.W. Allendorf. 1985. Absence of developmental incompatibility in hybrids between rainbow trout and two subspecies of cutthroat trout. Biochemical Genetics 23:557-570.

Danzmann, R.G., M.M. Ferguson, and F.W. Allendorf. 1985. Does enzyme heterozygosity influence developmental rate in rainbow trout? Heredity 56:417-425.

Hedrick, P.W., P.F. Brussard, F.W. Allendorf, J. Beardmore, and S. Orzak. 1986. Protein variation, fitness, and captive propagation. Zoo Biology 5: 91-100.

Allendorf, F.W. 1986. Genetic drift and the loss of alleles versus heterozygosity. Zoo Biology 5: 181-190.

Danzmann, R.G., M.M. Ferguson, and F.W. Allendorf. 1986. Heterozygosity and developmental rate in a strain of rainbow trout. Evolution 40:86-93.

Scheerer, P.D., G.H. Thorgaard, F.W. Allendorf, and K.L. Knudsen. 1986. Androgenetic rainbow trout produced from inbred and outbred sperm sources show similar survival. Aquaculture 57:289-298.

Allendorf, F.W., J.E. Seeb, K.L. Knudsen, G.H. Thorgaard, and R.F. Leary. 1986. Gene-centromere mapping of 25 loci in rainbow trout. J. Heredity 77:307-312.

Allendorf, F.W., and C. Servheen. 1986. Conservation genetics of grizzly bears. Trends in Ecology and Evolution 1:88-89.

Danzmann, R.G., M.M. Ferguson, and F.W. Allendorf. 1987. Heterozygosity and oxygen consumption rate as predictors of growth and developmental rate in rainbow trout. Physiol. Zool. 60:211-220.

Marnell, L.F., R.J. Behnke, and F.W. Allendorf. 1987. Genetic identification of the cutthroat trout (*Salmo clarki*) in Glacier National Park, Montana. Can. J. Fish. Aquat. Sci. 44:1830-1839.

Leary, R.F., F.W. Allendorf, S.R. Phelps, and K.L. Knudsen. 1987. Genetic divergence and identification of seven subspecies of cutthroat trout and rainbow trout. Trans. Amer. Fish. Soc. 116:580-587.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1987. Differences in inbreeding coefficients do not explain the association between heterozygosity at isozyme loci and developmental stability in rainbow trout. Evolution 41:1413-1415.

Ferguson, M.M., R.G. Danzmann, and F. W. Allendorf. 1987. Adaptive significance of developmental rate in rainbow trout: an experimental test. Biol. J. Linnean Soc. 33:205-216.

Leary, R.F., F.W. Allendorf, S.R. Phelps, and K.L. Knudsen. 1988. Population genetic structure of westslope cutthroat trout: Genetic variation within and among populations. Proc. Montana Acad. Sci. 48:57-70.

Danzmann, R. G., M. M. Ferguson, and F. W. Allendorf. 1988. Heterozygosity and components of fitness in a strain of rainbow trout. Biol. J. Linnean Soc. 33:285-304.

Ferguson, M.M., K. L. Knudsen, R. G. Danzmann, and F. W. Allendorf. 1988. Developmental rate and viability of rainbow trout with a null allele at a lactate dehydrogenase locus. Biochem. Genet. 26:177-189.

Ferguson, M.M., R.G. Danzmann, and F.W. Allendorf. 1988. Developmental success of hybrids between two taxa of salmonid fishes with moderate structural gene divergence. Can. J. Zool. 66:1389-1395.

Allendorf, F.W., and R.F. Leary. 1988. Conservation and distribution of genetic variation in a polytypic species, the cutthroat trout. Conservation Biology 2:170-184.

Allendorf, F. W. 1988. Conservation biology of fishes. Conservation Biology 2:145-148.

Lesica, P., R.F. Leary, F.W. Allendorf, and D.E. Bilderback. 1988. Lack of genic diversity within and among populations of an endangered plant, *Howellia aquatilis*. Conservation Biology 2:275-282.

Harris, R.B., and F. W. Allendorf. 1989. Genetically effective population size of large mammals: Assessment of estimators. Conservation Biology 3:181-191.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1989. Genetic differences among rainbow trout spawned on different days within a single spawning season. Progressive Fish-Culturist 51:10-19.

Leary, R.F., and F.W. Allendorf. 1989. Fluctuating asymmetry as an indicator of stress:

Implications for conservation biology. Trends Ecol. Evol. 4:214-217.

Shaklee, J.B., F.W. Allendorf, D.C. Morizot, and G.S. Whitt. 1989. Genetic nomenclature for protein-coding loci in fish: proposed guidelines. Trans. Amer. Fish. Soc. 118:218-227.

Danzmann, R. G., M.M. Ferguson, and F.W. Allendorf. 1989. Genetic variability and components of fitness in hatchery strains of rainbow trout. J. Fish Biol. 35 (Supplement A):313-320.

Ferguson, M.M., R.G. Danzmann, F.W. Allendorf, and K.L. Knudsen. 1990. Metabolic effects of the expression of a phosphoglucomutase locus in the liver of rainbow trout. Canad. J. Zool. 68:1499-1504.

Shaklee, J.B., F.W. Allendorf, D.C. Morizot, and G.S. Whitt. 1990. Gene nomenclature system for protein-coding loci in fish. Trans. Amer. Fish. Soc. 119:2-15.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1991. Effects of rearing density on meristics and developmental stability of rainbow trout. Copeia 1991(1):44-49.

Forbes, S.H., and F.W. Allendorf. 1991. Associations between mitochondrial and nuclear genotypes in cutthroat trout hybrid swarms. Evolution 45:1332-1349.

Forbes, S.H., and F.W. Allendorf. 1991. Mitochondrial genotypes have no detectable phenotypic effects in cutthroat trout hybrid swarms. Evolution 45:1350-1359.

Allendorf, F.W. 1991. Ecological and genetic effects of fish introductions: Synthesis and recommendations. Canadian J. Fish. and Aquatic Sciences 48 (Suppl. 1):178-181.

Scheerer, P.D., G.H. Thorgaard, and F.W. Allendorf. 1991. Genetic analysis of androgenetic rainbow trout. J. Exp. Zool. 260:382-390.

Campton, D.E., F.W. Allendorf, R.J. Behnke, and F.M. Utter. 1991. Reproductive success of hatchery and wild steelhead: A reanalysis. Trans. Amer. Fish. Soc. 120:816-822.

Allendorf, F.W., R.B. Harris, and L.H. Metzgar. 1991. Estimation of effective population size of grizzly bears by computer simulation. Proceedings Fourth International Congress of Systematics and Evolutionary Biology, pp. 650-654. Dioscorides Press, Portland, Oregon.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1992. Genetic, environmental, and developmental causes of meristic variation in rainbow trout. Acta Zoologica Fennica 191:77-93.

Lesica, P., and F.W. Allendorf. 1992. Are small populations of plants worth protecting? Conservation Biology 6:135-139.

Allendorf, F.W. 1993. Delay of adaptation to captive breeding by equalizing family size. Conservation Biology 7:416-419.

Ryman, N., F. Utter, F.W. Allendorf, C. Busack, and J. Shaklee. 1993. Genetic concerns about hatchery populations - A comment on conclusions of Nyman and Ring. J. Fish Biology 42:471-480.

Leary, R.F., F.W. Allendorf, and S.H. Forbes. 1993. Conservation genetics of bull trout in the Columbia and Klamath River drainages. Conservation Biology 7:856-865.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1993. Null allele heterozygotes at two lactate dehydrogenase loci in rainbow trout are associated with decreased developmental stability. Genetica 89:3-13.

Allendorf, F. W., W. A. Gellman, and G. H. Thorgaard. 1994. Sex linkage of two enzyme loci in rainbow trout. Heredity 72:498-507.

Forbes, S.H., K.L. Knudsen, T. W. North, and F.W. Allendorf. 1994. One of two growth hormone genes in coho salmon is sex-linked. Proc. Nat. Acad. Sci. USA. 91:1628-1631.

Allendorf, F.W. 1994. Comparative utility of genetic markers in the management of Pacific salmon: proteins, nuclear DNA, and mitochondrial DNA. NOAA Technical Memorandum NMFS-NWFSC-17, pp. 127-133.

Forbes, S.H., K.L. Knudsen, and F.W. Allendorf. 1994. Genetic variation in coho salmon detected by PCR amplification of growth hormone gene introns. NOAA Technical Memorandum NMFS-NWFSC-17, pp. 29-33.

Utter, F.M., and F. W. Allendorf. 1994. Phylogenetic relationships among species of *Oncorhynchus*: A consensus view. Conservation Biology 8:864-867.

Leary, R.F., F.W. Allendorf, and G.K. Sage. 1995. Hybridization and introgression between introduced and native fish. Amer. Fish. Soc. Symposium 15:91-101.

Allendorf, F.W. 1995. Genetics: Defining the units of conservation. Amer. Fish. Soc. Symposium 17:000-000.

Lesica, P.L., and F.W. Allendorf. 1995. When are peripheral populations valuable for conservation? Conservation Biology 9:753-760.

Allendorf, F.W., and N. Kanda. 1995. Genetics and the conservation of salmonid fishes in western North America and Japan. Fish Genetics and Breeding Science (Japan) 21:79-102.

Forbes, S.H., J.T. Hogg, F.C. Buchanan, A.M. Crawford, and F.W. Allendorf. 1995. Microsatellite evolution in congeneric mammals: Domestic and bighorn sheep. Molec. Biol. Evol.

Allendorf, F.W., D. Bayles, D. Bottom, K. Currens, C. A. Frissell, D. Hankin, J.

A. Lichatowich, W. Nehlsen, and P.C. Trotter. In press. Criteria for prioritizing stocks of Pacific salmon for conservation and recovery. Conservation Biology.

Kanda, N., R.F. Leary, and F.W. Allendorf. In press. Population genetic structure of bull trout in the Upper Flathead River drainage. Proceedings, Friends of the Bull Trout Conference, Calgary, Alberta, 1994.

Luikart, G., and F.W. Allendorf. In press. Conservation genetics and mtDNA variation in bighorn sheep. J. Mammalogy.

Mills, L.S., and F.W. Allendorf. In press. The one-migrant-per-generation rule in conservation and management. Conservation Biology

Hedrick, P., R. Lacy, F.W. Allendorf, and M. Soulé. In press. Conservation Biology. ***

Other Key Personnel - Paul Spruell: Research Scientist

BORN: August 14, 1965 Bloomington, IL USA

EDUCATION:

B.S.. Ecology, Ethology and Evolution, University of Illinois 1987
M.S. Fisheries and Wildlife, Michigan State University 1989
Ph.D. Zoology, Washington State University 1994

AWARDS

Guy Brislawn Award for the Outstanding WSU Zoology graduate student. 1994.

SOCIETIES

American Fisheries Society 1987-present
American Society of Ichthyologists and Herpetologists 1993-present

RESEARCH INTERESTS

Conservation genetics of fishes
Population genetics of fishes
Alternate reproductive strategies in fishes
Application of molecular tools to conservation and management
Evolutionary biology and systematics of fishes

TECHNICAL EXPERIENCE

Protein electrophoresis to detect sunfish hybrids
(Illinois Nat. Hist. Survey, with Dr. David Philipp)
Chromosome manipulation and ploidy analysis of salmonids
(Michigan State University, with Dr. Donald Garling)
DNA fingerprinting
Semen cryopreservation of salmonids
Androgenesis and Gynogenesis
(Washington State University, with Dr. Gary H. Thorgaard)
Molecular phylogenetic analysis
(S.U.N.Y. - Stony Brook, with Dr. Axel Meyer)
Randomly Amplified Polymorphic DNA of moths and plants
(Washington State University, with Dr. John N. Thompson)
Microsatellite analysis of fishes
(University of Montana, with Dr. Fred Allendorf)

POSITIONS

Post-doctoral Research Associate, University of Montana	08/95-present
Post-doctoral Research Associate, Washington State University	11/94-08/95
Post-doctoral Research Associate, S.U.N.Y-Stony Brook	08/94-11/94
Graduate Assistant, Washington State University	08/89-08/94
Graduate Assistant, Michigan State University	06/83-08/89

PUBLICATIONS:

Dissertations and Thesis:

Spruell, P. 1989. Evaluation of triploid induction in chinook salmon using microwave radiation and growth comparisons of diploid and triploid chinook salmon. M.S. thesis. Michigan State University.

Spruell, P. 1994. DNA fingerprinting of fishes using tandemly repeated and interspersed DNA sequences. Ph.D. dissertation. Washington State University.

Primary Literature:

Spruell, P., S. A. Cummings, Y. Kim, and G. H. Thorgaard. 1994. Comparison of three anadromous rainbow trout populations using DNA fingerprinting and mixed DNA samples. Can. J. Fish. Aquat. Sci. 51 (Suppl. 1): 252-257.

Spruell, P. and G. H. Thorgaard. in press . SINE sequences detect DNA fingerprints in salmonid fishes. Heredity (accepted 7/95)

Spruell, P. and A. G. Wilson. in review. DNA fingerprinting distinguishes geographically isolated populations of Plethodon salamanders.

Thorgaard, G. H., P. Spruell, S. A. Cummings, A. S. Peek, and E. Brannon. in press. Relationship of kokanee and sockeye salmon as determined by DNA fingerprinting. Am. Fish. Soc. Symp. (accepted 5/95)

Thorgaard, G. H., P. Spruell, P. A. Wheeler, A. S. Peek, J. Valentine, and B. Hilton. in press. Albinism as an indicator of induced triploidy. Aquaculture (accepted 6/95)

LITERATURE CITED

Allendorf, F. W., W. A. Gellman, and G. H. Thorgaard. 1994. Sex-linkage of two enzyme loci in *Oncorhynchus mykiss* (rainbow trout). Heredity 72:498-507.

Allendorf, F.W., and R.F. Leary. 1986. Heterozygosity and fitness in natural populations of animals. In: Conservation Biology: The Science of Scarcity and Diversity. M. Soule', editor. Sinauer Assoc. pp. 57-76.

Allendorf, F. W. and G. H. Thorgaard. 1984. Tetraploidy and the evolution of salmonid fishes. Pages 1-53 in B. J. Turner, ed. Evolutionary Genetics of Fishes. Plenum Publishing Corp., New York.

Altukhov, Yu. P., E. A. Salmenkova, and Yu. P. Kartavtsev. 1991. Relation between allozyme heterozygosity and viability and growth rate of pink salmon. Cytology and Genetics 25:47-51.

Archibald, A.L. 1994. From mapping to manipulating the vertebrate genome. Anim. Biotech. 5:233-242.

Biggs, E., T. Baker, M. McGurk, J. E. Hose and R. Kocan. 1991. Injury to Prince William Sound Herring. State/Federal Natural Resources Damage Assessment Draft Preliminary Status Report. Unpub. rep. Alaska Department of Fish and Game, Cordova, AK.

Ferguson, M.M. 1992. Enzyme heterozygosity and growth in rainbow trout - genetic and physiological explanations. Hered. 68:115-122.

Forbes, S. H., K. L. Knudsen, T. W. North, and F. W. Allendorf. 1994. One of two growth hormone genes in coho salmon is sex-linked. Proc. Nat. Acad. Sci. USA 91:1628-1631.

Gharrett, A.J. and W.W. Smoker. 1991. Two generations of hybrids between even-year and odd-year pink salmon (*Oncorhynchus gorbuscha*): A test for outbreeding depression? Can. J. Fish. Aquat. Sci. 48:1744-1749.

Jacob, H.J. and 19 other authors. 1995. A genetic linkage map of the laboratory rat, *Rattus norvegicus*. Nature Genetics 9:63-69.

Johnson, K. R., J. E. Wright Jr., and B. May. 1987. Linkage relationships reflecting ancestral tetraploidy in salmonid fish. Genetics 116:579-591.

Karl, S. A. and J.C. Avise. 1992. Balancing selection at allozyme loci in oysters - Implications from nuclear RFLPs. Science 256:100-102.

Koehn, R.K., W.J. Diehl, and T. M. Scott. 1988. The differential contribution of glycolysis and protein catabolism to the relationship between heterozygosity and growth rate in the coot clam, *Mulina lateralis*. Genetics 118:121-130.

Lander, E.S. and 6 other authors. 1987. MAPMAKER: an interactive computer package for constructing primary genetic linkage maps of experimental and natural populations. Genomics 1:174-181.

Lander, E.S., and Schork, N.J. 1994. Genetic dissection of complex traits. Science 265:2037-2048.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1987. Differences in inbreeding coefficients do not explain the association between heterozygosity at isozyme loci and developmental stability in rainbow trout. Evolution 41:1413-1415.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1989. Genetic differences among rainbow trout spawned on different days within a single spawning season. Progressive Fish-Culturist 51:10-19.

Lie, O., A. Slettan, F. Lingaas, I. Olsaker, I. Hordvik, and T. Refstie. 1994. Haploid gynogenesis: A powerful strategy for linkage analysis in fish. Anim. Biotech. 5:33-45.

Lincoln, S.E., and E.S. Lander. 1992. Systematic detection of errors in genetic linkage data. Genomics 14:604-610.

Longwell, A. C. 1977. A genetic look at fish eggs and oil. Oceanus 20(4):46-58.

Malkin, D. 1994. Germline p53 mutations and heritable cancer. Annual Reviews in Genetics 28:443-465.

Mironov, O. G. 1969. The development of some Black Sea fishes in seawater polluted by petroleum products. Probl. Ichthyol. 9(6):1136-1139

Moles, A., M. M. Babcock and S. D. Rice. 1987. Effects of oil exposure on pink salmon (*Oncorhynchus gorbuscha*) alevins in a simulated intertidal environment. Marine Environment Research 21:49-58.

Parsons, R. and 8 other authors. 1995. Mismatch repair deficiency in phenotypically normal human cells. Science 268:738-740.

Perlin, M.W., M.B. Burks, R.C. Hoop, and E.P. Hoffman. 1994. Toward fully automated genotyping: Allele assignment, pedigree construction, phase determination, and recombination detection in Duchenne muscular dystrophy. Am. J. Hum. Genet. 55:777-787.

Pogson, G. H., K. A. Mesa, and R. G. Boutilier. 1995. Genetic population structure and gene flow in the Atlantic cod *Gadus morhua*: A comparison of allozyme and nuclear RFLP loci. Genetics 139:375-385.

Postlethwait, J.H. and 14 other authors. 1994. A genetic linkage map for the zebrafish. Science 264:699-703.

Scheerer, P.D., G.H. Thorgaard, F.W. Allendorf, and K.L. Knudsen. 1986. Androgenetic rainbow

trout produced from inbred and outbred sperm sources show similar survival. Aquaculture 57:289-298.

Schmitt, K., and 8 other authors. 1994. Multipoint linkage map of the human pseudoautosomal region, based on single-sperm typing: Do double crossovers occur during male meiosis? Am. J. Hum. Genet. 55:423-430.

Smoker, W.W., A.J. Gharrett, and M.S. Stekoll. In press. Genetic variation in timing of anadromous migration within a spawning season in a population of pink salmon. In B.E. Riddell, ed. Proc. Int. Symp. on Biol. Interactions of Enhanced and Wild Salmonids. Can. Spec. Publ. Fish & Aquat. Sci.

Stanley, J. G. 1983. Gene expression in haploid embryos of Atlantic salmon. J. Hered. 74:19-22.

Taylor, B.A., A. Navin, and S.J. Phillips. 1994. PCR-Amplification of simple sequence repeat variants from pooled DNA samples for rapidly mapping new mutations of the mouse. Genomics 21:626-632.

Van der Beek, S., and Van Arendonk, J.A.M. 1993. Criteria to optimize designs for detection and estimation of linkage between marker loci from segregating populations containing several families. Theor. Appl. Genet. 86:269-280.

Zhivotovsky, L. A., K. I. Afanasiev, and G. A. Rubtzova. 1987. Selection for enzyme loci in the pink salmon (*Oncorhynchus gorbuscha* Walbaum). Genetika 23:1876-1883.

Zouros, E.W., and D. Foltz. 1986. The use of allelic isozyme variation for the study of heterosis. In: M.C. Rattazzi, J.G. Scandalios, and G.S. Whitt (eds.), Isozymes: Current Topics in Biological and Medical Research, Volume 13. Alan R. Liss, New York, New York.

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997	LONG RANGE FUNDING REQUIREMENTS					
			Estimated FFY 1998	Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	
Personnel	$0.0	$0.0						
Travel	$0.0	$0.0						
Contractual	$150.0	$250.0						
Commodities	$0.0	$0.0						
Equipment	$0.0	$0.0						
Subtotal	$150.0	$250.0						
General Administration	$17.7	$17.5						
Project Total	$167.7	$267.5	$268.0	$268.0	$0.0	$0.0	$0.0	
Full-time Equivalents (FTE)		0.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

1997

Project Number: 97190
Project Title: Construction of a Linkage Map for the Pink Salmon Genome
Agency: AK Dept. of Fish & Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: 4/18/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1997
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		0.0	0.0	0.0	
					Personnel Total	$0.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FFY 1997
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.0

1997

Project Number: 97190
Project Title: Construction of a Linkage Map for the Pink Salmon Genome
Agency: AK Dept. of Fish & Game

FORM 3B
Personnel
& Travel
DETAIL

Prepared: 4/18/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Contractual Costs:	Proposed
Description	FFY 1997
Amend contract with the University of Montana	250.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$250.0

Commodities Costs:	Proposed
Description	FFY 1997
Commodities Total	$0.0

1997

Project Number: 97190
Project Title: Construction of a Linkage Map for the Pink Salmon Genome
Agency: AK Dept. of Fish & Game

FORM 3B
Contractual & Commodities DETAIL

Prepared: 4/18/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1997
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

1997

Project Number: 97190
Project Title: Construction of a Linkage Map for the Pink Salmon Genome
Agency: AK Dept. of Fish & Game

FORM 3B
Equipment
DETAIL

Prepared: 4/18/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997	LONG RANGE FUNDING REQUIREMENTS					
			Estimated FFY 1998	Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	
Personnel	$43.5	$145.2						
Travel	$5.7	$14.2						
Contractual	$0.0	$0.0						
Commodities	$12.0	$38.6						
Equipment	$72.9	$0.0						
Subtotal	$134.1	$198.0						
Indirect	$15.9	$52.0						
Project Total	$150.0	$250.0	$250.0	$250.0	$0.0	$0.0	$0.0	
Full-time Equivalents (FTE)		43.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

1997

Project Number: 97190
Project Title: Construction of a Linkage Map for the Pink Salmon Genome
Name: University of Montana

FORM 4A
Non-Trustee
SUMMARY

Prepared: 4/18/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FFY 1997
Fred Allendorf	Project Director		3.0	6,500		19.5
Paul Spruell	Research Scientist		12.0	2,625		31.5
Kevin Sage	Research Assistant		12.0	2,083		25.0
Vacant	Research Assistants		16.0	1,844		29.5
						0.0
	Fringe benefits					39.7
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		43.0	13052.0	0.0	
					Personnel Total	$145.2

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FFY 1997
Missoula to Anchorage for workshops and meetings with ADF&G	692	8	40	90	9.1
and the Trustee Council staff.					0.0
					0.0
Charter flights from Anchorage to PWS Hatcheries	1,000	3	3	0	3.0
					0.0
Professional/Scientific Meetings	755	2	6	90	2.1
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$14.2

1997

Project Number: 97190
Project Title: Construction of a Linkage Map for the Pink Salmon Genome
Name: University of Montana

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 4/18/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Contractual Costs:	Proposed FFY 1997
Description	
Contractual Total	$0.0

Commodities Costs:	Proposed FFY 1997
Description	
Materials and supplies for PCR analysis	27.0
Communications	0.6
FMBIO fluorescent scanner service contract	6.0
Equipment repair and maintenance	5.0
Commodities Total	$38.6

1997

,

Prepared:

Project Number: 97190
Project Title: Construction of a Linkage Map for the Pink Salmon Genome
Name: University of Montana

FORM 4B
Contractual & Commodities DETAIL

4/18/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1997
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	
Hitachi FMBIO Fluorescent Imaging Scanner	1	

1997

Project Number: 97190
Project Title: Construction of a Linkage Map for the Pink Salmon Genome
Name: University of Montana

FORM 4B
Equipment
DETAIL

Prepared: 4/18/96

Field Examination of Oil-Related Embryo Mortalities That Persist in Pink Salmon Populations in Prince William Sound

Project Number:	97191A
Restoration Category:	Research and Monitoring
Proposer:	Alaska Department of Fish and Game
Lead Trustee Agency:	Alaska Department of Fish and Game
Cooperating Agencies:	None
Alaska SeaLife Center:	
Duration:	9th year, 10- year project
Cost FY 97:	$283,400
Cost FY 98:	$164,200
Cost FY 99:	$ 58,700
Cost FY 00:	$ 00.0
Cost FY 01:	$ 00.0
Cost FY 02:	$ 00.0
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pink Salmon

ABSTRACT

Elevated embryo mortalities were detected in populations of pink salmon inhabiting oiled streams following the March 1989 *Exxon Valdez* oil spill. These increased rates of mortality persisted annually through the 1993 field season, three generations after the oil spill, suggesting that genetic damage may have occurred as a result of exposure to oil during early developmental life-stages. The consequences of this putative genetic damage include physiological dysfunction of individuals and reduced reproductive capacity of wild pink salmon populations. The 1994 field results show no statistical difference in embryo mortality between oil-contaminated and reference streams. The purpose of this project is to continue to monitor the recovery of pink salmon embryos in the field, and

to verify and identify the occurrence of genetic damages.

INTRODUCTION

Elevated embryo mortalities were detected in populations of pink salmon *Oncorhynchus gorbuscha* inhabiting oiled streams following the March 1989 *Exxon Valdez* oil spill (EVOS). These increased rates of mortality persisted annually through the 1993 field season, three generations after the oil spill, suggesting that genetic damage may have occurred as a result of exposure to oil during early developmental life-stages. The consequences of this putative genetic damage include physiological dysfunction of individuals and reduced reproductive capacity of wild pink salmon populations.

These effects would likely persist in populations of pink salmon for a longer duration than would be observed in other vertebrates because of the tetraploid nature of the salmonid genome. Salmonids evolved through a gene duplication event 25 million years ago (Allendorf and Thorgaard 1984). Pink salmon basically possess a duplicate set of chromosomes (tetraploid instead of diploid); although, some of the duplicates have been lost through subsequent evolutionary processes. However, the extra genes found for many loci would mask deleterious recessive alleles. The effects of these deleterious mutations would be uncovered in the homozygotes formed through the mating of heterozygotes in subsequent generations.

The purpose of this study is to continue to monitor the recovery of pink salmon embryos in the field and to close out the molecular genetics investigations in the laboratory. In this study we will survey the same streams examined during the Natural Resource Damage Assessment (NRDA) process for pink salmon embryos in order to monitor recovery. We will also complete the DNA-sequence-based analyses of the of the families of oiled lineages and provide a final reporting. Finally, we will produce the families needed for the genetic mapping experiments conducted by the University of Montana.

NEED FOR THE PROJECT

A. Statement of the Problem

Pink salmon embryos and fry that incubated in the oiled intertidal spawning areas in Prince William Sound (PWS) in 1989, 1990, 1991, 1992, and 1993 appear to have been adversely affected by EVOS. Oil was deposited in layers of varying thickness in the intertidal portions of streams utilized by spawning pink salmon during the spring of 1989. Pink salmon eggs deposited in 1988 (1988 brood year) emerged as fry through the oiled spawning gravels during the spring of 1989 and began feeding on oiled plankton. These fish showed decreased growth due to oiling (Willette et. al. 1994). Although gross oil levels decreased during the summer of 1989, contamination in the intertidal zone was still evident. The pink salmon eggs deposited during the late summer of 1989 (the 1989 brood year) were exposed to intra-gravel contamination from late August 1989 through mid-May 1990. Sharr et al. (1994a) and Bue et al. (1996) detected elevated mortalities of pink salmon embryos in the intertidal zones of oiled streams while no difference between oiled and non-oiled streams was detected above mean high tide. Elevated embryo mortalities in oiled streams were again detected in the 1990

brood year, but only in the highest intertidal spawning zone (Sharr et al. 1994a; Bue et al. 1996). Visual observations indicated that the majority of the remaining oil was deposited in this zone. Spawning areas lower in the intertidal zone seemed to be recovering as embryo mortalities in these areas were not statistically different from non-oil impacted streams.

Surprisingly, Sharr et al. (1994a) and Bue et al. (1996) found increased embryo mortalities in oiled streams during the 1991 fall survey. Furthermore, significant differences in embryo mortality occurred at all tidal zones, including the area above mean high tide. Clearly, the elevated embryo mortalities in the oiled streams were not the direct effect from recent oiling. The 1991 adult returns were the progeny of the 1989 brood year, the group with the highest exposure to intra-gravel oil (the 1989-90 incubation period). We hypothesize that the elevated embryo mortalities in 1991 may be the result of genetic damage acquired during embryonic development. Elevated embryo mortalities at all tidal zones in oiled streams were again detected during the 1992 survey (Sharr et al. 1994b; Bue et al. 1996). A hatchery incubation experiment using gametes from fish returning to oiled and control streams in 1993 indicate that mortality differences observed during past studies cannot be attributed to environmental factors or sampling design (Sharr et al. 1994c).

The aggregate of evidence from the field studies and incubation experiment suggests that the embryos exposed to oil in 1989 and 1990 accumulated deleterious mutations in the germline. This hypothesis of genetic damage is consistent with previous field observations and laboratory experiments on the effects of crude oil on early life stages of fish. Long term intra-gravel oil exposures (7-8 months) to freshly fertilized eggs provide embryos sufficient time to accumulate polynuclear aromatic hydrocarbons (PAH's) from very low aqueous concentrations of crude oil. PAH's are abundant in crude oil and are potent clastogens (i.e. capable of breaking chromosomes). Mironov (1969) observed reduced survival of fish embryos and larvae exposed to very low aqueous doses (1 ul oil/l seawater) of oil. Longwell (1977) reported genetic damage in pelagic embryos affected by the *Argo Merchant* oil spill. Moles et al. (1987) confirmed that pink salmon embryos take up PAH's and demonstrated that the uptake was much greater in an intertidal environment than in strictly freshwater conditions. Biggs et al. (1991) found greater numbers of chromosome aberrations in larval herring which incubated in oiled areas than in non-oiled areas. It is logical that the same type of damage may have occurred in pink salmon, and this damage could have affected the germline of exposed individuals (cf., Malkin 1994).

Genetic damage induced by genotoxins can be classified into two general categories: small changes to nucleotide sequence caused by base substitutions, deletions, or additions (microlesions); and changes in chromosome structure through inversions, larger scale deletions, or translocations (macrolesions). Increasing concern about the effects of chemicals in the environment has lead to a proliferation of assays developed to assess their genotoxic potential (reviewed in Landolt and Kocan 1983, Kocan and Powell 1985, Liguori and Landolt 1985). Because chemical agents that induce mutations in DNA are also likely to produce cytologically recognizable chromosome damage expressed as structural changes or "aberrations" (Evans 1976), cytogenetic techniques can be used to detect these kinds of damage. Alternatively, microlesions may be detected by exposing detrimental recessive alleles through haploid androgenesis (Armstrong and Fletcher 1983) or by directly examining the base-pair structure of the DNA molecule (e.g., Orita et al. 1989a, 1989b; Hovig et al. 1991).

B. Rationale/Link to Restoration

In this project we propose to continue monitoring embryo survival rates in oiled and reference streams. Information gained from this study will provide resource managers with insight into the magnitude and persistence of damages sustained by wild pink salmon due to EVOS. Efforts to restore damaged pink salmon populations depend upon the ability of fishery managers to identify sources of reduced survival and to monitor their persistence. The potential of long term oil exposures to cause genetic damage needs to be understood so that spawning escapement goals can be adjusted if necessary. In addition, verification of the genetic hypothesis would provide the first evidence that the germline of fish exposed to chronic or acute sources of oil pollution can be compromised.

C. Location

Embryo sampling in PWS will be conducted in the fall on 31 streams (Figure 1). These same 31 streams have been sampled annually since 1989.

COMMUNITY INVOLVEMENT

Laboratory analyses and reporting are technical pursuits that will be conducted by or supervised by professional scientists. Wherever possible, local-hire will be used to fill field positions required for sampling or for routine laboratory positions. People from the communities in PWS will have an opportunity to participate in this project as employees of the ADF&G which gives local residents priority in hiring for state employment.

PROJECT DESIGN

A. Objectives

The purpose of this project is to monitor the recovery of damaged pink salmon populations in oil-contaminated streams. Working objectives are:

a. Estimate the density, by tidal zone, of embryos in 31 streams using counts of live and dead embryos.

b. Estimate embryo mortality of pink salmon embryos in both oil contaminated streams and noncontaminated reference streams.

c. Close out the molecular genetic tests for microlesion damage conducted by ADF&G.

d. Produce haploid and diploid families for the gene-mapping experiments to be

conducted at the University of Montana.

B. Methods

a. Data Collection

Embryo sampling will be conducted from late September to mid-October in 31 streams (Figure 1). Embryo development by this time includes stages from uneyed embryo through recently hatched fry. The streams were selected using the following criteria:

(1) Adult salmon returns were adequate to support a high probability of success in embryo sampling.
(2) Embryo sampling had been done in past years.
(3) Streams with low to no oil impact, i.e., reference streams, were selected in the immediate vicinity of high oil impact streams to control for possible variability in embryo survival due to environmental conditions.

Twenty eight of the 31 streams are located in the western half of PWS in close geographic proximity to each other and in the area where oil impacts were greatest. Twelve experienced impacts ranging from light to heavy oiling. Most of the streams which sustained suspected or obvious oil impact were not sampled for embryos or fry prior to the EVOS. Among the 12 streams where oil was visibly present in 1989, only one had a history of embryo sampling.

Methods for embryo sampling were modeled after procedures described by Pirtle and McCurdy (1977). On each study stream, four zones, three intertidal and one above most tidal influence, were measured from the mean low tide mark using computer generated tide tables and a surveyors level. Boundaries between zones were marked with stakes. The four zones were: 1.8-2.4 m, 2.4-3.0 m, 3.0-3.7 m above mean low water, and upstream of mean high tide (3.7 m). A linear transect 30.5 m in length was established for embryo samples in each zone. The transect ran diagonally across the stream. To insure continuity of transects between years, transect locations were marked with stakes and carefully photographed from at least two perspectives. Fourteen 0.186 m^2, circular digs were systematically made along each transect using a high pressure hose to flush embryos from the gravel. Embryos and fry were caught in a specially designed net.

The following data will be collected for each tide zone transect during embryo sampling:

(1) The sample date.
(2) The sample tide zone.
(3) The start and stop time for each tide zone transect.
(4) Numbers and condition (live or dead) of embryos by species.
(5) A subjective estimate of the overall percent yolk sac absorption for fry.

Data will be transferred from field notebooks into a Lotus spreadsheet for editing and summarizing.

Pink salmon embryos will be separated from chum *O. keta* and coho *O. kisutch* salmon embryos by their smaller size. Chum salmon embryos will be separated from coho salmon embryos by their greater development and different coloration. An embryo will be considered dead if it is opaque or discolored with coagulated lipids. Sampling often kills fry (especially newly hatched fry), so fry will only be considered dead if decomposition is evident.

b. Data Analysis

Numbers of live and dead embryos and fry will be summarized by date, stream, level of hydrocarbon impact, and stream zone. Densities of live embryos for stream i, zone j in m^2 (E_{ij}) will be estimated by:

$$\hat{E}_{ij} = \frac{\Sigma LE_{ijk}}{0.3n_{ij}} \quad , \tag{1}$$

where LE_{ijk} is the number of live embryos found in the k^{th} dig, in stream i, zone j, and n_{ij} is the number of digs from stream i, zone j. Densities of dead embryos will be calculated using the same estimator with appropriate substitutions.

Pink salmon embryo mortality will be estimated for each stream using the following relationship:

$$\hat{M}_{ij} = \frac{\Sigma(DE_{eijk} + DF_{eijk})}{\Sigma(LE_{eijk} + DE_{eijk} + LF_{eijk} + DF_{eijk})} \quad , \tag{2}$$

where DE_{eijk}, DF_{eijk}, LE_{eijk}, and LF_{eijk} are the number of dead embryos, dead fry, live embryos, and live fry for the k^{th} dig from stream i, zone j, collected during embryo dig e, respectively.

The Arcsin square root transformation will be examined as well as the Logit transform of embryo mortality [ln (odds)].

$$Logit_{ij} = \ln\left[\frac{\Sigma(DE_{eijk} + DF_{eijk})}{\Sigma(LE_{eijk} + LF_{eijk})}\right] \tag{3}$$

Differences in embryo mortality will be examined using a mixed effects two-factor experiment with repeated measures on one factor (Neter et al. 1990):

$$Y_{ijk} = \mu_{..} + O_i + Z_j + (OZ)_{ij} + S_{k(i)} + e_{(ijk)}. \tag{4}$$

The two treatments will be level of oiling, (O_i, 2 levels; oiled and non-oiled), and height in the intertidal zone (Z_j, 4 levels; 2.1, 2.7, and 3.4 m above mean low water, and upstream) both fixed effects. The data will be blocked by stream ($S_{k(i)}$), a random effect nested within level of oiling. The interaction of level of oiling and height in the intertidal zone will also be examined. Equality of variances will be tested using the F_{max}-test (Sokal and Rohlf, 1981), while normality will be visually assessed using normal quantile-quantile and box plots (Chambers et al. 1983). If the data distribution appears to be non-normal, data transformations will be examined. If a significant difference due to oiling is detected ($\alpha = 0.05$), four contrasts (oil vs. non-oiled for the four stream zones) and corresponding Bonferroni family confidence intervals ($\alpha = 0.10$ overall) will be estimated.

Extent of oiling for analysis will be based on visual observations of streams (NRDA F/S Study 1 and 2) and hydrocarbon results from mussel samples (NRDA F/S Study 1).

c. DNA Assays

DNA will be extracted using Puregene DNA isolation kits for animal tissues (Gentra Systems, Inc. P.O. Box 13159, Research Triangle, N.C. 27709-13159). This process includes: (1) a buffered solution that protects the DNA from degradation; (2) a Proteinase K digest to deactivate the proteins; (3) an RNase treatment to digest RNA; (4) protein precipitation to remove Proteinase K, RNase, and denatured proteins; (5) isopropanol to precipitate the DNA; (6) 70% ethanol to wash the DNA; and finally (7) a hydration solution to rehydrate the DNA.

After extraction, the DNA will be amplified using the polymerase chain reaction (PCR; Saiki et al. 1988). Primer selection for PCR will include loci from three potentially useful categories: (1) nDNA that was shown to be conserved among salmonid species and shows intraspecific variation (e.g., introns C and D of *GH-1* and *GH-2*, Forbes et al. 1994; Linda Park, National Marine Fisheries Service, personal communication); (2) microsatellite loci that have been shown to have high rates of natural mutation (Park and Moran 1994; Wright and Bentzen 1994); and (3) hot spot regions (*HSR A-D*) that have been most frequently associated with germline mutations in the otherwise highly conserved tumor suppressor gene *p53* in other species (Malkin 1994).

Genetic data will be collected using automated DNA assays. Fragment analysis for detection of restriction fragment length polymorphisms (RFLP) will be done following the methods of Forbes et al. (1994), except that data will be collected on an Applied Biosystems Incorporated (ABI) model 373 series automated sequencer. Sequence analyses will be conducted on an ABI model 377 automated sequencer. Additionally, a sister set of tissues will be provided to a consulting laboratory, obtained through the state procurement process, to aid in the screening for genetic damage.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The Alaska Department of Fish and Game will be completing all work on this project.

SCHEDULE

A. Measurable Project Tasks for FY 97 (October 1,1996 - September 30, 1997)

Recovery Monitoring of Injury to Pink Salmon Embryos in Prince William Sound

15 Sep - 30 Oct 1996:	Embryo deposition sampling.
30 Sep 1996 - 28 Feb 1997:	Complete DNA assays.
30 Oct 1996 - 30 Mar 1997:	Analysis of brood year 1995 embryo data and completion of firstdraft of 96191A report.
28 Feb 1997 - 30 Sep 1997:	Navigate DNA-sequence data from all laboratories contributing to this project during all years. Finalize reports and papers on mutation screens.
30 Oct 1997 - 30 Mar 1998:	Analysis of brood year 1997 embryo data and completion of first draft of 97191A report (98191A).

B. Project Milestones and Endpoints

Annual review: terminate project component if embryo mortalities are not significantly different between oiled and non-oiled study sites for two consecutive years for both the odd- and two-even broodlines

C. Completion Date

The population monitoring components of this study should be continued until the methodology used to monitor is unable to detect a difference in pink salmon embryo mortality between oil contaminated and reference streams. Results to date indicate that recovery is likely ongoing. However, we recommend that this project continue until both odd- and even-broodline pink salmon exhibit no difference in embryo mortality between oiled and non-oiled study sites for two consecutive years based upon the statistical tests described. We will close out ADF&G molecular studies this fiscal year; we will support future gene-mapping studies of University of Montana under a separate project to be initiated at the Alaska Sealife Center.

PUBLICATIONS AND REPORTS

Field activities will continue for two generations past when injury to salmon embryos and fry can no longer be detected. Until field activities cease, the main product from this project will be an annual report which summarizes the results of the current-year embryo data. The most significant information on damages demonstrated in 1989 through 1992 were presented in a close-out reports for NRDA Study #2 and Restoration Studies R60C and 93003. These results will also be published in a peer-reviewed journal. Preliminary findings from molecular study are in preparation for journal submission; manuscripts from flow cytometry and straying components of Restoration Study 94191 were revised with input from peer reviewers and will be submitted pending ADF&G approval.

When restoration field work is complete, a follow up journal article may be appropriate if there have been findings which add significantly to or alter results reported from the NRDA study. An annual project report for FY 96 will be submitted by March 30, 1997.

PROFESSIONAL CONFERENCES

Travel funds have been requested for this project to attend meetings with personnel in Anchorage and Juneau. Two professional conferences are also planned for 1997, the Pink and Chum Workshop, and the state American Fisheries Society meeting. The place and time for these meeting has not been set at this time.

NORMAL AGENCY MANAGEMENT

The Alaska Department of Fish and Game did not fund this research prior to the 1989 *Exxon Valdez* Oil Spill and has no plans to continue funding after recovery is complete. In the past an embryo mortality study was implemented with federal disaster funds following the 1964 earthquake and continued until 1975 when recovery was complete. Continued monitoring of this resource is necessary to document complete recovery.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The field data collection for Component 1 of this project is very specific to individual wild pink salmon streams and occurs after most field activities of SEA (96320) and other pink salmon related projects each year. Consequently extensive coordination of field activities is not feasible. However, the vessel used by this project does collect physical and biological oceanographic data for the ADFG, PWSAC, and University of Alaska Cooperative Fisheries and Oceanographic Project, and these data will be utilized by several SEA studies.

Final edited data from both components of this project will be stored electronically as computer databases, and final versions will be provided annually to the Information Modelling portion of SEA for incorporation into a centralized ecosystem database.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

Due to the recovering status of pink salmon, the laboratory verification of the field results was removed from this project in FY96. Closeout for this portion is complete and no additional funds are requested for this portion in FY97. The request for molecular genetics support was halved from the amount listed in the 15 February 1996 *Invitation to Submit Restoration Proposals* reflecting reduced laboratory effort and closeout of this portion of the project.

PERSONNEL

Mark Willette, Area Research Biologist
Commercial Fisheries Management and Development
Alaska Department of Fish and Game
P.O. Box 669
Cordova, Alaska 99574
907-424-3212 (phone)
907-424-3235 (fax)
MARKW%FISHGAME@STATE.AK.US

A. Mark Willette, Area Research Biologist

Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division
P.O. Box 669
Cordova, Alaska 99574
(907)424-3214

PROJECT RESPONSIBILITIES: Design and supervision of embryo surveys, analysis, report writing

EDUCATION:
1985 Master of Science, Fisheries Oceanography, University of Alaska Fairbanks
1983 Bachelor of Science, Fisheries Science, University of Alaska Fairbanks

PROFESSIONAL EXPERIENCE:

1995 - present Area Research Biologist, Cordova, Commercial Fisheries Management and Developent , ADFG
1991 - 1995 Area Resource Development Biologist, Cordova, Commercial Fisheries Management and Developent, ADFG
1986 - 1991 Fisheries Instructor/ Assistant Research Professor, School of Fisheries & Ocean Sciences, University of Alaska Fairbanks
1983 - 1985 Research Assistant, School of Fisheries & Ocean Sciences, University of Alaska Fairbanks
1978 - 1983 Fish and Wildlife Technician, Commercial Fisheries Division, ADFG

SELECTED PUBLICATIONS:

Willette, T.M. 1995 Impacts of the Exxon Valdez Oil Spill on the migration, growth, and survival of juvenile pink salmon in Prince William Sound. In: Proceedings of the Exxon Valdez Oil

Spill Symposium, American Fisheries Society Symposium Series, (in press).

R.T. Cooney, T.M. Willette, and S. Sharr. 1992 The effect of climate on Pacific salmon production in the northern Gulf of Alaska: examining the details of a natural experiment. In: Proceedings of the International Symposium on Climate Change and Northern Fish Populations, Can. Spec. Publ. Fish. Aquat. Sci.

Willette, T.M. and R.T. Cooney. 1991 An empirical orthogonal functions analysis of sea surface temperature anomalies in the North Pacific Ocean and cross-correlations with pink salmon (*Oncorhynchus gorbuscha*) returns to southern Alaska. In: Proceedings of the 1991 Pink and Chum Salmon Workshop.

Eggers, D.M., L.R. Peltz, B.G. Bue, and T.M. Willette. 1991. Trends in the abundance of hatchery and wild stocks of pink salmon in Cook Inlet, Prince William Sound, and Kodiak, Alaska. In: Proceedings of the International Symposium on the Biological Interactions of Enhanced Salmonids, Can. Spec. Publ. Fish. Aquat. Sci.

B. Andrew Craig, Fisheries Biologist I

Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division
P.O. Box 669
Cordova, Alaska 99574
(907)424-3212

PROJECT RESPONSIBILITIES: Design and supervision of embryo surveys, analysis, report writing

EDUCATION: 1990 Bachelor of Science, Fisheries Science, Cornell University

PROFESSIONAL EXPERIENCE:

1992 - present Fisheries Biologist I, Cordova, Commercial Fisheries Management and Developent, ADFG

1991 - 1992 Fish and Wildlife Technician, Commercial Fisheries Division, ADFG

SELECTED PUBLICATIONS:

Craig, A.K., S. Sharr, and S.D. Moffitt. 1995. A compilation of historical preemergent fry and egg deposition survey data from Prince William Sound, 1961-1995. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 2A95-49, Anchorage.

Bue, B.G., S. Sharr, S.D. Moffitt, and A.K. Craig. *In Press.* Effects of the *Exxon Valdez* oil spill on pink salmon embryos and preemergent fry. *In* Rice, S.D., R.B. Spies, D.A. Wolfe, and B.A. Wright, editors. *Exxon Valdez* Oil Spill Symposium Proceedings. American Fisheries Society Symposium. *Accepted Pending Publication.*

Sharr, S., B. G. Bue, S. D. Moffitt and A. K. Craig. 1994a. Injury to salmon eggs and preemergent fry in Prince William Sound - F/S 2. State/Federal Natural Resources Damage Assessment Final Report. *Exxon Valdez* Trustee Council, Anchorage, Alaska.

Sharr, S., J. E. Seeb, B. G. Bue, S. D. Moffitt, A. K. Craig and G. D. Miller. 1994b. Injury to salmon eggs and preemergent fry in Prince William Sound - R60C. State/Federal Natural Resources Restoration Final Report. *Exxon Valdez* Trustee Council, Anchorage, Alaska.

Sharr, S., J. E. Seeb, B. G. Bue, S. D. Moffitt, A. K. Craig and G. D. Miller. 1994c. Injury to salmon eggs and preemergent fry in Prince William Sound - 93003. State/Federal Natural Resources Restoration Final Report. *Exxon Valdez* Trustee Council, Anchorage, Alaska.

C. Brian G. Bue, Biometrician II

Commercial Fisheries Management and Development
Alaska Department of Fish and Game
Anchorage, Alaska 99518-1599 (907) 267-2123 BrianB%fishgame@state.ak.us

PROJECT RESPONSIBILITIES: Study design and analysis

EDUCATION:
B.S., Fisheries, 1978, University of Alaska, Fairbanks
B.S., Biology, 1978, University of Alaska, Fairbanks
M.S., Fisheries, 1986, University of Alaska, Fairbanks

PROFESSIONAL EXPERIENCE:

1988-present	Biometrician II, CFMD, Alaska Dept. Fish and Game
1987-1988	Biometrician I, CFMD, Alaska Dept. Fish and Game
1978-1987	Fisheries Biologist I, CFMD, Alaska Dept. Fish and Game
1974-1977	Fish and Wildlife Technician, Alaska Dept. Fish and Game

SELECTED PUBLICATIONS AND PRESENTATIONS:

Bue, B.G., S. Sharr, S.D. Moffitt, and A.K. Craig. *In Press.* Effects of the *Exxon Valdez* oil spill on pink salmon embryos and preemergent fry. *In* Rice, S.D., R.B. Spies, D.A. Wolfe, and B.A. Wright, editors. *Exxon Valdez* Oil Spill Symposium Proceedings. American Fisheries Society Symposium. *Accepted Pending Publication.*

Geiger, H.J., B.G. Bue, S. Sharr, A.C. Wertheimer, and T.M. Willette. *In Press*. A life history approach to estimating damage to Prince William Sound Pink Salmon from the *Exxon Valdez* oil spill. *In* Rice, S.D., R.B. Spies, D.A. Wolfe, and B.A. Wright, editors. *Exxon Valdez* Oil Spill Symposium Proceedings. American Fisheries Society Symposium. *Accepted Pending Publication*

Rowell, K.A., H.J. Geiger, and B.G. Bue. 1990. Stock identification of Pacific Herring in the Eastern Bering Sea trawl bycatch and in the Dutch Harbor directed food and bait fishery. Proceedings of the International Herring Symposium, Alaska Sea Grant Report No. 91-01,Fairbanks.

Bue, B.G. and D.M. Eggers. 1989. An age-length key for sockeye salmon smolt. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 2D89-5, Anchorage.

Bue, B.G. 1986. Effects of gill net selectivity on sockeye salmon in the Egegik and Naknek-Kvichak Districts, Bristol Bay, Alaska. Master's Thesis. University of Alaska, Fairbanks.

Bue, B.G. 1986. Comparison of cable lay and center core gill net catches from the Port Moller offshore test fishery, 1985. Alaska Department of Fish and Game, Division of Commercial Fisheries, Bristol Bay Data Report No. 86-4, Anchorage.

Bue, B.G., S. Sharr, G.D. Miller, and J.E. Seeb. 1995. Evidence of genetic damage in pink salmon inhabiting Prince William Sound, Alaska, three generations after the *Exxon Valdez* oil spill. Presented to the 1995 Pink and Chum Salmon Workshop, March, 1995, Bellingham, Washington.

Bue, B.G. and R. Gates. 1991. Pink salmon escapement estimation using aerial observations. Presented to the Alaska Chapter of the American Statistical Association, September, 1991, Juneau.

D. David Evans, Biometrician I
Commercial Fisheries Management and Development
Alaska Department of Fish and Game
Anchorage, Alaska 99518-1599 (907) 267-2176 DavidE%fishgame@state.ak.us

PROJECT RESPONSIBILITIES: Study design and analysis

EDUCATION: B.S., Soil Science, University of Nottingham (U.K.)
M.S., Soil Science, University of Guelph (Ontario, Canada)
M.S., Statistics, Oregon State University
Ph.D., Soil Science, University of Guelph (Ontario, Canada)

PROFESSIONAL EXPERIENCE:

1991-present	Biometrician I, CFMD, Alaska Dept. Fish and Game
1978-1987	Fisheries Biologist I, CFMD, Alaska Dept. Fish and Game
1974-1977	Fish and Wildlife Technician, Alaska Dept. Fish and Game

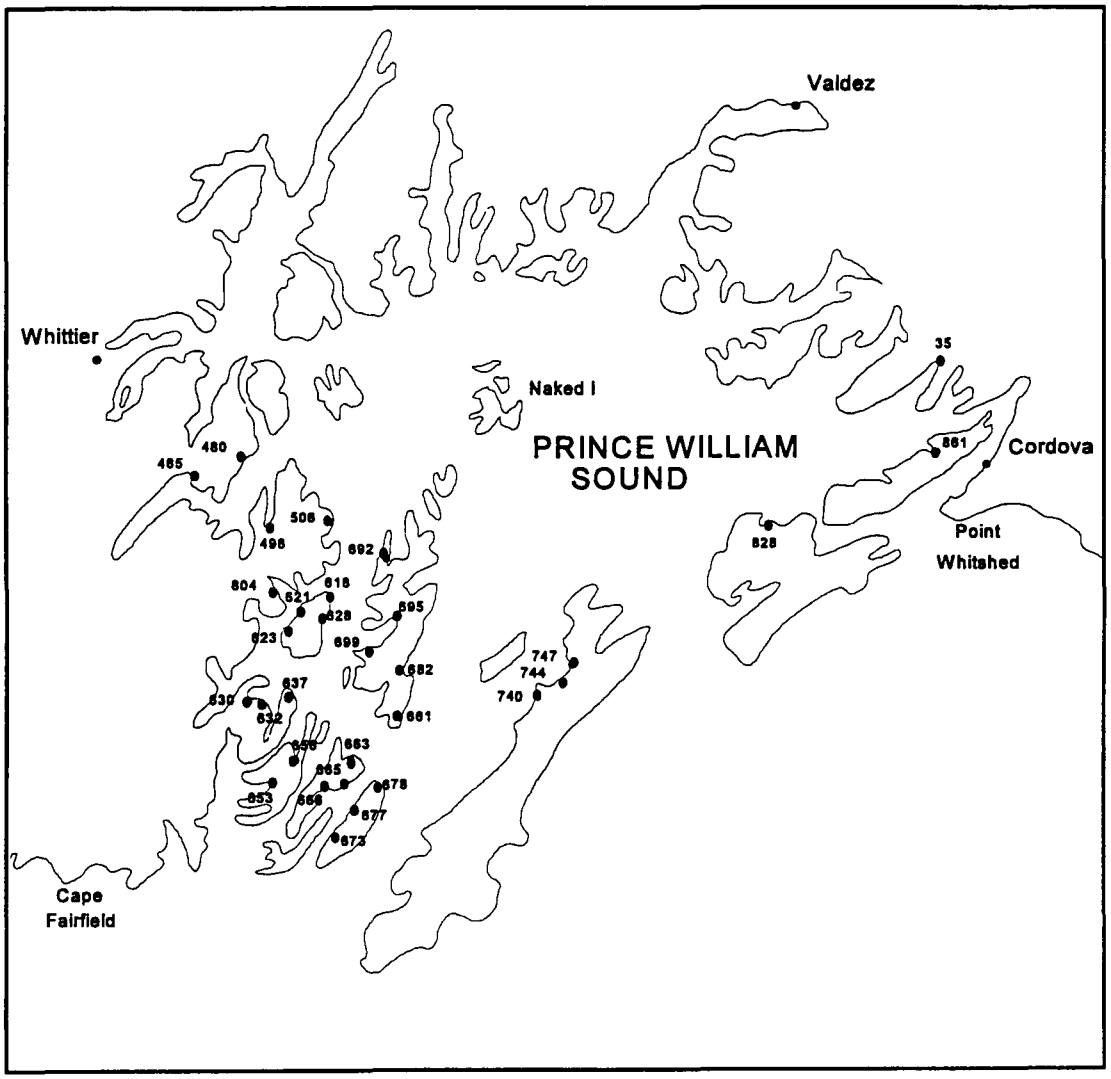


Figure I. Location of streams to be sampled for embryo deposition.

LITERATURE CITED

Allendorf, F. W. and G. H. Thorgaard. 1984. Tetraploidy and the evolution of salmonid fishes. Pages 1-53 *in* B. J. Turner, ed. Evolutionary Genetics of Fishes. Plenum Publishing Corp., New York.

Armstrong, J. B. and W. S. Fletcher. 1983. Assessment of mutagenic damage following ethyl methanesulfonate mutagenesis in the Axolotl (*Ambystoma mexicanum*). The Journal of Experimental Zoology. 226:333-340.

Bickham, J. W. 1990. Flow cytometry as a technique to monitor the effects of environmental genotoxins on wildlife populations. Pages 97-108 *in* S.S. Sandhu et al., ed. In Situ Evaluations of Biological Hazards of Environmental Pollutants. Plenum Press, New York, New York.

Biggs, E., T. Baker, M. McGurk, J. E. Hose and R. Kocan. 1991. Injury to Prince William Sound Herring. State/Federal Natural Resources Damage Assessment Draft Preliminary Status Report. Unpub. rep. Alaska Department of Fish and Game, Cordova, AK.

Bue, B. G., S. Sharr, S. D. Moffitt and A. K. Craig. In press. Effects of the *Exxon Valdez* oil spill on pink salmon embryos and preemergent fry. *In* Rice, S.D., R.B. Spies, D.A. Wolfe, and B.A. Wright, editors. *Exxon Valdez* Oil Spill Symposium Proceedings. American Fisheries Society Symposium.

Chambers, J. M., W. S. Cleveland, B. Kleiner and P. A. Tukey. 1983. Graphical methods for data analysis. Duxbury Press, Boston, MA.

Evans, H. J. 1976. Cytological methods for detecting chemical mutagens. Pages 1-29 *in* A. Hollaender, ed. Chemical mutagens, principles and methods for their detection, Vol. 4. Plenum Press, New York, NY.

Forbes S. H., K. L. Knudsen, T. W. North and F. W. Allendorf. 1994. One of two growth hormone genes in coho salmon is sex-linked. Proceedings of the National Academy of Sciences USA. 91:1628-1631.

Hovig, E., B. Smith-Sorensen, Brogger and A-L. Borresen. 1991. Constant denaturant gel electrophoresis, a modification of denaturing gradient gel electrophoresis, in mutation detection. Mutation Research. 262:63-71.

Kocan, R. M., D. B. Powell and V. M. Liguori. 1985. Relationship between visible and heritable chromosome damage in trout cells and embryos. Marine Environmental Research. 17:320-323.

Lamb, T., J. W. Bickham, J. Whitfield Gibbons, M. J. Smolen and S. McDowell. 1991. Genetic

damage in a population of Slider Turtles (*Trachemys scripta*) inhabiting a radioactive reservoir. Arch. Environ. Contam. Toxicol. 20:138-142.

Landolt, M. and R. M. Kocan. 1983. Fish cell cytogenetics: a measure of the genotoxic effects of environmental pollutants. Pages 336-350 *in* J. O. Ngriagu, ed. Aquatic toxicology. John Wiley and Sons, Inc.

Liguori, V. M. and M. L. Landolt. 1985. Anaphase aberrations: An in vivo measure of genotoxicology. Pages 87-97 *in* Waters, Sandhu, Lewtas, Claxton, Strauss, and Nesnow, eds. Short-term Bioassays in the Analysis of Complex Environmental Mixtures IV. Plenum Publishing Co., New York, NY.

Longwell, A. C. 1977. A genetic look at fish eggs and oil. Oceanus. 20(4):46-58.

Malkin, D. 1994. Germline p53 mutations and heritable cancer. Annual Reviews in Genetics 28:443-465.

McBee, K. and J. W. Bickham. 1988. Petrochemical-related DNA damage in wild rodents detected by flow cytometry. Bull Environ. Contam. Toxicol. 40:343-349.

Miller, G. D., J. E. Seeb, B, G. Bue and S. Sharr. 1994. Saltwater exposure at fertilization induces ploidy alterations, including mosaicism, in salmonids. Canadian Journal of Fisheries and Aquatic Sciences. 51(Supp.1):42-49.

Miller, G. D., J. E. Seeb and B. G. Bue. (in prep.) Limitations of flow cytometry as a screen for potential genotoxic effects of crude oil exposure in pink salmon. Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99518.

Mironov, O. G. 1969. The development of some Black Sea fishes in seawater polluted by petroleum products. Probl. Ichthyol. 9(6):1136-1139

Moles, A., M. M. Babcock and S. D. Rice. 1987. Effects of oil exposure on pink salmon (*O. gorbuscha*) alevins in a simulated intertidal environment. Marine Environment Research 21:49-58.

Neter, J., W. Wasserman and M. H. Kutner. 1990. Applied linear statistical models. Third Edition. Irwin, Homewood, IL.

Orita, M., Y. Suzuki, T. Sekiya and K. Hayashi. 1989a. Rapid and sensitive detection of point mutations and DNA polymorphisms using polymerase chain reaction. Genomics 5:874-879.

Orita, M., H. Iwahana, H. Kanazawa, K. Hayashi and T. Sekiya. 1989b. Detection of polymorphisms of human DNA by gel electrophoresis as single-strand conformation polymorphisms. Proceedings of the Natural Academy of Sciences USA. 86:2766-2770.

Park, L. K. and P. Moran. 1994. Developments in molecular genetic techniques in fisheries. Reviews in Fish Biology and Fisheries 4:272-299.

Pirtle, R. B. and M. L. McCurdy. 1977. Prince William Sound general districts 1976 pink and chum salmon aerial and ground escapement surveys and consequent brood year egg deposition and preemergent fry index programs. Technical Data Report 9. Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau, AK.

Sharr, S., B. G. Bue, S. D. Moffitt and A. K. Craig. 1994a. Injury to salmon eggs and preemergent fry in Prince William Sound - F/S 2. State/Federal Natural Resources Damage Assessment Final Report. *Exxon Valdez* Trustee Council, Anchorage, Alaska.

Sharr, S., J. E. Seeb, B. G. Bue, S. D. Moffitt, A. K. Craig and G. D. Miller. 1994b. Injury to salmon eggs and preemergent fry in Prince William Sound - R60C. State/Federal Natural Resources Restoration Final Report. *Exxon Valdez* Trustee Council, Anchorage, Alaska.

Sharr, S., J. E. Seeb, B. G. Bue, S. D. Moffitt, A. K. Craig and G. D. Miller. 1994c. Injury to salmon eggs and preemergent fry in Prince William Sound - 93003. State/Federal Natural Resources Restoration Final Report. *Exxon Valdez* Trustee Council, Anchorage, Alaska.

Sokal, R. R. and F. J. Rohlf. 1981. Biometry. W.H. Freeman and Company, San Francisco, CA.

Willette, T. M., G. Carpenter, P. Shields, S. Carlson. 1994. Early marine salmon injury assessment in Prince William Sound. Federal/State Natural Resources Damage Assessment Fish/Shellfish Project Number 4. Alaska Department of Fish and Game, Cordova, Ak.

Wright, J. M. and P. Bentzen. 1994. Microsatellites: genetics markers of the future. Reviews in Fish Biology and Fisheries 4:384-388.

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997	LONG RANGE FUNDING REQUIREMENTS					
			Estimated FFY 1998	Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	Estimated FFY 2003
Personnel	$152.40	$129.9						
Travel	$13.30	$13.9						
Contractual	$149.30	$87.6						
Commodities	$31.90	$24.3						
Equipment	$2.10	$2.1						
Subtotal	$349.00	$257.8						
General Administration	$58.0	$25.6						
Project Total	$407.0	$283.4	$164.2	$58.7	$0.0	$0.0	$0.0	$0.0
Full-time Equivalents (FTE)		2.5						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

Estimated costs for 'Field Monitoring' and genetic close out in FY 97.

Costs for FY98 and beyond are estimated assuming that field monitoring will continue to show no difference in embryo mortality between oiled and non-oiled sites for two additional years. FY99 costs are for close out of field monitoring only.

1997

Prepared:

Project Number: 97191A
Project Title: Investigating and Monitoring Oil Related Egg and Alevin Mortalities
Agency: AK Dept. of Fish & Game

FORM 3A
AGENCY
PROJECT
DETAIL

4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Personnel Costs:			GS/Range/	Months	Monthly		Proposed
PM	Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1996
						0	0.0
	M. Willette	Fishery Biologist III	18F	2.0	6,309	0	12.6
	A. Craig	Fishery Biologist I	14B	7.0	4,270	1,300	31.2
	Vacant	6 - Fish and Wildlife Technician II & III	11A	7.0	3,992	1,000	28.9
	D. Evans	Biometrician I	17E	4.0	5,279	0	21.1
	P. Trautman	Field Office Assistant	11A	1.0	3,509	0	3.5
	Vacant	Fish and Wildlife Technician III	11E	9.2	3,544		32.6
			Subtotal	30.2	26,903	2,300	
Those costs associated with program management should be indicated by placement of an *.						Personnel Total	$129.9

Travel Costs:		Ticket	Round	Total	Daily	Proposed
PM	Description	Price	Trips	Days	Per Diem	FFY 1996
	Attend biometrics consultation and planning mtg.	200	9	13	95	3.0
	Attend pink and chum workshop	500	3	6	95	2.1
	Attend meeting with NMFS personnel	500	3	9	95	2.4
	Attend state AFS meeting	400	3	4	95	1.6
	2 Round Trips Anchorage to Valdez	200	2	2	95	0.6
	2 Round trips to Little Port Walter	1000	2	10	95	3.0
	1 Round trip Scientific meeting	800	1	4	95	1.2
Those costs associated with program management should be indicated by placement of an *.					Travel Total	$13.9

1997

Project Number: 97191A
Project Title: Investigating and Monitoring Oil Related Egg and Alevin Mortalities
Agency: AK Dept. of Fish & Game

FORM 3B
Personnel
& Travel
DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Contractual Costs:	Proposed
Description	FFY 1996
Vessel charter for Fall Embryo Sampling (R/V Montague @ $1.2K/day for 25 days)	30.0
Air charter for Fall Embryo sampling (12 hours @ $0.25/hour)	3.1
D.O.T. vehicle rental (2 months @ $0.3/month)	0.6
Air charter (Little Port Walter/Sitka) 2 RT @ $ 0.5/RT	1.0
Outboard maintenance($0.5)	0.5
Publication Costs	2.4
Post Doc Contract to University	50.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$87.6

Commodities Costs:	Proposed
Description	FFY 1996
Data processing supplies	1.5
Field sampling supplies ($2.8)	2.8
Biochemicals, Miscellaneous laboratory supplies, DNA biochemicals	19.0
Office Supplies	1.0
Commodities Total	$24.3

1997

Project Number: 97191A
Project Title: Investigating and Monitoring Oil Related Egg and Alevin Mortalities
Agency: AK Dept. of Fish & Game

FORM 3B
Contractual & Commodities DETAIL
4/15/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1996
Fry pump for field monitoring (Component A)			0.5
Replacement outboard motor (25 hp) for field sampling			1.6
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$2.1

Existing Equipment Usage: Description	Number of Units	Inventory Agency
Hydraulic fry pumps	4	ADFG

1997

Project Number: 97191A
Project Title: Investigating and Monitoring Oil Related Egg and Alevin Mortalities
Agency: AK Dept. of Fish & Game

FORM 3B
Equipment
DETAIL

4/15/96

Pink Salmon Spawning Habitat Recovery

Project Number: ~~97~~ 97194

Restoration Category:

Proposer: Michael L. Murphy and Stanley D. Rice
NMFS Auke Bay Laboratory

Lead Trustee Agency: NOAA

Cooperating Agencies:

Alaska SeaLife Center:

Duration: 1st year, 1.5-year project

Cost FY 97: 138.3

Cost FY 98: 65.0

Geographic Area: Prince William Sound (field work completed)

Injured Resource/Service: Pink salmon

ABSTRACT

This project would examine the level of oil contamination in pink salmon streams in 1989-90 and 1995 by analyzing sediment samples collected in 1989-90 by ADFG (Oil Spill Response) and similar samples collected in 1995 by the Auke Bay Laboratory. Over 800 samples from 200 streams were collected by ADFG in 1989-90, but few were analyzed. An additional 97 similar samples were collected by the Auke Bay Laboratory in 1995. Analysis and comparison of the 1989-90 and 1995 data would complete the understanding of the injury to pink salmon by documenting the initial exposure level and subsequent habitat recovery. This study would complement and help in interpreting other Trustee studies of oil-related embryo mortality in pink salmon (Projects 96191A and B). After determining the past and present potential for oil exposure, we propose to estimate the extent of damage from oiled stream gravels by synthesizing the field contamination data, the elevated embryo mortality data of Project 96191A, and the oiled gravel/egg experiments of Project 96191B. If restoration of contaminated stream gravels were contemplated, now or in future oil spills, the data from this study, along with the synthesis of all three studies, would provide valuable information for guidance.

INTRODUCTION

The *Exxon Valdez* oil spill caused increased mortality and possible long-term genetic damage in pink salmon (*Oncorhynchus gorbuscha*) eggs and embryos that incubated in oiled intertidal sections of freshwater streams. Damage appears to be long term and persistent. Embryo mortality was still higher in oiled streams in 1993 (Sharr et al. 1993), but appears to have returned to pre-spill levels in 1994 and 1995. Nevertheless, pink salmon stocks in Prince William Sound are not recovering (*Exxon Valdez* Oil Spill Trustee Council 1996)

Although impacts of oil on eggs and embryos appear evident, little information exists on the levels of oil contamination that the incubating embryos were initially exposed to. Only a small number of sediment samples from streams have been analyzed, and oil concentration ranged considerably. Total polynuclear aromatic hydrocarbon (PAH) concentration ranged as high as 2,783 µg/g (GERG 1990, 1991). Some workers (Heintz and Weidmer, in press) found that PAH levels in 1990 were high enough to cause metabolic and mutagenic effects, but other workers (Brannon et al., in press) disagreed, claiming that PAH levels were too low to cause ill effects. The question of long-term impacts is difficult to answer without better data on actual exposure levels.

Fortunately, ADFG collected over 800 intertidal sediment samples from about 200 salmon streams in 1989 and 1990 as part of the oil spill response effort. For lack of funds, only 52 of these samples from 12 streams were ever analyzed. The rest were kept frozen and secured. Their existence was unknown to the Trustees until the samples were identified and acquired by the Auke Bay Laboratory (ABL) in 1995. The critical importance of these samples became evident when Trustee studies demonstrated continued impaired survival of pink salmon eggs and embryos. Projects 96191A and B did not collect data on oil levels in stream sediments. Such data are critical to interpreting results of these studies in relation to initial and possibly continuing oil exposure. These samples can indicate how widespread and acute the initial exposure was after the oil spill.

Because of the significance of these sediment samples, ABL analyzed 29 of the 1989-90 samples from 11 streams in 1995 to explore potential results of a more complete analysis. Results varied widely by stream, with mean total oil concentration ranging from 1 µg/g to over 45,000 µg/g. Further analysis would help interpret variation in salmon egg mortality found in Project 96191A. A full analysis of all remaining samples would indicate the distribution of the initial oil exposure at salmon streams throughout Prince William Sound and adjacent areas.

No monitoring of oil contamination in pink salmon spawning areas has been done since 1990; thus, whether or not oil still persists in these areas is a matter of speculation. Although the study by Sharr et al. (1994), in which eggs from oiled and non-oiled streams were incubated at the AFK Hatchery, indicated that increased embryo mortality was due to genetic damage, the continued exposure to oil in the streams was not ruled out. Buried oil deposits may still be leaching toxic compounds into intertidal salmon spawning areas, and this seeping oil could still be contributing to embryo mortality, in addition to mortality from impaired genes.

To determine if residual oil could still be contaminating pink salmon spawning habitat in 1995, ABL collected an additional 97 samples from intertidal salmon spawning areas at 12 of the ADFG sites. Analysis of these samples would indicate whether oil exposure continues at these sites and may help to corroborate the data showing recovery of egg survival in Project 96191A.

This proposal requests funds to analyze the archived ADFG samples to determine the levels of exposure in 1989-90, and to process ABL's 1995 samples to determine habitat recovery and current oil exposure, if any. Natural recovery in many areas is probably adequate by now; however, specific streams may still suffer. If persistent oil exposure is indicated by these samples, a proposal would be offered for FY 98 to evaluate further options for restoring intertidal spawning areas. Finally, this study would synthesize results of all three studies related to damage and recovery of pink salmon spawning habitat.

This study would provide data on the magnitude of the initial acute exposure and determine whether pink salmon spawning areas continue to be exposed to oil contamination from beached and buried oil deposits. Data on the initial exposure are needed to evaluate the potential for long-term genetic impacts. Data on the persistence of oil are needed to assess habitat recovery and evaluate the need for additional restoration of pink salmon spawning habitat.

The requested funds for this project include only funds needed to analyze existing samples and report results. The ABL has already contributed considerable funds and labor in acquiring and securing the samples and documentation for the ADFG samples collected in 1989-90. The ABL has analyzed a small number of these samples, and has contributed further effort to gather samples in 1995 because of the importance of this study. Logistics supporting the collections in 1995 were coordinated with other Trustee project charters at no cost, and the labor was contributed by ABL.

NEED FOR THE PROJECT

A. Statement of Problem

Pink salmon embryos that incubate in intertidal sections of streams contaminated by the *Exxon Valdez* oil spill continued to show poor survival compared to those from non-oiled streams until 1994. The cause of the reduced survival is thought to be genetic damage from the initial acute exposure after the spill (Sharr et al. 1994). The mortality could also be due, at least in part, to continuing oil exposure from persistent oil deposits that seep toxic compounds into salmon spawning areas. Water draining through the beach during ebb tide could dissolve and carry to the stream low concentrations of hydrocarbons that could be taken up by incubating embryos. The biology of incubating salmon eggs contributes to potential exposure. Long-term incubation through the winter in stream gravels of intertidal zones, large yolk reserves that may absorb and accumulate low-level and intermittent oil exposures, and embryos at a critical phase of development are all factors that contribute to the vulnerability of this life stage. Existing data on oil levels in stream and beach sediments are insufficient to determine the magnitude of the initial exposure experienced by pink salmon embryos after the spill, or to evaluate present habitat condition.

B. Rationale/Link to Restoration

The proposed project would provide data on initial oil concentrations in stream and adjacent beach sediments and on their current condition. Data on initial oil concentrations would allow a more accurate assessment of the probability of genetic damage, and data on current condition would provide an assessment of the recovery of spawning habitat and the need for additional restoration efforts. This project relates directly to the Oil Spill Restoration Plan objective to recover healthy and productive pink salmon populations to prespill abundance.

C. Location

All 1995 samples were from within Prince William Sound at the sites listed in Table 2. Samples to be analyzed from 1989-1990, however, are from the entire oil spill impact area, including Prince William Sound, Kodiak, and the Alaska and Kenai Peninsulas.

COMMUNITY INVOLVEMENT

As all field work has already been completed, only limited community involvement is envisioned for this project. We would submit an article and photographs for the Trustee Council newsletter.

PROJECT DESIGN

A. Objectives

The major hypotheses are 1) that initial oil concentrations were sufficient to cause long-term genetic damage in pink salmon, and 2) that residual oil from beached deposits continues to seep into salmon spawning areas, contributing to poor embryo survival. Specific objectives would be to:

1. Measure oil in ADFG-collected stream gravels collected in 1989-90;
2. Measure oil in ABL-collected stream gravels collected in 1995;
3. Examine PAH profiles in 1989-90 and 1995 samples and compare to *Exxon Valdez* crude for confirmation of source of oil;
4. Prepare a report on the stream gravel concentrations, rate of recovery, and need and potential for restoration; and
5. Synthesize results with Projects 96191A and B to determine the past and present potential of oil levels in stream gravel to cause long-term damage to pink salmon eggs.

If results indicate that oil persists at salmon streams, further work would be proposed to determine the extent of the beached oil reservoirs, describe pathways for how oil moves from these reservoirs into salmon spawning areas, measure the dosage of oil contaminants that incubating salmon embryos are actually exposed to in the streams, and develop options for additional restoration.

B. Methods

Existing unanalyzed sediment samples collected by ADFG in 1989-90 consist of a total of 770 samples, including 663 from Prince William Sound, 80 from Kodiak, 17 from the Alaska Peninsula, and 10 from the Kenai Peninsula. Because samples were taken in pairs, about one-half of the samples are duplicates. All of the non-duplicate samples (approximately 350) would be analyzed by fast-screening ultraviolet fluorescence (UVF) to provide a semi-quantitative measure of the total concentration of petroleum hydrocarbons. Of these samples, 10% would be analyzed by gas chromatography/mass spectroscopy (GCMS) to determine concentrations of individual PAH analytes and to confirm the source of the oil (Table 1).

Table 1. Number of samples to be analyzed, broken down by year collected and analysis type, with cost per sample and total cost.

Year collected	Analysis type	Number of samples	Cost per	Total cost
1989-90	UVF	350	$ 60	21.0 K
	GCMS	60	$500	30.0 K
1995	UVF	97	$ 60	5.8 K
	GCMS	40	$500	20.0 K

Twelve streams sampled by ADFG in 1989-90 (11 oiled and 1 non-oiled) were resampled by ABL in May 1995 to assess persistence of oil and recovery rate (Table 2). Included were the seven oiled streams that were intensively sampled by ADFG at which permanent sampling stations were mapped with survey techniques. Also included were most oiled streams used by Sharr et al. (1994) in their AFK Hatchery experiment. Of the eight oiled streams used by Sharr et al., seven were also sampled by ADFG and three were mapped. One non-oiled stream was sampled as a control.

Sampling at 12 streams in 1995 duplicated the ADFG 1989-90 sampling. At the seven mapped streams, samples were taken at the same locations as in 1989. At each of these streams, ADFG established three to four permanent sampling stations, and also took paired samples from the lower, middle, and upper intertidal zone. In 1995, we took single samples from each of these locations. In addition, at most of the 12 streams, "ad hoc" samples were taken at several pits in areas most likely to have oil to determine persistence of oil reservoirs. A total of 97 samples were taken in 1995, including 25 from permanent stations, 24 from lower, middle, and upper intertidal stations at each stream, and 48 from "ad hoc" locations. All samples would be fast-screened by UVF, and 20 would be analyzed by GCMS (Table 1).

Table 2. Number of samples taken at twelve streams sampled by ADFG in 1989-90 and resampled by the Auke Bay Laboratory (ABL) in 1995. Streams mapped by ADFG and also used by Sharr et al. (1994) are bold.

Station	Segment	Location	ADFG 1989-90 Samples	ABL 1995 Samples
ADFG Mapped streams				
2262016180	**CH002**	**Chenega Island, north tip**	**26**	**11**
2264016630	**EV017**	**Evans Island, Little Shelter Bay**	**19**	**10**
2264016780	**LA018**	**Latouche Island, Sleepy Bay**	**21**	**7**
2261016922	KN103	Knight Island, Lower Passage	11	9
2261016982	KN132	Knight Island, Herring Bay, west side	15	15
2263016840	KN701	Knight Island, Marsha Bay	22	9
2264016613	EV025	Evans Island, Shelter Bay	13	12
Other Sharr et al. sites sampled by ADFG but not mapped				
2262016280	CH001	Chenega Island, west coast	10	3
2264016650	EV900	Evans Island, Latouche Passage	6	6
2263016820	KN401	Knight Island, Snug Harbor	11	8
2265016370	LA041	Latouche Island, southwest	6	4
Control				
2262016864	KN551	Knight Island, Lower Herring Bay	2	3

C. Cooperating Agencies, Contracts, and Other Agency Assistance

No contracts or other agency assistance are anticipated.

SCHEDULE

A. Measurable Project Tasks for FY 97

October 1996: Prioritize samples for fast screening and GCMS analysis.

November-March: Analyze samples for hydrocarbons.

April-May 1997: Data entry and statistical analysis. Prepare DPD for FY 98 if warranted.

May-Sept 1997: Write final report on hydrocarbon concentrations.

Oct 1997-June 1998: Synthesize analytical results of this study with those from Project 96191A and B.

B. Project Milestones and Endpoints

All analytical objectives would be met on the same schedule because both archived and new sets of samples will be analyzed concurrently. All samples will be in hand at start of fiscal year.

March 1997: Sample analysis completed.

April 1997: Annual report submitted.

May 1997: Data entry and statistical analysis completed.

September 1997: Final report submitted.

June 1998: Synthesis manuscript completed.

C. Completion Date

The completion date for analyses and reporting of objectives 1 through 4 would be during FY 97. The completion date for a synthesis involving this study and Project 96191A and B would be June 1, 1998. If oil concentrations in 1995 samples continue to be high and widespread, and additional work or restoration is warranted, further work would be proposed for FY 98 and beyond. That is not expected at this time.

PUBLICATIONS AND REPORTS

A final report would be submitted by September 1997. This report would address results of the analysis of all samples, including initial oil concentrations in 1989-90 and habitat condition in 1995. It would confirm the match to *Exxon Valdez* oil.

A synthesis manuscript would be completed in June 1998, comparing the analytical results of this study with the biological impacts measured in the two other related Trustee studies.

NORMAL AGENCY MANAGEMENT

NOAA NMFS has statutory stewardship for all living marine resources; however, if the oil spill had not occurred NOAA would not be conducting this project. NOAA NMFS proposes to make a significant contribution (as stated in the proposed budget) to the operation of this project, making it truly cooperative.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project would be coordinated with other projects conducted by ABL. Much coordination has already been achieved during sample acquisition through shared logistics and data and in developing the objectives for this project. The data from this project would be directly relevant to ongoing Restoration projects dealing with the recovery of pink salmon and oil-related egg and alevin mortalities.

PROPOSED PRINCIPAL INVESTIGATORS

Michael L. Murphy and Stanley D. Rice
NOAA NMFS
Auke Bay Laboratory
11305 Glacier Hwy
Juneau, AK 99801
Phone: (907) 789-6036
Fax: (907) 789-6094
E-mail: mmurphy@abl.afsc.noaa.gov

PERSONNEL

Principal Investigator: GS-12 Fisheries Research Biologist - Michael L. Murphy

Mr. Murphy received a BA (1974) in Zoology from University of Wisconsin, Madison, WI, and MS (1978) in Fisheries from Oregon State University, Corvallis, OR. Mike has been employed at the Auke Bay Laboratory since 1981. His principal studies have included research on stream/riparian habitat issues and ecology of juvenile salmonids, and he has written more than 40 papers related to these topics. Mike presently leads the Anadromous Fish Habitat Task at the Auke Bay Laboratory.

Co-Principal Investigator: GM-14 Physiologist - Stanley D. Rice

Dr. Rice received a BA (1966) and MA (1968) in Biology at Chico State University, and Ph.D. (1971) in Comparative Physiology at Kent State University. Employed at the Auke Bay Laboratory since 1971 as a research physiologist and task leader, Dr. Rice has been Habitat Program Manager since 1986. He has researched oil effects since 1971 and has published over 70 papers. His studies have ranged from field to lab tests, behavioral to biochemical studies, and salmonids to invertebrates. Dr. Rice has conducted and managed cooperative projects since 1974, including the Auke Bay Laboratory's *Exxon Valdez* damage assessment studies. Activities since the oil spill include management of 10 damage assessment projects, establishment of chemistry lab and analyses, establishment of hydrocarbon database management. Dr. Rice has provided principal investigators and managers in NOAA and other agencies with reviews and critical input into agency decisions, and he has interacted closely with other agencies on logistics coordination, critiquing study design, and interpreting observations.

Chemistry Laboratory Manager: GS-13 Chemist - Jeffrey Short

Mr. Short is an analytical chemist and leads the hydrocarbon analysis at the Auke Bay Laboratory. Mr. Short holds a BS in biochemistry and an MS in physical chemistry from the University of California. He was principal investigator of NRDA projects Subtidal Study #3 and has conducted extensive research on effects of Alaska crude oil on marine biota before and after the *Exxon Valdez* oil spill.

LITERATURE CITED

Brannon et al. In press. Field studies of embryo survival in Prince William Sound. Proceedings of the pink and chum workshop, Bellingham, WA, March 1-3, 1995.

Exxon Valdez Oil spill Trustee Council. 1996. Invitation to submit restoration proposals for federal fiscal year 1997.

GERG. 1990. Oil spill study for Alaska Department of Fish and Game, November 1990. The Geochemical and Environmental Research Group, Texas A&M University. Technical Report #90-095.

GERG. 1991. Oil spill study for Alaska Department of Fish and Game. The Geochemical and Environmental Research Group, Texas A&M University. Report to ADF&G, November 1991.

Heintz, R. A., and M. Weidmer. In press. Laboratory evidence for short- and long-term damage to pink salmon incubating in oiled gravel. Proceedings of the pink and chum workshop, Bellingham, WA, March 1-3, 1995.

Sharr, S., J. E. Seeb, B. Bue, A. Craig, and G. D. Miller. 1994. Injury to pink salmon eggs and pre-emergent fry in Prince William Sound -- Restoration Study 93003. ADFG Regional Information Report No. 2A94-48. ADFG, Division of Commercial Fisheries Management and Development, 333 Raspberry Rd. Anchorage, AK 99518-1599.

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997						
Personnel		$102.7						
Travel		$2.9						
Contractual		$0.0						
Commodities		$17.3						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$122.9	Estimated FFY 1998	Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	
General Administration		$15.4						
Project Total	$0.0	$138.3	$65.0	$0.0	$0.0	$0.0	$0.0	
Full-time Equivalents (FTE)		1.7						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$55.0	$37.7	$30.7					

Comments:
Other Resources:

NOAA contribution of ABL Habitat Program Manager, J. Rice, 2 mo = $ 22.4K: Senior Chemist, J. Short, 1 mo = $ 8.3K: Principal Investigator Mike Murphy 1 mo = $ 7K for a total of $ 51.7K (in addition to mo. covered in next section) for a total of $ 37.7K in FY97.

NOAA contribution in FY 95 estimated at $55.0K. This includes obtaining oil spill response samples from ADFG, consultation to identify and verify that collection data was compatible with the Trustee database, and field work to collect comparable samples in PWS in 1995. This project was not funded by the Trustee Council in FY95 nor FY96.

1997

Prepared:

Project Number: ~~9~~ 97194
Project Title: Pink Salmon Spawning Habitat Recovery
Agency: National Oceanic & Atmospheric Administration

FORM 3A
TRUSTEE
AGENCY
SUMMARY

4/12/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1997
M Murphy	Fishery Research Biologist	12/4	3.0	7.0		21.0
J. Lunasin	Research Chemist	9/5	6.0	5.0		30.0
D. Fremgen	Research Chemist	9/5	8.0	5.0		40.0
L. Ewing	Fishery Research Biologist	7/4	3.0	3.9		11.7
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		20.0	20.9	0.0	
					Personnel Total	$102.7

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FFY 1997
Anchorage, Workshop & other Planning Mtgs., 2	0.4	2	6	0.3	2.6
Car Rental and miscellaneous for above					0.3
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$2.9

1997

Prepared:

Project Number: 97___
Project Title: Pink Salmon Spawning Habitat Recovery
Agency: National Oceanic & Atmospheric Administration

FORM 3B
Personnel
& Travel
DETAIL

4/12/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

Contractual Costs:	Proposed
Description	FFY 1997
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed
Description	FFY 1997
Chemistry laboratory solvents	6.0
Chemistry laboratory supplies (disposables, glassware, etc.)	8.5
Computer repairs, maintenance, software upgrades	1.0
Production of Reports	1.8
Commodities Total	$17.3

1997

Prepared:

Project Number: 97___
Project Title: Pink Salmon Spawing Habitat Recovery
Agency: National Oceanic & Atmospheric Administration

FORM 3B
Contractual & Commodities DETAIL

4/12/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 1997
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.	**New Equipment Total**		$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
Autosampler	1	NOAA
Detector	1	NOAA
Balance	2	NOAA

1997

Project Number: 97___
Project Title: Pink Salmon Spawning Habitat Recovery
Agency: National Oceanic & Atmospheric Administration

FORM 3B
Equipment
DETAIL

Prepared: 4/12/96

Project Title: Pristane Monitoring in Mussels and Predators of Juvenile Pink Salmon and Herring

Project Number:	97195
Restoration Category:	Research and Monitoring
Proposer:	Jeffrey W. Short and Patricia M. Harris NMFS/Auke Bay Lab
Lead Trustee Agency:	NOAA
Cooperating Agencies:	
Alaska Sea Life Center:	
Duration:	2nd year, 5 year project
Cost FY97:	$115,300
Cost FY98:	$115,000
Cost FY99:	$115,000
Cost FY00:	$115,000
Cost FY01:	$ 75,000
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pink Salmon, Pacific Herring

ABSTRACT

This project will continue to monitor pristane in mussels as an indirect index of potential year-class strength for pink salmon and herring and to identify critical pink salmon and herring marine habitat in Prince William Sound.

INTRODUCTION

Pristane is a hydrocarbon biosynthesized from chlorophyll by herbivorous copepods in the genera *Calanus* and *Neocalanus*. These copepods are the only proven modern marine source of pristane (Avigan & Blumer, 1968, J. Lipid Res. **9**:350; it also occurs in petroleum), and they typically contain concentrations that approach 1% dry weight (i.e. 10,000,000 ppb). As a branched alkane, pristane is highly lipophilic and resistant to metabolic degradation, which suggests that it may be a useful "tracer" molecule that would quantitatively label fats in predators of these copepods (Blumer *et al.*, 1964, Helgo. Wiss. Meeres. **10**:187). The low detection limit (about 100 ppb) of the inexpensive analytical method further suggests the utility of pristane as a natural indicator of energy flow from these copepods to higher trophic levels.

The hydrocarbon database produced for the *Exxon Valdez* Natural Resources Damage Assessment (NRDA) and Restoration phases from 1989 to 1995 provides an opportunity to evaluate the distribution of pristane among species in an ecosystem where *Calanus* and *Neocalanus* copepods are important prey. *(Neo)Calanus spp.* are marine zooplankters 3 - 10 mm in length, and can be the dominant marine herbivores in Prince William Sound (PWS) during the spring zooplankton bloom. They are consequently important prey for juveniles of many predators.

Following the *Exxon Valdez* oil spill, more than 50 species and 20 tissue types were collected and analyzed for hydrocarbons, including pristane. Examination of the *Exxon Valdez* database shows that the distribution of pristane among these species is generally consistent with known trophic relationships. We see about a 10-fold decrease of pristane concentrations in lipids at successive trophic levels (herbivore to primary predator to secondary predator). Important direct copepod predators identified include storm petrels, herring, and juvenile pink salmon. In addition, pristane concentrations that range to 50,000 ppb (dry weight) are evident in filter feeding organisms such as mussels and some clams during spring. Recent experiments conducted at the Auke Bay Laboratory confirm that pristane can be accumulated by mussels through ingestion of fecal material of *(Neo)Calanus* predators, e.g. juvenile pink salmon. Pristane concentrations in Prince William Sound (PWS) mussels therefore reflect the timing and simultaneous abundance of *(Neo)Calanus spp.* and their predators in seawater adjacent to sampled mussels.

Together, these results suggest that tissue analysis of pristane may be used an inexpensive new tool to investigate the PWS marine ecosystem in at least 3 ways. First, such analyses may identify predators that have a direct dietary dependence on *(Neo)Calanus spp.*, and these predators may include heretofore unrecognized "prey-switching" species that switch predation to larval herring and juvenile salmon in years of relatively low copepod abundance. Prey-switching has been hypothesized as major determinant of pink salmon and herring recruitment success in the Sound Ecosystem Assessment (95320 and 96320) studies. Second, a regular monitoring program for pristane in mussels could provide a quantitative basis for comparing inter-annual energy flow through *(Neo)Calanus spp.* to commercially important predators such as herring and pink salmon. This may provide a relatively inexpensive indicator of survival through the early juvenile stages for these species. Finally, the monitoring program could identify locations where this flow is consistently high, i.e. critical marine habitats. These approaches may clarify some of

the important natural factors that affect recruitment of juvenile salmon and herring, which is necessary for determining the restoration of these resources.

Analysis of data collected durring the pilot study phase of this project (1994 and 1995) supports these conclusions: Mussels at sites adjacent the deep marine trenches in Knight Island Passage had consistently high pristane concentraions in 1994 and 1995, relative to mussels at other sites. This is probably due to the overwintering of *(Neo)Calanus spp.* in these trenches. From September until mid-March pristane concentrations thoroughout the sound are below 300 ng/g . By the begining of April, pristane concentrations more than tripled in mussels at Knight Island Passage sites. These increases appear to radiate over a wider area by late April and by mid-May, pristane conctrations again increased sharply by another triple or more throughout most of PWS. Pristane concentrations in mussels remained high until mid-June, then gradually declined to the end of July, reflecting the descent of pristane producing copepods to overwintering depths away from and below the near shore food web.

Mussels adjacent to a shallow trench north of Hawkins Island had very high pristane concentrations in 1994, but low in 1995, suggesting copepod overwitnering in 1994, but not 1995. Despite inter-annual differences in productivity at some sites (see pristane accumulation index discusssion in the method section), productiviy in the sound as a whole was similar in 1994 and 1995.

The sampling of possible predators for pristane, the first objective of our 1996 work, will be concluded in that year. However, the data analysis and synthesis of information related to prey-switching will continue into FY97 as will the monitoring element.

NEED FOR THE PROJECT

A. Statement of Problem

Determination of the causes of the dramatic declines in populations of pink salmon and herring following the *Exxon Valdez* oil spill requires an assessment of natural factors that effect recruitment of these species, because any negative effects of the spill may be confounded by these natural factors. In addition, natural factors impose constraints on the recovery potential of these species. Pink salmon and herring are identified as species that have not recovered. If the recent population declines of these two species are the result of changes in the basic ecology of PWS due to natural phenomena (e.g. El Nino), then recovery of these populations to pre-spill levels may not be possible, and the criteria for recovery must recognize these changes.

B. Rationale

The proposed project will continue to provide information that may be used to evaluate the effect of natural constraints on the recovery of Prince William Sound pink salmon and herring populations. One of the major natural factors thought to be affecting the recovery of these species is prey-switching by predators. Under this hypothesis, predators are thought to prey primarily on juvenile pink salmon and larval herring in years of low copepod abundance, but

switch to copepods in years of higher abundance. This project addresses this hypothesis in two ways: (1) by identifying unrecognized "pre-switching predators", and (2), by indirectly monitoring survival of pink salmon and herring through their juvenile stages. Identification of prey-switching species will permit subsequent evaluation of the effect of those predators on recruitment of pink salmon and herring and annual monitoring of pristane concentrations in mussels will permit an indirect evaluation of the effects of juvenile survival on requitment. In addition, the monitoring will identify important near shore nursery areas for pink salmon and herring, the conservation of which may promote their recovery. Monitoring pristane in mussels will be necessary for at least 4 more consecutive years to provide a minimal statistical basis for any observed relationship between pristane concentrations in mussels and pink salmon and herring recruitment .

C. Location

Mussel samples will be collected in PWS and will be analyzed for pristane concentrations at the Auke Bay Laboratory, Juneau, Alaska. The identification of important productive areas in PWS and inter-annual productivity data will be useful to local fishery managers. Educational materials and the brochure will be most appropriate for residents and students of the sound, but will also be available for others.

COMMUNITY INVOLVEMENT

We will continue to involve PWS residents in the monitoring element of this project to share knowledge and interest in PWS ecosystems and to reduce sampling costs. Since 1994, the Prince William Sound Aquaculture Association has collected mussels near their 4 hatcheries at the appropriate times and stored them until the end of the season for pick-up. In 1996, students involved with Youth Area Watch (Project 96210) and independent students are collecting mussels at Tatitlek, Two Moon Bay, Whittier, Chenega, Kenny Cove, Valdez and Cordova. We will provide materials for each participating school that explains the rationale of the project and compares specific results for each school with the results for the whole effort. The underlying biology of this project gets to the heart of how the Sound turns sunlight into fish which we believe can provide a very useful local teaching tool. Youth Area Watch students will also be invited to practice pristane analysis laboratory techniques at a 1-day workshop at ABL. A color brochure describing the project and reporting results will be updated to include 1995 and 1996 data and will be available for volunteer collectors and others who are interested.

PROJECT DESIGN

A. Objectives

In 1997 this project has 2 objectives:

1. Measure pristane concentrations in mussels collected biweekly during spring from 36 stations in Prince William Sound to evaluate inter-annual variability of energy conversion

from *(Neo)Calanus* copepods to their nearshore, shallow sea-depth predators (FY97 - FY00).

2. Determine the existence and location of regions inside Prince William Sound where the energy conversion of objective 1 is consistently above average, and synthesize these data over time and geographic location each succeeding project year (FY97 - FY00).

B. Methods

Project objectives will be addressed by determining the seasonal variability of pristane concentrations in mussels (*Mytilus trossulus*) from 36 sites in PWS. Mussels will be collected biweekly, beginning in late March through June 1, then July 1 and August 1 for a total of 8 collection periods. The collection frequency is initially higher to more accurately establish the onset of the initial rise of pristane concentrations in the mussels, which is correlated with the zooplanton bloom and may vary from year to year. Collected mussels will be stored frozen and analyzed for whole-body pristane concentration.

Mussels (20) will be collected from selected mussel beds and placed into a plastic bag together with collection documentation (i.e. date, time, location, collector). Selected mussels will range in length, 20-45 mm. Mussels are collected along a transect parallel with the shoreline; one mussel is collected every consecutive meter. Previous results archived in the *Exxon Valdez* restoration database for hydrocarbons indicates that pristane concentrations in mussels collected in this way are representative of entire mussel beds.

Pristane concentrations in mussels will be analyzed statistically using repeated-measures ANOVA, both intra- and inter-annually. The intra-annual repeated-measures ANOVA will be used to determine whether pristane concentrations in mussels differ significantly among stations. The inter-annual ANOVA will be used to evaluate variability of a pristane accumulation index (PAI) calculated for each station each year. The PAI is calculated as the product of pristane concentration and sampling interval, and is an approximation of the integral of concentration and time at each station. Variability of this index will be used to evaluate the significance of pristane concentration differences among years for the sound as a whole, and to evaluate persistent annual differences among stations. Results from FY97 will be combined with results from 1994, 1995, and 1996 to examine annual variability, although the power will be low. The power will increase substantially with each succeeding year of results.

Pristane analysis: The chemical analysis of pristane involves pentane extraction of macerated tissues, lipid removal with silica gel, and separation and measurement of pristane by gas chromatography equipped with a flame ionization detector. Pristane measurement will use the internal standard method, with deuterated hexadecane and deuterated eicosane added to pentane initially as the internal standard. Pristane identification will be based on retention time relative to the internal standard. Quality control samples include method blanks, spiked method blanks, and reference sample analyzed with each batch of 20 samples to verify method accuracy, precision, and absence of laboratory introduced artifacts and interferences. Recovery of the internal standard will be determine by adding a second internal standard prior to instrumental analysis. Method detection limits will be assessed annually for the mussel tissue matrix, and these

detection limits will be assumed for the other matrixes analyzed. Based on previous performance, we anticipate accuracy of ±15% of National Institute of Science and Technology-certified values for the spiked blank and reference samples, precision of 95% of reference samples within ±15% of sample means, and laboratory artifacts below detection limits more than 99% of the time. This level of analytical performance will insure that variability due to sample analysis is negligible compared with variability among replicate mussel samples.

Percent moisture and percent lipid will also be determined in samples so that results may be analyzed on dry weight and lipid weight bases. Dry weights will be determined by heating samples at 60°C to constant final weight. Lipid proportions will be calculated from weight loss due to dichloromethane extraction.

C. Contracts and Other Agency Assistance

There will be no contracts under this project.

SCHEDULE

A. Measurable Project Tasks for FY97

FY97:

Oct 1 - Jan 1:	Analyze 1996 hydrocarbon data; revise brochure
Jan 1 - Feb 1:	Prepare and present results from 1996 at Restoration workshop.
Feb 1-Mar 15:	Plan logistics for FY97 field season.
Feb 1 - Apr 15:	Prepare annual report, report for public & high schools (94, 95 & 96 data).
Apr 1 - Aug 1:	Collect mussel samples.
Aug 1 - Sep 30:	Analyze samples for pristane.

B. Project Milestones and Endpoints

Objectives 1 & 2 should be met by FY00, possibly sooner, depending on the results. The endpoints are completion of the statistical analyses described under Methods above.

C. Completion Date

The monitoring element will be performed annually for 4 more years; FY 97 through FY 00.

PUBLICATIONS AND REPORTS

This project requires consistent multi-year funding to be successful. Annual reports are therefore appropriate, but publication in a peer-reviewed journal is also anticipated for all project

objectives, when collected data become sufficiently definitive. Annual reports will be submitted on April 15 of each year.

PROFESSIONAL CONFERENCES

The principal investigator will attend a conference in FY97; the details of the specific meeting are not yet known. A possible paper topic is the use of pristane to trace the flow of energy in PWS, to identify predators of juvenile pink salmon and herring, to identify the most productive areas in PWS, and to develop an index to predict the strength of each year class of pink salmon and herring.

NORMAL AGENCY MANAGEMENT

Although NOAA NMFS has statutory stewardship for all living marine resources, NOAA is conducting this project only because the the oil spill occurred and marine resources were injured. NOAA NMFS will, however, make a significant contribution (as stated in the proposed budget) to the operation of this project.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project is closely coordinated with the SEA projects in general, and with SEA project 97320i in particular. The proposed methods afford an independent assessment of hypotheses initially advanced by SEA participants. We are also cooperating closely with Youth Area Watch (97210), which is providing us with samples and to whom we are providing training and educational materials.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

There have been increases in the original budget to cover increased and previously unanticipated air charter costs and include additional travel--two additional workshop trips to Anchorage, a trip to participate in a Youth Area Watch orientation cruise, and travel to a scientific conference.

PROPOSED PRINCIPAL INVESTIGATOR

Jeffrey W. Short
Auke Bay Laboratory, Alaska Fisheries Science Center
National Marine Fisheries Service, NOAA
11305 Glacier Highway, Juneau, Alaska 99801-8626
Phone: (907) 789-6065
FAX: (907) 789-6094
e-mail: jshort@abl.afsc.noaa.gov

PERSONNEL

Jeffrey W. Short

Education:

BS, 1972, University of California, Riverside (Biochemistry & Philosophy)
MS, 1982, University of California, Santa Cruz (Physical Chemistry)

Relevant Experience:
1989- Present: Established and managed the hydrocarbon analysis facility at ABL to analyze hydrocarbon samples generated by the *Exxon Valdez* NRDA effort (about 20% of these samples were analyzed at ABL). Principal investigator of ST8--designed to evaluate and insure integrity of all hydrocarbon data in the Trustee database. This process will also allow increased user friendly access to database information.
1989 - 1992: Principal Investigator, *Exxon Valdez* project Air/Water #3: Determination of petroleum hydrocarbons in seawater by direct chemical analysis and through the use of caged mussels deployed along the path of the oil spill.
1991 - 1992: Principal Investigator, *Exxon Valdez* project Subtidal #8: Development of computer-based statistical methods for global examination of sediment and mussel hydrocarbon data produced for the *Exxon Valdez* NRDA effort for systematic bias, and for identification of probable sources of hydrocarbons. In addition, this project produced both hard-copy and computer display maps of all the sediment and mussel hydrocarbon data.
1994 - 1995: Initiated data analysis and pilot projects that established the role of pristane in Prince William Sound.
1996: Principal Investigator 96195 and 96290

Patricia M. Harris

Education: University of Alaska Fairbanks; B.S. Biological Science 1966
Graduate work at U of A Fairbanks, U of A Southeast, University of British Columbia

Experience: 1986 - present. Researcher, Auke Bay Laboratory, National Marine Fisheries Service, Juneau, Alaska. As co-principal investigator of NRDA study Subtidal 3, was responsible for field logistics and sample collection; and, assisted in data analysis and report preparation; also assisted other NRDA projects in field collections. 1992 -1996, co-principal investigator of the oiled mussel bed project (93036, 94090, 95090,96090); as such, participated in study design, field work, proposal preparation, data analysis, and report preparation for mussel bed monitoring and restoration. Conducted and initiated logistic planning, sampling, and community invlovement coordination for the pilot pristane project and 96195. Other areas of research have been habitat requirements of juvenile red king crab and sockeye salmon stock separation using parasites.

Relevant publications: Co-author of final reports for NRDA study Subtidal 3 and several publications pertaining to distribution of *Exxon Valdez* oil in mussels and underlying sediments. Several public presentations of oil-related scientific research.

Responsibilities: Initiate and coordinate sample collection logistics and collect mussel samples; data analysis; report and proposal preparation; and preparation of science educational materials and reports.

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Budget Category:	Authorized FFY 1996	Proposed FFY 1997	LONG RANGE FUNDING REQUIREMENTS					
			Estimated FFY 1998	Estimated FFY 1999	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	
Personnel	$57.8	$56.6						
Travel	$32.3	$43.2						
Contractual	$0.2	$0.2						
Commodities	$15.8	$6.8						
Equipment	$0.0	$0.0						
Subtotal	$106.1	$106.8						
General Administration	$8.7	$8.5						
Project Total	$114.8	$115.3	$115.0	$115.0	$115.0	$75.0		
Full-time Equivalents (FTE)	0.9	0.8						
		Dollar amounts are shown in thousands of dollars.						
Other Resources	$57.7	$63.2	$58.0	$58.0	$58.0	$25.0		

Comments:

This proposal is for the 3rd year of 5 years of field sampling.

NOAA contribution towards this project:

Habitat Program Manager, S. Rice, 1 mo @ $ 11.6K
Senior Chemist, Principal Investigator, J. Short, 6 mo. = $ 51.6K
for a total of $ 63.2K

1997

Prepared:

Project Number: 97195
Project Title: Pristane in Mussels and Fish Predators
Agency: National Oceanic & Atmospheric Administration

FORM 3A
TRUSTEE
AGENCY
SUMMARY

4/12/96

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1997
P. Harris	Zoologist	11/1	6.0	5.3		31.8
L Holland	Research Chemist	11/6	4.0	6.2		24.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		10.0	11.5	0.0	
					Personnel Total	$56.6

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FFY 1997
Anchorage Workshop & coordination meetings, 3	0.4	3	9	0.2	3.0
					0.0
Cordova & PWS to collect mussels, 9 trips	0.4	9	36	0.2	10.8
Vehicle/Miscellaneaous					1.5
Air Charter with PWS	0.8	33			26.4
					0.0
Unidentified Scientific Meeting: Present Paper					1.5
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$43.2

1997

Prepared:

Project Number: 97195
Project Title: Pristane in Mussels and Fish Predators
Agency: National Oceanic & Atmospheric Administration

FORM 3B
Personnel
& Travel
DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1996 - September 30, 1997

Contractual Costs:	Proposed
Description	FFY 1997
Transportation/freight	0.2
NOAA considers air charters (listed under Travel) as Travel costs.	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.2

Commodities Costs:	Proposed
Description	FFY 1997
Chemicals, solvents for pristane analyses	2.0
Chemistry lab supplies (consummables, glassware, equipment repairs)	2.5
Collecting gear and supplies (coolers, plastic bags, film, etc.)	2.0
Project informational brochures for PWS school children and public	0.3
Commodities Total	$6.8

1997

Prepared:

Project Number: 97195
Project Title: Pristane in Mussels and Fish Predators
Agency: National Oceanic & Atmospheric Administation

FORM 3B
Contractual & Commodities DETAIL

1997 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1996 - September 30, 1997

New Equipment Purchases:	Number of Units	Unit Price	Proposed FFY 1997
Description			
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number of Units	Inventory Agency
Description		
Camera	1	NOAA
Computer, Compaq	1	NOAA
NEC Monitor	1	NOAA
Hand-held VHS Radio	1	NOAA
GPS Unit		

1997

Prepared:

Project Number: 97195
Project Title: Pristane i Mussels and Fish Predators
Agency: National Oceanic & Atmospheric Administration

FORM 3B
Equipment
DETAIL

4/12/96