NOTE: This proposal is also included in 99369.

Seasonal Map Series Depicting Environmentally Sensitive Areas in Prince William Sound, Alaska - Proposal #1

(Summary Maps Only)

RECEIVED
APR 0 2 1998
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

Project Number:	99368
Restoration Category:	General Restoration
Proposer:	Hazardous Materials Response and Assessment Division, National Oceanic and Atmospheric Administration (NOAA)
Lead Trustee Agency:	NOAA
Cooperating Agencies:	U.S. Forest Service
Alaska Sea Life Center:	No
Duration:	1st year, 1-year project
Cost FY 99:	$35.2 (an additional $20. is necessary for the project and is being sought as addressed in section C. Cooperating Agencies, Contracts, and Other Agency Assistance)
Geographic Area:	Prince William Sound
Injured Resource/Service:	All resources and services injured by the *Exxon Valdez* spill, since it is a sensitive areas mapping project

ABSTRACT

A series of seasonal maps depicting environmentally sensitive areas in Prince William Sound will be produced in both hardcopy and digital formats. A previous series was produced in paper format in 1988. However, these maps need to be updated with new information on the distribution, abundance, life history, and sensitivity of the natural resources in Prince William Sound. NOAA proposes to integrate and depict the most current information onto an updated series of maps, produced at a scale of 1:250,000 (previous maps were at 1:333,300). The maps will be produced as posters, folded maps, and a digital product.

INTRODUCTION

One of the primary objectives of spill response, after protecting human life, is to reduce the environmental consequences of the spill and clean-up efforts. This objective is best achieved if the locations of sensitive resources are identified in advance of a spill so that protection priorities can be established and clean-up strategies identified. The most widely used approach to sensitivity mapping in the United States is known as the Environmental Sensitivity Index (ESI). This approach systematically compiles information in standardized formats for shoreline

sensitivity, biological resources, and human-use resources. The strategy emphasizes standardization in the following areas: definitions of shoreline sensitivity rankings; data structures for organizing resource information; and map formats, for both electronic and hard copy output.

ESI maps have been prepared for Prince William Sound in two formats: 1) a detailed atlas consisting of 42 maps at a scale of 1:63,360 published in 1983; and 2) a series of four seasonal maps each at a scale of 1:333,300 published in 1988. The summary maps are a subset of the more detailed data included in the ESI atlas, focusing on the most sensitive resources. Summary maps have also been produced for Cook Inlet/Kenai Peninsula in 1994 and Kodiak Island/Shelikof Straits in 1997.

NOAA proposes to update the Prince William Sound summary maps, integrating the new information learned from the numerous studies of the impact of the *Exxon Valdez* oil spill. This process will also address the need to update the identification and prioritization of sensitive areas for protection, since the natural resource agencies will be involved in providing data and reviewing the maps.

NEED FOR THE PROJECT

A. Problem Statement

The seasonal sensitivity maps of Prince William Sound have been shown to be a valuable tool for oil spill planning and response. The maps were published in 1988, thus they are out of date as well as being out of print.

B. Rationale/Link to Restoration

Updating of the seasonal summary maps will satisfy several needs:

1) The existing maps are out of date, particularly considering the extensive work conducted in the Sound since the *Exxon Valdez* spill. Planners and responders need the most accurate information on which to base response decisions and to protect the most sensitive species.

2) The existing maps are also out of print. NOAA considered reprinting them in the last few years to meet the current demand for copies.

3) In addition to the hardcopy map products, there will be a digital version of the maps and data, which provides other types of use.

4) The process of gathering data and reviewing the maps will provide the opportunity for resource agencies to discuss the concepts of what resources are most sensitive and require priority protection.

C. Location

The area to be covered by the seasonal sensitivity maps will be the same as the existing maps, that is, all of Prince William Sound and the Copper River delta.

COMMUNITY INVOLVEMENT & TRADITIONAL ECOLOGICAL KNOWLEDGE

As in past seasonal mapping projects, local communities are involved in providing data, such as for key subsistence areas, and reviewing the draft maps. NOAA will invite representatives from each community in the Sound to participate in all planning and data-collection activities, and make sure that a set of review maps is provided to each community. NOAA will work with Hugh Short, the Spill Area-Wide Coordinator, and the network of community facilitators to make sure that the communities in the Sound are award of the mapping project and given the opportunity to participate.

PROJECT DESIGN

A. Objectives

The objective of the mapping project is to:

> Update the seasonal sensitivity map series for Prince William Sound, integrating the results of recent studies on the biological and human-use resources in the area since the *Exxon Valdez* oil spill.

B. Methods

NOAA has taken the lead in the U.S. in developing standards for sensitivity mapping for oil spill planning and response. Detailed guidelines for developing sensitivity maps have recently been revised and described in an October 1997 manual, *Environmental Sensitivity Index Guidelines, Version 2.0*, published as NOAA Tech. Memo. NOS ORCA 115, by the Hazardous Materials Response and Assessment Division. The Prince William Sound seasonal sensitivity map series will be produced in accordance with these guidelines, following the map content and format as used in the recent projects in Cook Inlet/Kenai Peninsula and Kodiak Island/Shelikof Strait.

The methods for collecting data and determining which resources are to be included on the maps are well defined, since NOAA has produced similar map products recently. We have good working relationships with all of the key data providers and technical experts who will be reviewing the draft maps. We have established protocols for obtaining the necessary data from each source and for the review process.

There are several key data sources. Alyeska Pipeline Service Company (Alyeska) has developed a computer database for Prince William Sound and adjoining areas on the south-central coast of Alaska. The software, called the Graphical Resource Database (GRD), holds the sensitive area data of the Prince William Sound Tanker Oil Discharge Prevention and Contingency Plan. The geographic coverage of the GRD spans an approximately 500-mile-long region that includes the Copper River Delta, Prince William Sound, the lower Kenai Peninsula, lower Cook Inlet, the Kodiak Archipelago, and Shelikof Strait. The GRD consists of 105 layers of digital data records of biological resources (such as seabird colony sites and sea otter concentration areas), socioeconomic resources (such as commercial fishing areas and small boat harbors), and shoreline types. The expansion and update effort were coordinated by a committee of federal and state natural-resource trustee agencies (including the Alaska Department of Environmental Conservation, Alaska Department of Fish and Game, U.S. Fish and Wildlife Service, and NOAA), citizens oversight groups, Alyeska, and oil shipping

companies. The project is currently undergoing maintenance as data updates are intermittently provided by trustee agencies.

The GRD will be a primary source of digital data for the seasonal maps in Prince William Sound. However, primary data providers will be contacted, particularly for those databases that are regularly updated by management agencies. Examples include the USFWS digital database and colony status record files for seabird colonies and eagle nest sites, and the ADF&G catalog of waters important to anadromous fish.

Description of Sensitive Resources to be Shown on the Seasonal Maps

ESI atlases are comprised of three general types of information:

1) Shoreline Habitat Classification – Shoreline habitats are ranked according to a scale relating to biological sensitivity, natural persistence of oil, and ease of cleanup.

2) Biological Resources – Includes oil-sensitive animals and non-shoreline habitats such as submerged aquatic vegetation.

3) Human-Use Resources – Specific areas that have added sensitivity and value because of their use by humans, such as high-use amenity beaches, parks, marine sanctuaries, water intakes, and archaeological sites.

The seasonal maps show a sub-set of the most sensitive resources. Thus, only the most sensitive shoreline types will be shown, namely:

ESI 7	Exposed tidal flats
ESI 9	Sheltered tidal flats
ESI 10	Marshes

Since so much of the shoreline in Prince William Sound consists of ESI 8, sheltered rocky shores, this shoreline type will not be mapped (it was not mapped in the original series). The shoreline types will be obtained from the GRD database, which was originally digitized from the 1983 ESI maps. During the review process, any significant changes in these shoreline types will be addressed.

NOAA has developed a standard biological scheme which identifies seven major biological elements, based on major taxonomic and functional groupings. Each element is divided into groups of species, or sub-elements, with similar taxonomy, morphology, life-history, and/or behavior relative to oil spill vulnerability and sensitivity. Table 1 lists the biological resources to be included on the seasonal sensitivity maps for Prince William Sound. Table 2 lists the human-use resources to be included on the maps. This list will be finalized based on meetings with community representatives, natural resource trustees, and response organizations.

TABLE 1. Biological resources to be included on the seasonal sensitivity map series for Prince William Sound.

Data element	Sub-element	Areas/Sites to be mapped
Marine Mammal	Pinniped (harbor seal and northern sea lion)	Haulouts, concentration areas
	Sea otter	Concentration areas
	Whale	Migratory or other concentration areas
Terrestrial Mammal	Deer	Intertidal concentration areas
	Small mammal (river otter)	Aquatic fur-bearer concentrations
Bird	Seabirds (see list in text)	Nesting colonies; concentration areas
	Raptor (bald eagle)	Nesting sites; concentration areas
	Shorebird	Migratory concentration areas
	Waterfowl	Wintering and migratory concentrations
	Passerine	Threatened/endangered or rare occurrences
Fish	Anadromous fish	Spawning streams
	Pacific herring	Spawning areas
Shellfish	Bivalve	Harvest areas; abundant beds
Habitat/Rare Plant	Rare plant	Threatened/endangered or rare species or communities
	SAV	Submerged aquatic vegetation

TABLE 2.Human-use resources to be included on the seasonal sensitivity map series for Prince William Sound.

Data element	Sub-element	Comments
Recreation/Access	Marina	Site
	Landing strip	Site
Management Area	National Park	Boundary
	State Park	Site
	National Forest	Boundary
	National Wildlife Refuge	Boundary
	State Critical Habitat Area	Boundary
Resource Extraction	Aquaculture site	Hatcheries
	Commercial fishery	Set-net sites
	Subsistence fishing	Designated key harvest sites
Cultural Resources	Archaeological site	Water-, coastal-, wetland-associated
	Historical site	Water-, coastal-, wetland-associated
Other Features	Oil facilities	
	Port facilities	
	Communities	
	Political boundaries	Boroughs
	Roads	
	Dispersant pre-approval zones	
	Annotation	

Biology and Human-Use Compilation and Digitization

The collection of biological and human-use data requires a close working relationship with federal, state, and local resource and information-system experts, beginning at the start of the project and continuing until all data are reviewed. The general sequence of data compilation entails:

- Making contacts with scientists and resource managers who can provide expert knowledge and suggest relevant source materials;
- Gathering as much digital information as possible before meeting with experts;
- Reviewing existing hardcopy data sources;
- Meeting with individuals or groups of experts to delineate the locations of resources for which hardcopy or digital data are not available;
- Drawing resource distributions for non-digital data onto compilation maps based on hardcopy data and expert opinion; and
- Recording non-spatial or attribute data, and associating it with the resource locations delineated on the maps.

Based on the most recent mapping projects, NOAA has developed a template for the types of data to be included, the cartographic styles, the text, and the legend, which can be efficiently modified for each area. The seasonal map for Prince William Sound will be designed from this template with the necessary changes to reflect the special requirements of the area.

Four sets of the draft maps will be printed for review by all appropriate agencies and communities. The review maps will include all data, symbology, legends, notations, etc., to be shown on the final maps. NOAA will coordinate the review of the maps.

When the review information comes back, all edits will be entered and a check of all final data will be made. The data are then converted to the NOAA data structure with unique identification numbers, lookup tables, and data tables, and the final data sets and accompanying digital and hardcopy documents are prepared.

The production of the negative film separations is a completely digital process. The negative film separations will be quality-checked by generating a Chromalin color proof consisting of four photosensitized overlays, each in a different process color (CMYK), precisely registered and laminated to a white backing material. When the color proof meets quality standards, the films will be used to generate the printing plates which transfer the ink to the paper on the printing press, producing the best quality printing at the least cost for larger quantities of maps.

Two types of maps will be printed:

1) Full-color posters (35 x 40 inches) printed at 1:250,000 on heavy paper
2) Full-color maps at the same size but printed on water- and tear-resistant paper and folded, so they will be easy to carry and use in the field.

NOAA will print 1500 copies of the posters and 200 copies of the folded field maps.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Cooperating agencies who will provide information and review data include:

U.S. Forest Service, Chugach National Forest: Contacts and cooperation have been established with Karen Murphy, biologist with the Chugach National Forest, who is the principal investigator on the PWS Human Use and Wildlife Disturbance Model. Our project will be establishing locations and concentrations of wildlife against which the human-use data for PWS will be compared. These two projects are particularly amenable since both data sets will be generated in ArcInfo GIS format. In addition, we hope to be able to use Karen as a local knowledge source for PWS since she is already quite familiar with many of the biological projects that have been and are being conducted under the EVOS Trustee umbrella.

Alaska Department of Fish & Game

Alaska Department of Natural Resources

U.S. Fish & Wildlife Service

National Marine Fisheries Service

Prince William Sound Science Center

Communities of Chenega Bay and Tatitlek

Prince William Sound Regional Citizens Advisory Council

Also, funds and in-kind contributions have been obtained from a wide range of partners involved in oil spill planning and response.

Alyeska will provide their natural-resource databases.

Alaska Department of Conservation has agreed to provide funding so that the state resource agencies can budget adequate time to provide data & to review the draft ESI maps.

The U.S. Coast Guard has agreed to submit $10K in their FY99 budget for this mapping effort. We will know sometime this summer if the funding is approved.

The PWS Regional Citizens Advisory Council feels fairly confident that they can identify $10K in their FY99 budget and earmark it for this project.

Summary of Proposed Project Funding Arrangement (several yet to be confirmed)

Coast Guard	$10
PWS RCAC	$10
EVOS Trustee Council	$30
EVOS (Karen Murphy local liaison)	$5.2

. SCHEDULE

A. Measurable Project Tasks for FY 99 (October 1, 1998 - September 30, 1999)

The project schedule is outlined below.

October 1:	Begin data collection and evaluation
December 1:	Finalize the list of resources to be mapped
March 1:	Send out draft maps for review
April 15:	Review maps returned for final editing
June 15:	Digital data complete
July 15:	Color separates completed and approved; printing of maps advertised for bids
September 30:	Printed maps and digital data delivered

B. Project Milestones and Endpoints

The milestones and endpoints for this project are straightforward: Printed maps and a digital database, completed within one year. The schedule is shown above.

C. Completion Date

The maps and digital databases will be completed during FY99.

PUBLICATIONS AND REPORTS

There are no planned publications or reports, other than the maps themselves, the digital data, and the metadata.

PROFESSIONAL CONFERENCES

None anticipated.

NORMAL AGENCY MANAGEMENT

Although NOAA HAZMAT is in the normal business of making ESI maps throughout the United States, updating the PWS summary ESI map series would not normally receive attention

until much later. The last edition was developed in 1988 and, as a result, retains adequate accuracy for use in oil spill response. Also, since 1989, Alyeska has developed a Graphical Resource Database (GRD) of the biological and human-use resources of PWS that was last updated in 1995. This digital-only product has been made available to all the resource agencies in a read-only version (the files are in a rather proprietary, arcane format that makes that virtually inaccessible). Currently there is a national drive to update and convert ESI maps to a digital format, and NOAA HAZMAT is heavily involved in this effort. Considering the vast amount of sensitive U.S. coastline and the present status of the PWS resource data, NOAA would not be undertaking this summary map ESI update of PWS as part of its normal activities in the near future. Yet we recognize the vast amount of new data that has been generated with the EVOS Restoration Project. This ESI summary mapping project will allow us the unique opportunity to collate, digitize, and display all this data in poster form and in a digital data format that is consistent and uniform, thus making the information much more accessible to a much larger audience.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

There will be a high degree of coordination among Trustee and management agencies in all phases of data gathering and map review. Interaction would be initiated with principal investigators of the SEA, APEX, and NVP ecosystem projects to ascertain new information that has been developed on locations and areas of concentrations of biological species that populate the Sound. Contact with other principal investigators and review of their work would also be conducted to obtain information pertinent to this summary environmental sensitivity mapping effort.

In particular, contacts and cooperation have been established with Karen Murphy, biologist with the Chugach National Forest, who is the principal investigator on the PWS Human Use and Wildlife Disturbance Model. Our project will be establishing locations and concentrations of wildlife against which the human-use data for PWS will be compared. Similarly, her modeling project may be able to supply some data layers to assist in our mapping effort. These two projects are particularly amenable, since both data sets will be generated in ArcInfo GIS format. In addition, we hope to be able to use Karen as a local knowledge source and liaison for PWS since she is already quite familiar with many of the biological projects that have been and are being conducted under the EVOS Trustee umbrella.

PROPOSED PRINCIPAL INVESTIGATOR

John Whitney, NOAA HAZMAT, Anchorage, Alaska

PRINCIPAL INVESTIGATOR QUALIFICATIONS

Mr. Whitney is the NOAA Scientific Support Coordinator for Alaska. He has managed the last three seasonal sensitivity mapping projects conducted by NOAA and the U.S. Coast Guard, namely Cook Inlet/Kenai Peninsula, Kodiak Island/Shelikof Strait, and the Pribilof Islands.

OTHER KEY PERSONNEL

Robert Pavia, Chief, HAZMAT Scientific Support Coordination Branch

Jill Petersen, HAZMAT Geographic Information System Specialist

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized	Proposed	PROPOSED FY 1999 TRUSTEE AGENCIES TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
	FY 1998	FY 1999				$5,175.0		$51,253.5
Personnel	$0.0	$4,500.0						
Travel	$0.0	$5,361.0						
Contractual	$0.0	$44,000.0						
Commodities	$0.0	$1,000.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$54,861.0		Estimated 2000	Estimated 2001			
General Administration	$0.0	$1,567.5						
Project Total	$0.0	$56,428.5		$0.0	$0.0			
Full-time Equivalents (FTE)	0.0	0.1						
			Dollar amounts are shown in thousands of dollars.					
Other Resources	$0.0	$0.0		$0.0	$0.0	$0.0	$0.0	

Comments:

1999

Prepared:

Project Number: 99368
Project Title: Seasonal Environmental Sensitive Maps
Lead Agency: NOAA

FORM 2A
MULTI-TRUSTEE
AGENCY
SUMMARY

4/6/98

1998 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$5,361.0
Contractual		$44,000.0
Commodities		$1,000.0
Equipment		$0.0
Subtotal	$0.0	$50,361.0
General Administration		$892.5
Project Total	$0.0	$51,253.5
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001			
Dollar amounts are shown in thousands of dollars.					

Comments:

1999

Prepared:

Project Number: 99xxx
Project Title: Seasonal Environmental Sensitive Maps
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

1998 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
						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	FY 1999
Seattle-Anchorahe-Valdez-Seattle	927.0	3	12	215.0	5,361.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$5,361.0

1999

Project Number: 99xxx
Project Title: Seasonal Environmental Sensitive Maps
Agency: NOAA

FORM 3B
Personnel
& Travel
DETAIL

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Contractual Costs:	Proposed
Description	FY 1999
printing of maps	42,000.0
duplication and mailing costs	2,000.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$44,000.0

Commodities Costs:	Proposed
Description	FY 1999
printer/plotter paper	500.0
printer/plotter suplies	250.0
base maps	250.0
Commodities Total	$1,000.0

1999

Project Number: 99xxx
Project Title: Seasonal Environmental Sensitive Maps
Agency: NOAA

FORM 3B
Contractual & Commodities DETAIL

Prepared: 4 of 10

4/6/98

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
			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: Description	Number of Units	Inventory Agency

1999

Project Number: 99xxx
Project Title: Seasonal Environmental Sensitive Maps
Agency: NOAA

FORM 3B
Equipment
DETAIL

Prepared: 4/6/98

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$4,500.0
Travel		$0.0
Contractual		$0.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$4,500.0
General Administration		$675.0
Project Total	$0.0	$5,175.0
Full-time Equivalents (FTE)		0.1
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001			

Dollar amounts are shown in thousands of dollars.

Comments:

1999

Project Number: 99xxx
Project Title: Seasonal Environmental Sensitive Maps
Agency: USFS

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: 4/6/98

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
K. Murphy	wildlife biologist	GS 9/6	1.0	4500.0		4,500.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.0	4500.0	0.0	
					Personnel Total	$4,500.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
					0.0
					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

1999

Project Number: 99xxx
Project Title: Seasonal Environmental Sensitive Maps
Agency: USFS

FORM 3B
Personnel
& Travel
DETAIL

Prepared:

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Contractual Costs:	Proposed FY 1999
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

1999

Project Number: 99xxx
Project Title: Seasonal Environmental Sensitive Maps
Agency: USFS

FORM 3B
Contractual & Commodities DETAIL

Prepared: 8 of 10

4/6/98

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 1999
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		

1999

Project Number: 99xxx
Project Title: Seasonal Environmental Sensitive Maps
Agency: USFS

FORM 3B
Equipment
DETAIL

Prepared: 4/6/98

NOTE: This proposal includes 99368

Seasonal and Detailed Map Series Depicting Environmentally Sensitive Areas

in Prince William Sound, Alaska - Proposal #2

(Summary & Detailed Maps)

Project Number: 99369

Restoration Category: General Restoration

Proposer: Hazardous Materials Response and Assessment Division, National Oceanic and Atmospheric Administration (NOAA)

Lead Trustee Agency: NOAA

Cooperating Agencies: U.S. Forest Service

Alaska Sea Life Center: No

Duration: 1st year, 1-year project

Cost FY 99: $55.2 (an additional $100. is necessary for the project and is being sought as addressed in section C. Cooperating Agencies, Contracts, and Other Agency Assistance)

Geographic Area: Prince William Sound

Injured Resource/Service: All resources and services injured by the *Exxon Valdez* spill, since it is a sensitive areas mapping project

ABSTRACT

A series of summary seasonal and detailed maps depicting environmentally sensitive areas in Prince William Sound will be produced in both hardcopy and digital formats. A previous summary series and detailed series were produced in paper format only in 1988 and 1983, respectively. However, these maps need to be updated with new information on the distribution, abundance, life history, and sensitivity of the natural resources in Prince William Sound. NOAA proposes to integrate and depict the most current information onto an updated series of maps, produced at a scale of 1:250,000 (previous maps were at 1:333,300) for the summary maps, and 1:63,360 (previous maps at this same scale) for the detailed maps. The summary maps will be produced as posters and folded maps; and the 42 detailed maps will be bound in an atlas format; both will be rendered as a digital product.

These two scales of maps will allow for a much broader range of use than just one scale alone, and doing them together will be very cost effective. The range of possible utilizations include general resource information, both oil spill strategic planning and tactical planning (geographic response plans, GRP's), human use patterns as a function of biological resource locations, land use planning and management, recreational use, etc. As a result attempts are being made to estabish a large partnership of groups to provide the full funding necessary to realize the development of these two different scales of mapping, and these will be addressed in a later section of this proposal.

INTRODUCTION

One of the primary objectives of spill response, after protecting human life, is to reduce the environmental consequences of the spill and clean-up efforts. This objective is best achieved if the locations of sensitive resources are identified in advance of a spill so that protection priorities can be established and clean-up strategies identified. The most widely used approach to sensitivity mapping in the United States is known as the Environmental Sensitivity Index (ESI). This approach systematically compiles information in standardized formats for shoreline sensitivity, biological resources, and human-use resources. The strategy emphasizes standardization in the following areas: definitions of shoreline sensitivity rankings; data structures for organizing resource information; and map formats, for both electronic and hard copy output.

ESI maps have been prepared for Prince William Sound in two formats: 1) a detailed atlas consisting of 42 maps at a scale of 1:63,360 published in 1983; and 2) a series of four seasonal maps each at a scale of 1:333,300 published in 1988. The summary maps are a subset of the more detailed data included in the ESI atlas, focusing on the most sensitive resources. Summary maps have also been produced for Cook Inlet/Kenai Peninsula in 1994 and Kodiak Island/Shelikof Straits in 1997.

NOAA proposes to update both the Prince William Sound summary and detailed maps, integrating the new information learned from the numerous studies of the impact of the *Exxon Valdez* oil spill. This process will also address the need to update the identification and prioritization of sensitive areas for protection, since the natural resource agencies will be involved in providing data and reviewing the maps. With the more detailed maps actual graphical response plans (GRP's) can be developed which show the details of boom placement, boom lengths, anchor points, current speed and direction, etc. The GRP is a a much bigger and more involved process; however, these more detailed maps are the essential first ingredient.

NEED FOR THE PROJECT

A. Problem Statement

The seasonal and detailed sensitivity maps of Prince William Sound have been shown to be a valuable tool for oil spill planning and response. The maps were published in 1988 and 1983, respectively, thus they are out of date as well as being out of print.

B. Rationale/Link to Restoration

Updating of the seasonal summary and detailed maps will satisfy several needs:

1) The existing maps are out of date, particularly considering the extensive work conducted in the Sound since the *Exxon Valdez* spill. Planners and responders need the most accurate information on which to base response decisions and to protect the most sensitive species.

2) The existing summary maps are also out of print. NOAA considered reprinting them in the last few years to meet the current demand for copies. Only a handful of the detailed map atlases have ever existed, and generally people are unaware of this valuable resource.

3) The detailed maps are essential for developing oil spill GRP's, the tactical level of spill response planning.

4) In addition to the hardcopy map products, there will be a digital version of the maps and data, which provides other types of use.

5) The process of gathering data and reviewing the maps will provide the opportunity for resource agencies to discuss the concepts of what resources are most sensitive and require priority protection.

C. Location

The area to be covered by the sensitivity maps will be the same as the existing maps, that is, all of Prince William Sound and the Copper River delta.

COMMUNITY INVOLVEMENT & TRADITIONAL ECOLOGICAL KNOWLEDGE

As in past ESI mapping projects, local communities are involved in providing data, such as for key subsistence areas, and reviewing the draft maps. NOAA will invite representatives from each community in the Sound to participate in all planning and data-collection activities, and make sure that a set of review maps is provided to each community. NOAA will work with Hugh Short, the Spill Area-Wide Coordinator, and the network of community facilitators to make sure that the communities in the Sound are award of the mapping project and given the opportunity to participate.

PROJECT DESIGN

A. Objectives

The objective of the mapping project is to:

Update both the seasonal and detailed sensitivity map series for Prince William Sound, integrating the results of recent studies on the biological and human-use resources in the area since the *Exxon Valdez* oil spill.

B. Methods

NOAA has taken the lead in the U.S. in developing standards for sensitivity mapping for oil spill planning and response. Detailed guidelines for developing sensitivity maps have recently been revised and described in an October 1997 manual, *Environmental Sensitivity Index Guidelines, Version 2.0*, published as NOAA Tech. Memo. NOS ORCA 115, by the Hazardous Materials Response and Assessment Division. The Prince William Sound seasonal sensitivity map series will be produced in accordance with these guidelines, following the map content and format as used in the recent projects in Cook Inlet/Kenai Peninsula and Kodiak Island/Shelikof Strait. Detailed digital sensitivity maps have never been made for Alaska, but are currently being planned for the North Slope. Several examples of the detailed maps are available from California, Delaware, New Jersey, and Pennsylvania.

The methods for collecting data and determining which resources are to be included on the maps are well defined, since NOAA has produced similar map products recently. We have good working relationships with all of the key data providers and technical experts who will be reviewing the draft maps. We have established protocols for obtaining the necessary data from each source and for the review process.

There are several key data sources. Alyeska Pipeline Service Company (Alyeska) has developed a computer database for Prince William Sound and adjoining areas on the south-central coast of Alaska. The software, called the Graphical Resource Database (GRD), holds the sensitive area data of the Prince William Sound Tanker Oil Discharge Prevention and Contingency Plan. The geographic coverage of the GRD spans an approximately 500-mile-long region that includes the Copper River Delta, Prince William Sound, the lower Kenai Peninsula, lower Cook Inlet, the Kodiak Archipelago, and Shelikof Strait. The GRD consists of 105 layers of digital data records of biological resources (such as seabird colony sites and sea otter concentration areas), socioeconomic resources (such as commercial fishing areas and small boat harbors), and shoreline types. The expansion and update effort were coordinated by a committee of federal and state natural-resource trustee agencies (including the Alaska Department of Environmental Conservation, Alaska Department of Fish and Game, U.S. Fish and Wildlife Service, and NOAA), citizens oversight groups, Alyeska, and oil shipping companies. The project is currently undergoing maintenance as data updates are intermittently provided by trustee agencies.

The GRD will be a primary source of digital data for the maps in Prince William Sound. However, primary data providers will be contacted, particularly for those databases that are regularly updated by management agencies. Examples include the USFWS digital database and colony status record files for seabird colonies and eagle nest sites, and the ADF&G catalog of waters important to anadromous fish.

Description of Sensitive Resources to be Shown on the Seasonal Maps

ESI atlases are comprised of three general types of information:

1) Shoreline Habitat Classification – Shoreline habitats are ranked according to a scale relating to biological sensitivity, natural persistence of oil, and ease of cleanup.

2) Biological Resources – Includes oil-sensitive animals and non-shoreline habitats such as submerged aquatic vegetation.

3) Human-Use Resources – Specific areas that have added sensitivity and value because of their use by humans, such as high-use amenity beaches, parks, marine sanctuaries, water intakes, and archaeological sites.

The seasonal maps show a sub-set of the most sensitive shorelines; however, the detailed maps will show the sensitivity of every foot of shoreline (all 10 ESI types). . Thus, only the most sensitive shoreline types will be shown on the summary maps, namely:

ESI 7	Exposed tidal flats
ESI 9	Sheltered tidal flats
ESI 10	Marshes

Since so much of the shoreline in Prince William Sound consists of ESI 8, sheltered rocky shores, this shoreline type will not be mapped (it was not mapped in the original series). The shoreline types will be obtained from the GRD database, which was originally digitized from the 1983 ESI maps. During the review process, any significant changes in these shoreline types will be addressed.

NOAA has developed a standard biological scheme which identifies seven major biological elements, based on major taxonomic and functional groupings. Each element is divided into groups of species, or sub-elements, with similar taxonomy, morphology, life-history, and/or behavior relative to oil spill vulnerability and sensitivity. Table 1 lists the biological resources to be included on the seasonal sensitivity maps for Prince William Sound. Table 2 lists the human-use resources to be included on the maps. This list will be finalized based on meetings with community representatives, natural resource trustees, and response organizations.

TABLE 1.Biological resources to be included on the seasonal sensitivity map series for Prince William Sound.

Data element	Sub-element	Areas/Sites to be mapped
Marine Mammal	Pinniped (harbor seal and northern sea lion)	Haulouts, concentration areas
	Sea otter	Concentration areas
	Whale	Migratory or other concentration areas
Terrestrial Mammal	Deer	Intertidal concentration areas
	Small mammal (river otter)	Aquatic fur-bearer concentrations
Bird	Seabirds (see list in text)	Nesting colonies; concentration areas
	Raptor (bald eagle)	Nesting sites; concentration areas
	Shorebird	Migratory concentration areas
	Waterfowl	Wintering and migratory concentrations
	Passerine	Threatened/endangered or rare occurrences
Fish	Anadromous fish	Spawning streams
	Pacific herring	Spawning areas
Shellfish	Bivalve	Harvest areas; abundant beds
Habitat/Rare Plant	Rare plant	Threatened/endangered or rare species or communities
	SAV	Submerged aquatic vegetation

TABLE 2.Human-use resources to be included on the seasonal sensitivity map series for Prince William Sound.

Data element	Sub-element	Comments
Recreation/Access	Marina	Site
	Landing strip	Site
Management Area	National Park	Boundary
	State Park	Site
	National Forest	Boundary
	National Wildlife Refuge	Boundary
	State Critical Habitat Area	Boundary
Resource Extraction	Aquaculture site	Hatcheries
	Commercial fishery	Set-net sites
	Subsistence fishing	Designated key harvest sites
Cultural Resources	Archaeological site	Water-, coastal-, wetland-associated
	Historical site	Water-, coastal-, wetland-associated
Other Features	Oil facilities	
	Port facilities	
	Communities	
	Political boundaries	Boroughs
	Roads	
	Dispersant pre-approval zones	
	Annotation	

Biology and Human-Use Compilation and Digitization

The collection of biological and human-use data requires a close working relationship with federal, state, and local resource and information-system experts, beginning at the start of the project and continuing until all data are reviewed. The general sequence of data compilation entails:

- Making contacts with scientists and resource managers who can provide expert knowledge and suggest relevant source materials;
- Gathering as much digital information as possible before meeting with experts;
- Reviewing existing hardcopy data sources;
- Meeting with individuals or groups of experts to delineate the locations of resources for which hardcopy or digital data are not available;
- Drawing resource distributions for non-digital data onto compilation maps based on hardcopy data and expert opinion; and
- Recording non-spatial or attribute data, and associating it with the resource locations delineated on the maps.

Based on the most recent mapping projects, NOAA has developed a template for the types of data to be included, the cartographic styles, the text, and the legend, which can be efficiently modified for each area. The seasonal map for Prince William Sound will be designed from this template with the necessary changes to reflect the special requirements of the area.

Four sets of the draft maps will be printed for review by all appropriate agencies and communities. The review maps will include all data, symbology, legends, notations, etc., to be shown on the final maps. NOAA will coordinate the review of the maps.

When the review information comes back, all edits will be entered and a check of all final data will be made. The data are then converted to the NOAA data structure with unique identification numbers, lookup tables, and data tables, and the final data sets and accompanying digital and hardcopy documents are prepared.

The production of the negative film separations is a completely digital process. The negative film separations will be quality-checked by generating a Chromalin color proof consisting of four photosensitized overlays, each in a different process color (CMYK), precisely registered and laminated to a white backing material. When the color proof meets quality standards, the films will be used to generate the printing plates which transfer the ink to the paper on the printing press, producing the best quality printing at the least cost for larger quantities of maps.

Three types of maps will be printed:

1) Full-color posters (35 x 40 inches) printed at 1:250,000 on heavy paper; 1500 copies
2) Full-color maps at the same size but printed on water- and tear-resistant paper and folded, so they will be easy to carry and use in the field. 200 copies
3) 11 x 17 bound atlas of 42 detailed maps at 1:63,360; maps will be color copied from

an initial color print and plastic laminated; 100 copies

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Cooperating agencies who will provide information and review data include:

U.S. Forest Service, Chugach National Forest: Contacts and cooperation have been established with Karen Murphy, biologist with the Chugach National Forest, who is the principal investigator on the PWS Human Use and Wildlife Disturbance Model. Our project will be establishing locations and concentrations of wildlife against which the human-use data for PWS will be compared. These two projects are particularly amenable since both data sets will be generated in ArcInfo GIS format. In addition, we hope to be able to use Karen as a local knowledge source for PWS since she is already quite familiar with many of the biological projects that have been and are being conducted under the EVOS Trustee umbrella.

Alaska Department of Fish & Game

Alaska Department of Natural Resources

U.S. Fish & Wildlife Service

National Marine Fisheries Service

Prince William Sound Science Center

Alyeska Pipeline Service Company (Alyeska)

Communities of Chenega Bay and Tatitlek

Prince William Sound Regional Citizens Advisory Council (will serve as the coordinator of local input)

Also, funds and in-kind contributions have been obtained and/or are being sought from a wide range of partners involved in oil spill planning and response.

Alyeska will provide their natural-resource databases.

Alaska Department of Conservation has agreed to provide adequate funding so that the state resource agencies can budget adequate time to provide data and to review the draft ESI maps.

The U.S. Coast Guard has agreed to submit $10K in their FY99 budget for this mapping effort. We will know sometime this summer if the funding is approved.

The PWS Regional Citizens Advisory Council hopes to be able to identify $40K in their FY99 budget and earmark it for this project.

The Oil Spill Recovery Institute in Cordova hopes to put up $50K , to be matched by the EVOS Trustee Council , to carry out this mapping project.

Summary of Proposed Project Funding Arrangement (hopefully all these pieces can be confirmed by sometime this summer)

Coast Guard, PWS RCAC, Industry	$50
OSRI	$50
EVOS Trustee Council (matching)	$50
EVOS (Karen Murphy local liaison)	$5.2

. SCHEDULE

A. Measurable Project Tasks for FY 99 (October 1, 1998 - September 30, 1999)

The project schedule is outlined below.

October 1:	Begin data collection and evaluation
December 1:	Finalize the list of resources to be mapped
March 1:	Send out draft maps for review
April 15:	Review maps returned for final editing
June 15:	Digital data complete
July 15:	Color separates completed and approved for summary ESI maps; printing of maps advertised for bids
August 15	Copies of detailed maps completed and plastic laminated;
September 30:	Printed maps, bound atlases, and digital data delivered

B. Project Milestones and Endpoints

The milestones and endpoints for this project are straightforward: Printed maps and a digital database, completed within one year. The schedule is shown above.

C. Completion Date

The maps and digital databases will be completed during FY99.

PUBLICATIONS AND REPORTS

There are no planned publications or reports, other than the maps themselves, the digital data, and the metadata.

PROFESSIONAL CONFERENCES

None anticipated.

NORMAL AGENCY MANAGEMENT

Although NOAA HAZMAT is in the normal business of making ESI maps throughout the United States, updating the PWS ESI map series would not normally receive attention until much later. The last editions was developed in 1988 and 1983 and, as a result, retains passable accuracy for use in oil spill response. Since 1989, Alyeska has developed a Graphical Resource Database (GRD) of the biological and human-use resources of PWS that was last updated in 1995. This digital-only product has been made available to all the resource agencies in a read-only version (the files are in a rather proprietary, arcane format that makes that virtually inaccessible). Currently there is a national drive to update and convert ESI maps to a digital format, and NOAA HAZMAT is heavily involved in this effort. Considering the vast amount of sensitive U.S. coastline and the present status of the PWS resource data, NOAA would not be undertaking this ESI map update of PWS as part of its normal activities in the near future. Yet we recognize the vast amount of new data that has been generated with the EVOS Restoration Project. This ESI mapping project will allow us the unique opportunity to collate, digitize, and display all this data in poster form, atlas format, and in a digital data format that is consistent and uniform, thus making the information much more accessible to a much larger audience.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

There will be a high degree of coordination among Trustee and management agencies in all phases of data gathering and map review. Interaction would be initiated with principal investigators of the SEA, APEX, and NVP ecosystem projects to ascertain new information that has been developed on locations and areas of concentrations of biological species that populate the Sound. Contact with other principal investigators and review of their work would also be conducted to obtain information pertinent to this summary environmental sensitivity mapping effort.

In particular, contacts and cooperation have been established with Karen Murphy, biologist with the Chugach National Forest, who is the principal investigator on the PWS Human Use and Wildlife Disturbance Model. Our project will be establishing locations and concentrations of wildlife against which the human-use data for PWS will be compared. Similarly, her modeling project may be able to supply some data layers to assist in our mapping effort. These two projects are particularly amenable, since both data sets will be generated in ArcInfo GIS format. In addition, we hope to be able to use Karen as a local knowledge source and liaison for PWS since she is already quite familiar with many of the biological projects that have been and are being conducted under the EVOS Trustee umbrella.

PROPOSED PRINCIPAL INVESTIGATOR

John Whitney, NOAA HAZMAT, Anchorage, Alaska

PRINCIPAL INVESTIGATOR QUALIFICATIONS

Mr. Whitney is the NOAA Scientific Support Coordinator for Alaska. He has managed the last three seasonal sensitivity mapping projects conducted by NOAA and the U.S. Coast Guard, namely Cook Inlet/Kenai Peninsula, Kodiak Island/Shelikof Strait, and the Pribilof Islands.

OTHER KEY PERSONNEL

Robert Pavia, Chief, HAZMAT Scientific Support Coordination Branch

dJill Petersen, HAZMAT Geographic Information System Specialist

1998 EXXON VALDEZ TRUST COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Budget Category:	Authorized	Proposed	PROPOSED FY 1999 TRUSTEE AGENCIES TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
	FY 1998	FY 1999				$5,175.0		$152,992.5
Personnel	$0.0	$4,500.0						
Travel	$0.0	$7,148.0						
Contractual	$0.0	$141,600.0						
Commodities	$0.0	$1,400.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$154,648.0		Estimated 2000	Estimated 2001			
General Administration	$0.0	$3,519.5						
Project Total	$0.0	$158,167.5		$0.0	$0.0			
Full-time Equivalents (FTE)	0.0	0.1						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$0.0	$0.0		$0.0	$0.0	$0.0	$0.0	

Comments:

1999

Prepared:

Project Number: 99369
Project Title: Summary and Detailed Environmental Sensitive Maps
Lead Agency: NOAA

FORM 2A
MULTI-TRUSTEE
AGENCY
SUMMARY

4/6/98

1998 EXXON VALDEZ TRUST COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1998	Proposed FY 1999						
Personnel		$0.0						
Travel		$7,148.0						
Contractual		$141,600.0						
Commodities		$1,400.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$150,148.0		Estimated FY 2000	Estimated FY 2001			
General Administration		$2,844.5						
Project Total	$0.0	$152,992.5						
Full-time Equivalents (FTE)		0.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

1999

Project Number: 99xxx
Project Title: Summary and Detailed Environmental Sensitive Maps
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: 4/6/98

1998 EXXON VALDEZ TRUST[illegible]OUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
						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	FY 1999
Seattle-Anchorahe-Valdez-Seattle	927.0	4	16	215.0	7,148.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$7,148.0

1999

Project Number: 99xxx
Project Title: Summary and Detailed Environmental Sensitive Maps
Agency: NOAA

FORM 3B
Personnel
& Travel
DETAIL

Prepared: 4/6/98

1998 EXXON VALDEZ TRUST[illegible]OUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Contractual Costs:	Proposed
Description	FY 1999
printing of maps	139,000.0
duplication and mailing costs	2,600.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$141,600.0

Commodities Costs:	Proposed
Description	FY 1999
printer/plotter paper	600.0
printer/plotter suplies	350.0
base maps	450.0
Commodities Total	$1,400.0

1999

Project Number: 99xxx
Project Title: Summary and Detailed Environmental Sensitive Maps
Agency: NOAA

FORM 3B
Contractual & Commodities DETAIL

Prepared: 4 of 10

4/6/98

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
			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

1999

Project Number: 99xxx
Project Title: Summary and Detailed Environmental Sensitive Maps
Agency: NOAA

FORM 3B
Equipment
DETAIL

Prepared: 4/6/98

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$4,500.0
Travel		$0.0
Contractual		$0.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$4,500.0
General Administration		$675.0
Project Total	$0.0	$5,175.0
Full-time Equivalents (FTE)		0.1
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001			

Dollar amounts are shown in thousands of dollars.

Comments:

1999

Project Number: 99xxx
Project Title: Summary and Detailed Environmental Sensitive Maps
Agency: USFS

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: 4/6/98

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
K. Murphy	wildlife biologist	GS 9/6	1.0	4500.0		4,500.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.0	4500.0	0.0	
					Personnel Total	$4,500.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
					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

1999

Project Number: 99xxx
Project Title: Summary and Detailed Environmental Sensitive Maps
Agency: USFS

FORM 3B
Personnel
& Travel
DETAIL

Prepared: 4/6/98

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

Contractual Costs:	Proposed FY 1999
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

1999

Project Number: 99xxx
Project Title: Summary and Detailed Environmental Sensitive Maps
Agency: USFS

FORM 3B
Contractual & Commodities DETAIL

Prepared: 8 of 10

4/6/98

1998 EXXON VALDEZ TRUST COUNCIL PROJECT BUDGET
October 1, 1997 - September 30, 1998

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
			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

1999

Project Number: 99xxx
Project Title: Summary and Detailed Environmental Sensitive Maps
Agency: USFS

FORM 3B
Equipment
DETAIL

Prepared: 4/6/98

Effects of Harbor Seal Metabolism on Stable Isotope Ratio Tracers

Project Number:	99~~xxx~~ 371
Restoration Category:	Research
Proposer:	University of Alaska Fairbanks
Lead Trustee Agency:	ADFG
Cooperating Agencies:	none
Alaska SeaLife Center:	yes
Duration:	1st year, 3-year project
Cost FY 99:	$99,000
Cost FY 00:	$95,000
Cost FY 01:	$95,000
Geographic Area:	Prince William Sound/Gulf of Alaska
Injured Resource/Service:	Harbor seal

ABSTRACT

A major concern with the use of stable isotope tracers in ecosystem studies is the fidelity with which ratios are transferred up food chains. Use of specific habitats or prey cannot be assessed if geographic gradients in isotope ratios are laid on top of trophic effects and/or prey switching. To remove these problems we will seek specific conservative biomarkers such as essential amino acids or fatty acids that carry isotope ratios unmodified by metabolism. Amino acids labeled with ^{15}N and ^{13}C will be used to follow transamination and carbon relocation during metabolic processes in the seals at the Alaska SeaLife Center. Specific fatty acid isolation and determination of suitability as habitat biomarkers will follow in years 2 and 3 of the project.

INTRODUCTION

Stable isotope ratios have become an essential tool in the study of living organisms and their physiology. The hazards of handling radioisotopes and severe protocol requirements when using live organisms have resulted in a steadily increasing shift to the use of stable isotopes as tracers for both human and animal subjects. Some uses, such as the detection of *Helicobacter pylori* infections in ulcer patients, are now routine and bringing stable isotope analysis to many hospitals as a standard method. In contrast with the employment of natural abundance techniques in the marine environment, most physiology experiments employ compounds enriched with ^{13}C or ^{15}N to enhance detectability and to follow the transfers to different metabolites within the organism. Improved lower limits of detectability and smaller sample size requirements now allow the use of stable isotopes where only radioisotopes would have worked in the past.

This proposal describes experiments to be undertaken at the Alaska SeaLife Center (ASLC) and at the University of Alaska Fairbanks (UAF) to provide calibration and more detailed information on stable isotope transfers and fractionation in marine mammals (and perhaps sea birds in the future). This will enable better interpretation of natural abundance isotope data acquired in Prince William Sound and the adjacent Gulf of Alaska. Coordination with the work of Michael Castellini, who is conducting feeding experiments and dietary studies at ASLC, will lead to a thorough integration of efforts and optimization of the use of animal subjects in all years of the study. Year 1 will consist of the refinement of analytical techniques isolating amino acids and testing for the presence of essential amino acids in harbor seals at ASLC. Succeeding years will focus on the search for biomarkers useful in identification of specific habitat usage and as indicators of the assimilation of various species of forage fishes.

Over the past two decades, isotope ratio analysis has emerged as a powerful tool in ecosystem research, both on the process scale and as a validation technique for large-scale ecosystem models (Michener and Schell, 1994). In relevant applications to this study, Saupe et al. (1989) and Schell et al. (1989) described a geographic gradient in isotope ratios in biota across the Alaskan Beaufort Sea and the Bering–Chukchi seas and showed that this gradient could be applied to describing bowhead whale natural history. The isotopic gradient arises from the primary producers in the ecosystem and is passed up food chains to label consumers up to the top predators. Within each biome, there is reasonable fidelity to the ^{13}C observed in the primary producers and a predictable increase in the ^{15}N with each known increase in trophic level. However, among individuals of each taxon analyzed there are often large ranges in values, especially in the carbon isotope ratios.

A fundamental assumption in the employment of isotope ratios as natural tracers is that the amount of isotopic fractionation in the process of metabolizing food is known during the incorporation of assimilated components into the consumer. For marine mammals, these data are scarce and most of the ongoing work is based on the findings derived from terrestrial bird and mammal studies. The accurate interpretation of isotope ratio data on food webs and marine mammals depends completely on knowledge of fractionation effects arising from dietary sufficiency and composition. To date, we do not have this knowledge because it has become evident that there exist marked geographic gradients in isotope ratios in Prince William Sound and the Gulf of Alaska. This project is thus aimed at the goal of identifying specific biomarker molecules and acquiring accurate isotope fractionation data on harbor seals through controlled feeding and laboratory experiments. This project will be thoroughly integrated with ongoing

research on harbor seals at the ASLC and will be complementary to the physiological research projects in progress.

NEED FOR THE PROJECT

A. Statement of Problem

Harbor seals were undergoing an unexplained decline in numbers before the oil spill and the decline was further accelerated by the disaster. Since that time the population has not recovered and is still at a low level, although now perhaps finally stabilized. No definitive cause and effect relationships have been found for the decline or failure to recover. It is becoming increasingly evident, however, that change in the marine environment in the past two decades has altered the carrying capacity downward in the northern Gulf of Alaska and that the effects are being felt to the top of the food chain. Carbon isotope ratios in biota of the northern Pacific Ocean appear to have been declining for nearly twenty years (Schell, in preparation) and imply that a major decrease in productivity has occurred. Isotope ratios from wild seals also show changes over time in the isotope ratios but the interpretation requires knowledge of both the fractionation that occurs during assimilation and the natural variations arising from migrational movements. If one or more essential amino acids can be identified in the diet of seals, these would allow a conservative tracer independent of isotope fractionation effects. There are almost no data regarding marine mammals on this subject and none on harbor seals. This study will undertake to follow both the "whole animal" carbon and nitrogen isotopic fractionation and the determination of specific biomarkers arising from diet that would allow clearer insight into dietary dependencies.

B. Rationale/Link to Restoration

Carbon isotope ratios serve as conservative tracers of energy supply between trophic levels (phytoplankton to zooplankton to fishes to top consumers). Seals, cetaceans, birds, etc. acquire the isotope ratios in proportion to the amount of food derived from each differing source. This, in turn, is reflected in the composition of body tissues and in keratinous tissues (claws, feathers, baleen, whiskers) as a temporal record when multiple sources of food are consumed over time and space. This allows the discerning of important habitats and food resources in animals such as harbor seals that seasonally migrate or undergo periods of hyper- and hypotrophy. Little is known, however, of the internal fractionation of isotopes that occurs in mammals during fasting and/or extended periods of suboptimal diets. The planned experiments on the effects of differing diets on captive harbor seals to be conducted at the ASLC will provide an ideal opportunity to enhance the physiological data gained by investigating the efficiency of amino acid transfers in diets and the presence of essential amino acids in pinnipeds.

Nitrogen isotope ratios reflect both the food sources and the trophic status of that animal. As nitrogen in food is consumed and assimilated by a consumer, the heavy isotope is enriched by approximately 3‰, with accompanying loss of the lighter isotope through excretion. The enrichment occurs with each trophic step and thus allows the construction of conceptual models and food webs and the assignment of relative trophic status to species for which dietary data are sparse. Hobson and Welch (1992) used isotope ratios to describe the trophic relationships of birds and mammals to the available prey species in the Canadian Arctic. Further extension to the

benthos by Dunton et al. (1991) and to fishes (Vinette, 1992) has confirmed that the isotopic trends are evident across the entire food web. As fasting or starvation occurs, nitrogen isotopes may be fractionated during transamination reactions, leading to overall shifts in the average isotope ratios of the whole animal. Best and Schell (1996) observed, for example, that ^{15}N enrichment in southern right whales was evident during the winter breeding season in South African waters, though carbon isotope ratios revealed that very little feeding occurred. Detailed interpretation of data from samples taken from wild seals requires that these effects be known.

C. Location

The research effort will be conducted at the Alaska SeaLife Center and the University of Alaska Fairbanks. The instrumental analyses such as HPLC and gas chromatography–mass spectrometry will initially be undertaken at UAF on samples collected during the dietary studies and sampling at ASLC by Dr. Castellini's group. In years 2 and 3 more of the effort will be shifted to ASLC as detailed dietary experiments are conducted.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Much of the research will be conducted at the Alaska SeaLife Center. The Principal Investigator anticipates both community interaction and explanation of the research approach and usefulness at the site.

PROJECT DESIGN

A. Objectives

The null hypotheses to be tested in 1998–1999 and succeeding years are as follows:

1. The isotope ratios of harbor seals accurately reflect diet under all conditions. Increased fractionation does not occur during periods of fasting or suboptimal feeding and does not affect either carbon or nitrogen isotope ratios in harbor seals.

2. There are no essential amino acids in harbor seals and their prey that can act as conservative markers of specific habitats of food sources or of specific prey species.

The objectives of this study are divided into three elements:

1. Year 1 will consist of developing methods and protocols for the isolation of metabolites from harbor seal blood and tissue samples to be employed during the following controlled diet studies. The Institute of Marine Science has purchased a new GC-IRMS (gas chromatograph–isotope ratio mass spectrometer) that will be used to determine isotope ratios in the individual amino acids isolated from serum samples. These amino acids will be separated by high performance liquid chromatography using semi-preparative columns and inorganic buffers. Testing for essential amino acids in harbor seals will be initiated using blood samples acquired from seals being used by Michael Castellini for food assimilation efficiency studies. By feeding ^{15}N and ^{13}C-labeled glycine to the seals prior to blood sample collection, it will be

evident if the label has been transaminated to all amino acids and to what extent. If some amino acids remain unlabeled, the corresponding labeled amino acid will be administered to see if transamination occurs in the reverse direction.

2. The second component will be a study of the effects of suboptimal versus optimal diet on the fractionation of carbon and nitrogen isotopes in harbor seals. Diets of known amount and composition (isotopic and energetic) will be fed to the seals at ASLC and blood protein amino acids will be monitored for composition and isotope ratios. This research will be closely coordinated with studies of controlled diet/assimilation efficiencies in harbor seals by Castellini so that minimal animal handling and sampling will be necessary.

3. The third component will be to determine source prey for isotopically distinct fatty acids or other metabolites. The identification of specific fatty acids that carry a conservative signal to top consumers (birds, cetaceans, fissipeds) would yield an extraordinarily valuable tool to follow food web transfers or to identify specific habitat importance. This will be accomplished by the analysis of lipids in prey species from locations around the study areas and from seals. Many of the prey species samples are already archived and analysis can begin very soon.

B. Methods

Isotopic Analysis of Blood Protein Amino Acids

The proteins in blood serum samples from captive harbor seals and muscle protein from Native-harvested seals will be separated from inorganic components via ion retardation columns, and the isolated protein hydrolyzed to free amino acids. Multiple procedures to optimize amino acid preservation will be employed, such as acid and basic hydrolysis and through the use of proteolytic enzymes. Once isolated, the free amino acids will be separated by HPLC (high performance liquid chromatography) and the aliquots with individual amino acids will be taken to dryness. These samples will then be run on an elemental analyzer coupled to the isotope ratio mass spectrometer. The nitrogen and carbon dioxide liberated in the elemental analyzer will be separated by gas chromatography and run individually in the IRMS. By either orally or intravenously dosing a seal with ^{13}C or ^{15}N-labeled glycine, the appearance of the label will be noted over time in the amino acid spectrum. Those amino acids remaining free of the label will be identified as probable essential amino acids derived solely from diet. Mobilization and isotopic fractionation of these amino acids will be tested further in reverse dietary studies wherein the labeled amino acid will be infused and the rate of transamination followed in feeding and fasting seals.

Isotope Fractionation During Fasting and Suboptimal Diets

Many marine mammals undergo periods of fasting or suboptimal diets such as during molt or reproduction. Nothing is known regarding the effects of these periods on the fractionation of either carbon or nitrogen isotopes in harbor seal tissues. The amino acid threonine, for example, has been shown to become very isotopically depleted in ^{15}N during starvation, with lesser effects on glycine and serine (Hare et al., 1991). In coordination with studies of dietary effects on blood hormones or other work requiring harbor seal blood samples at ASLC, we will analyze aliquots as described above for shifts in the isotope ratios. Mobilization of amino acids during fasting can be tested via isotope dilution of labeled amino acids given intravenously at the start of the fast. These experiments will be conducted in the second year of the experiment and will be carefully

planned to minimize animal handling and for maximum synergy with other researchers. Although we plan to coordinate our sampling with that of Dr. Castellini, all procedures will be approved by the ASLC scientific committee and conducted as required by the IACUC (Institutional Animal Care and Use Committee) of the University of Alaska Fairbanks and ASLC.

Sources of Essential Amino Acids in the Diets of Harbor Seals
The identification of specific metabolites, specifically fatty acids and amino acids, in the tissues of harbor seals (Iverson et al., in press) will be followed by a survey of potential prey species to identify probable sources. Fatty acids will be isolated using the procedures of Iverson et al. (1993) and run from the gas chromatograph directly into the microcombustion unit of the preparatory system and then into the mass spectrometer. This will yield both a fatty acid spectrum and the isotope ratios for each component. The combination of chemical markers may provide a powerful tool for the identification of specific prey or habitat usage. The APEX program currently supported by EVOS will be a source of samples, as will other opportunistic cruises in the spill and control areas. Herring, sand lance, pollock and capelin will be special targets, given their importance in the food chains of Prince William Sound.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Michael Castellini is concurrently submitting a renewal proposal (99341) for related work on blood hormones and food assimilation efficiency studies at the Alaska SeaLife Center. This project will be completely coordinated with his work to optimize sampling and mutual assistance.

SCHEDULE

A. Measurable Project Tasks for FY 99 (October 1, 1998 – September 30, 1999)

October–February:	Analysis of standard amino acid samples from seal tissues Protocol development for fatty acid analysis
March–July:	Establish methodology and protocols for the isolation and identification of amino acids from harbor seal blood proteins
March–April:	Begin isotopically labeled feeding experiments
April–December:	Analytical work, continue feeding experiments

B. Project Milestones and Endpoints

The following are additional specific goals beyond FY 99:

FY 00–01

November–August:	Isolate amino acids from prey species and establish isotope ratios in any essential amino acids identified; prepare annual report on FY 99 (and prior) work
August–December:	Conduct feeding experiments, prepare draft manuscripts

FY 01

October–May:	Complete experiments; synthesize data and identify gaps; prepare manuscripts and submit draft final report.
June–October:	Complete manuscripts and final report

C. Completion Date

This project will be completed by September 2001. Manuscript preparation and submissions may continue past the nominal completion date.

PUBLICATIONS AND REPORTS

Results of this project will be made available via the following:

Annual Reports: These reports will detail progress and preliminary findings and notable achievements. These are anticipated for the ends of FY 99 and FY 00.

Final Report: A final report will be provided. Technical results in this report will be shared with EVOS collaborators and assistance provided as opportune during the experiments. Preliminary exchange of findings will be conducted with EVOS investigators and the scientific community via professional meetings and informal communications.

Peer-reviewed publications: Over the course of this study peer-reviewed publications will be generated for the open literature based on the scientific findings. These publications will be generated by the PI and graduate students as first author publications when the primary focus is on the findings produced by the isotopic techniques or as second author publications when the isotope work is a minor part of other scientific results resulting from feeding experiments conducted by colleagues.

Papers at scientific society meetings: We request support for travel to appropriate scientific meetings for dissemination of results and interaction with colleagues. It is anticipated that the PI and a graduate student will attend the Society for Marine Mammalogy and/or the American Society for Limnology and Oceanography meetings.

Public lectures: Interaction with the public will arise through formal and informal presentation of results as part of ongoing public participation in the work at ASLC. Synthesis meetings designed to explain the findings will be presented at meetings coordinated by ASLC or EVOS and open to the public. Informal presentation of results will occur through interaction with interested members of the public, press and scientific community. Classroom instruction will also involve integration of findings into the presentation of educational material.

PROFESSIONAL CONFERENCES

The results of this project will be communicated at appropriate meetings. The biennial meeting of the Society for Marine Mammalogy or the American Society for Limnology and

Oceanography is a typical forum for this type of presentation, as are specific workshops and meetings emphasizing application of isotope techniques to biological problems.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Resources and Services—This study focuses on harbor seals in Prince William Sound and requires the facilities for animal holding at the Alaska SeaLife Center. Insofar as the PI is requesting no seal handling or holding support in this project it is essential that it be closely coordinated with ongoing projects that can provide subsamples of blood or biopsies for analysis. To this end, the PI has made the project outline and goals available to Dr. Castellini and presumes a very close interaction with his program. It is expected that the Ph.D. student supported by this project will be integrated with Dr. Castellini's project and will share time and assistance with his project team. We seek to provide a set of useful biomarker tools that will aid future field efforts in Prince William Sound and can be expanded to other injured species. Although the major effort is concerned with harbor seals, other marine mammal tissues will be analyzed if available to provide context and comparable data. Sea lions held at ASLC will also be sampled if conditions allow and if funds are derived from other sources. To simplify animal use and care permitting, we will coordinate all projects' permitting closely under the direction of Dr. Castellini, based on mutual interests and animal handling requirements.

PROPOSED PRINCIPAL INVESTIGATOR

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PRINCIPAL INVESTIGATOR

Donald M. Schell has been involved in stable isotope studies for over 25 years. His research has included natural abundance tracer studies and enrichment experiments. His work on bowhead whales and geographic gradients in stable isotope ratios has been published and subjected to rigorous reviews. The findings have been upheld and have provided insight into bowhead whale natural history unattainable by other techniques.

Dr. Schell oversees the Stable Isotope Ratio Mass Spectrometry Facility on the UAF campus. This consists of three working instruments that are dedicated to specific elements, as demand requires. A Europa automated continuous flow system will be used for most samples but backup analytical capability is available. A new machine with the ability to determine isotope ratios on individual fatty acids and on derivatized amino acids has recently been installed. This machine will expand the sample analysis capability and provide increased sensitivity for small samples.

As Principal Investigator, Schell will oversee the Quality Assurance/Quality Control aspects of this project. Protocols for sampling have been established and working standards are cross-calibrated with other nationally recognized laboratories.

OTHER KEY PERSONNEL

Machine operations are the responsibility of Norma Haubenstock and Bruce Barnett, technicians. They are well trained and have more than nine years' experience with mass spectrometers. Additional funds are budgeted for an assistant to prepare samples, load and operate the automated system and to aid in data processing and archiving for all users. A Ph.D. student will also be included in the project.

LITERATURE CITED

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1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$59.9
Travel		$6.5
Contractual		$10.4
Commodities		$2.4
Equipment		
Subtotal		$79.2
Indirect		$19.8
Project Total		$99.0
Full-time Equivalents (FTE)		1.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$95.0	$95.0			

Dollar amounts are shown in thousands of dollars.

Comments:

The indirect rate is 25% TDC, as negotiated by the *Exxon Valdez* Oil Spill Trustee Council with the University of Alaska.

Personnel costs for Ph.D. student include two semesters of resident tuition ($2,916).

FY 99

Project Number: 99[redacted]371

Project Title: Effects of Harbor Seal Metabolism on Stable Isotope Radio Tracers

Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

Prepared: 4/9/98

1999 EXXON VALDEZ TRUS[illegible]E COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 1999
Schell, D.	Principal Investigator/Professor		2.0	12.4		24.8
Haubenstock, N.	Technician		3.0	5.2		15.6
Barnett, B.	Research Associate		0.5	4.5		2.3
TBN	Ph.D. Student		12.0	1.4		16.8
	Adjustment to recognize rounding					0.4
	Subtotal		17.5	23.5	0.0	
					Personnel Total	$59.9

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 1999
Fairbanks to Anchorage – EVOS meeting		0.3	1	5	0.1	0.8
Fairbanks to Seward – research at Alaska SeaLife Center		0.4	2	20	0.1	2.8
Fairbanks to Lower 48 – presenters at ASLO meeting or Society for Marine Mammalogy meeting		0.7	2	8	0.1	2.2
	Adjustment to recognize rounding					0.7
					Travel Total	$6.5

FY 99

Project Number: 99xxx
Project Title: Effects of Harbor Seal Metabolism on Stable Isotope Radio Tracers
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 4/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
Mass spectrometry (535 samples @ $18/sample)	9.6
Publication, page charges	0.6
Communications, photocopying	0.2
Contractual Total	$10.4

Commodities Costs:	Proposed FY 1999
Description	
HPLC supplies, chemicals, expendables	2.2
Computer supplies	0.2
Commodities Total	$2.4

FY 99

Project Number: 99xxx
Project Title: Effects of Harbor Seal Metabolism on Stable Isotope Radio Tracers
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities
DETAIL

Prepared: 4/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 1999
Those purchases associated with replacement equipment should be indicated by placement with an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number	
Description	of Units	

FY 99

Project Number: 99xxx
Project Title: Effects of Harbor Seal Metabolism on Stable Isotope Radio Tracers
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

Prepared: 4/9/98

Effect of Herring Egg Distribution and Ecology on Year-Class Strength and Adult Distribution

Project Number:	99375
Restoration Category:	Research
Proposer:	University of Alaska Fairbanks
Lead Trustee Agency:	ADFG
Cooperating Agencies:	none
Alaska SeaLife Center:	no
Duration:	1st year, 2-year project
Cost FY 99:	$84,400
Cost FY 00:	$45,000
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pacific herring

ABSTRACT

The objective of this project is to examine the effect of Pacific herring egg distribution and abundance as well as oceanographic processes on year-class strength and adult distribution. Existing data is used in the analysis. The findings of this study will aid in understanding stock structure and population dynamics of herring in Prince William Sound. This information will facilitate area-specific targeting of catches and provide maximum conservation of the overall population. The methodology is applicable to other species and areas. This project will provide scientific documentation of unpublished fishery data. The companion proposal to this is entitled "Distribution and Ecology of Forage Fish and Effects on Herring Year-Class Strength."

INTRODUCTION

The overall objective of this project is to refine our understanding of Pacific herring (*Clupea pallasi*) population structure and trends in Prince William Sound (PWS) by examining current and historic data on fish distribution within an ecological context. The components of this project include:

1. Defining temporal trends of early life history (eggs) distribution.

2. Describing the relationship between that distribution and the oceanography of PWS.

3. Analyzing the impact of that distribution on population structure and abundance 3–4 years later.

If this approach produces significant results, it can be continued in FY00 to include biological indices such as size-at-age, and for recent years, energetic content, isotopic values, fatty acid signatures, growth rates, feeding rates, and others. The second-year analysis would strengthen any conclusions about population structure and resulting population dynamics.

This proposal addresses the problem statement entitled, "Herring Population Ecology and Biomass" on page 10 of the EVOS "Invitation to Submit Restoration Proposals for Federal Fiscal Year 1999."

It is important, at this stage, to define terms used in this proposal:

Population	A genetically unique and reproductively isolated group of individuals; i.e., the size of a shared gene pool (Sinclair 1988).
Sub- or Meta-population	A group of individuals that may not be genetically unique but is identified by unique distributions in time and space. Recruitment processes specific to the sub-population act in maintaining its separateness. Sub-population may be equivalent to the fisheries term "stock" (defined as a management unit or stratum).

Populations or sub-populations of Pacific herring can be defined by their unique distributions at each life stage, although overlap among populations does occur (Sinclair 1988). The spatial dimensions and characteristics of the area encompassing a unique population fundamentally affect population size and variability. Current SEA research (97320-T; Stokesbury et al., 1997) revealed that although there is some overlap in spawning, juvenile nursery, adult summer feeding, and both juvenile and adult overwintering distributions in PWS, the distributions are largely distinct. The implications for population structures nested within these defined distributions are unclear. Iles and Sinclair (1982) and Sinclair (1988) described unique areas used by different life stages of Atlantic herring. Others have defined herring stocks as a function of distribution of the life stages over time (Carlson 1980). Stocker (1993) described two types of herring populations in British Columbia: major migratory stocks and smaller resident stocks, usually found at the heads of bays or inlets.

In PWS, "milt sightings" have been recorded in distinct regions since 1973 (Brady 1987). Major spawning has occurred on beaches in central (Montague and Naked Islands), northern (North Shore), northeastern, and southeastern PWS (Figure 1; Table 1; Biggs et al. 1992), while minor spawnings have been observed in western and southwestern portions of the sound (SEA, unpublished data). The areas with the most consistent annual spawn are Montague Island and northeastern PWS (Table 1). The extent of major spawning has varied from 21 to 268 km since 1973. Spatial variability in location of spawning and egg density is highly variable between years (Figures 2 and 3). Current SEA aerial and vessel surveys reveal minor spawnings in PWS that appear to be due to small local adult groups. These minor spawnings are separate from the major spawning recorded by the Alaska Department of Fish and Game and are later in the year, but could have large ramifications in terms of recruitment, herring availability as forage, and population stability. The recurring use of the major spawning areas, the distances between these areas, and the differences in spawn timing compared with the minor spawning areas all point to the possibility of multiple stocks or sub-populations within PWS.

Tagging studies on Pacific herring in BC reveal that discrete spawning populations can occur on the scale of approximately half of PWS (Hourston 1982; Stevenson 1955) with a range in homing between 64 and 87% (Hourston 1982). Wheeler and Winters (1984) report homing fidelity of spawning Atlantic herring at 90%.

Other tools to separate stocks (genetics using electrophoresis and mitochondrial DNA, morphology and meristics) have provided information valuable for discerning differences on large scales (e.g., BC to PWS) but generally fail when used in trying to distinguish within an area the size of PWS (Schweigert 1981 and 1990; Meng and Stocker 1984; Grant and Utter 1984; Schweigert and Withler 1990; Safford and Booke 1992). These techniques also provide little information about movement and recruitment dynamics. Genetic homogeneity, probably due to larval drift and dispersion (Hay and McCarter 1991), prevents discernment of the stocks at the scale needed to assess movement or the occurrence of sub-populations.

It appears, based on data from current and past studies, that Pacific herring in PWS compose a genetically homogeneous population (J. Seeb, ADFG, personal communication). Evidence of two relatively separate sub-populations based on the existence of 1) two major spawning areas (northeast PWS and northern Montague Island; Figure 1), 2) two main overwintering adult aggregations (Port Gravina and Montague Strait) (Biggs et al. 1992; ADFG unpublished data), and 3) consistent adult size-at-age differences between the groups (eastern versus central PWS). A mechanism explaining genetic homogeneity is mixing at the larval stage. A mechanism explaining the maintenance of separate sub-populations occurs once larvae have recruited to near-shore nursery bays. If juvenile herring remain separated in these nursery bays until large enough to join adult schools, then recruitment to each sub-population may be specific to the associated region of the sound (i.e., east-side nursery area juveniles recruit to the Port Gravina/northeast side adults). This implies that there is fidelity of adult herring to major spawning regions within PWS. Evidence from current studies by SEA indicate that juvenile herring age 1.5 disappear from nursery bays in late summer (July and August) and mix with adult schools (based on age composition of catches; Stokesbury et al. 1997) prior to the overwintering period. Therefore, the location of nursery bays becomes important in the determination of population structure. The location of nursery bays may depend on the location of natal habitats and on larval drift trajectories. The relative abundance of juveniles within the nursery bays may in turn depend on density of eggs at associated natal habitats. If conditions within nursery bays

vary, producing differences in juvenile herring growth and survival, than changes in distribution of herring among nursery bays has an impact on overall recruitment. Therefore, changes in the distribution and density of spawn could affect overall population structure by impacting larval drift and the resulting location and relative abundance of juvenile herring.

Since 1995, our knowledge and understanding of herring ecology in PWS and the Outer Kenai have improved considerably because of the work by SEA (Cooney 1997). In addition, great strides have been made in understanding the oceanography within PWS, along with the variability of the food base in space and time. Many of the components of ocean circulation as well as primary and secondary production have been successfully modeled. Also, in recent years, progress has been made toward understanding the effects of climate and oceanography on the population dynamics of Pacific herring (Schweigert, 1995; Zebdi and Collie, 1995). The current project will build upon that knowledge by examining present and historic distributions of herring eggs within the context of environmental conditions. The project is cost-effective since it is largely an analysis of existing data which, to a large degree, have never been published. This is an important step in the synthesis of ecological data for this key forage species.

The main working hypothesis for this project is:

> Adult Pacific herring year-class strength and distribution is dependent on the initial distribution and density of herring embryos, modulated by ocean conditions during the first two years of life.

A second companion proposal entitled, "Distribution and Ecology of Forage Fish and Effects on Herring Year-Class Strength," addresses an expanded version of the hypothesis stated above:

> Adult Pacific herring year-class strength and distribution are dependent upon the initial distribution and density of herring embryos, modulated by ocean conditions during the first two years of life, *and highly correlated with the resulting distribution and relative abundance of juvenile fish schools observed in the summer.*

The companion proposal deals with the second part of the hypothesis that involves the link between juvenile herring distribution, oceanography and adult population structure and distribution.

NEED FOR THE PROJECT

A. Statement of Problem

Pacific herring are a key species in the marine ecosystem of Prince William Sound. The health of the apex predator community may depend on the magnitude of herring recruitment and the condition of individual fish, since herring are the key forage fish in the sound (Lew Haldorson, UAF, personal communication). The decline of the PWS herring population (Brown et al. 1996a and 1996b) has had serious and significant negative impacts on commercial fisheries, subsistence food-harvest patterns, and distribution of wildlife in areas now devoid of herring spawning and feeding. The effects of these impacts on oil-injured predators of herring are only beginning to be understood by other EVOS-funded researchers. Nine years after the spill, Pacific herring are still

listed by the EVOS Trustee Council as "injured and not recovering." Direct restoration of this species is not practical; however, understanding and monitoring its recovery is important in order to improve stock assessment for management of commercial fisheries. Recovery can only take place via successful recruitment of juvenile herring to the adult population in PWS.

B. Rationale/Link to Restoration

The research completed under this project combined with historic data from ADFG and current information from the SEA project will help us refine models describing processes controlling and regulating herring recruitment. This information will help us to better understand the dynamics of the recovery of this species.

C. Location

The data for the work included in the proposal are limited to Prince William Sound.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

We will utilize the results of the TEK project 98320-T supplement entitled, "Documenting Forage Fish Natural History through Local and Traditional Ecological Knowledge." Specifically, the findings of this project will be compared with observations from resource users over the past 50 years. The TEK project documents observations of individuals which coincide with observations herring researchers have recorded in recent years. The Principal Investigator, Evelyn Brown, is also the Principal Investigator for the TEK project and will assist with closeout and publication preparation. The findings of this study will be shared with interested participants in the herring TEK project.

PROJECT DESIGN

A. Objectives

The research questions followed by the specific objectives are:

FY 99
How does herring egg density and year-class strength 3–4 years later vary geographically over time?

1. Determine temporal and spatial variability of herring spawn and year-class strength.

2. Identify natural groupings of the data and areas with greater variability.

Is there coherence in the trends of the two life stages?

3. Determine the correlation between the magnitude of spawn and the year-class strength.

How are egg and adult distributions compartmentalized oceanographically in PWS?

4. Define oceanographic regions and their associated hydrography within PWS.

How do oceanographic trends within the regions modify the coherence among the trends of herring egg and adult distribution and abundance?

5. Determine the relationships and interactions among the regional magnitude of spawn, oceanographic conditions, and year-class strength.

6. Examine areas of greater variability or similarity in the biological indices by comparing the oceanography.

FY 00
Is there biological evidence consistent with the ecological evidence for regionalization or the formation of sub-populations of herring in PWS?

1. Compile biological indices (energetics, growth, diet, etc.) stratified by region for juvenile and adult herring in PWS.

2. Determine how biological indices interact with oceanographic variables and affect year-class strength.

B. Methods

Fish Data
Historic information on miles of spawn, adult herring biomass, age structure, and distributions are readily available from ADFG for most years since 1973. These data will provide at least 20 years' information for comparison in the statistical models. As a proxy for egg density or abundance, we will use "mile-days" of milt (converted to km) which represents the cumulative spawn over a number of days in a given area.

Oceanographic Data
The oceanographic data come from multiple sources and are available over a range of time and space scales. For the purposes of this study, we will focus on data for the time period in which eggs are laid (April) until the time larvae recruit to near-shore nursery bays (July). This is the time period in which partitioning of the population occurs if it happens at all. From 1993 on, satellite images are available in a variety of formats, each providing different information about PWS and the adjacent Gulf of Alaska. Advanced Very High Radiation Radiometer (AVHRR) images will indicate eddies and currents. Sea-Viewing Wide Field-of-View Sensor (SeaWiFS) images provide ocean color, and Synthetic Aperture Radar (SAR) images show ocean front structure under cloud cover. These three images together, along with a subset of hydrographic data within regions of interest, may indicate structure that affects partitioning of the herring population (during larval drift and rearing in nursery areas). Kevin Engle, a satellite imagery specialist at the UAF Geophysical Institute, will compile and summarize these images for the project. For years prior to 1993, oceanographers at the Prince William Sound Science Center have compiled a set of historic hydrographic and meteorological data for the region. By subsampling this dataset within the same regions subsampled for the recent data series,

hydrographic data should be comparable between the two time periods (post- and pre-1993). Therefore, we should be able to look, retrospectively, at the same conditions that may act in partitioning. We will most likely do this for a subset of the 20 years since there are holes in the historic dataset. We will subcontract for the hiring of an oceanographer from PWSSC for help with the interpretation and analysis.

Statistical Analysis

A variety of graphic and statistical methods will be applied in this analysis. The distribution data (eggs and adult population) vary in time and space. The simplest way to visualize this variability is to draw a circle that encompasses all historic spawning and adult spawner staging areas, stretch that circle out in a line, and plot the abundance information on the line. In this way, segments of the line represent regions. Although this linear scale is arbitrary (not a true continuous variable like time), statistical analyses can be performed between segments of the line which represent independent events (individual spawning areas). By looking at each year individually and at all years pooled graphically, we will use the data to identify clusters (i.e., regions). The initial graphical examination of the data will indicate trends that will be obvious and will guide the analysis itself.

The first step, once extended graphical analysis is complete, will be to run a cross-correlation (time-series method; Rothschild et al. 1996) between the predictor variable of spawn abundance versus the response variable year-class strength within each region. Coherence between the trends may be highly variable, but that information will tell us which regions vary more and will guide the link to the environment. In performing the time-series, instances of auto-correlation between areas and years may become evident. The models selected from analysis should be able to deal with this problem.

Checking our data for violation of statistical model assumptions will be an important step. We have chosen to use general additive models (GAM), categorized as non-parametric regression, since that approach does not require linearity or normality. However, uniform variance is an assumption. Therefore, we will examine the residuals of the variables among regions. If there are serious departures from uniform variance, transformations may have to be performed. If the relationships between the predictor and response variables are largely linear (or can be linearized via transformations), we can perform a simple analysis of variance (ANOVA) and multiple regression to identify the important parameters. However, it is anticipated that many of the relationships will be non-linear and that oceanographic variables will be non-normal. The choice for a GAM is therefore clear.

Once we have a thorough understanding of the data and variability, we can proceed with the GAM analysis. This step involves compartmentalizing all the variables, biological and physical, within the regions identified. The general model takes the form:

$$\ln(R) = \alpha + \sum_{j=1}^{p} f(E_j) + g(S) + \varepsilon$$

where R is the year-class strength, α is an intercept parameter, p is the number of environmental predictor variables, $f(E_j)$ a function of the environment predictor variables (continuous or class; linear or non-linear forms), and $g(S)$ is the function of egg abundance ("mile-days" of spawn)

(modified from Hastie and Tibshirani 1990; Jacobson and MacCall 1995; Swartzman et al. 1992). Multiple iterations of this model will be run with some variables falling out and others emphasized.

It is probable that there will be regions of high variability (i.e., major but inconsistent spawning areas). It could be that those areas are at the edges of oceanographic regions and that the variability is due to "phase" shifts in the environment. We will explore trends in those regions more thoroughly by adding class variables to the analysis to account for significant interannual shifts in conditions. There may also be indications for pooling of regions with similar trends in population dynamics and ocean conditions.

Adding Biological Indices – FY 00

Biological indices such as size-at-age of herring can easily be incorporated with the approach suggested in this proposal. Regional herring age, weight, length, and age composition data are available for at least 20 of the past 25 years in PWS. In recent years, regional information on adult herring energetics, isotope composition, and fatty acid signatures have also become available. It is possible that historic otolith and scale patterns may become available if currently proposed research is funded (Peter Hagen and John Wilcock, ADFG, personal communication). Using regions delineated by the FY99 analysis, the biological indices can be built into the GAM relatively easily. Other statistical tools such as ANOVAs (given normal distribution and independence of indices), non-parametric tests such as the Mantel test (Legendre and Fortin 1989), or clustering can be explored. The biological indices may provide hard evidence of any population structure that exists. Defining population structure is critical to understanding the population dynamics of herring in PWS. The decision to proceed with this analysis will largely depend on significant findings in the previous year.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The University of Alaska Fairbanks is the main entity included in this proposal. We will contract with the prince William Sound Science Center for an oceanographer to help with the compilation of oceanographic data and assist in interpretation. We will use historic data provided by the Alaska Department of Fish and Game and will share all findings with that agency.

If this project is continued for a second year, it is anticipated that the role ADFG will play in the analysis, interpretation, and report completion will increase dramatically.

SCHEDULE

A. Measurable Project Tasks for FY 99 (October 1, 1998 – September 30, 1999)

November 30: Digitize historic spawn and adult herring distribution information within a geographic context; plot distributions for each year as oscillations along an axis representing linear space. Examine plots for each year thoroughly using both 3- and 4-year lags; identify natural regions (groupings of points) along the linear space scale; identify areas (regions) along the curve with greater variability.

December 31:	Within each region complete a cross correlation (time-series analysis) to determine what, if any, relationship exists between spawn and year-class strength within a given area. Within each region determine the mean and variance of each variable; run a residual analysis to look for violations of uniform variability.
February 28:	Acquire an appropriate set of oceanographic data matching time and space scales of the newly created regions; oceanographic variables can be set up as continuous (i.e., temperature anomalies, SST) or class (high flow vs. low flow) predictor variables for the analysis. Set up a general additive model (GAM) with the response variable being year-class strength and several predictor variables including spawn density (miles of milt), a class variable for regions and the oceanographic variables.
May 31:	Determine statistically significant relationships; proceed with further analysis of regional differences as warranted using only the variables showing significant relationships. One result may be pooling of regions with similar physical and biological dynamics, correlation coefficients, and temporal trends.
August 31:	Finalize publication for project.

B. Project Milestones and Endpoints

FY 99

November 30:	Documentation of variability of herring spawn and year-class strength (Objective 1 and 2) completed
December 31:	Finish correlation between spawn and year-class strength (Objective 3)
February 28:	Oceanographic regions defined with accompanying data sets (Objective 4) Initial run of GAM done (Objective 5)
March 24:	Attend EVOS symposium
May 31:	Statistical analysis completed (Objectives 5 and 6)
August 31:	Publication finalized
September:	Attend AFS meeting

FY 00

October 27–30:	Attend Lowell Wakefield Symposium
November 30:	Compile the biological indices stratified by the regions defined in FY99 (Objective 1)
February 28:	Include the indices in the GAM model. Explore other statistical tools for determining significant and temporally consistent relationships between the biological and physical predictor variables, including their interactions. (Objective 2)
May 31:	Complete analysis of the data and compile the results in a publication endpoint
August 31:	Second publication completed

C. Completion Date

September 30, 2000

PUBLICATIONS AND REPORTS

The final report for this project will be in the form of publication reprints. Documentation of all the findings will be available to EVOS as attached appendices. This report will also be included as a Ph.D. dissertation chapter by Evelyn Brown. The draft title for the publication is:

> Effects of trends in herring egg distribution and local oceanography on Pacific Herring year-class strength. E.D. Brown, S. Vaughn, and B.L. Norcross.

For the second year of the project, the publication would most likely be entitled:

> Evidence of ecologically induced population structure and spatial segregation on Pacific herring in Prince William Sound, Alaska. E.D. Brown and these potential co-authors: B.L. Norcross, K.D.E. Stokesbury, R.J. Foy, A.J. Paul, F. Funk, J. Wilcock, T. Kline.

PROFESSIONAL CONFERENCES

During FY99 we will attend the EVOS symposium scheduled for March and the Alaska Chapter meeting of the American Fisheries Society (exact in-state location unknown). We would also like to attend the Lowell Wakefield Symposium entitled, Spatial Processes and Management of Fish Populations, October 27–30, 1999. Although this meeting occurs outside the fiscal year and would be budgeted for in FY 00, preparations and manuscripts would be prepared in FY99. In the future, we plan to participate in the International Herring Symposium scheduled for January 2000, location unknown.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project represents a synthesis of historic data and current information resulting from EVOS restoration research. Data from the SEA project (98320) and from ADFG are pivotal in the research. This will also be one of the first attempts to relate satellite data to effects on marine fishes. The results from this study also dovetail with work on herring recruitment being completed by Terry Quinn (UAF Juneau Center) and Erik Williams. The scale of the analyses differ substantially.

PRINCIPAL INVESTIGATORS

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Year	Southeast	Northeast	North Shore	Naked Area	Montague Area	Total
1973	0.00	47.47	4.83	0.00	16.09	68.39
1974	0.00	37.82	0.00	0.00	24.14	61.96
1975	0.00	44.58	0.00	0.00	10.46	55.04
1976	0.00	47.63	0.00	0.00	3.70	51.34
1977	0.00	60.75	0.00	0.00	2.41	63.16
1978	0.00	45.86	0.00	0.00	0.32	46.19
1979	33.79	52.30	0.00	0.00	1.61	87.71
1980	16.50	56.00	0.00	0.00	8.77	81.27
1981	22.29	46.67	9.25	0.00	59.14	137.35
1982	0.48	30.33	25.43	5.63	16.90	78.77
1983	4.51	21.32	16.90	28.48	37.17	108.38
1984	14.00	19.47	26.15	12.15	24.94	96.72
1985	5.15	56.32	53.83	26.31	21.24	162.86
1986	4.51	41.04	59.70	0.00	11.26	116.51
1987	11.10	34.28	42.24	3.70	13.68	105.00
1988	6.03	91.49	24.78	29.45	115.87	166.30
1989	5.63	34.76	49.40	22.05	46.51	98.40
1990	4.18	70.33	29.29	8.69	38.94	151.43
1991	6.28	45.86	1.93	0.00	39.27	93.34
1992	11.59	51.82	0.00	0.00	56.32	74.70
1993	2.74	8.85	0.00	0.00	21.24	32.83
1994	0.32	0.43	0.00	0.00	14.02	14.77
1995	9.33	3.22	0.00	0.00	20.28	32.83
1996	3.86	16.09	0.32	0.00	23.50	43.77
1997	11.30	25.10	3.40	0.00	29.00	68.70
Average	**6.94**	**39.59**	**13.90**	**5.46**	**26.27**	**83.91**
Percent Of total	**0.08**	**0.47**	**0.17**	**0.07**	**0.31**	

Table 1. Historical herring spawn shoreline kilometers from aerial and spawn deposition surveys by area and year for Prince William Sound, 1973–1997.

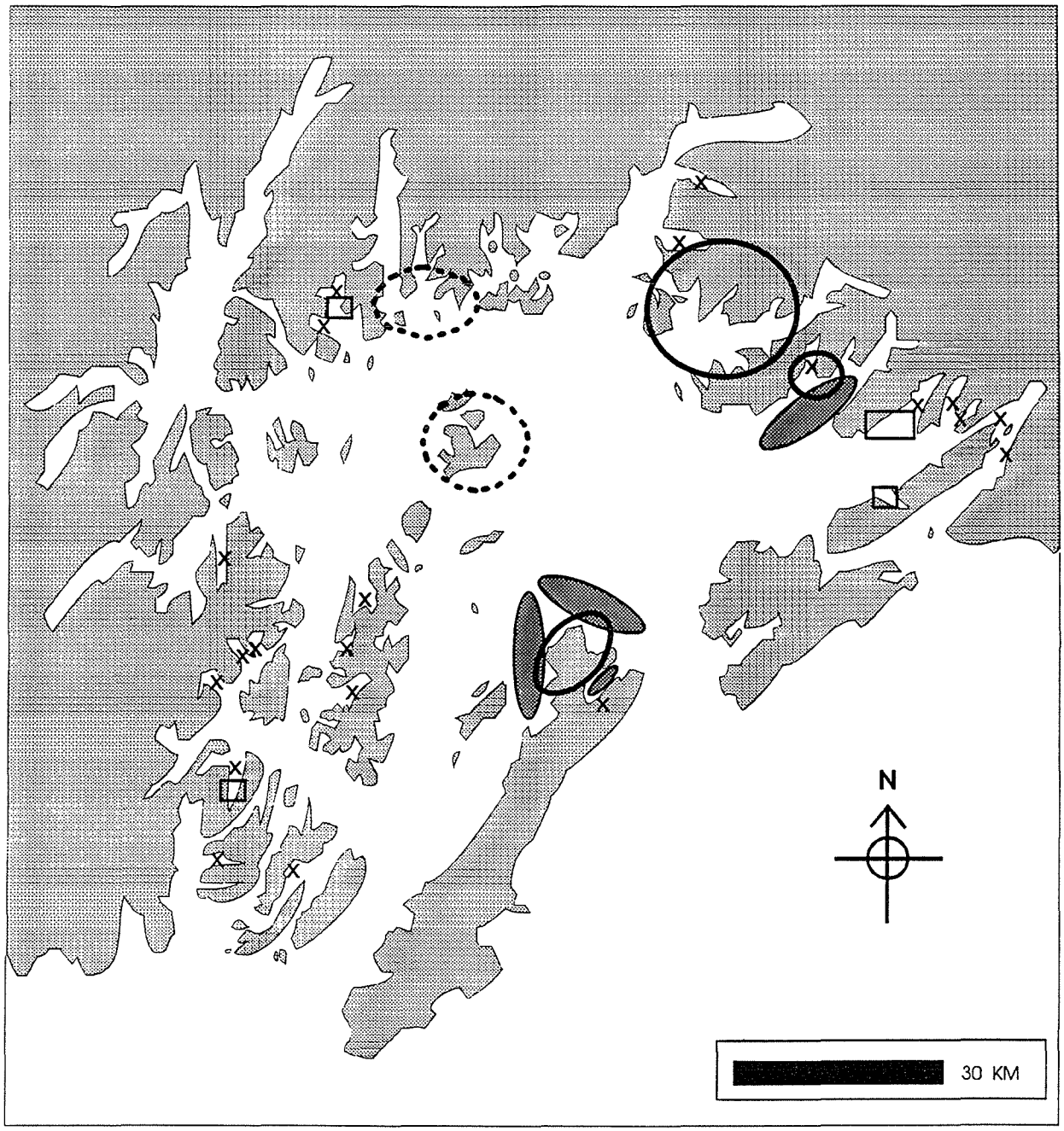

Figure 1. Map of Prince William Sound, Alaska, showing major consistent annual spawning areas (circles with solid line), major inconsistent spawning areas (circles with dotted line), minor spawning areas (squares), adult overwintering areas (shaded ovals), and juvenile nursery areas (Xs).

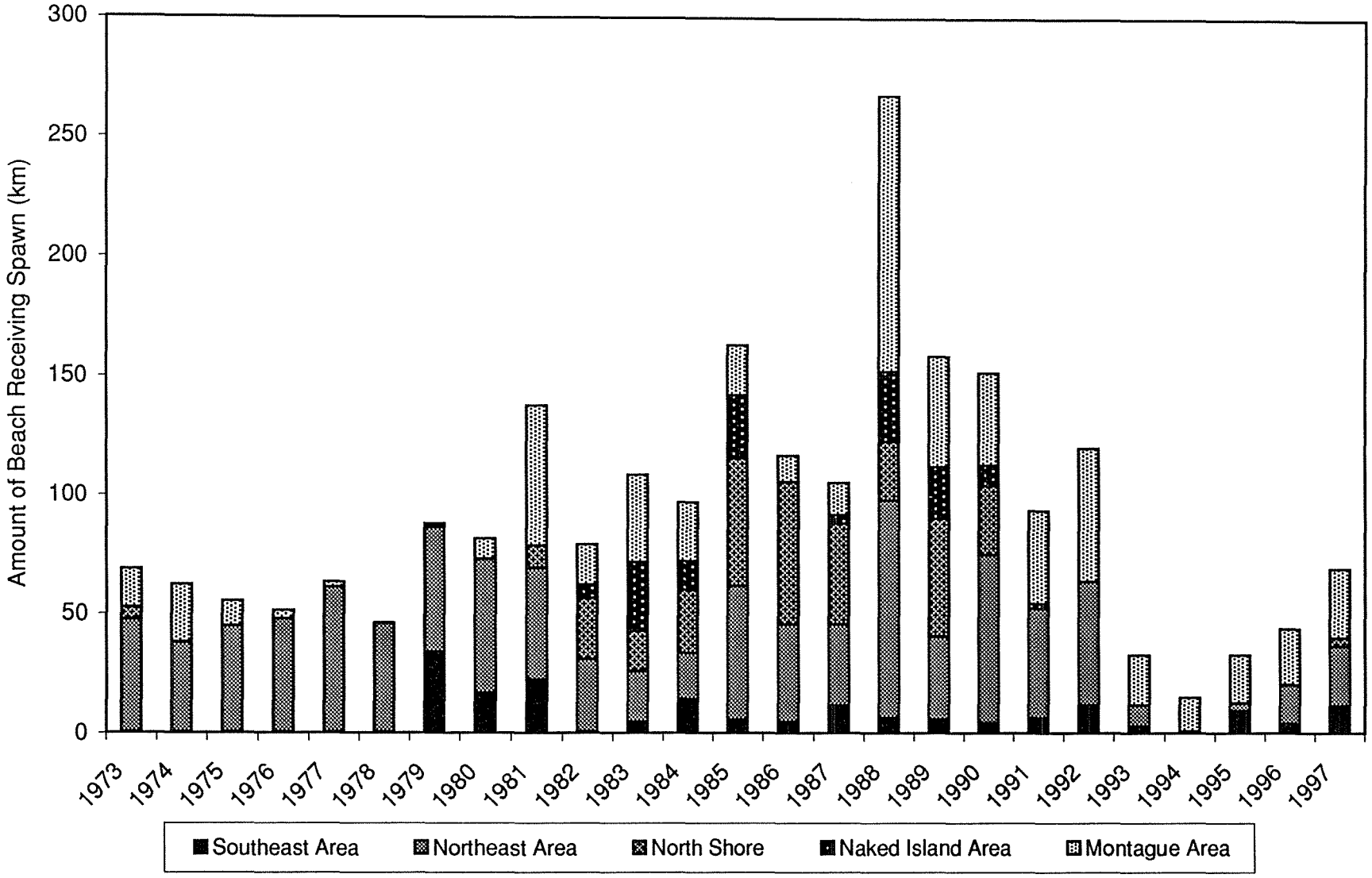

Figure 2. Interannual variability in Pacific herring spawn in Prince William Sound, Alaska.

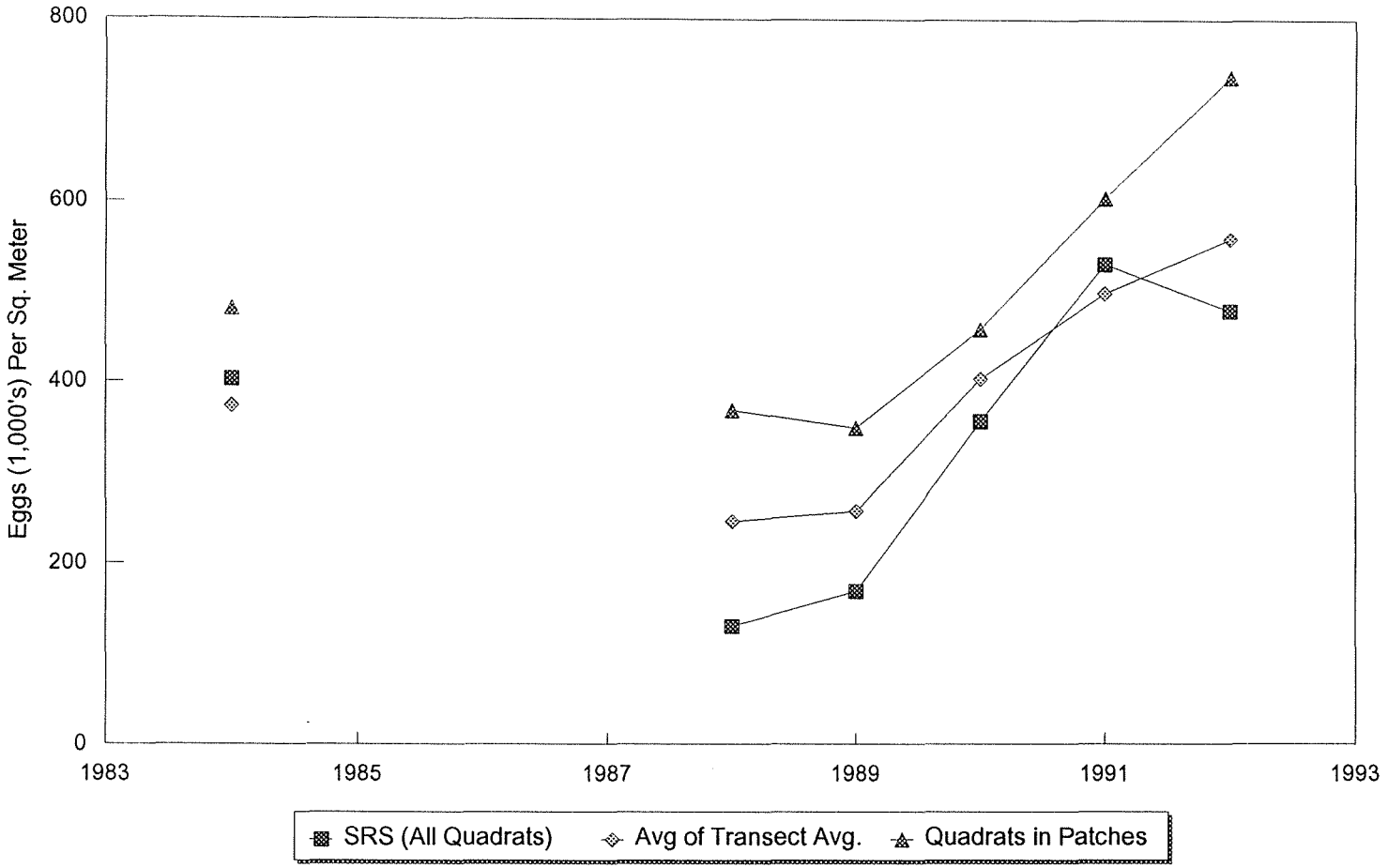

Figure 3. Interannual variation in herring eggs density estimated by the root mean squared (SRS) average from all quadra sampled, by the average egg density of all the transect averages, and by the average within a herring egg patch or area from 1984, 1988–1992 in Prince William Sound, Alaska. (Fritz Funk, ADFG, unpublished data)

PRINCIPAL INVESTIGATOR

Evelyn D. Brown

The Principal Investigator is responsible for all project tasks and objectives.

Education:
B.S. Zoology and Chemistry, University of Utah, Salt Lake City, 1977
M.S. Fisheries Biology and Aquacultural Engineering, Oregon State University, Corvallis, 1980

Experience:
Project Manager, University of Alaska Fairbanks, 1995 to present.
Herring Research Biologist, Alaska Department of Fish and Game, Cordova, Alaska 1988–1995.
Principal Investigator, Injury to Prince William Sound Herring, NRDA FS 11, 1989–1992.
Fisheries Biologist, Alaska Department of Fish and Game, Cordova, Alaska, 1985–1987. Sonar projects, stream surveys, aerial surveys, and net sampling.
Commercial Fisherperson, various skippers, 1982–1984.
Fisheries Consultant, self-employed. Contracts included Prince William Sound Aquaculture Corporation for fish tagging and stream surveys; Metlakatla Indian Community on Annette Island for salmon stream survey manual and estimate of production potential and for environmental impact statement for logging activity.
Fisheries Biologist, Florida Department of Natural Resources, St. Petersburg, Florida, 1987–1988. Employed for one winter to conduct a hydroacoustic survey of mullet in the Manistee River and in Tampa Bay; also worked on a mullet tagging project encompassing the entire west coast of Florida.
Fisheries Management Biologist, Metlakatla Indian Community, Annette Island, Alaska, 1980–1982. Completed an oyster culture feasibility study, provided management recommendations on shellfish harvests, participated in herring egg deposition survey and salmon management through the use of commercial fish traps.

Current Research Interests:
- Juvenile herring population dynamics; interactions of biological and physical parameters
- Spatial patterns of forage fish distribution and related ecological parameters
- Prince William Sound herring stock model

Field Experience:
From 1978 to the present, I have participated in numerous field programs, from ground surveys of streams out of skiffs, to aerial surveys of salmon streams and herring aggregations, to SCUBA surveys of herring egg deposition and shellfish resources, to open ocean cruises aboard large research platforms performing large scale fisheries oceanography surveys (R/V *Oshoro Maru*, 1983). I have operated fish weirs and fixed-site sonars from remote field camps and from trailers located in urban areas (Bradenton, Florida). I have repaired outboards, carried firearms for protection from dangerous animals (brown bears and wolves), and assisted in construction of structures including cabins and tent platforms. I have operated vessels ranging from 12 to 72 ft by myself and assisted in skippering vessels up to 84 ft (crabber out of Kodiak, Alaska). I have experience operating navigational equipment including GPS, Loran, Radar, and Searchlight sonar, and using nautical charts, compasses, parallels, etc.

Publications, Contributed Publications, and Reports:

Final Reports Submitted to Trustee Council:

Biggs, E.D. and T.T. Baker. Studies on Pacific herring in Prince William Sound following the *Exxon Valdez* oil spill, 1989–1992 (former FS11 G-egg loss and H-fecundity are included with this report).

E.D. Brown, T.T. Baker, F. Funk, J.E. Hose, R.M. Kocan, G.D. Marty, M.D. McGurk, B.L. Norcross and J.W. Short. 1994. Injury to Prince William Sound herring following the *Exxon Valdez* oil spill: Final Report for Natural Damage Assessment Fish/Shellfish Study No. 11; EVOC T., Anchorage, AK, 310 pp.

Baker, T.T. and E.D. Biggs. 1993. Measurements of the survival of Pacific herring eggs in the field following the *Exxon Valdez* oil spill, 1989–1991.

Journal Articles:

Brown, E.D., T.T. Baker, J.E. Hose, R.M. Kocan, G.D. Marty, M.D. McGurk, B.L. Norcross and J. Short. 1996. Injury to the early life history stages of Pacific herring in Prince William Sound after the *Exxon Valdez* oil spill. Am. Fish. Soc. Symp. 18, pp. 448–462.

Brown, E.D., B.L. Norcross and J.W. Short. 1996. An introduction to studies on the effects of the *Exxon Valdez* oil spill on early life history stages of Pacific herring, *Clupea pallasi*, in Prince William Sound, Alaska. *Can. J. Fish. Aq. Sci.* 53: 2337–2342.

Brown, E.D. and E.M. Debeves. In press. Effects of the *Exxon Valdez* oil spill on in situ survival of Pacific herring (*Clupea pallasi*) eggs. *Can. J. Fish. Aq. Sci.*

McGurk, M.D. and E.D. Brown. 1996. Egg-larval mortality of Pacific herring in Prince William Sound, Alaska, after the *Exxon Valdez* oil spill. *Can. J. Fish. Aq. Sci.* 53: 2343–2354.

Hose, J.E., M.D. McGurk, G.D. Marty, D.E. Hinton, E.D. Brown and T.T. Baker. 1996. Sublethal effects of the *Exxon Valdez* oil spill on herring embryos and larvae: Morphologic, cytogenetic, and histopathological assessments, 1989–1991. *Can. J. Fish. Aq. Sci.*

Kocan, R.M., J.E. Hose, E.D. Brow, and T.T. Baker. 1996. Pacific herring (*Clupea pallasi*) embryo sensitivity to Prudhoe Bay petroleum hydrocarbons: Laboratory evaluation and *in situ* exposure at oiled and unoiled sites in Prince William Sound. *Can. J. Fish. Aq. Sci.* 53: 2366–2375.

Norcross, B.L., J.E. Hose, M. Frandsen and E.D. Brown. 1996. Distribution, abundance, morphological condition and cytogenetic abnormalities of larval herring in Prince William Sound, Alaska, following the *Exxon Valdez* oil spill. *Can. J. Fish. Aq. Sci.* 53: 2376–2387.

Kocan, R.M., G.D. Marty, M.S. Okihiro, E.D. Brown and T.T. Baker. 1996. Reproductive success and histopathology of individual Prince William Sound Pacific herring three years after the *Exxon Valdez* oil spill. *Can. J. Fish. Aq. Sci.* 53: 2388–2393.

Marty, G.D., J.E. Hose, M.D. McGurk, E.D. Brown and D. E Hinton. In press. Histopathology and cytogenetic evaluation of Pacific herring larvae exposed to petroluem hydrocarbons in the laboratory or in Prince William Sound, Alaska, after the *Exxon Valdez* oil spill. *Can J. Fish. Aq. Sci.*

CO-PRINCIPAL INVESTIGATOR

Brenda L. Norcross

The Co-Principal Investigator will review survey design, data, and analysis; review reports and publications.

Education:

A.B., Biology, MacMurray College, Jacksonville, Illinois, 1971
M.S., Biology, St. Louis University, St. Louis, Missouri, 1976
Ph.D., Marine Science, Virginia Institute of Marine Science, School of Marine Science, College of William and Mary, Gloucester Point, Virginia, 1983

Experience:

Associate Professor, Institute of Marine Science, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, 1989–present
Sabbatical leave, Caribbean region, 1997–1998
Assistant Professor, Institute of Marine Science, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, 1989–1996
Assistant Professor, Division of Biological Oceanography and Fisheries Science, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia, 1986–1988
Assistant Professor, Computer Center, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia, 1984–1986
Research Biologist/Oceanographer, Ocean Research and Education Society, Inc., Gloucester, Massachusetts, 1984
Graduate Research Assistant, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia, 1978–1983
Research Associate and Laboratory Supervisor, Renal Division, Department of Pediatrics, Washington University, School of Medicine, St. Louis, Missouri, 1973–1978
Science and Math Teacher, Andrew Jackson Junior High School, Prince George's County Public Schools, Suitland, Maryland, 1971–1973

Field Experience:

- S/V *Phaedrus,* 52-foot ketch, Sabbatical leave – live aboard, Sailing techniques, applied oceanography, meteorology, climatology and fisheries (Florida, The Bahamas, Turks and Caicos, Dominican Republic, Puerto Rico, U.S. Virgin Islands, British Virgin Islands, St. Martin, Anguilla, St. Barths, St. Eustatius, St. Kitts, Nevis, Antigua, Montserrat, 9 months), 1997–98.
- One fisheries vessel, Principal Investigator, Pelagic fish, zooplankton, hydroacoustics, oceanography, underwater camera (Prince William Sound, 7 days), 1998.
- One–five fisheries vessels, Principal Investigator, Pelagic fish, zooplankton, hydroacoustics, oceanography, underwater camera, aerial surveys (Prince William Sound, 34 days), 1997.
- 26-foot Boston whaler, Principal Investigator, Inshore demersal fish and crabs, sediment, and CTD (Kodiak Island, 10 days), 1997.
- R/V *Tiglax*, Principal Investigator, Near-shore demersal fish, mid-water fish, sediment, CTD, and underwater camera (Aleutians to Homer, AK, 26 days), 1997.

- F/V *Tracy Ann*, Principal Investigator, Near-shore demersal fish, mid-water fish, sediment, CTD, and underwater camera (Forrester Island, 7 days), 1997.
- Five fisheries vessels, Principal Investigator, Pelagic fish, zooplankton, hydroacoustics, oceanography, aerial surveys (Prince William Sound, 60 days), 1996.
- F/V *Bering Explorer*, Chief Scientist and Principal Investigator, Near-shore demersal fish, sediment, underwater camera, and CTD (Lower Cook Inlet, 8 days), 1996.
- 26-foot Boston whaler, Principal Investigator, Inshore demersal fish and crabs, sediment, and CTD (Kodiak Island, 12 days), 1996.
- R/V *Tiglax*, Principal Investigator, Near-shore demersal fish, sediment, and water samples (Aleutians to Homer, AK, 34 days), 1996.
- 28-foot skiff, Principal Investigator, Inshore demersal fish and crabs, benthos, sediment, and CTD (Kachemak Bay, 30 days), 1996.
- Six fisheries vessels, Principal Investigator, Pelagic fish, hydroacoustics, oceanography, aerial surveys (Prince William Sound, 22 days), 1995.
- 28-foot skiff, Chief Scientist and Principal Investigator, Inshore fish and crabs, benthos and sediment (Kachemak Bay, 7 days), 1994.
- 26-foot Boston whaler, Chief Scientist and Principal Investigator, Inshore fish and crabs, benthos and sediment (Kodiak Island, 12 days), 1994.
- 24-foot skiff, Chief Scientist and Principal Investigator, Inshore fish, benthos and sediment (Afognak Island, 8 days), 1994.
- F/V *Maritime Maid*, Fisheries Scientist, Distribution of juvenile fishes (Aleutian Islands, 16 days), 1994.
- 26-foot Boston whaler, Chief Scientist and Principal Investigator, Inshore fish and crabs, benthos and sediment (Kodiak Island, 9 days), 1993.
- F/V *Big Valley*, Chief Scientist and Principal Investigator, Inshore fish, benthos, sediment, ROV and water samples (Kodiak Island, 14 days), 1992.
- 24-foot skiff, Chief Scientist and Principal Investigator, Inshore fish, benthos, sediment and water samples (Kodiak Island, 6 days), 1992.
- 21-foot Boston whaler, Scientist, Inshore fish (Auke Bay, 2 days), 1992.
- F/V *Big Valley*, Chief Scientist and Principal Investigator, Inshore fish, benthos, sediment and water samples (Kodiak Island, 7 days), 1991.
- 24-foot skiff, Chief Scientist and Principal Investigator, Inshore fish, benthos, sediment and water samples (Kodiak Island, 12 days), 1991.
- R/V *Alpha Helix*, Associate Scientist and Principal Investigator, Distribution of larval fish (Alaska to Hawaii, 17 days), 1991.
- R/V *Alpha Helix*, Associate Scientist, Distribution of larval fish (Gulf of Alaska, 3 cruises, 9 days), 1990.
- R/V *Alpha Helix*, Chief Scientist and Principal Investigator (One cruise), Associate Investigator (three cruises), Distribution of larval fish, oil spill (Prince William Sound, 27 days), 1989.
- F/V *Jennie Girl*, Principal Investigator, Distribution of larval fish, oil spill (Prince William Sound, 10 days), 1989.
- NOAA Ship *John Cobb*, Chief Scientist and Principal Investigator, Distribution of larval fish, oil spill (Prince William Sound, 7 days), 1989.
- R/V *Little Dipper*, Chief Scientist and/or Principal Investigator, Distribution and transport of larval fish (Resurrection Bay, 4 cruises, 20 days), 1989.

Selected Publications:

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Moles, A. and B. L. Norcross. 1998. Effects of oil-laden sediments on growth and health of juvenile flatfishes. *Can. J. Fish. Aquat. Sci.* 55: In press.

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1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$38.5
Travel		$2.8
Contractual		$25.3
Commodities		$0.9
Equipment		
Subtotal		$67.5
Indirect		$16.9
Project Total		$84.4
Full-time Equivalents (FTE)		0.6
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$45.0				

Dollar amounts are shown in thousands of dollars.

Comments:

The indirect rate is 25% TDC, as negotiated by the *Exxon Valdez* Oil Spill Trustee Council with the University of Alaska.

FY 99

Project Number: 99375
Project Title: Effect of Herring Egg Distribution and Ecology on Year-Class Strength and Adult Distribution
Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

Prepared: 4/13/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 1999
	Brown, E.	Principal Investigator/Project Manager	3.0	6.1		18.3
	Norcross, B.	Principal Investigator/Assoc. Professor	0.5	8.5		4.3
	Moreland, S.	Laboratory Assistant	1.5	3.7		5.6
	Engle, K.	Satellite Imagery Specialist	1.0	5.5		5.5
	Vallarino, M.	Programmer	1.0	5.1		5.1
		Adjustment to recognize rounding				-0.3
		Subtotal	7.0	28.9	0.0	
					Personnel Total	$38.5

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1999
	Fairbanks to Cordova – meet with PWSSC oceanographer	0.4	1	4	0.1	0.8
	Fairbanks to Anchorage – EVOS meeting	0.3	1	5	0.1	0.8
	Fairbanks to Anchorage – present at AFS meeting	0.3	1	5	0.1	0.8
	Adjustment to recognize rounding					0.4
					Travel Total	$2.8

FY 99

Project Number: 99375
Project Title: Effect of Herring Egg Distribution and Ecology on Year-Class Strength and Adult Distribution
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 4/13/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
Communications	0.3
Publication costs	24.3
Subcontract with PWSSC (oceanographer to assist with compilation of data and with satellite image interpretation)	0.8
Adjustment to recognize rounding	-0.1
Contractual Total	$25.3

Commodities Costs:	Proposed FY 1999
Description	
Computer supplies	0.3
Unix upgrade to S plus for GAM analysis	0.7
Adjustment to recognize rounding	-0.1
Commodities Total	$0.9

FY 99

Project Number: 99375
Project Title: Effect of Herring Egg Distribution and Ecology on Year-Class Strength and Adult Distribution
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities DETAIL

Prepared: 4/13/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 1999
Those purchases associated with replacement equipment should be indicated by placement with an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number	
Description	of Units	

FY 99

Project Number: 99375
Project Title: Effect of Herring Egg Distribution and Ecology on Year-Class Strength and Adult Distribution
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

Prepared: 4/13/98

Distribution and Ecology of Forage Fish and Effects on Herring Year-Class Strength

Project Number:	99376
Restoration Category:	Research
Proposer:	University of Alaska Fairbanks
Lead Trustee Agency:	ADFG
Cooperating Agencies:	none
Alaska SeaLife Center:	no
Duration:	1st year, 10-year project
Cost FY 99:	$134,500
Cost FY 00:	$109,800
Cost FY 01:	$109,800
Cost FY 02:	$109,800
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pacific herring

ABSTRACT

The main goal for this project is to improve our understanding of trends in abundance of juvenile Pacific herring, sandlance, capelin and eulachon. Several project objectives are included: 1) framing the distribution of fish in an oceanographic context, 2) examining how juvenile herring abundance and distribution affects year-class strength and adult distribution, and 3) continued collection of field data needed for analysis of longer-term trends. This project is cost effective since it builds on existing data. Geostatistical analyses and general additive models will be used to report significant findings. A long-term monitoring scheme is proposed.

INTRODUCTION

This project addresses several research objectives including descriptive science, a testable hypothesis, and a synthesis of existing data. A primary objective is to frame the distribution of larval and juvenile Pacific herring (*Clupea pallasi*) and other forage species (including sandlance [*Ammodytes hexapterus*], capelin [*Mallotus villosus*], and eulachon [*Thaleichthys pacificus*]) in an oceanographic context. A secondary objective is to refine our understanding of Pacific herring population structure and trends in Prince William Sound (PWS) by examining juvenile herring in an ecological context and examining the effect of that distribution on year-class strength. This will include an analysis of the coherence between larval and juvenile herring distribution. A third objective is to continue collection of field data necessary to test the statistical models developed by this project, including a monitoring scheme that will address all forage species in PWS. This proposal is related to and can be paired with a second proposal entitled, "Effect of Herring Egg Distribution and Ecology on Year-Class Strength and Adult Distribution." Data from this project will be shared with seabird and mammal researchers interested in forage fish distribution as well as fishery managers interested in improving their understanding of herring stock dynamics. The components of this project include descriptions of the temporal trends of larval herring entering the nursery areas, and temporal trends of juvenile herring (and other forage species) distribution and the relation of juvenile to larval herring dispersion. These distributions are examined within the ecological context of the oceanography of PWS and analyzed in terms of the impact of the juvenile herring distribution on population structure and abundance three to four years later.

This proposal addresses the problem statement entitled, "Herring Population Ecology and Biomass" on page 10 of the EVOS "Invitation to Submit Restoration Proposals for Federal Fiscal Year 1999."

There is limited information about the distribution of larval herring and other forage species within and out of PWS. Herring, capelin, and pollock numbers composed three of the top five species caught as larvae in PWS in 1989 (Norcross and Frandsen 1996). That study documented that larval abundance of herring, capelin, pollock, and sandlance peaked in June and fell off in July in offshore waters (over 1 km from shore) (B. Norcross, UAF, unpublished data). During the summers of 1996 and 1997, pre-metamorphic larval herring were captured at the entrances to and within documented herring nursery areas in PWS (Stokesbury et al. 1997). Peak capture rates occurred in July. During the same month, peak numbers of age-0 juvenile herring were observed via aerial surveys within the same nursery bays (Stokesbury et al. in prep.). Peak numbers of age-0 sandlance were also observed at near-shore beaches in PWS. This represents the first documentation of the process of larval recruitment into the near-shore nursery areas. Between the two years, variability in abundance and distribution of both the larval and juvenile herring was observed. This variability has implications on recruitment to adult populations, population structure, and distribution of newly recruited adults for both sandlance and herring.

In order to build upon this limited knowledge of forage species, we will include an analysis of oceanographic conditions synoptic with the time frame of the fish distribution data. By defining oceanographic regions within PWS and examining the fish distribution within those regions, we will be able to see if partitioning among the species is occurring. We will also begin to describe habitat characteristics that positively or negatively affect the availability of these species as forage food if we continue to collect the fish distribution information.

For herring, it is desirable to know more about population structure and dynamics since it is not only a forage fish, but commercially harvested. If there are subpopulations, a possible mechanism for the separation occurs once larvae have recruited to near-shore nursery bays. If juvenile herring remain separated in these nursery bays until large enough to join adult schools, then recruitment to each sub-population may be specific to the associated region of the Sound (i.e., east-side nursery area juveniles recruit to the Port Gravina/northeast-side adults. In addition, we do not understand the importance of the Outer Kenai as a nursery site for PWS herring populations. The authors, ADFG, and local fisherman have seen large concentrations of herring there (Figure 1) and observed massive eastward migrations of herring to the southwest entrances to PWS (Schroeder 1989; Leroy Cabana, commercial fisherman, Homer, Alaska, personal communication). The observations of large numbers of juveniles in the Outer Kenai correspond to strong year-class signals within PWS. Clearly this will be an important research question for the future.

Both inside and outside PWS, it appears that an outmigration of juvenile herring from the nursery areas occurs in August. From current studies by SEA, juvenile herring age-1.5 disappear from nursery bays in late summer (July and August) and mix with adult schools (based on age composition of catches; Stokesbury et al. 1997) prior to the overwintering period. This is further evidenced by the dramatic decrease in juvenile herring schools seen from the air from July to August. Therefore, the location of nursery bays becomes important in the determination of population structure. If conditions within nursery bays vary, producing differences in juvenile herring growth and survival, then changes in distribution of herring between nursery bays impact overall recruitment.

No analogous model for stock structure has been proposed for sandlance. The data collected from 1995 to 1997 represent the first documentation of sandlance distribution and abundance in PWS. It also includes documentation of adult capelin and eulachon.

Since 1995, our knowledge and understanding of juvenile herring ecology in PWS and the Outer Kenai have improved considerably because of the work by SEA and APEX. In particular, we now have three years of distribution information on juvenile herring that reveals the locations of nursery sites (from aerial and acoustic surveys). During June aerial surveys, age-1 herring abundance was measured. During July, the distribution and abundance of newly-recruited age-0 herring to near-shore areas were documented. In addition, great strides in understanding the oceanography within PWS have been made along with an understanding of the variability of the food base in space and time (Cooney 1997). Many of the components of ocean circulation as well as primary and secondary production have been modeled with optimistic success. This project will build upon that knowledge by examining current information (1995–1997, 1999; see example of data in Figure 1) about the distribution of juvenile herring (and other forage fish) within the context of newly defined environmental conditions. The project is cost effective since a major portion concerns analysis of existing data. The field component is small (one broad-scale aerial survey) and provides data for hypothesis testing as well as for the continuation of baseline information on other forage species. This is an important step in the synthesis of ecological data for the key forage species.

Although much of this project involves descriptive science, there is a working hypothesis concerning herring:

Adult Pacific herring year-class strength and distribution are highly correlated with the resulting distribution and relative abundance of juvenile fish schools observed in the summer.

A second companion proposal entitled, "Effect of Herring Egg Distribution and Ecology on Year-Class Strength and Adult Distribution" addresses the first part of an expanded version of the hypothesis stated above:

Adult Pacific herring year-class strength and distribution are dependent on the initial distribution and density of herring embryos, modulated by ocean conditions during the first two years of life, *and are highly correlated with the resulting distribution and relative abundance of juvenile fish schools observed in the summer.*

This project is cost effective because the analysis is largely based on existing data and the proposed field work is a supplement to field work proposed by APEX project 99163-T, "Aerial Survey Support for the APEX Project". Data from both projects will be used to meet the objectives listed in this study.

NEED FOR THE PROJECT

A. Statement of Problem

Pacific herring are a key species in the marine ecosystem of Prince William Sound. The health of the apex predator community may depend on the magnitude of herring recruitment and the condition of individual fish since herring are the key forage fishes in the Sound (L. Haldorson, UAF, personal communication). The decline of the PWS herring population (Brown et al. 1996a; 1996b) has had serious and significant negative impacts on the commercial fisheries, subsistence food harvest patterns, and distribution of wildlife in areas now devoid of herring spawning and feeding. The effects on oil-injured predators of herring are only beginning to be understood by other EVOS-funded researchers. Nine years after the spill, Pacific herring are still listed by the EVOS Trustee Council as injured and not recovering. Direct restoration of this species is not practical; however, understanding and monitoring its recovery is important in order to improve stock assessment for management of commercial fisheries. Recovery can only take place via successful recruitment of juvenile herring to the adult population in PWS.

Researchers focusing on sea birds and marine mammals (including oil-injured species) have hypothesized that the lack of a forage base is affecting long-term population trends and reproduction (EVOS TC 1997 Status Report). This project will provide the only baseline information available on population trends of sandlance, capelin, and eulachon in PWS and the adjacent Gulf of Alaska waters.

B. Rationale/Link to Restoration

The research completed under this project, combined with historic data from ADFG and current information from the SEA project, will help us refine herring recruitment models. Information on age-1 herring abundance from 1995, 1996, and 1997 can be compared to year-class strength of adults in 1998, 1999, and 2000; if the trends show coherence, the methods in the project can be used as a monitoring tool. The three years' data on juvenile herring can also be used as validation

for the SEA herring overwintering recruitment model (Stokesbury et al. 1997) by comparing predicted overwinter survival with actual abundances of age-1 herring. This information will help us to better understand the dynamics of the recovery of this species and can be incorporated into management practices for Pacific herring.

The findings of this study will be broadly applicable for examining relationships between forage fishes and apex predators. We can compare abundance trends in the target forage species, and reproductive or growth and condition indices of foraging birds and mammals in overlapping regions to see if those relationships exist. The descriptive baseline information from this study includes: identification of key forage species in the region, elucidation of spatial and temporal trends, and regional distributions of foraging sea birds and mammals.

Much of this information will be critical for future planning of PWS ecosystem work and model development.

C. Location

The data for the work included in the proposal are primarily from PWS, although some data from the Outer Kenai and the Gulf of Alaska bordering PWS will be used. Communities within the region include Cordova, Valdez, Whittier, Tatitlek, Chenega Bay, and Seward.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

We will compare our distribution descriptions with the results of the TEK project 98320-T supplement entitled, "Documenting Forage Fish Natural History through Local and Traditional Ecological Knowledge." Consistency may indicate some long-term stability in locations where the forage fish are found given the interannual variability in abundance. The Principal Investigator, Evelyn Brown, is directly involved with that TEK project and will assist with closeout and publication preparation. The findings of this study will be shared with interested participants in the herring TEK project and the APEX program.

PROJECT DESIGN

A. Objectives

The research objectives are:

1. Determine how juvenile herring and other forage fish distributions and abundance co-vary with oceanographic structure.

2. Determine the coherence between the recruitment of larval herring to near-shore areas and the resulting distribution of age-0 juvenile herring.

3. Determine the relationship, including spatial variability, between age-1 juvenile herring abundance and year-class strength 3–4 years later.

4. Determine the long-term trends in distribution and abundance of forage fish in PWS, the Outer Kenai, and the adjacent waters of the Gulf of Alaska.

B. Methods

In order to meet the objectives of this project, data from three sources are necessary. We will use broadscale aerial survey results to describe the fish distributions. Net catches from vessel surveys conducted at the same time as aerial surveys will be used to validate aerial results. We will use oceanographic data from satellite images, from recent oceanographic cruises (see Cooney 1997), and from remote buoys. Finally, we will use data collected by SEA in the last three years, including larval catches during the summer, energetic content, stomach contents, growth rates, age composition, and size-at-age (much of which is currently being published; Stokesbury et al. 1997 and in prep.).

Aerial Survey Data

Aerial surveys were conducted in PWS, a small adjacent portion of the Gulf of Alaska, and the Outer Kenai from 1995 to 1997 (Brown and Norcross, in prep.). Methodology for this project was developed in those years. In all three years surveys were flown during the months of June and July; in 1995 and 1996 surveys were also flown during May and August. Seasonal, regional, and interannual variability in distribution and abundance were observed within and between species of forage fishes (herring, sandlance, capelin, and eulachon)(Stokesbury et al. in prep.; Appendix I). However, for the purposes of this study, it was found that in all years numbers of visible surface schools peaked in June and July. Because of this fish behavior, June and July are preferred months for this type of data collection. Objectives for June surveys vary slightly from those in July. In June, our main objective is to define the distribution and abundance of age-1 herring, pre-spawning capelin, and post-spawning eulachon. In July, once age-0 herring and sandlance have recruited to near-shore areas, our objective concerns mainly those two species, but we will examine multiple year classes for each. Data for July will come from Evelyn Brown's involvement with the APEX project.

During the month of June, a single broad-scale aerial survey covering PWS, the entrance to PWS, and the Outer Kenai from Hinchinbrook Entrance to Nuka Point (Figure 1) will be conducted. A survey of the entire area requires 6 days and consists of 3–6 hours each day flying a Cessna 185 float plane at approximately 110 knots. However, for this project, more days will be required since we will also be directing a capture/acoustic vessel. An area approximately 1/5 the size of PWS (about 3,400 km^2) is denoted at the beginning of each survey day and the pilot follows the shoreline within this area to the best of his ability. We will prioritize overflights in areas where fish are being captured by nets, acoustics, or underwater videos to maximize validation of sightings. Areas inaccessible due to topography or weather are not sampled. The transect or shoreline is followed in a single line but doubling back is allowed when school or recorded feature density is high, to ensure total counts within a given swath area. Since the flight path is recorded, the increase in sampling frequency of areas with high feature densities is measured to ensure that proper statistical weighting is given.

The preferred altitude range has been established at 275–365 m (900–1200 ft) based on school sizes measured during previous surveys. Juvenile herring schools (modal frequency 3–50 m^2) are much smaller than spawning aggregations (modal frequency 100–300 m^2) measured in Bristol Bay (Funk et al. 1995). Therefore, the preferred altitude for herring (Lebida and Whitmore,

1985) or capelin (Carscadden et al. 1994) spawner surveys (457 m or 1500 ft) was too high to distinguish 1 m^2 schools. An altitude of 305 m (1000 ft) provided a swath width of approximately 700 m (established in 1995; Brown and Norcross, in prep.), but allows distinction of an object as small as a single gull or sea otter. At times, lower altitudes were flown due to a low cloud ceiling, but each altitude change was noted on the computer during the survey.

Fish schools will be counted and surface area estimated using a sighting tube. The sighting tube is constructed of PVC pipe with a grid drawn on mylar on the end. The focal length of the tube is 216 mm and can be calibrated for ground distance covered by reference line (X) for any survey altitude, when length of the grid reference line (L), focal length of the tube (F), and survey altitude (A) are known, by using the following equation (Lebida and Whitmore 1985; Brady 1987):

$$X = A\,(L/F)$$

The use of the grid is particularly important for large schools. For elliptically shaped schools, maximum length and width provide a rough estimate of surface area; for irregularly shaped schools (U-shaped, long wavy bands, etc.) length and width of separate sections are measured and combined to give a total estimate. Video or still camera photos are taken as often as possible to provide validation of school recognition when matched with catches and for measurement of recognition error (explained below).

During the survey, both flight path (transect) and features along the path are recorded using a hand-held GPS connected to a laptop computer, with a flight log program recording latitude, longitude, and time of day in 2-second intervals. At the beginning of each flight, information detailing pilot, weather, water visibility, wind, wind direction, tide stage, wave height, and other notes concerning the survey are recorded in the log program. Information or "sightings" such as numbers of fish schools, species of fishes, surface area of schools, numbers of birds or mammals, behavior of birds, or oceanographic features (tidal fronts) are recorded on the computer log program. Net captures, acoustic surveys, diver surveys, validation via landing on top of schools, or observations recorded on film are also recorded on the log program. Single or double letter codes are used for fishes, birds and mammal species (such as h for herring, sd for sandlance, kw for kittiwakes, hs for harbor seals, etc). Bird behavior is recorded as foraging or plunging (pl), resting on water (rw), resting on shore (rs), aggregated tightly on water over school (tw), traveling (tr), or flying in a "broad area search" (bs).

In order to minimize the effect of survey condition bias on accuracy of the results, we selected criteria for determining whether a survey should be flown or not. We do not fly if the winds are over 25 knots (creating a sea state of over 1 on the Beaufort wind scale or wave heights of more than 1 m), if the average ceiling (cloud cover) is below 200 m, or on rainy days.

Adaptive sampling methods using a modified line transect have been adopted for this survey. The main data output is a measure of relative (rather than absolute) density of fish schools and other detectable events such as foraging gulls (Irons 1992). We modified the standard line transect methodology (Thompson 1992; Krebs 1989) by following a shore line as a transect path (except when offshore). We will sample offshore areas where they are targeted (Hinchinbrook Entrance) or when crossing bays and bodies of water to reach other shorelines. We eliminated the problem of decreasing detectability with distance perpendicular to the transect center (Krebs 1989;

Gunderson 1993) because we established an altitude-dependent visual swath with uniform detectability. Therefore, we assumed that detectability was a function of survey conditions (water visibility, precipitation, surface water disturbances, or wind-driven waves), glare, spatial distribution of schools and school aggregates, and surveyor bias. This method is equivalent to the "narrow-strip" method suggested by Thompson (1992). Only features observed within the visual swath are recorded. It is therefore likely that density or abundance estimates derived from this survey are a function of: 1) effective area surveyed (altitude), 2) detectability, and 3) density of the detections along the transect line (Thompson 1992). Surveyor bias is related to density because counting error increases with counting rate (especially in situations where schools are plentiful [Gunderson 1993]). In this situation, most surveyors tend to undercount (Krebs 1989). It is for this reason that variability introduced by surveyor bias is considered in the final treatment of the results (Brown and Norcross, in prep.).

Vessel Support

Throughout the survey, we will employ a fishing vessel and direct catches on schools observed from the air. In addition, we will synoptically measure the acoustic density of schools observed from the air. Methodologies for the acoustic and net captures are similar to those used by the SEA program for the past three years (Cooney 1997). The nets used include a 17-fathom anchovy seine, a 15-m small-mesh purse seine (operated from a skiff), and a small trawl designed especially for forage fishes.

Each day the vessel will be directed to an area over which reconnaissance flights were made on the preceding day. The coordinates of target schools will be communicated and the vessel will contact the aircraft when on site. The aircraft will then double back and set the vessel on a number of schools using a pre-assigned numbering system for ease of identification of individual schools during post-processing of the data. In this manner, the aircraft will "leap-frog" the vessel until the entire target study area is covered.

Acoustic density measurements of each school will allow aerial estimates of surface area to be converted to biomass. It is also possible, with smaller schools, that an entire school can be captured and weighed for absolute biomass measurements. The vessel will be required to have a brailer bag attached to a scale, standard equipment for fishing vessels which double as tender vessels during small-boat fisheries. The addition of acoustics and the ability to capture and weigh entire schools is in direct response to reviewer comments the authors have received (R. Spies, Applied Sciences, personal communication). If this validation method can be accomplished in conjunction with an active fishery (in the case of capelin), we will coordinate with ADFG.

Estimating Density

Using narrow-strip transect methodology we can ignore the probability of sightings with distance estimates. The narrow strip is the visual swath. Density is estimated using the following equation (Thompson 1992):

$$\hat{D} = \frac{y_0}{2w_0 L}$$

where y_0 is the number of fish or total surface area of fish schools spotted along the transect length L, w_0 is the maximum distance from the center line to which detectability is uniform ($2w_0$

is equivalent to swath width), and $\hat{D}$ is the estimate of fish schools or school surface area along that transect section. Within a study region with an area A, the total number of fish schools or school surface area ($\hat{\tau}$) is estimated as:

$$\hat{\tau} = A\hat{D} = \frac{Ay_0}{2w_0 L}$$

Because transects were not selected randomly, we do not attempt to expand the density estimates to areas not surveyed. Since all schools recorded were inside the visual swath, no observations are left out of the analysis. This removes the disadvantage of using narrow-strip methodology, since, generally, observations are left out of the analysis (Thompson 1992). It would be difficult to use other methods of expansion of the data since estimates of distance off the transect line were not estimated in this survey.

Oceanographic Data

The oceanographic data come from multiple sources and are available over a range of time and space scales. For the purposes of this study, we will focus on data for the time period that eggs are laid (April) until larvae recruit to near-shore nursery bays where they will spend the next year (July). This is the time period during which partitioning of the population occurs if it happens at all. From 1993 on, satellite images are available in a variety of formats, each providing different information about PWS and the adjacent Gulf of Alaska. Advanced Very High Radiation Radiometer (AVHRR) images indicate eddies and currents. Sea-Viewing Wide Field-of-View Sensor (SeaWiFS) images provide ocean color, and Synthetic Aperture Radar (SAR) images show ocean front structure under cloud cover. These three images together, along with a subset of hydrographic data within regions of interest, may indicate structure that affects partitioning of the herring population (during larval drift and rearing in nursery areas). A satellite imaging specialist at the UAF Geophysical Institute will compile and summarize these images for the project. For years previous to 1993, oceanographers at the Prince William Sound Science Center have compiled a set of historic hydrographic and meteorological data for the region. By subsampling this dataset within the same regions subsampled for the recent data series, hydrographic data should be comparable between the two time periods (post- and pre-1993). Therefore, we should be able to look retrospectively at the same conditions that may act in partitioning. We will most likely do this for a subset of the 20 years, as there are holes in the historic dataset. We will subcontract an oceanographer from the Prince William Sound Science Center for help with the interpretation and analysis.

Statistical Analysis

A variety of graphic and statistical methods will be applied for this analysis. The distribution data vary in time and space. Sampling is discrete over time, with a month as a unit of time; we therefore do not expect temporal autocorrelation problems. The spatial data, however, are very likely autocorrelated; we propose three separate approaches to different aspects of the study robust to autocorrelation problems.

For the comparison of larval and juvenile herring distribution, we propose using a Cramér-von Mises test described by Syrjala (1996). This test is non-parametric and is appropriate for testing the difference between the spatial distribution of two populations (in this case, both are of the same species). The aerial data set will be sub-sampled randomly within an area encompassing the

larval study area. Envision that the total area resembles a rectangle—once both data sets are compiled within a single defined rectangular region, the data must be normalized to account for the difference in scale and population size within a Cartesian coordinate system. A cumulative distribution function (the sum of the normalized densities along a line within the rectangle) is calculated for each population and the square of the distance between the two is calculated, resulting in the test statistic. Multiple iterations of the test statistic should be run, from at least each of the four corners of the rectangle, and the values averaged. The null hypothesis is that the distribution between larvae and juveniles is coherent (i.e., the location of pre-metamorphic larval herring is consistent with the resulting location of age-0 herring observed).

Once the preceding step has been accomplished, the rigorous analysis of ecological effects on fish distribution can be performed. This will include the relationship between juvenile herring distribution and resulting adult year-class strength. There are many possible approaches for this type of analysis. The Mantel test can be applied to test for specific habitat components (from the oceanographic variables) affecting fish distribution (Legendre and Fortin 1989). We can also apply a general additive model (GAM) approach (Swartzman et al. 1992; Wright and Begg 1997). An important step in this analysis will be the examination of the residuals of any continuous variable within each region. If there are serious departures from uniform variance, transformations may have to be performed. Assumptions of linearity and normality are not critical in this analysis.

The GAM approach involves several steps. The first involves compartmentalizing all the variables, biological and physical, within the regions identified. If the relationships between the predictor and response variables are largely linear (or can be linearized via transformations), we can perform a simple analysis of variance (ANOVA) and multiple regression to identify the important parameters. However, it is anticipated the many of the relationships will be non-linear and that oceanographic variables will be non-normal. The choice for GAM is therefore clear. The general model takes the form:

$$\ln(R) = \alpha + \sum_{j=1}^{p} f(E_j) + g(S) + \varepsilon$$

where R is the year-class strength, α is an intercept parameter, p is the number of environmental predictor variables, $f(E_j)$ are a function of the environment predictor variables (continuous or class; linear or non-linear forms), $g(S)$ is the function of egg abundance ("mile-days" of spawn) (modified from Hastie and Tibshirani 1990; Jacobson and MacCall 1995; Swartzman et al. 1992). Multiple iterations of this model will be run with some variables falling out and others emphasized. The significant findings of the procedure will be reported.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The University of Alaska Fairbanks is the main entity included in this proposal. We will use satellite images from the Geophysical Institute at UAF, obtained under the companion proposal, "Effect of Herring Egg Distribution and Ecology on Year-Class Strength and Adult Distribution". We will contract with PWSSC for an oceanographer to assist in the compilation and interpretation of oceanographic data. We will use historic data provided by the Alaska Department of Fish and Game and will share all findings with that agency. In addition, ADFG

will provide approximately $8000 in field support. We will also continue to coordinate with the APEX project and other sea bird researchers interested in the study area. We will contract with local fishermen as catcher vessels.

If this project is continued for a second year, it is anticipated that the role ADFG will play in the analysis, interpretation, and report completion will increase dramatically.

SCHEDULE

A. Measurable Project Tasks for FY 99 (October 1, 1998 – September 30, 1999)

November 30:	Overlay the distribution of larval herring and age-0 herring observed during late June and July; compare the coherence between the two in one- and two-dimensional formats
December 31:	Test for statistically significant differences in the two distributions Acquire satellite and oceanographic data matching the time and space scale of the juvenile herring distribution
February 28:	Use extended graphical analysis to identify oceanographic regions within the Sound and use the hydrographic data to pool areas with similar characteristics Overlay the distribution of fish and the oceanographic regions; describe that relationship
March 24:	Prepare for and attend the EVOS symposium
April 30:	Explore whether biological indices of juvenile herring (e.g., growth rates or energetic content) vary on a scale similar to the oceanographic regions
June 30:	Conduct a single broad-scale aerial survey of PWS during the month of June, with vessel support

B. Project Milestones and Endpoints

FY 99

December 31:	Determine the coherence between larval and juvenile herring distributions
February 28:	Determine how juvenile herring and other forage fish distributions vary with oceanographic regions
March 24:	Participate in EVOS symposium and workshop
April 30:	Begin to address the relationship between age-1 herring and year-class strength
June 30:	Field work completed for FY99

FY 00

August 31:	Continue documenting long-term trends in forage fish distribution and abundance Re-evaluate the time series with 1999 field season added
September 28:	Prepare first project publication as annual or final report
June 30:	Continue documenting long-term trends in forage fish distribution and abundance

April 30:	Complete statistical models for herring recruitment analysis
September 28:	Complete project publications as final report
September 30:	Within each oceanographic region determine the mean and variance of the juvenile herring distribution data; run a residual analysis to look for violations of uniform variability; plot the data for checking assumptions of normality (this will, to some extent, determine the appropriate tests) Plot the regional abundance estimates versus regional year-class strength (lagged 3–4 years) for a variety of pooled regional scenarios. Report on the findings of all three analyse
June 30:	Continue to monitor the distribution and abundance of age-1 herring

Future tasks

1. Built upon Objectives 1, 3, and 4 for FY99 until a sufficient number of data points exists to analyze the relationships statistically (n > 3 years).

2. Perform straight regressions between regional juvenile herring abundance and regionalized year-class strength (after checking assumptions); multiple iterations can be performed varying regional pooling of parameters.

3. Pending promising relationships, set up a general additive model (GAM) with the response variable as year-class strength (lagged 3–4 years) and the predictor variables as regional abundance of age-0 and age-1 juvenile herring, a class variable for oceanographic regions and the oceanographic variables within each region.

4. Perform other tests, such as the Mantel Test or develop a GAM for other forage species and physical variables such as depth, distance from shore, hydrographic information, or currents, depending on what is available.

5. Determine statistically significant relationships; proceed with further analysis of regional differences as warranted using only the variables showing significant relationships. One result may be pooling of regions with similar physical and biological dynamics, correlation coefficients, and temporal trends.

6. Complete analysis of the data and compile the results in a publication endpoint.

C. Completion Date

September 30, 2000 for analyses as proposed.

September 30, 2009 for monitoring component (forage fish distribution).

PUBLICATIONS AND REPORTS

An annual report will be prepared for the April 1999 deadline, but our final report will be in the form of a publication reprint. The herring-related publications will also be included as dissertation chapters for a Ph.D. by the Principal Investigator. The draft title for the FY99 publication is:

Recruitment of larval Pacific herring and other forage fish to the near-shore waters of Prince William Sound, Alaska, and effects of oceanographic structure on distribution. E.D. Brown, S. Vaughn, K. Engle, and B.L. Norcross

For the second year of the project, the publications would most likely be entitled:

Statistical models of ecological factors affecting juvenile herring and other forage fish distribution and abundance. E.D. Brown and B.L. Norcross

Effects of juvenile Pacific herring distribution and oceanographic conditions on year-class strength and adult distribution. E.D. Brown, S. Vaughn and B.L. Norcross

PROFESSIONAL CONFERENCES

During FY99 we will attend the EVOS symposium scheduled for March and the Alaska Chapter meeting of the American Fisheries Society (exact in-state location unknown). We would also like to attend the Lowell Wakefield Symposium entitled, Spatial Processes and Management of Fish Populations, October 27–30, 1999. Although this meeting occurs outside the fiscal year and would be budgeted for in FY 00, preparations and manuscripts would be prepared in FY99. In the future, we plan to participate in the International Herring Symposium scheduled for January 2000, location unknown.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project represents a synthesis of historic data and current information resulting from EVOS restoration research. Data from the SEA project (98320) and ADFG are pivotal in the research. This will also be one of the first attempts to relate satellite data to effects on marine fish. The results from this study also dovetail with work on herring recruitment being completed by Terry Quinn (UAF Juneau Center) and Erik Williams. The scale of the analyses differ substantially.

PROPOSED PRINCIPAL INVESTIGATORS

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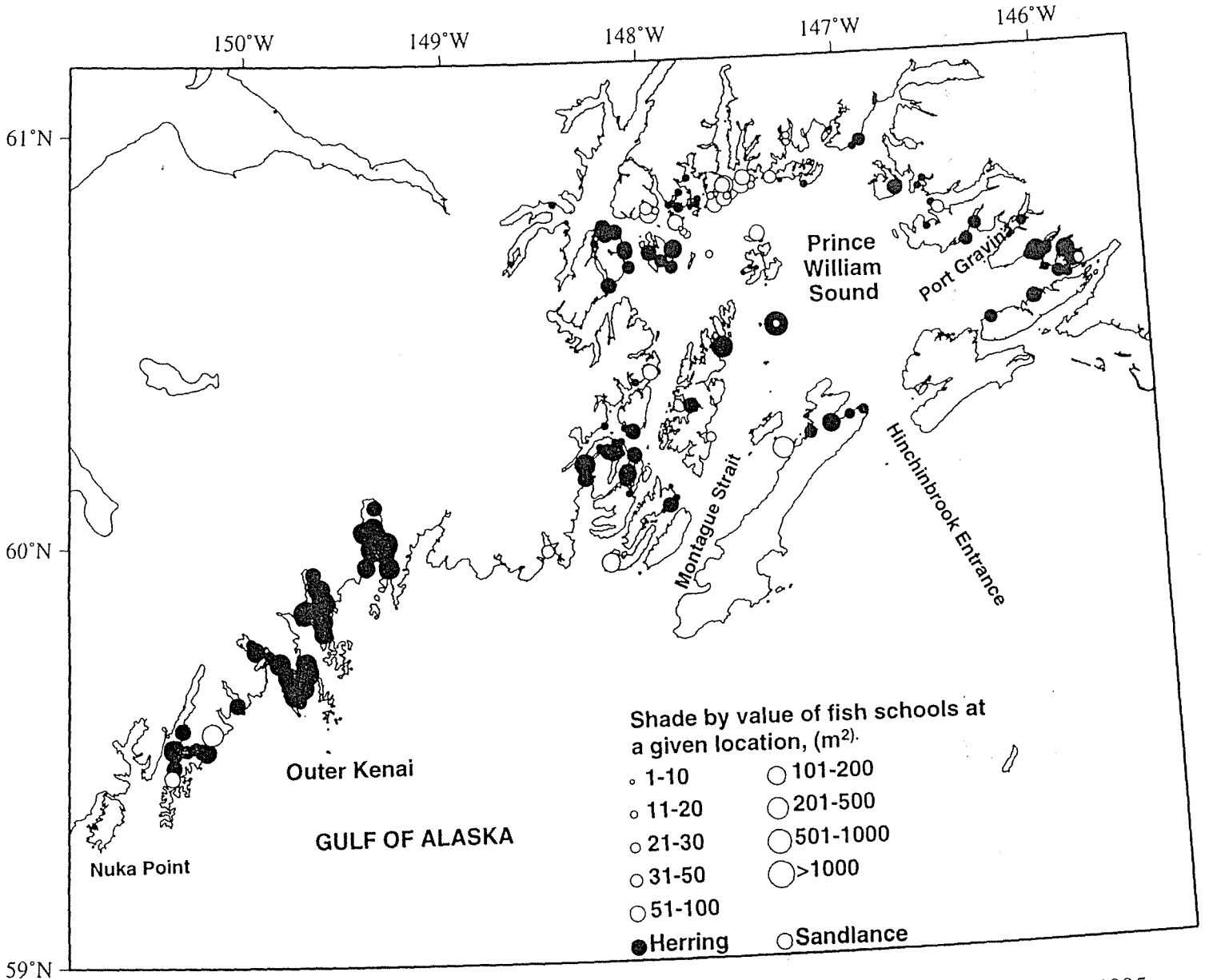

Figure 1. The study area proposed for this project and an example of summer fish distribution, July 1995.

PRINCIPAL INVESTIGATOR

Evelyn D. Brown

The Principal Investigator is responsible for all project tasks and objectives.

Education:

B.S. Zoology and Chemistry, University of Utah, Salt Lake City, 1977
M.S. Fisheries Biology and Aquacultural Engineering, Oregon State University, Corvallis, 1980

Experience:

Project Manager, University of Alaska Fairbanks, 1995 to present.
Herring Research Biologist, Alaska Department of Fish and Game, Cordova, Alaska 1988–1995.
Principal Investigator, Injury to Prince William Sound Herring, NRDA FS 11, 1989–1992.
Fisheries Biologist, Alaska Department of Fish and Game, Cordova, Alaska, 1985–1987. Sonar projects, stream surveys, aerial surveys, and net sampling.
Commercial Fisherperson, various skippers, 1982–1984.
Fisheries Consultant, self-employed. Contracts included Prince William Sound Aquaculture Corporation for fish tagging and stream surveys; Metlakatla Indian Community on Annette Island for salmon stream survey manual and estimate of production potential and for environmental impact statement for logging activity.
Fisheries Biologist, Florida Department of Natural Resources, St. Petersburg, Florida, 1987–1988. Employed for one winter to conduct a hydroacoustic survey of mullet in the Manistee River and in Tampa Bay; also worked on a mullet tagging project encompassing the entire west coast of Florida.
Fisheries Management Biologist, Metlakatla Indian Community, Annette Island, Alaska, 1980–1982. Completed an oyster culture feasibility study, provided management recommendations on shellfish harvests, participated in herring egg deposition survey and salmon management through the use of commercial fish traps.

Current Research Interests:

- Juvenile herring population dynamics; interactions of biological and physical parameters
- Spatial patterns of forage fish distribution and related ecological parameters
- Prince William Sound herring stock model

Field Experience:

From 1978 to the present, I have participated in numerous field programs, from ground surveys of streams out of skiffs, to aerial surveys of salmon streams and herring aggregations, to SCUBA surveys of herring egg deposition and shellfish resources, to open ocean cruises aboard large research platforms performing large scale fisheries oceanography surveys (R/V *Oshoro Maru*, 1983). I have operated fish weirs and fixed-site sonars from remote field camps and from trailers located in urban areas (Bradenton, Florida). I have repaired outboards, carried firearms for protection from dangerous animals (brown bears and wolves), and assisted in construction of structures including cabins and tent platforms. I have operated vessels ranging from 12 to 72 ft by myself and assisted in skippering vessels up to 84 ft (crabber out of Kodiak, Alaska). I have experience operating navigational equipment including GPS, Loran, Radar, and Searchlight sonar, and using nautical charts, compasses, parallels, etc.

Publications, Contributed Publications, and Reports:

Final Reports Submitted to Trustee Council:

Biggs, E.D. and T.T. Baker. Studies on Pacific herring in Prince William Sound following the *Exxon Valdez* oil spill, 1989–1992 (former FS11 G-egg loss and H-fecundity are included with this report).

E.D. Brown, T.T. Baker, F. Funk, J.E. Hose, R.M. Kocan, G.D. Marty, M.D. McGurk, B.L. Norcross and J.W. Short. 1994. Injury to Prince William Sound herring following the *Exxon Valdez* oil spill: Final Report for Natural Damage Assessment Fish/Shellfish Study No. 11; EVOC T., Anchorage, AK, 310 pp.

Baker, T.T. and E.D. Biggs. 1993. Measurements of the survival of Pacific herring eggs in the field following the *Exxon Valdez* oil spill, 1989–1991.

Journal Articles:

Brown, E.D., T.T. Baker, J.E. Hose, R.M. Kocan, G.D. Marty, M.D. McGurk, B.L. Norcross and J. Short. 1996. Injury to the early life history stages of Pacific herring in Prince William Sound after the *Exxon Valdez* oil spill. Am. Fish. Soc. Symp. 18, pp. 448–462.

Brown, E.D., B.L. Norcross and J.W. Short. 1996. An introduction to studies on the effects of the *Exxon Valdez* oil spill on early life history stages of Pacific herring, *Clupea pallasi*, in Prince William Sound, Alaska. *Can. J. Fish. Aq. Sci.* 53: 2337–2342.

Brown, E.D. and E.M. Debeves. In press. Effects of the *Exxon Valdez* oil spill on in situ survival of Pacific herring (*Clupea pallasi*) eggs. *Can. J. Fish. Aq. Sci.*

McGurk, M.D. and E.D. Brown. 1996. Egg-larval mortality of Pacific herring in Prince William Sound, Alaska, after the *Exxon Valdez* oil spill. *Can. J. Fish. Aq. Sci.* 53: 2343–2354.

Hose, J.E., M.D. McGurk, G.D. Marty, D.E. Hinton, E.D. Brown and T.T. Baker. 1996. Sublethal effects of the *Exxon Valdez* oil spill on herring embryos and larvae: Morphologic, cytogenetic, and histopathological assessments, 1989–1991. *Can. J. Fish. Aq. Sci.*

Kocan, R.M., J.E. Hose, E.D. Brow, and T.T. Baker. 1996. Pacific herring (*Clupea pallasi*) embryo sensitivity to Prudhoe Bay petroleum hydrocarbons: Laboratory evaluation and *in situ* exposure at oiled and unoiled sites in Prince William Sound. *Can. J. Fish. Aq. Sci.* 53: 2366–2375.

Norcross, B.L., J.E. Hose, M. Frandsen and E.D. Brown. 1996. Distribution, abundance, morphological condition and cytogenetic abnormalities of larval herring in Prince William Sound, Alaska, following the *Exxon Valdez* oil spill. *Can. J. Fish. Aq. Sci.* 53: 2376–2387.

Kocan, R.M., G.D. Marty, M.S. Okihiro, E.D. Brown and T.T. Baker. 1996. Reproductive success and histopathology of individual Prince William Sound Pacific herring three years after the *Exxon Valdez* oil spill. *Can. J. Fish. Aq. Sci.* 53: 2388–2393.

Marty, G.D., J.E. Hose, M.D. McGurk, E.D. Brown and D. E Hinton. In press. Histopathology and cytogenetic evaluation of Pacific herring larvae exposed to petroluem hydrocarbons in the laboratory or in Prince William Sound, Alaska, after the *Exxon Valdez* oil spill. *Can J. Fish. Aq. Sci.*

CO-PRINCIPAL INVESTIGATOR

Brenda L. Norcross

The Co-Principal Investigator will review survey design, data, and analysis; review reports and publications.

Education:

A.B., Biology, MacMurray College, Jacksonville, Illinois, 1971
M.S., Biology, St. Louis University, St. Louis, Missouri, 1976
Ph.D., Marine Science, Virginia Institute of Marine Science, School of Marine Science, College of William and Mary, Gloucester Point, Virginia, 1983

Experience:

Associate Professor, Institute of Marine Science, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, 1989–present
Sabbatical leave, Caribbean region, 1997–1998
Assistant Professor, Institute of Marine Science, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, 1989–1996
Assistant Professor, Division of Biological Oceanography and Fisheries Science, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia, 1986–1988
Assistant Professor, Computer Center, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia, 1984–1986
Research Biologist/Oceanographer, Ocean Research and Education Society, Inc., Gloucester, Massachusetts, 1984
Graduate Research Assistant, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia, 1978–1983
Research Associate and Laboratory Supervisor, Renal Division, Department of Pediatrics, Washington University, School of Medicine, St. Louis, Missouri, 1973–1978
Science and Math Teacher, Andrew Jackson Junior High School, Prince George's County Public Schools, Suitland, Maryland, 1971–1973

Field Experience:

- S/V *Phaedrus,* 52-foot ketch, Sabbatical leave – live aboard, Sailing techniques, applied oceanography, meteorology, climatology and fisheries (Florida, The Bahamas, Turks and Caicos, Dominican Republic, Puerto Rico, U.S. Virgin Islands, British Virgin Islands, St. Martin, Anguilla, St. Barths, St. Eustatius, St. Kitts, Nevis, Antigua, Montserrat, 9 months), 1997–98.
- One fisheries vessel, Principal Investigator, Pelagic fish, zooplankton, hydroacoustics, oceanography, underwater camera (Prince William Sound, 7 days), 1998.
- One–five fisheries vessels, Principal Investigator, Pelagic fish, zooplankton, hydroacoustics, oceanography, underwater camera, aerial surveys (Prince William Sound, 34 days), 1997.
- 26-foot Boston whaler, Principal Investigator, Inshore demersal fish and crabs, sediment, and CTD (Kodiak Island, 10 days), 1997.
- R/V *Tiglax*, Principal Investigator, Near-shore demersal fish, mid-water fish, sediment, CTD, and underwater camera (Aleutians to Homer, AK, 26 days), 1997.

- F/V *Tracy Ann*, Principal Investigator, Near-shore demersal fish, mid-water fish, sediment, CTD, and underwater camera (Forrester Island, 7 days), 1997.
- Five fisheries vessels, Principal Investigator, Pelagic fish, zooplankton, hydroacoustics, oceanography, aerial surveys (Prince William Sound, 60 days), 1996.
- F/V *Bering Explorer*, Chief Scientist and Principal Investigator, Near-shore demersal fish, sediment, underwater camera, and CTD (Lower Cook Inlet, 8 days), 1996.
- 26-foot Boston whaler, Principal Investigator, Inshore demersal fish and crabs, sediment, and CTD (Kodiak Island, 12 days), 1996.
- R/V *Tiglax*, Principal Investigator, Near-shore demersal fish, sediment, and water samples (Aleutians to Homer, AK, 34 days), 1996.
- 28-foot skiff, Principal Investigator, Inshore demersal fish and crabs, benthos, sediment, and CTD (Kachemak Bay, 30 days), 1996.
- Six fisheries vessels, Principal Investigator, Pelagic fish, hydroacoustics, oceanography, aerial surveys (Prince William Sound, 22 days), 1995.
- 28-foot skiff, Chief Scientist and Principal Investigator, Inshore fish and crabs, benthos and sediment (Kachemak Bay, 7 days), 1994.
- 26-foot Boston whaler, Chief Scientist and Principal Investigator, Inshore fish and crabs, benthos and sediment (Kodiak Island, 12 days), 1994.
- 24-foot skiff, Chief Scientist and Principal Investigator, Inshore fish, benthos and sediment (Afognak Island, 8 days), 1994.
- F/V *Maritime Maid*, Fisheries Scientist, Distribution of juvenile fishes (Aleutian Islands, 16 days), 1994.
- 26-foot Boston whaler, Chief Scientist and Principal Investigator, Inshore fish and crabs, benthos and sediment (Kodiak Island, 9 days), 1993.
- F/V *Big Valley*, Chief Scientist and Principal Investigator, Inshore fish, benthos, sediment, ROV and water samples (Kodiak Island, 14 days), 1992.
- 24-foot skiff, Chief Scientist and Principal Investigator, Inshore fish, benthos, sediment and water samples (Kodiak Island, 6 days), 1992.
- 21-foot Boston whaler, Scientist, Inshore fish (Auke Bay, 2 days), 1992.
- F/V *Big Valley*, Chief Scientist and Principal Investigator, Inshore fish, benthos, sediment and water samples (Kodiak Island, 7 days), 1991.
- 24-foot skiff, Chief Scientist and Principal Investigator, Inshore fish, benthos, sediment and water samples (Kodiak Island, 12 days), 1991.
- R/V *Alpha Helix*, Associate Scientist and Principal Investigator, Distribution of larval fish (Alaska to Hawaii, 17 days), 1991.
- R/V *Alpha Helix*, Associate Scientist, Distribution of larval fish (Gulf of Alaska, 3 cruises, 9 days), 1990.
- R/V *Alpha Helix*, Chief Scientist and Principal Investigator (One cruise), Associate Investigator (three cruises), Distribution of larval fish, oil spill (Prince William Sound, 27 days), 1989.
- F/V *Jennie Girl*, Principal Investigator, Distribution of larval fish, oil spill (Prince William Sound, 10 days), 1989.
- NOAA Ship *John Cobb*, Chief Scientist and Principal Investigator, Distribution of larval fish, oil spill (Prince William Sound, 7 days), 1989.
- R/V *Little Dipper*, Chief Scientist and/or Principal Investigator, Distribution and transport of larval fish (Resurrection Bay, 4 cruises, 20 days), 1989.

Selected Publications:

Norcross, B. L., A. Blanchard and B. A. Holladay. In press. Models for defining near-shore nursery areas of flatfishes in Alaskan waters. *Fish.Oceanog.*

Moles, A. and B. L. Norcross. 1998. Effects of oil-laden sediments on growth and health of juvenile flatfishes. *Can. J. Fish. Aquat. Sci.* 55: In press.

Norcross, B. L., F. -J. Müter and B. A. Holladay. 1997. Habitat models for juvenile flatfishes around Kodiak Island, Alaska. *Fish. Bull.* (U.S.) 95(3): 504–520.

Norcross, B. L., J. E. Hose, M. Frandsen, and E. D. Brown. 1996. Distribution, abundance, morphological condition, and cytogenetic abnormalities of larval herring in Prince William Sound, Alaska, following the *Exxon Valdez* oil spill. Can. J. Fish. Aquat. Sci. 53: 2376–2387.

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FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$6.0
Travel		$0.0
Contractual		$137.1
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$143.1
General Administration		$10.5
Project Total	$0.0	$153.6
Full-time Equivalents (FTE)		1.0

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$155.0	$155.0	$155.0		

Dollar amounts are shown in thousands of dollars.

Other Resources

Comments:

FY 99

Project Number: 99376
Project Title: Distribution and Ecology of
Forage Fish and Effects on Herring Year-Class Strength
Agency: ADF&G

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared:

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
						0.0
To be named	Field Tech		1.0	3.5	2.5	6.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.0	3.5	2.5	
					Personnel Total	$6.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
					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

FY 99

Prepared:

Project Number: 99376
Project Title: Distribution and Ecology of
Forage Fish and Effects on Herring Year-Class Strength
Agency: ADF&G

FORM 3B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

Contractual Costs:				Proposed
Description				FY 1999
4A Linkage				135.1
Vessel charter	10 days	at	$200 per day	2.0
When a non-trustee organization is used, the form 4A is required.			**Contractual Total**	$137.1

Commodities Costs:	Proposed
Description	FY 1999
Commodities Total	$0.0

FY 99

Prepared:

Project Number: 99376
Project Title: Distribution and Ecology of
Forage Fish and Effects on Herring Year-Class Strength
Agency: ADF&G

FORM 3B
Contractual &
Commodities
DETAIL

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
			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

FY 99

Project Number: 99376
Project Title: Distribution and Ecology of
Forage Fish and Effects on Herring Year-Class Strength
Agency: ADF&G

FORM 3B
Equipment
DETAIL

Prepared:

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$57.8
Travel		$5.0
Contractual		$41.8
Commodities		$1.0
Equipment		$2.5
Subtotal	$0.0	$108.1
Indirect		$27.0
Project Total	$0.0	$135.1
Full-time Equivalents (FTE)		0.9
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$109.8	$109.8	$109.8		

Dollar amounts are shown in thousands of dollars.

Comments:

The Indirect rate is 25% TDC, as negotiated by the Exxon Valdez Oil Spill Trustee Council with the University of Alaska.

FY 99

Prepared:

Project Number: 99376
Project Title: Distribution and Ecology of
Forage Fish and Effects on Herring Year-Class Strength
Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 1999
	Brown, E.	Principal Investigator/ Project Manager	4.0	6.1		24.4
	Norcross, B.	Principal Investigator/ Assoc. Professor	0.5	8.5		4.3
	Moreland, S.	Laboratory Assistant	4.0	3.7		14.8
	Vallarino, M.	Programmer	2.0	5.1		10.2
	TBN	Statistician	0.5	9.1		4.6
						0.0
						0.0
						0.0
						0.0
		Adjustment to recognize rounding				-0.5
						0.0
						0.0
		Subtotal	11.0	32.5	0.0	
					Personnel Total	$57.8

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1999
	Fairbanks to Cordova - field work (Moreland - on vessel)	0.3	1	5	0.1	0.8
	Fairbanks to Cordova - field work (Brown - aerial surveys)	0.3	1	15	0.1	1.8
	Fairbanks to Anchorage - EVOS Meeting	0.3	1	5	0.1	0.8
	Fairbanks to Anchorage - present at AFS Meeting	0.4	1	5	0.1	0.9
						0.0
						0.0
						0.0
	Adjustment to recognize rounding					0.7
						0.0
						0.0
						0.0
						0.0
				Travel Total		$5.0

FY 99

Prepared:

Project Number: 99376
Project Title: Distribution and Ecology of
Forage Fish and Effects on Herring Year-Class Strength
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
Communications	0.3
Publication Costs	1.0
Subcontract with PWSSC - acoustic measurements	9.0
Subcontract with PWSSC - oceanographic analyses	8.5
Vessel Charter - large seiner with jitney (wet) (10 days at $1300/ day)	13.0
Aircraft charter (4hr/day x 8 days at $250/hr)	8.0
Aircraft charter (4hr/day x 8 days at $250/hr)	0.5
Air freight for samples	1.5
Equipment Repair (electronic measuring boards, GPS, etc)	
Contractual Total	$41.8

Commodities Costs:	Proposed FY 1999
Description	
Skiff fuel	0.5
Field supplies (bags, gloves, raingear)	0.5
Commodities Total	$1.0

FY 99

Prepared:

Project Number: 99376
Project Title: Distribution and Ecology of Forage Fish and Effects on Herring Year-Class Strength
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities DETAIL

Improving population models for herring (*Clupea pallasi*) management along the northern Gulf of Alaska

Project Number:	99378
Restoration Category:	Research
Proposer: Game	Alaska Department of Fish and
Lead Trustee Agency: Game	Alaska Department of Fish and
Cooperating Agencies:	None
Alaska SeaLife Center:	No
Duration:	1st year, 3-year project
Cost FY 99:	$ 384.3K
Cost FY 00:	$ 403.3K
Cost FY 01:	$ 182.5K (close-out)
Cost FY 02:	$ 0.0
Geographic Area:	PWS, Kodiak, Lower Cook Inlet
Injured Resource/Service:	Pacific herring/commercial fishing

ABSTRACT

Pacific herring is a key species in the marine ecosystem affected by the 1989 *Exxon Valdez* oil spill. Three herring stocks spawning at Kodiak Island, Kamishak Bay, and PWS are currently recognized in the spill impacted area along the northern Gulf of Alaska. The age-structured analysis models used to project biomass and set harvest levels for these stocks require estimates of catch at age in all fisheries exploiting a stock, gear selectivity, weight at age, and spawning biomass. Project 99378 will develop better tools for (1) identifying discrete stocks of herring in

mixed-stock fisheries, (2) projecting weight at age, and (3) estimating spawning biomass. Project results will be applied by managers to improve the population models used to set harvest levels.

INTRODUCTION

Pacific herring *Clupea pallasi* within the spill area, and particularly within Prince William Sound (PWS), were injured by the 1989 *Exxon Valdez* oil spill (Brown 1995) and have not yet fully recovered (EVOS Restoration Plan 1998). Elevated levels of physical and genetic abnormalities in newly hatched larvae and reduced hatching success of embryos were documented in 1989 (Brown 1995). Significant histopathological damage was measured in adults collected in oiled areas in both 1989 and 1990 confirming exposure of the fish to toxins (Brown 1995). In 1993, the herring population in PWS collapsed. The total observed spawning population was less than one third of preseason predictions and the average sizes of herring in each age class were some of the smallest on record. The total commercial harvest for that year was one of the lowest on record. In 1994, the total observed spawning population was below threshold biomass required to conduct a commercial harvest and no fishing occurred. Pathology studies indicated that viral hemorrhagic septicemia and the fungus *ichthyophonus hoferi* contributed most to the population decline (Meyers 1994, Marty et al. 1996).

Herring are an important component of the marine ecosystem providing a trophic pathway for energy flowing from secondary producers to apex predators. Throughout their life, herring are prey to birds (Logerwell and Hargreaves 1997), marine mammals (Iverson et al. 1997), invertebrates (e.g. hydromedusae: Wespestad and Moksness 1989), other fish (Tanasichuk et al. 1991), and humans (Fischer et al. 1997). Understanding the role herring occupy in the food web of marine ecosystems is relevant to sustaining viable populations of herring and the species that prey on them (Schweigert 1997).

Age-structured population (ASA) models are used to manage the herring populations along the northern Gulf of Alaska coastline. For management purposes, three herring stocks spawning at Kodiak Island, Kamishak Bay, and PWS are currently recognized in the spill impacted area along the northern Gulf of Alaska. The ASA models used to project biomass and set harvest levels for these stocks require estimates of catch at age in all fisheries exploiting a stock, gear selectivity, weight at age, and spawning biomass (Funk 1995, Otis and Bechtol 1997). Project 99378 will develop better tools for (1) identifying discrete stocks of herring in mixed-stock fisheries, (2) projecting weight at age, and (3) estimating spawning biomass. Three techniques will be evaluated for discrimination of stocks: scale pattern analysis (SPA), elemental analysis (EA), and fatty acid analysis (FAA). Analyses of historical databases and archived scale collections will be used to develop models relating herring growth to population size and environmental factors. Acoustic techniques will developed to estimate the biomass of spawning herring around Kodiak Island as well as provide data needed to better scale aerial survey estimates.

NEED FOR THE PROJECT

A. Statement of Problem

After the closure of the PWS commercial herring fishery in1993, which may have links to the

1989 oil spill, fishing effort shifted to the Kodiak area. This shift in fishing and processing effort greatly intensified the Kodiak area fishery, making this fishery much more difficult to manage, and many management sections around Kodiak are now closed due to low stock abundance. One of the underlying principles of sustainable fisheries management is the ability to monitor the dynamics (environmental, biological, and human induced) of individual populations (Mundy 1996). Harvest levels for herring stocks along the northern Gulf of Alaska coast are based on results of models which use information gathered from aerial surveys and catch sampling programs (Otis and Bechtol 1997). Several important model parameter values (e.g. annual recruitment, natural mortality) are not based on actual measurements, and the accuracy and precision of ancillary data used to scale model results (e.g. aerial surveys) is poorly known. Harvest levels around Kodiak Island have been based mainly on fishery performance data and observations of the fishery in over forty management sections. Project 99378 will determine the feasibility of acoustic surveys for assessing herring biomass around Kodiak Island as well as provide data needed to better scale aerial survey estimates.

The inability to accurately apportion the catch from mixed stock fisheries is a common problem that undermines fishery managers' abilities to manage populations discretely. The fall food\bait fishery in Shelikof Strait likely exploits fish that spawn at Kamishak Bay and Kodiak Island (Johnson et al. 1987). Many diverse techniques have been investigated to discriminate between fish populations including: nuclear and mtDNA analysis (Seeb 1995), enzyme electrophoresis (Schweigert and Withler 1990), parasite markers (Moles et al. 1990), scale pattern analysis (Ross and Packard 1990), otoliths thermal marking (Joyce et al. 1996), fluorescent markers (Beckman et al 1990), and meristic and morphometric characteristics (Schweigert 1990). While many of these techniques have proven successful for specific applications, each has its own set of limitations that may reduce its effectiveness in certain situations. For instance, DNA analysis and enzyme electrophoresis are often able to discriminate stocks on a broad geographic scale, however, these techniques can falter when even a small amount of genetic drift occurs between closely distributed populations. Project 99378 will conduct a comparative analysis of scale pattern analysis (SPA), elemental analysis (EA), and fatty acid analysis (FAA) for identifying herring originating from Kodiak Island, Kamishak Bay, and PWS. Our principal objective will be to determine which of these three stock identification tools or combination of biomarkers provided by them is the most accurate, precise, and cost-effective. The stock identification technique developed through this project will be applied to the Shelikof Strait fishery.

Fatty acid compositions of fish lipids have been investigated for decades (Ackman et al. 1963). Much of the early lipid research was directed at determining the commercial value of fish oils (e.g. Ackman 1966) and understanding how fat content relates to various life history functions (e.g. Rajasilta 1992). Because the composition of certain lipids can be closely related to the types of food recently ingested (Navarro et al. 1995), recent investigations have been directed at diet analysis and foraging distribution (e.g. Iverson et al 1997, Kirsch et al. *in press*). The composition of phospholipid fatty acids prominent in some body tissues (e.g., heart tissue, eggs) have been shown to have a more stable genetic or environmental basis that makes analysis of these tissues appropriate for stock identification studies. As early as the 1930's it was demonstrated that different stocks of fin whale *Balaenoptera physalus* could be distinguished by the degree of unsaturation of their oils (measured as iodine value: Lund 1934, as cited in Grahl-Nielsen et al. 1993). Recently, fatty acid analysis of eggs has been used to discriminate between

American lobster *Homarus americanus* populations (Castell et al. 1995), and also Baltic cod *Gadus morhua* stocks (Pickova et al. 1997).

Chemometry of fatty acids from heart tissue has been used to discriminate stocks of striped bass *Morone saxatilis* (Grahl-Nielsen and Mjaavatten 1992) and also Atlantic herring *Clupea harengus harengus* (Grahl-Nielsen and Ulvund 1990). It is often the fatty acid profile (i.e., unique composition of an array of fatty acid levels; also referred to as a 'signature' by Iverson et al. 1997 and 1998) that distinguishes individual stocks, and not a single distinct fatty acid. Considerable variability can naturally occur in the fatty acid profiles (especially lipid profiles) between individual fish (Viga and Grahl-Nielsen 1990). This variability can be influenced by changes in diet, water temperature, salinity, growth, reproductive cycle, and pollution (Viga and Grahl-Nielsen 1990). The fatty acid profiles of certain tissues (e.g., heart) and specific lipids (e.g., phospholipids) are considered more stable, but still exhibit some variability. Recent, as yet unpublished research, found significant differences in the fatty acid profiles of heart tissue extracted from representatives of 2 cod stocks that had been reared under identical conditions since hatching (Pers. Comm. Dr. Otto Grahl-Nielsen, University of Bergen, Norway, March 1998). Furthermore, the direct methanolysis techniques Dr. Grahl-Nielsen's lab developed reduce the high labor costs normally associated with fatty acid extraction and analysis without compromising significant results. Using a Super Critical Fluid Extractor to help automate the extraction process could make FAA even more cost-effective (Pers. comm., Ron Heintz, NMFS, Auke Bay Lab, March 1998). Although fatty acid analysis is not yet a proven stock identification tool, these recent published and ongoing studies indicate the technique can be both effectual and cost-effective.

Trace elemental analysis of otoliths has been used to identify stocks of pink snapper, (Edmonds et al. 1989), orange roughy (Edmonds et al. 1991), yellow-eye mullet (Edmonds et al. 1992), Atlantic cod (Campana and Gagne 1995, Campana et al. 1995), and salmonids (Kalish 1990). Otoliths are acellular, so once accreted, the material is not resorbed or reworked (Campana and Nielson 1985). As a result, otolith microchemistry can be used to identify the environments inhabited by fish during their life (Gunn et al. 1992, Radtke and Shafer 1992, Secor et al. 1994). The use of otoliths as records of environmental exposure is based on the premise that otolith microchemistry reflects differences in water chemistry in the environment (Radtke and Shafer 1992, Campana and Gagne 1994). The trace elemental composition of fish otoliths is determined by the elemental composition of the endolymph (Kalish 1989, 1991). The concentration of various trace elements in the environment and the physiology of the fish largely determine the composition of the endolymph. Physiological processes may be modified by temperature (Kalish 1991), or subtle differences in the genetics of the fish affecting the uptake of various elements and their inclusion in the endolymph (Thresher et al. 1994). Controlled laboratory studies have shown that otolith microchemistry is strongly affected by temperature, salinity and ontogeny (Fowler et al. 1995a, 1995b).

Successful application of trace otolith elemental analysis for stock discrimination is likely dependent on the extent of the differences in water chemistry between the environments inhabited by each stock. But, the need to identify stocks often arises when they are exploited in mixed-stock fisheries in the same environment. Two methods are commonly employed for otolith elemental analysis. Solution-based inductively coupled plasma mass spectrometry (ICPMS) is typically used to measure elemental concentrations in whole otolith samples or

portions of whole otoliths (Date 1991). Laser-ablation ICPMS is a technique that can be used to analyze specific loci (30 μm) on the otolith (Gray 1985, Denoyer et al. 1991). Solution-based ICPMS may successfully discriminate stocks that inhabit different environments exhibiting different water chemistries during the majority of their life history (Campana et al. 1995). Laser-ablation ICPMS may be a more appropriate technique for identifying stocks that spawn in different environments but later reside in similar environments (Coutant and Chen 1993). In this case, the microchemistry of the otolith accreted during the embryo or larval stage may indicate differences between stocks. It is unknown to what extent herring spawning around Kodiak Island, in Kamishak Bay or PWS may inhabit similar environments throughout their life history. Therefore, the proposed project will examine the efficacy of solution-based ICPMS of whole otoliths and laser-ablation ICPMS of the primordium of the otolith for discriminating these three herring stocks.

Scale pattern analysis has proven to be a useful method for separating stocks or groups of stocks of many species, including salmon (e.g. Cook and Lord 1978, Cook 1987), stripped bass (Ross and Packard 1990), and Norwegian herring (Barros and Holst 1995). Alaskan herring have also been evaluated for SPA (Rogers and Schnepf 1985, Johnson et. al 1987, Rowell et. al 1991), and there are some indications that the method can be successfully used to discriminate between spawning populations. For Bering Sea herring, Rogers and Schnepf (1985) and Rowell et. al (1991) used measurements of annual increment spacing combined with various transformations based on body size and scale size to identify herring captured in the Dutch Harbor bait fisheries. The studies used discriminate function analysis models which were specific to age class. Rogers and Schnepf (1985) concluded that with sufficient representation of stocks and by selecting scales from the preferred body area on herring, it is possible to create standards for the SPA composed of scales collected over different years to represent all age classes. Rowell et. al (1991) examined collections from a greater number of spawning populations than Rogers and Schnepf (1985) and found that while the method was sufficient for discriminating between some populations, there were difficulties when numerous stocks were present and there was a similarity in growth histories among most stocks. The experience of Barros and Holst (1995) was similar: the method appeared to work best when a broad geographic distance separated stock groupings at an earlier life stage before mixing as adults. Johnson et al. (1987) in their study on the origin of herring in the Shelikof Straits bait fishery, applied a similar method of using annual growth measurements as input into discriminate analysis models. That approach appeared to be able to separate out Kamishak stocks, but Kodiak and Afognak were not separable from each other and needed to be combined in the SPA.

Fish grow in response to the extrinsic influences of their environment constrained by the intrinsic influences of genetic predisposition for growth and of size already attained (Weatherley and Gill 1987, Weisberg 1993). Understanding how these intrinsic and extrinsic sources of variability influence growth is important for several reasons. The effects of stock size and environmental conditions on growth have been studied by a number of investigators (Peterman and Bradford 1987, Anthony and Fogarty 1985, Rijnsdorp and van Leeuwen. 1992, Kreuz et al. 1982, Stocker et al. 1985, Hagen and Quinn 1991), primarily because of the consequences that growth variation can have on reproductive potential through its influences on fecundity and spawn timing (Ware and Tanasichuk 1989), natural mortality, recruitment, and age at maturity (Schmitt and Skud 1978, Haist and Stocker 1985). Haist and Stocker 1985 stated that factors affecting growth rates

can be of fundamental importance to the understanding of the dynamics of exploited populations and the responses of natural populations to abundance and environmental influences have remained a central issue in population biology (Sinclair et al. 1982, Tanasichuk 1997). Growth variation has a strong impact on the selection of appropriate harvest policies through the use of demographic models that reflect these natural processes (Methot 1997, Tanasichuk 1997).

The underlying mechanisms for cyclic changes in annular growth for herring in the northern Gulf of Alaska are currently unknown. Herring from PWS have exhibited long-term cyclic changes in average body size that strongly coincided with cyclic changes in herring from Sitka Sound (Fritz Funk, ADFG, Juneau, unpublished data). In addition, a period of the lowest observed average body sizes for PWS herring coincided with a period of historic high abundance followed by a catastrophic population decline associated with outbreaks of viral hemorrhagic septicemia virus (VHSV) and *Ichthyophonus hoferi* (Marty et al. 1998). Although the links between herring energetic condition (growth) and disease susceptibility are not yet well understood, it is postulated that the observed drastic population decline was a result of density-dependant poor growth leading to decreased fitness and resistance to disease. Analysis of growth increments between annular patterns on scales can provide a means to reconstruct past growth changes that can help in determining the possible environmental and density-dependant causes of growth variation. The current picture of growth is based on cross sectional size at age data. In contrast, growth increment information incorporates a longitudinal history of growth that increases the effective degrees of freedom and can be used in modeling changes in growth in relationship to environmental and population indices (Weisberg 1993, Kreuz et al. 1982, Chambers and Miller 1995, Tanaischuk 1997). Determining the underlying distribution of individual growth patterns can provide improved inputs into population dynamics models that are used to establish harvest guidelines.

This project will require compilation of a regional catalog of scales available from the ADF&G archives in individual area offices, and research in developing the methodology for measuring growth information from herring scales. Technique development will include the use of image processing methods to semi-automate the data collection. During the first year of this project, it will be necessary to examine validation of assigned ages, natural variability in scale measurements between and within individual fish from a single population, and variability among representative populations from individual locations. Techniques developed during the initial phase of this project will provide important information for the successful use of SPA as a stock discrimination technique for the herring stock structure project components. The second year of this project will consist primarily of completing the measurements of scale growth increments from representative samples from the archived collections, modeling the relationships of changes in growth to environmental and biological indices, and developing the means to use model results as inputs to stock assessment models.

B. Rationale/Link to Restoration (Why should work be done)

Pacific herring is a key species in the marine ecosystem affected by the 1989 Exxon Valdez oil spill. This species is a critical forage species for other marine fishes, birds and mammals, and are also used extensively by subsistence and commercial fishers. The age-structured analysis models used to project biomass and set harvest levels for herring stocks require estimates of catch at age in all fisheries exploiting a stock, gear selectivity, weight at age, and spawning biomass. Several

important model parameter values (e.g. annual recruitment, natural mortality) are not based on actual measurements, and the accuracy and precision of ancillary data used to scale model results (e.g. aerial surveys) is poorly known. Harvest levels around Kodiak Island are based mainly on fishery performance data and observations of the fishery in over forty management sections. Project 99378 will develop better tools for (1) identifying discrete stocks of herring in mixed-stock fisheries, (2) projecting weight at age, and (3) estimating spawning biomass. Project results will be applied by managers to improve the population models used to set harvest levels.

C. Location

This project will be conducted in PWS, Lower Cook Inlet (Kamishak Bay), and Kodiak Island waters. Because of observed colinearity in both growth and abundance between PWS and Sitka Sound herring, growth increments for a subset of archived Sitka Sound scales will also be measured for comparison with a stock outside the spill impacted region. Scale measurements and data analysis will take place in Juneau, Cordova and possibly Kodiak.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Herring remain a vital component of traditional use by local communities. Information on spawning areas and other aspects of life history will be solicited from subsistence and commercial users. Once a time series of growth is constructed, traditional ecological knowledge will be used to help interpret the meaning of the changes in relationship to historical use patterns. Efforts will also be made to inform and obtain input from communities in the study area through various meetings (e.g. State regional planning teams, Board of Fisheries advisory committees), news announcements, and routine communications with fishing organizations and the public.

PROJECT DESIGN

A. Objectives

FY99:

1. Determine the feasibilities and accuracies associated with SPA, EA, FAA or a combination of these techniques for discriminating among northern Gulf of Alaska herring stocks,
2. Develop techniques and evaluate the feasibility of retrospective herring scale growth analyses,
3. Determine the feasibility of aerial and/or acoustic surveys to estimate the biomass of pre-spawning herring around Kodiak Island.

FY00:

4. Determine the precision and cost-effectiveness associated with the stock identification technique or combination of techniques selected in FY99, and estimate the stock composition of herring exploited in the Kodiak food\bait fishery,
5. Examine the effects of environmental and biological factors on the growth dynamics of northern Gulf of Alaska herring and incorporate this information into ASA models,
6. Incorporate aerial and acoustic biomass estimates into ASA models for herring stocks in the

Kodiak Island area.

B. Methods

FY99:

Objective 1:

The feasibilities and accuracies associated with SPA, EA, and FAA will be evaluated from analyses of herring samples collected during the spring of 1999 from the PWS, Kodiak and Kamishak areas immediately prior to spawning. These calibration samples will be used to establish the SPA, EA, and FAA signatures of each stock if they exist. During October/November of 1998, samples will be collected from herring harvested during the Kodiak food/bait fishery and archived for later laboratory analyses. Herring harvested from northwest Kodiak Island (e.g., Shuyak, Afognak, and Raspberry Is.) during this fishery are presumed to include both Kodiak and Kamishak stocks (Johnson et al. 1987). Results from analyses of the spring 1999 calibration samples will be used to determine whether SPA, EA, FAA or a combination of the biomarkers provided by these techniques can successful identify fish from these three areas. Only biomarkers which have been determined to discriminate among stocks will be measured and applied to unknown samples from the Kodiak food/bait fishery,. Additional samples will collected from the Kodiak food/bait fishery in the fall of 1999. Analyses of these samples will be used to determine whether calibration samples should be taken before or after the food/bait fishery. This question may be particularly relevant for FAA which may be affected by diet composition during some of time period prior to sampling. If so, calibration samples collected in the spring prior to the fall food/bait fishery may not discriminate stocks as well as samples collected the following spring, because the fish are likely feeding heavily during summer.

To meet our first objective while minimizing costs, calibration samples will be collected only from female fish (225-250 mm length) at a similar maturity stage at each site. Collections will be made in areas where significant numbers of herring spawn and will target the first groups of returning fish (Table 1). For each specimen, length, wet weight and gonad maturity will be determined, and scale and heart tissues will be collected. Standard ADF&G procedures will be employed for collection and mounting of scales onto glass slides. Heads will be removed, individually labeled, and stored frozen in plastic bags for later laboratory processing. Whole hearts will be removed, transferred to labeled vials, placed in liquid nitrogen, and stored at –70° C until analyzed (Grahl-Nielsen and Mjaavatten 1992). Later in the laboratory, scale samples will be used to determine the age of each specimen. SPA, EA, and FAA will only be conducted on specimens from the same two adjacent age classes from each area (e.g. age 4 and 5). This approach will (1) control for effects on measured biomarkers associated with interannual differences in the distribution of each stock throughout the year, and (2) enable tests for

differences in measured biomarkers between years within year classes which may indicate environmental versus genetic effects on biomarkers. Initially, twenty-five samples from each area will be processed using each technique. Sample variances will then be estimated and minimum sample sizes determined for additional analyses using each technique (Johnson and Wichern 1992).

Table 1: Dates, locations, and sample sizes for FY99 collections to evaluate the feasibility of SPA, EA, and FAA to discriminate between northern Gulf of Alaska herring stocks.

Location	Date	Sample sizes		
		SPA	EA	FAA
KDK, Paramanof/Foul Bay	10/15-11/15	510	510	510
PWS, N. Montague	4/10-4/20	400	150	150
LCI, Chenik/Amakdedori	4/20-4/30	400	150	150
KDK, Paramanof/Foul Bay	4/15-4/30	400	150	150

Scale pattern analyses will be conducted using image-analysis software (e.g. Optimus). The distance from the scale focus to the edge as well as the distances to each annulus will be measured along several standard reference lines drawn on each scale. Luminance profiles will also be collected from each reference line for later Fourier analyses of striations (circuli) spacing within annuli zones (Ross and Pickard 1990). In addition texture analysis, which involves decomposing an image into its frequency components using high pass filtering masks, will also be evaluated (Hickinbotham et al. 1996). Herring scales can be relatively large (e.g. 6.0 to 10 mm) in relationship to the distance between the fine striation patterns (0.020 mm). Off-the-shelf imaging software will be used where possible, but additional customization of routines maybe necessary if multiple acquisition steps are necessary for each scale examined. High-resolution chip or line scanning cameras may be used for image capture if necessary. Texture analysis software, which will use S-Gabor filters as a basis for discriminating textures in fish scale images, will be evaluated from a sample of scales. If the method shows promise, porting the software as a class of DLL's for incorporation into an integrated suite of measurements will be explored in the second year project.

Direct methanolysis of the thawed heart tissue and gas chromatography of the resulting fatty acid methyl esters will follow procedures described by Viga and Grahl-Nielsen (1990) and Grahl-Nielsen and Mjaavatten (1992). Representative peaks (i.e. fatty acid levels) from the resulting chromatograms will be selected and quantified. Multivariate techniques have typically been used to classify fish stocks based on fatty acid compositions (Grahl-Nielsen and Mjaavatten 1992, Navarro et al 1995, Castell et al. 1995).

Otoliths will be removed from heads and processed as described by Fowler et al. (1995a). Left and right sagittal otoliths will be dissected from each specimen using glass probes on a glass surface, insuring that the otolith and dissection equipment do not touch metal. Tissue adhering to the otoliths will be removed with glass probes and the sample washed in Super Q water. Otoliths will be air dried in a positive flow flume hood and weighed to the nearest 0.01 mg. Left and right otoliths from each fish will be randomly selected for later solution-based or laser ablation ICPMS analyses. Those selected for solution-based ICPMS will be stored dry in acid-washed polyethylene vials. Those selected for laser-ablation ICPMS will be mounted on glass slides using thermal plastic cement, then ground and polished in the sagittal plane until the otolith primordium is visible. Polished otoliths will be rinsed in super Q water (deionized, purified through reverse osmosis, and millipore filtered) and stored in paper envelopes for later analysis (Fowler et al. 1995b). Methods described by Fowler et al. 1995a and Fowler et al. 1995b will be used for the solution-based ICPMS analyses of whole otoliths and the laser-ablation ICPMS analyses of the primordium of each otolith. Due to high analytical costs, solution-based and laser-ablation ICPMS will only be applied to a sample of 25 fish from a single age class from each area. The results from this analysis will be used to determine which analytical technique to apply to the remaining samples.

Discriminant function analysis (DFA) and principle component analysis (PCA) will be applied to the calibration samples collected from all areas to determine which analytical technique (SPA, EA, or FAA) or combination of techniques is the best stock discriminator (Johnson and Wichern 1992). Each technique produces a biomarker signature (annual growth measurements, trace elements, or fatty acid profiles) that will be evaluated for the level of discrimination (e.g. number of stocks identified) and the accuracy of discrimination. Each multivariate statistical technique will first be applied to the data sets derived from each analytical technique (SPA, EA, or FAA), separately. The misclassification probabilities associated with each technique will be compared to evaluate the accuracy of each method. DFA and PCA will then be conducted on the data set derived from all analytical techniques combined. This approach will enable us to determine whether a combination variables from the three analytical techniques provides greater classification accuracy than any of the individual techniques.

A stepwise discriminant analysis will first be applied to the variables derived from each analytical technique to identify any biomarker signatures associated with herring stocks or age classes. All variables found to be poor discriminators will be discarded. DFA will then be applied to the reduced set of variables. DFA produces a probability density function (pdf) for each group identified. If DFA can not discriminate between stocks it will combine all stocks into one pdf. The number of unique stocks identified will indicate the level of discrimination achieved. If DFA can discriminate between stocks, misclassification probabilities (accuracies) will be determined by the number of specimens that incorrectly fall outside the pdf for their respective stock in the calibration sample. Groups may be pooled if misclassification is high. This will reduce detail but increase overall accuracy.

PCA will be used to express the biomarker signatures as a set of principal component variables. Skree plots will be used to determine how many principal components are needed to accurately describe the variation in the biomarker signatures. To reveal relationships that exist within the signatures a varimax rotation of the principle components will be completed and the components will be graphed against each other. If PCA appears to distinguish among stocks, additional PCAs

will be conducted for each individual stock and perhaps age-classes within stocks. Cross-validation analysis will be used to determine the number of principal components that best describe the data (Wold 1978). Varimax rotation plots will be used to evaluate misclassification (accuracies).

Objective 2:

Development of scale growth analysis techniques will begin with evaluation of ADF&G scale archives and collation of this information into a common database. Extensive scale collections have been maintained for the PWS, Kamishak and Kodiak stocks. Data regarding sampling location, age, length, weight, and gonad maturity is generally available for each specimen. Methodologies for production-level scale growth measurements will initially be developed using samples from PWS followed by selected Cook Inlet and Kodiak samples.

Experienced scale readers will be brought together from across the state to determine consistent criteria for identifying and measuring annuli on herring scales. Problems in reading scales and potential biases in scale measurements will be addressed. Image processing techniques will be used to collect growth information from scales. The development of these procedures will take place concurrently with scale pattern analysis as part of objective 1. Off-the-shelf imaging software will be used where possible, but additional customization of routines may be necessary to streamline the data acquisition. An existing imaging system will be used to prototype the development and to identify the appropriate software and hardware for production-level scale measurements.

Herring scale collections were standardized in many locations in the mid 1980's by the identification of a preferred area on the body for scale removal. However, there is likely to be considerable variation on scale size and shape in earlier samples. Several approaches will be taken to determine methods for adjusting the growth increment data to accurately reflect body growth. The biological intercept model used for back calculation studies represents one possibility (Campana 1990). Other approaches may involve collecting multiple scales from several individuals to determine which transformations based on body size or scale size achieve the greatest reduction of within-individual variation of the growth increments using variance component analysis (Sokal and Rohlf 1981)

Concurrent studies on herring energetic content may also provide samples for comparison of scale growth and somatic growth. If such specimens are available they will be examined. Application of the biological intercept approach for back calculation requires estimates of body size at initial scale formation (Campana 1990). Collections of young of the year herring will be examined to determine body size at initial scale formation.

Approximately 200,000 herring scale samples from the PWS, Kamishak and Kodiak stocks extending back to the early 1970's are available for analysis. The number of scales drawn from these collections will be determined by a power analysis. The goal will be to measure enough scales such that biologically significant differences in growth increments between cohorts can be detected. Since the scales themselves may not have been examined since they were originally stored, considerable effort may be expended in examining selected scales to see if they are suitable for digitizing. Each scale selected for the study will be examined to confirm the original

age estimate assigned to the scale. Scales will be examined through a microscope equipped with a trinocular head attached to a video camera and a computer image analysis system. The distance from the scale focus to the edge as well as the distances to each annulus will be measured along several standard reference lines drawn on each scale. The number of annuli and the spacing between annuli will be archived in a database and later merged with other biological data associated with each specimen.

Objective 3:

Two methods to improve herring stock assessments in the Kodiak area will be examined: expanded aerial survey coverage and hydroacoustic studies. Spatial and temporal coverage of aerial surveys will be expanded to document the occurrence of spawning after commercial fishing has ceased and in areas not normally surveyed. This work will be done by department staff. Vessels may be chartered to sample fish schools to verify species and obtain biological samples. This will be done under the department's Test Fishing Receipts program authority.

Standard acoustic techniques for echo integration (Ehrenberg and Lytle 1972) will be used to independently estimate the biomass of herring present near spawning grounds in April and May. Acoustic surveys will be conducted in areas where significant herring biomass has been observed during aerial surveys. Acoustic surveys will be largely conducted at night when schools tend to be further offshore and further away from the bottom. Net sampling will be conducted to estimate species composition and size of acoustic targets.

The acoustic survey will employ two vessels with scientific echosounding equipment. A contract will be awarded to collect and analyze acoustic data from chartered purse seine vessels. The contractor will operate either a 70 or 120 kHz dual-beam echosounder. On both vessels, transducers will be mounted on a 1.2 m tow body in a down-looking configuration. The tow body will be operated at a depth of about 2 m approximately 5 m off the side of the vessel. Both vessels will collect net samples using standard commercial herring purse seines for determination of species/size of acoustic targets.

An adaptive sampling procedure will be employed to achieve optimal allocation of sampling effort within each survey area. Sampling effort will be allocated in proportion to fish density. To achieve optimal allocation of sampling effort, each area will be surveyed in two phases using a stratified systematic design. In the first phase, several large strata will be established within each survey area based on aerial surveys. The area of each stratum will be determined using coordinates recorded from a Global Positioning System (GPS) located on each vessel. Each stratum will be sampled using a series of evenly spaced parallel transects orthogonal to the coastline. A starting point will be selected at random from the first half kilometer of each stratum. A minimum of .79% of all possible transects in each stratum will be sampled during phase one. This level of sampling effort is based upon the sample variance from the acoustic herring biomass data collected in PWS. This level of sampling has been set to achieve an acoustic biomass estimate that is within plus or minus 25% of the true biomass 95% of the time.

Sampling effort will be allocated to areas of high herring density during the second phase of the survey. The vessel conducting the phase-one survey will notify the vessel responsible for phase-two surveys when high densities of herring are encountered. The phase-two vessel will establish

a stratum encompassing the area of high fish density. Areas sampled during phase two will be subtracted from the area of the phase-one strata. A minimum of 0.65 % of all possible transects in each stratum will be sampled during phase two. This level of sampling effort is based upon the sample variance from the acoustic herring biomass data collected in PWS. Data collected during phase-two sampling in 1999 will be used to re-evaluate the minimum number of phase-two transects to sample in future years. As much as possible, transects will extend orthogonal to the coastline and be arranged to insure that the total school is insonified. A starting point for the survey in each stratum will be randomly selected within a quarter kilometer of the school. Phase-two sampling in each stratum will be repeated until it is felt an accurate estimate has been obtained. The accuracy of the estimates will be evaluated from monitoring of school movements using side-looking scanning sonar.

Data collected in 1999 will be used to estimate the appropriate number of phase-one transects to sample in future years. These transects will be allocated among phase-one strata by

$$\frac{n_h}{n} = \frac{N_h s_h}{\sum_h N_h s_h} \qquad \mathbf{1}$$

where n is the total number of phase-one transects, n_h is the number of phase-one transects in the *h*th stratum, N_h is the total number of possible transects in the *h*th stratum, and s_h is the sample standard deviation for the *h*th stratum (Cochran 1977).

Bonferroni t-tests will be conducted to test for differences between biomass estimates obtained from phase one and phase one and two surveys combined. The tests will be conducted by survey area. Phase-one surveys may be discontinued if these tests indicate that biomass estimates obtained from phase one and two surveys combined are not significantly greater than estimates obtained from phase two surveys.

Echo integration will be used to determine the density of acoustic targets within each depth interval. The echo integral (E_k) for depth interval *k* is given by

$$E_k = \int_{t_1}^{t_2} |v(t)|^2 \, dt \qquad \mathbf{2}$$

where v(t) is the voltage produced by the echosounder at time t. The time gate t_1 to t_2 is chosen to correspond to a specific depth interval to be sampled (Ehrenberg and Lytle 1972).

Each sample transect will be divided into *j* elementary distance sampling units (EDSU). The length of the EDSU's will be chosen to minimize serial correlation without unnecessarily eliminating information on fish distribution. The mean echo integral (E_{jk}) will then be calculated for each depth interval-EDSU cell (MacLennan and Simmonds 1992). The biomass of fish per unit area in each cell (β_{jk}) is given by

$$\beta_{jk} = [(C\,\bar{g}/\Psi < \sigma >)]\, E_{jk} \qquad 3$$

where C is a calibration factor, g is the mean TVG correction factor, Ψ is the equivalent beam angle (a measure of beam width), $\langle\sigma\rangle$ is the mean acoustic cross section per unit weight of the target, and E_{jk} is the mean echo integral (MacLennan and Simmonds 1992). Data from various empirical studies (Nakken and Olsen 1977, Haldorsson and Reynissson 1983, Rusdstam et al. 1988, Misund and Overdal 1988) will be used to estimate target strength per kg using mean lengths of herring in each stratum estimated from net samples. We will examine the results from these studies and determine the most appropriate target strength - length relationship to use in the present study. When practical, *in situ* measurements of target strength from dual-beam echosounders will also be compared with results from these other studies. The method used to estimate mean length from net sampling is described under objective 1. The mean biomass per unit area of herring along the *i*th transect in the *h*th stratum (β_{ih}, kg m^{-2}) is given by

$$\overline{\beta_{ih}} = \frac{\sum_j \sum_k \beta_{jk}}{n_{jk}} \qquad 4$$

where n_{jk} is the number of depth interval-EDSU cells in the *i*th transect (MacLennan and Simmonds 1992). The mean biomass per unit area of herring in the *h*th stratum (β_h, kg m^{-2}) will be estimated by

$$\overline{\beta_h} = \frac{\sum_i (\overline{\beta_{ih}}\, w_{ih})}{n_h} \qquad 5$$

where n_h is the number of transects in the *h*th stratum, and $w_{ih} = L_{ih}/L_{ih}$, where L_{ih} is the length of the *i*th transect within the *h*th stratum (Jolly and Hampton 1990, MacLennan and Simmonds 1992).

The variance of β_h is given by

$$Var(\overline{\beta_h}) = \frac{1 - f_h}{n_h} \bullet \sum_i \frac{w_{ih}^2 (\overline{\beta_h} - \overline{\beta_{ih}})^2}{(n_h - 1)} \qquad 6$$

where $f_h = n_h/N_h$ is the fraction of all possible transects in the *h*th stratum (Thompson and Seber 1996).

The total biomass of herring in each survey area (β, kg) is then given by

$$\beta = \sum_h \overline{\beta_h} \bullet A_h \qquad 7$$

where A_h is the area (m^2) of the *h*th stratum in the survey area. The variance of β is given by

$$Var(\beta) = \sum_h A_h^2 Var(\overline{\beta_h}) \quad . \qquad 8$$

Aerial and acoustic biomass estimates, as well as information available from past work, will be used to develop ASA models for management sections of the Kodiak area that are currently closed as well as those open to exploitation. These models help ensure that harvest strategies are based on sustainability principles.

FY00:

Objective 4:

During FY00, we will determine the spatial, temporal, and structural variability of the stock discrimination technique or combination of techniques that were determined to be most powerful during FY99. Significant variability within stocks will not necessarily preclude successful discrimination between stocks. But, the source and degree of variability needs to be identified and measured so it can be controlled for in our calibration sampling.

In some areas, herring spawn in successive waves; the first wave is generally composed of the largest fish and subsequent waves consist of smaller fish (Ware and Tanasichuk 1989). Historic data documents such a phenomenon occurring in Kamishak Bay (Yuen 1994, Otis et al. in press). To evaluate spatial and temporal differences in the biomarkers of each stock, samples will be collected from 2 locations and 2 time periods in each area (Table 2). Samples from each of these collections will include both male and female representatives of various age classes and gonad maturities (if possible) to evaluate variability of biomarkers within the population. A subgroup of FY00 females from the same year classes as those analyzed in FY99 will be used to evaluate temporal variation in the biomarker signatures between years. The consistency of the biomarker signatures between years will be used to evaluate the frequency of calibration sampling needed to account for temporal changes. Once the discrimination criteria are evaluated for each group, cross-validation will be completed to determine how the discrimination criteria differ between each unique location–time sample.

Table 2: Dates, locations, and sample sizes for FY00 herring collections to determine the temporal, spatial, and structural variability of biomarkers used to discriminate between northern Gulf of Alaska herring stocks.

Geographic Area Sampled	Period A (first spawning wave)	# fish	Period B (later spawning wave)	# fish	Period C (Fall food/bait fishery)	# fish
PWS	St. Matthews	200	N. Montague	200	NA	0
LCI	Chenik/Amakdedori	200	Iniskin/Oil Bays	200	NA	0
	April 20-30		May 15-25			
Kodiak	Paramanof/Foul Bay	200	Sulua Bay	200	Paramanof/Foul Bay	510

In FY00, we will also determine the precision of laboratory analyses needed to measure our stock biomarkers. Three replicate subsamples from 5 fish from each unique location-time sample will be analyzed to evaluate the precision of the analytical method. Precision will be quantified as the separation distance between identical samples. The final evaluation of stock identification techniques will consider costs.

Additional samples will collected from the Kodiak food/bait fishery in the fall of 1999. Analyses of these samples will be used to determine whether calibration samples should be taken before or after the food/bait fishery. This question may be particularly relevant for FAA which may be affected by diet composition during some of time period prior to sampling. If so, calibration samples collected in the spring prior to the food/bait fishery may not discriminate stocks as well as samples collected the following spring, because the fish are likely feeding heavily during summer.

Objective 5:

Two approaches will be explored for analyses of environmental-growth relationships. The first approach involves time series and multiple regression analysis to examine relationships between time series of mean growth increments, herring population size and environmental or ecological conditions (sea surface temperature, upwelling indices, sea level pressure, zooplankton biomass, pollock biomass, etc.) (Anthony and Fogarty 1985, Pereira et al. 1995). A second approach involves examination of the overall variation of growth increment data that can be explained by time dependent factors such as age, year and year-class. This approach may employ general linear models to determine variation explained by age and year (Weisberg 1993) or construction of randomization tests to compare variation explained by year verses year-class (Hagen and Quinn 1991). It is expected that a combination of these approaches may provide insight into both the causes of changes in herring growth and the relative magnitude of these influences. The results from these analyses may be incorporated into ASA models in several ways. Herring growth may be related to (1) recruitment success through density-dependent effects on juvenile growth and overwinter survival, (2) natural mortality through effects on disease susceptibility (Marty et al. 1996, 1998), or (3) age at maturity through effects on gonad maturation.

Objective 6:

The ASA models used by ADF&G estimate initial herring cohort sizes and other parameters which best fit estimates of catch at age in all fisheries exploiting a stock, gear selectivity, weight at age, and spawning biomass (Funk 1995, Otis and Bechtol 1997). Given a set of estimates of initial cohort sizes, the model constructs the abundance of each cohort at every age according to a survival model, which accounts for all sources of mortality throughout the year. The model views estimated sampling data as begin drawn from a theoretical population with some kind of bias specific to each data source. Project 99378 will provide estimates of spawning biomass of herring which are needed to scale the ASA model estimates. A statistical approach similar to that developed by Deriso et al. (1985) will be used to determine the best fit parameters for all the data sources included in the analysis.

C. Cooperating Agencies, Contracts, and other Agency Assistance

When this project is funded, the department will draft specifications for FAA and EA and solicit bids from at least three qualified vendors. This process will follow standard State of Alaska bidding and contract award procedures. The successful bidder will be offered a co-authorship option if publishable findings result from the analyses. Standard State of Alaska competitive bidding procedures will also be used to award acoustic contracts and vessel charters for biomass estimation in the Kodiak Island area. Historic archives of scales collected by the Bureau of Commercial Fisheries and may be included in retrospective scale growth studies.

SCHEDULE

A. Measurable Project Tasks for FY99

October-November:	Collect otolith, scale and heart samples during Kodiak food/bait fishery and archive for later laboratory analyses. Compile database catalog of available archived scales and select subsets for evaluation. Develop age validation techniques and establish criteria for age assignment and growth increment measurement
Dec.-March:	Develop sample processing techniques of SPA and contract laboratories for EA and FAA analyses. Develop scale measurement procedures and process trial sample subset. Evaluate within- and between-fish variability of growth increments. Establish sample design and select subset of representative archived samples for analysis. Begin processes of representative scale samples.
April:	Collect otolith, scale and heart samples from spring spawning herring from PWS, Kodiak, and Kamishak. Conduct aerial and acoustic surveys to estimate herring biomass around Kodiak Island.
May-July:	Conduct SPA, EA, and FAA analyses of samples. Analyze acoustic data and prepare contractor report.
August-Sept:	Conduct multivariate statistical analysis of laboratory data.

B. Project Milestones and Endpoints

December 1999	Complete objectives 1 –3.
December 2000	Complete objectives 4-6.
April 2001	Complete project final report.

C. Completion Date

This project will be completed in FY01. A final report will be submitted by April 15, 2001.

PUBLICATIONS AND REPORTS

A project annual report will be submitted by April 15, 1999. Selected results from the project will be published in referred journals in FY00 and 01 as appropriate. A final report summarizing the results from the three years of the study will be complete by April 15, 2001.

PROFESSIONAL CONFERENCES

Travel funds have been requested to attend the EVOS annual workshop in Anchorage. Selected results from the project will be presented at professional conferences in FY00 as appropriate (e.g. Wakefield International Herring Symposium).

NORMAL AGENCY MANAGEMENT

The department does not have dedicated funding for herring stock structure studies, retrospective growth analyses or examination of alternative herring assessment methods. Stock structure studies would not have to be continued on a regular basis and, if successful, would either verify or lead to changes in existing management strategies and plans. Identification of better assessment methods could lead to realignment of existing department funds, as well as acquisition of additional funds from the State Legislature, so that these methods became a normal agency management function. Through its history of management ADF&G has developed an archive of scale samples as well as a long time series of population and size at age changes. While such information is invaluable for forecasting future abundance, the detailed retrospective examination of growth proposed in this project is not a normal agency management activity.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Project 99378 will utilize juvenile herring scale samples collected by the Sound Ecosystem Assessment (SEA) program to determine the initial size of herring at scale formation. In addition, we will provide samples of adult herring for a proposed study of oceanographic effects on isotopic signatures in the marine ecosystem (T. Kline, Prince William Sound Science Center, Cordova, Alaska, personal communication). Bioenergetic models developed for Pacific herring under the SEA program may be used to evaluate environmental and density effects on herring growth revealed through our analyses.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

This is a new project.

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Sockeye Salmon Restoration, 1994-1995; Principal Investigator, Forage Fish Influence on Recovery of Injured Species - Fish Diet Overlap, 1994; Principal Investigator, Fish\Shellfish Study No. 4A, Early Marine Salmon Injury Assessment in PWS, 1991-1993; Co-investigator, Conceptual Model of the Ecosystem of Kasegaluk Lagoon, Alaska, 1989-1990; Co-investigator, Distribution, Abundance, Age and Growth of Fishes in the Southeast Chukchi Sea and Kotzebue Sound, 1987-1988.

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Selected Publications:

Hagen, P.T. and K.P. Severin. 1998. An application of otolith elemental analysis to identify sympatric life history types. Trans. Amer. Fish. Soc. (in review).

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Meyers, T.R., S. Short, K. Lipson, W.N. Batts, J.R. Winton, **J. Wilcock**, and E. Brown. 1994. Association of viral hemorrhagic septicemia virus with epizootic hemorrhages of the skin in Pacific herring *Clupea pallasi* from Prince William Sound, Alaska, USA. Diseases of Aquatic Organisms Vol. 19:27-37, 1994.

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FY 99 EXXON VALDEZ TRUS[illegible]COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$156.8
Travel		$7.2
Contractual		$165.7
Commodities		$5.1
Equipment		$14.4
Subtotal	$0.0	$349.2
General Administration		$35.1
Project Total	$0.0	$384.3
Full-time Equivalents (FTE)		2.4
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
$403.3	$182.5			

Dollar amounts are shown in thousands of dollars.

Comments:

Samples for stock discrimination will be collected during normal agency catch sampling in each area. Thus, costs associated with vessel charters and field sampling crews will not be incurred by this project.

Scales for retrospective growth analyses will come from archived samples collected during normal agency catch sampling since early 1970's in each area. No field sampling costs will be incurred by this project.

FY 99

Prepared:

Project Number: 99378
Project Title: Improving population models for herring (Clupea pallasi) management along the northern Gulf of Alaska
Agency: ADF&G

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUS[illegible]COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
						0.0
Mark Willette	Fishery Biologist III (Cordova)	18F	3.0	6.6		19.8
Vacant	Fishery Biologist II (Cordova)	16E	3.0	5.6		16.8
Vacant	Fishery Biologist II (Kodiak)	16D	9.0	5.2	5.2	52.0
Joan Brodie	Fishery Biologist I (Kodiak)	14K	2.0	5.1		10.2
Vacant	Fishery Biologist I (Kodiak)	14C	2.0	4.7	2.4	11.8
Karen Hyer	Biometrician I (Cordova)	17C	4.0	5.6		22.4
Vacant	Fish and Wildlife Tech III (Cordova)	11D	5.0	3.8		19.0
Sandy Nehl	Field Office Assistant (Cordova)	11C	1.3	3.7		4.8
	Subtotal		29.3	40.3	7.6	
					Personnel Total	$156.8

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
RT Kodiak-Anch, Meet with biometrics staff	0.2	1	5	0.1	0.7
RT Kodiak-Alitak, Travel for acoustic sampling	0.3	1	0	0.0	0.3
RT Cordova-Anch., Attend EVOS annual workshop, 2 staff	0.2	2	10	0.1	1.4
RT Cordova-Juneau, Digitizer Training and Technique Dvlpment	0.5	2	12	0.1	2.2
RT Kodiak-Juneau, Digitizer Training and Technique Dvlpment	0.7	2	12	0.1	2.6
				Travel Total	$7.2

FY 99

Prepared:

Project Number: 99378
Project Title: Improving population models for herring (Clupea pallasi) management along the northern Gulf of Alaska
Agency: ADF&G

FORM 3B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRUS[illegible]COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed
Description	FY 1999
Contract for fatty acid analysis of 300 samples @ approx. $75 per sample	22.5
Contract for ICPMS analysis of 300 otolith samples @ approx. $70 per sample	21.0
Contract for Texture Analyses of herring scales	3.0
Aerial survey of pre-spawning herring around Kodiak Is. (90 hrs x $300/hr)	27.0
Contract for technical support of acoustic survey (acoustician)	40.0
Vessel charter for acoustic survey (40 days x $1300/day)	52.0
Car rental @ annual EVOS workshop	0.2
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$165.7

Commodities Costs:	Proposed
Description	FY 1999
Liquid Nitrogen (to fill four 35VHC containers)	0.4
Freight charges for liquid Nitrogen (Anchorage to field; field to contract lab)	1.2
Laboratory supplies (glass probes, chemicals, bottles, lapping film, etc.)	1.5
Office and computer supplies	1.0
Phone and fax	1.0
Commodities Total	$5.1

FY 99

Prepared:

Project Number: 99378
Project Title: Improving population models for herring (Clupea pallasi) management along the northern Gulf of Alaska
Agency: ADF&G

FORM 3B
Contractual & Commodities DETAIL

FY 99 EXXON VALDEZ TRUS[illegible]COUNCIL PROJECT BUDGET
October 1, 1998 - September 30, 1999

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
Video camera for scale pattern analysis	2	0.6	1.2
Frame grabber board for scale pattern analysis	2	1.0	2.0
Image analysis software for scale pattern analysis	2	4.0	8.0
Computer and monitor	1	3.2	3.2
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$14.4

Existing Equipment Usage: Description	Number of Units	Inventory Agency
35VHC liquid Nitrogen container	3	ADF&G
Personal computer	2	ADF&G
Research vessel (platform to sample herring during commercial fisheries in PWS, KDK, and Kamishak)	3	ADF&G
Optical Pattern Recognizition System (Includes microscope, video camera, monitor, frame grabber, software)	1	ADF&G
Personal computers	3	ADF&G

FY 99

Prepared:

Project Number: 99378
Project Title: Improving population models for herring (Clupea pallasi) management along the northern Gulf of Alaska
Agency: ADF&G

FORM 3B
Equipment
DETAIL

Assessment of Risk to Residual *Exxon Valdez* Oil in PWS Using P450 Activity in Fishes

Project Number:	99379
Restoration Category:	Research
Proposer:	University of Alaska Fairbanks
Lead Trustee Agency:	ADFG
Cooperating Agencies:	none
Alaska SeaLife Center:	no
Duration:	1st year, 1-year project
Cost FY 99:	$112,100
Geographic Area:	Prince William Sound
Injured Resource/Service:	Sea otter, River otter, Harlequin duck, Pigeon guillemot, Near-shore fishes, and Subsistence resources

ABSTRACT

This project will measure cytochrome P450 1A activity in fishes as an index of the spatial extent of the risk of exposure to hydrocarbons and as an index of the likely route of exposure. Masked greenling (*Hexagrammos octogrammus*) will be used as a surrogate to determine the spatial extent, to fishes as well as other near-shore vertebrates, of risk of exposure to hydrocarbons. Three common near-shore fishes (masked greenling, Pacific cod [*Gadus macrocephalus*], and Pacific sand lance [*Ammodytes hexapterus*]) that have different prey and habitat preferences will be used as indicators of pathways of oil exposure.

INTRODUCTION

Traces of residual oil from the *Exxon Valdez* Oil Spill (EVOS) can still be found in sediments in some coastal areas of Prince William Sound (PWS) (e.g., Munson and Brodersen, 1998; Jewett and Dean, 1997). Furthermore, elevated levels of P450 in a number of higher-order vertebrates that live or feed in the near-shore environment, including sea otters, river otters, and Barrow's goldeneye (Holland-Bartels *et al.*, 1998), provide evidence of continued exposure to hydrocarbons. It is uncertain whether elevated P450 levels are the result of exposure to residual oil or other hydrocarbons, but the fact that animals with elevated levels are largely restricted to parts of the Sound that were heavily oiled suggests that residual oil from the *Exxon Valdez* spill is the likely source of contamination. The potential consequences of exposure to populations or to individual animals is also unknown, but there is a strong correlation between exposure to oil and a lack of recovery in vertebrate populations (Holland-Bartels *et al.*, 1998).

In spite of its importance to recovery, we know little about the spatial distributions of potential exposure of hydrocarbons or the likely pathways of exposure. We cannot determine spatial patterns of exposure by direct measurement of hydrocarbons in sediments because of small-scale spatial variability in hydrocarbon concentrations (and also because of the high cost of hydrocarbon analyses). This was evidenced by high variability in sediment TPAH concentrations, even in heavily oiled sites shortly after the EVOS (Houghton *et al.*, 1993; O'Clair *et al.*, 1996). It was further indicated by a low incidence of elevated hydrocarbons in more recently sampled sediments in spite of indications of continued hydrocarbon exposure (Jewett and Dean, 1997). It is also difficult to indirectly infer spatial distributions of exposure by measurement of P450 in most vertebrates (e.g., sea otters or birds) because they are difficult to sample. Also, many of these animals integrate exposure over large areas, thereby reducing the ability to resolve spatial patterns in exposure. Pathways of exposure can be inferred by examining P450 activity or direct examination of various tissues (fur, feathers, gills, guts) of vertebrates, but this is difficult to do for most vertebrates (e.g., harlequin ducks) because of the difficulty in obtaining specimens without reducing already injured populations.

We propose to sample fish species in PWS to serve as an index of exposure for these and other vertebrate populations. Two tasks are proposed: 1) examine the spatial distribution of exposure to hydrocarbons, and 2) examine the possible pathway of exposure.

Investigations several years after the EVOS revealed elevated cytochrome P450s in several intertidal (Woodin and Stegeman, 1993) and near-shore fishes (Collier *et al.*, 1996), indicative of exposure to aromatic hydrocarbons. The first task, the spatial extent of exposure, will be examined by measuring cytochrome P450A1 levels in the livers of masked greenling (*Hexogrammus octogrammus*) collected from a variety of locations (both oiled and unoiled) in western PWS. These are common benthic fish in the Sound that live in relatively close proximity to the bottom and feed on a variety of benthic invertebrates (Tables 1 and 2). We have no direct measurements of home range for greenling, but we know they are territorial while defending egg masses in fall, and suspect that they have a relatively limited home range at other times of the year (perhaps on the order of 100s of meters). We measured P450 A1 via EROD activity in the livers of masked greenling collected in 1996 from the Herring Bay and Jackpot Bay areas. There was significantly higher activity in the fish from Herring Bay (an oiled site) than at Jackpot (a reference site) (Holland-Bartels *et al.*, 1998; Figure 1). Furthermore, spatial patterns of P450 in fish from Herring Bay suggest that fish from more heavily oiled parts of the Bay may have higher

P450 levels. Fish collected from within 100 m of moderately to heavily oiled sites (as determined by shoreline surveys conducted in 1989 and 1990) had average P450 levels of 5.4 (N = 4, range = 3 to 7.5). In contrast, fish collected from shorelines with no oil within 100 m had average P450 levels of 2.8 (N = 3, range = 1.5 to 4). While clearly preliminary, these data suggest that fish in PWS are being exposed to hydrocarbons, that the likely source of exposure is residual oil from the *Exxon Valdez* spill, and that masked greenling are relatively sensitive indicators of local hydrocarbon exposure, useful for determining spatial patterns of exposure to fish as well as other vertebrates.

The second task, to determine the likely pathway of exposure, will contrast P450 levels in various tissues of three fish species with different feeding modes and habitats. Species to be examined include masked greenling that live on the bottom and feed almost exclusively on benthic invertebrates, juvenile Pacific cod (*Gadus macrocepahalus*) that live primarily in the water column and feed on a mix of zooplankton and benthic invertebrates, and Pacific sand lance (*Ammodytes hexapterus*) that burrow in sediments, but feed almost exclusively on zooplankters (Tables 1 and 2). Fish will be examined for P450 activity in several tissues (e.g., gill, gut, and liver) to suggest levels of exposure and possible exposure pathways. In addition, the gut contents and carbon and nitrogen isotope ratios of each fish will be determined to confirm trophic status of the fish. Gut contents provide a detailed "snapshot" of feeding activity, while isotope ratios provide a less detailed but more temporally integrated estimate of trophic level. These data will provide an indication as to whether fish (and by inference, other near-shore vertebrates) are being exposed to hydrocarbons via food, or by direct contact with contaminated sediments or water. For example, if there are elevated P450 levels in sand lance and greenling but not cod, and if gill tissues have higher levels of exposure than the guts, then exposure via direct contact with contaminated sediments would be suggested.

NEED FOR THE PROJECT

A. Statement of Problem

There is mounting evidence that near-shore vertebrates in Prince William Sound, some of which have not fully recovered following the EVOS, are being exposed to hydrocarbons. However, the spatial patterns of potential exposure and the pathways of exposure remain unknown. Furthermore, there is currently no cost-effective means of measuring the risk of potential exposure.

B. Rationale/Link to Restoration

The degree and tissue localization of P450 (cytochrome P450 1A) expression in fish should help to determine both spatial patterns and routes of exposure. These data could then be used to identify specific areas within the Sound that may need additional monitoring or cleanup. Furthermore, if "hot spots" of potential exposure to oil can be identified, then there may be ways of keeping near-shore vertebrates (including subsistence users) from these sites, thereby reducing exposure.

Also, development of sensitive but inexpensive indices of exposure is important to future monitoring. Sampling TPAHs or other hydrocarbons in sediments is impractical because

extremely large sample sizes are required to overcome the low probability of detecting significant contamination because of spatial variability. The measurement of P450 in fish may, on the other hand, serve as an important tool that provides a more spatially integrated index of exposure that is both sensitive and relatively inexpensive to measure.

C. Location

All sampling will be conducted in western Prince William Sound, mainly in the vicinity of Knight, Naked, and northern Montague islands. The project's benefit of providing knowledge about continued exposure to oil would mainly be realized in the Sound, but monitoring efforts could be expanded to other areas.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

No community involvement or use of traditional ecological knowledge is anticipated for this investigation. The sampling will mainly be carried out on an opportunistic basis by diving biologists while participating in the final year of field activities of the Near-shore Vertebrate Predator project (98025). Knowledge about the relative distribution, abundance, and size of the target fishes has been attained through previous surveys in the Sound and elsewhere.

PROJECT DESIGN

A. Objectives

The objectives of the proposed study are to 1) identify the spatial extent of potential exposure to hydrocarbons by near-shore vertebrates, and 2) identify potential pathways of exposure.

B. Methods

TASK 1 – IDENTIFYING THE SPATIAL EXTENT OF POTENTIAL EXPOSURE

Sampling – Masked greenling (< 20 cm TL) will be collected from oiled and reference bays in western PWS to serve as a surrogate indicator of oil exposure. Masked greenling are widespread throughout the coastal waters of the Sound and are relatively easy to collect. Sampling will be conducted along shallow (< 10 m) shoreline segments using hook and line, or by spearing using SCUBA. Sampling will take place in the summer of 1998, simultaneous with research for another EVOS project (NVP: Project 98025). Ten specimens will be collected from each of five oiled bays (Northwest Bay, Clammy Bay, Bay of Isles, Sleepy Bay, and Herring Bay) and five reference bays (Cabin Bay, Rocky Bay, Port Chalmers, Mummy Bay, and Lower Herring Bay) (Figure 2 – site map). Fish will be quickly suffocated in air to prevent stomach regurgitation before being preserved in 5% formalin solution. The peritoneal cavity will be opened to ensure complete preservation of internal organs. Fish will be shipped to John Stegeman at Woods Hole Oceanographic Institution (WHOI) for cytochrome P450 1A analyses in FY 99. A total of 100 samples (10 sites x 10 fish per site x 1 tissue per fish) will be analyzed.

P450 analyses – Mixed function oxygenases (MFOs) are enzymes that play a critical role in detoxification of numerous endogenous compounds (such as steroids) and exogenous organic compounds (such as ethanol, drugs, and aromatic hydrocarbons). Cytochrome P450s are a family of iron-containing hemoproteins that catalyze the MFO reactions. The induction of cytochrome P450 by chemical exposure, and the specificity of induction of different members of the cytochrome P450 family by various compounds, have been demonstrated in experimental studies (Stegeman *et al.* 1992). A specific cytochrome P450, 1A (CYP1A), is induced in vertebrates by aromatic hydrocarbons, including polycyclic aromatic hydrocarbons (PAH) found in oil, and halogenated aromatic hydrocarbons, including PCBs. CYP1A thus can serve as a sensitive biomarker of exposure to these environmental contaminants. When organic compounds are "detoxified", the resulting metabolites may be inactive or, in some cases, they actually may be more toxic than the original compounds. Thus, elevated levels of cytochrome P450 not only indicate exposure but, potentially, deleterious effects to the animal. Tissues will be sectioned and processed, and CYP1A will be measured by an immunohistochemical assay (IHC) (Goksøyr *et al.* 1991; Stegeman 1989) using an antibody specific to the CYP1A protein in masked greenling livers. The occurrence and intensity of intracellular staining will be scored by light microscopy. Higher scores correspond to increased levels of CYP1A in samples (Woodin *et al.*, 1997).

Statistical analysis – Indices of CYP1A activity will be compared between sites using one-way analysis of variance. Two ANOVAs will be performed, the first comparing oiled and unoiled sites (with site means as the sampling unit) and the second comparing all sites (with individual fish as the sampling unit). In the latter, *a posteriori* contrasts will be conducted to identify sites with higher potential for exposure, as indicated by higher CYP1A activity levels. We will also examine the spatial relationship between historical levels of shoreline oiling and CYP1A by overlaying CYP1A levels on a map of oiling levels (unoiled, lightly oiled, moderately oiled, etc.) and by contrasting CYP1A activity in different oiling categories using a one-way ANOVA.

The proposed cost for Task 1 is $45,900.

TASK 2 – IDENTIFYING PATHWAYS OF EXPOSURE

Sampling – Three fish species with different habitat preferences will be used to identify potential pathways of exposure to hydrocarbons. Masked greenling, juvenile Pacific cod, and Pacific sand lance will be used to compare and contrast CYP1A induction, allowing inferences about the route of exposure to residual oil. Masked greenling are solitary demersal fish that live and feed mainly on algal-covered substrates (see Table 1). Sand lance generally school while feeding in the water column, but bury in sandy sediments when not feeding. Juvenile cod also generally school in the water column in close proximity to the substratum and feed equally on the bottom and in the water; young-of-the-year cod tend to take more pelagic prey (Laur and Haldorson, 1996). Ten specimens of each of these three fishes will be collected from oiled (Northwest Bay) and reference (Rocky Bay) areas (Figure 2). Samples will be collected by hook and line, spears, and seine nets during the summer of 1998. Fishes will be quickly suffocated in air to prevent stomach regurgitation before being preserved in 5% formalin solution. The peritoneal cavity will be opened to ensure complete preservation of internal organs.

P450 analyses – Induction of CYP1A will be determined (as described for determination of spatial patterns above) in 180 samples (2 sites x 3 species x 10 fish x 3 tissues [gill, gut and

liver]). The patterns of induction in different organs is related to the route of exposure (Woodin *et al.*, 1997; Van Veld *et al.*, 1997).

Stable isotope and gut analyses – In addition to P450 analysis, natural stable isotopes and stomach contents will also be examined in these fishes to verify feeding preferences. Carbon and nitrogen are key elements in ecosystem processes, each existing in two stable isotopes $^{13}C/^{12}C$ and $^{15}N/^{14}N$ (Ehleringer and Rundel, 1988; Tieszen and Boutton, 1988). The natural abundance of the heavier stable isotopes are much lower than those of the lighter ones and are expressed (by convention) in parts per thousand (per mil) deviation (d) from a recognized isotopic standard:

$$dX = (R_{sample} - R_{standard} / R_{standard}) \times 1000$$

where X = ^{13}C or ^{15}N, and R = $^{13}C/^{12}C$ or $^{15}N/^{14}N$. ^{13}C is expressed relative to PDB limestone, and ^{15}N relative to atmospheric N_2 (Ehleringer and Rundel, 1988).

Recent investigations of food webs have demonstrated that stable isotopes of carbon and nitrogen are correlated with trophic level and can provide dietary information when tissues of consumer and food are compared (i.e., fractionation values; Ambrose and DeNiro, 1986; Ben-David *et al.*, 1997a, b; Fry and Sherr, 1988; Gearing, 1991; Hobson, 1991; Hobson and Montevecchi, 1991; Kline *et al.*, 1993; Ramsay and Hobson, 1991; Schell *et al.*, 1988; Schoeninger and DeNiro, 1984; Welch and Parsons, 1993). The stable isotopic composition of animals appears to be enriched in ^{13}C relative to the diet by about 1% and ^{15}N by about 3–4% (Ambrose and Norr, 1993; Hobson, 1991). $\delta^{13}C$ will differentiate plankton-derived carbon from macrophyte-derived carbon in the fishes. If the carbon is mostly from plankton, contamination via ingestion is less likely, suggesting an alternate pathway such as surface contact. $\delta^{15}N$ predicts trophic level. This can be used to determine if contamination is bioconcentrated. If ingestion pathway is important and bioconcentrated then contamination is proportional to $\delta^{15}N$ content, i.e., trophic level. Stomach analysis will be used to validate what fishes are feeding on and where they are feeding (bottom or water column).

A total of 60 stable isotope samples (2 sites x 3 species x 10 fish) will be processed. Fish tissue samples (muscle) for stable isotopes will be dried at 60° to 70°C for 48 h. Subsequently, a subsample (1–1.5 mg) will be weighed into a miniature tin cup (4 by 6 mm) for combustion. We will use a Europa C/N continuous flow mass spectrometer to obtain the stable isotope ratios. Each sample will be analyzed in duplicate and results will be accepted only if the variance between the duplicates does not exceed that of the peptone standard. Values for possible prey items will be adapted from data available in the literature for coastal environments in Southeast Alaska and Prince William Sound, Alaska (Ben-David, 1996; Ben-David *et al.*, 1997b; Kline *et al.*, 1993).

Stomach analyses will be used to validate what fishes are feeding on and where they are feeding. Volumes of prey taxa within stomachs will be determined for 60 fish (2 sites x 3 species x 10 fish).

Diet of subtidal fishes from the oiled and nonoiled areas, as established by stable isotope and stomach analyses, will be compared with values of CYP1A in the tissues of the same individuals. This analysis will assist in elucidating the source of oil (habitat type) and possible exposure routes (feeding vs. physical contact) for fishes in PWS.

Statistical analysis – Indices of CYP1A activity will be compared between sites, species, and tissue types using a three-way analysis of variance. We will also contrast feeding modes of different species by testing for the independence of the proportion of different prey in the guts of each species, and the proportion of different isotopes, using chi-squared tests. The relationship between isotopic ratio and stomach content will be further examined by regression of the isotopic ratio vs. the proportion of food in the gut within different trophic levels.

The proposed cost for Task 2 is $67,500.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

This proposal is a collaborative research project of scientists from university and private research centers. It is being submitted by the University of Alaska Fairbanks (UAF), with collaborators from Woods Hole Oceanographic Institution (WHOI) and Coastal Resources Associates, Inc. (CRA), through the Alaska Department of Fish and Game as the trustee agency. Professional services contracts will be used to transfer funds from UAF to WHOI and CRA.

SCHEDULE

A. Measurable Project Tasks for FY 99 (October 1, 1998 – September 30, 1999)

Samples collected and archived in the summer of 1998 will be analyzed in FY99, with completion and final report in September 1999.

Summer 1998:	Samples collected and archived
October–September:	Samples analyzed
April–August:	Prepare draft final report
September:	Final report

B. Project Milestones and Endpoints

October–March:	Data analyses
September 30:	Submit draft final report

C. Completion Date

September 30, 1999

PUBLICATIONS AND REPORTS

We cannot yet anticipate publication schedules for FY99. Manuscript(s) for publication would presumably be produced after the final report. The final report will be produced as indicated in the above schedule.

PROFESSIONAL CONFERENCES

If the analyses progress sufficiently, a presentation of the preliminary findings will be made at the *Exxon Valdez* Oil Spill Symposium in March 1999.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This proposal has been developed as a collaborative effort among research scientists from UAF, WHOI, and Coastal Resources Associates, Inc. Stephen Jewett of UAF will coordinate the research. The Alaska Department of Fish and Game will serve as the lead trustee agency.

The project represents a unique cost-saving opportunity because no funds are requested to obtain the fish samples. All sampling will be conducted on an opportunistic basis while sampling the final year (summer of 1998) of the Near-shore Vertebrate Predator project (98025).

PROPOSED PRINCIPAL INVESTIGATOR

Stephen C. Jewett
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Fish Species	Number analyzed	Standard length (mm)	PREY TAXON								
			Copepods	Gammarid Amphipods	Caprillid Amphipods	Shrimps	Other Crustaceans	Polychaetes + Echiurids	Bivalves	Snails	Fishes
Hexagrammos octogrammus #	188	45-195	3	27	44	+	2	20	1	1	+
Ammodytes hexapterus #	4	79-133	50	10	0	0	34	0	0	5	0
Gadus macrocephalus #	14	81-199	4	53	6	17	7	1	0	0	14
G. macrocephalus ##	88	60-80	30	8	3	0	18	6	10	3	0

#: Source: McConnaughey (1978)
##: Source: Laur & Haldorson (1996)

Table 1. Volumetric stomach contents of fishes collected in Alaska. + indicates < 1% stomach contents volume.

Species	Habitat	Behavior	Predators
Hexagrammos octogrammus (masked greenling)	Shallow rocky areas w/kelp canopy	Solitary bottom dweller & benthic feeder; moves to shallow depths in summer to spawn on rocky substrate, returns to depth in fall.	River otter, other fishes
Juv. gadids: *Gadus macrocepha* lus (Pacific cod) & *Microgadus proximus* (Pacific tomcod)	Shallow depths over variable substrates w/ kelp or eelgrass	In small schools; feeds mainly on pelagic and epibenthic crustaceans & fishes	River otter, sea birds, other fishes
Ammodytes hexapterus (Pacific sand lance)	Intertidal to 100 m in coarse sand substrates	Schools over variable substrates; feeds on zooplankton, epibenthos & larval fishes; buries in coarse sand	Alcid and larid marine birds during nesting, sea otter, salmon, flatfishes, other fishes

Table 2. Habitat preferences, behavior, and predators of three near-shore fishes of Prince William Sound.

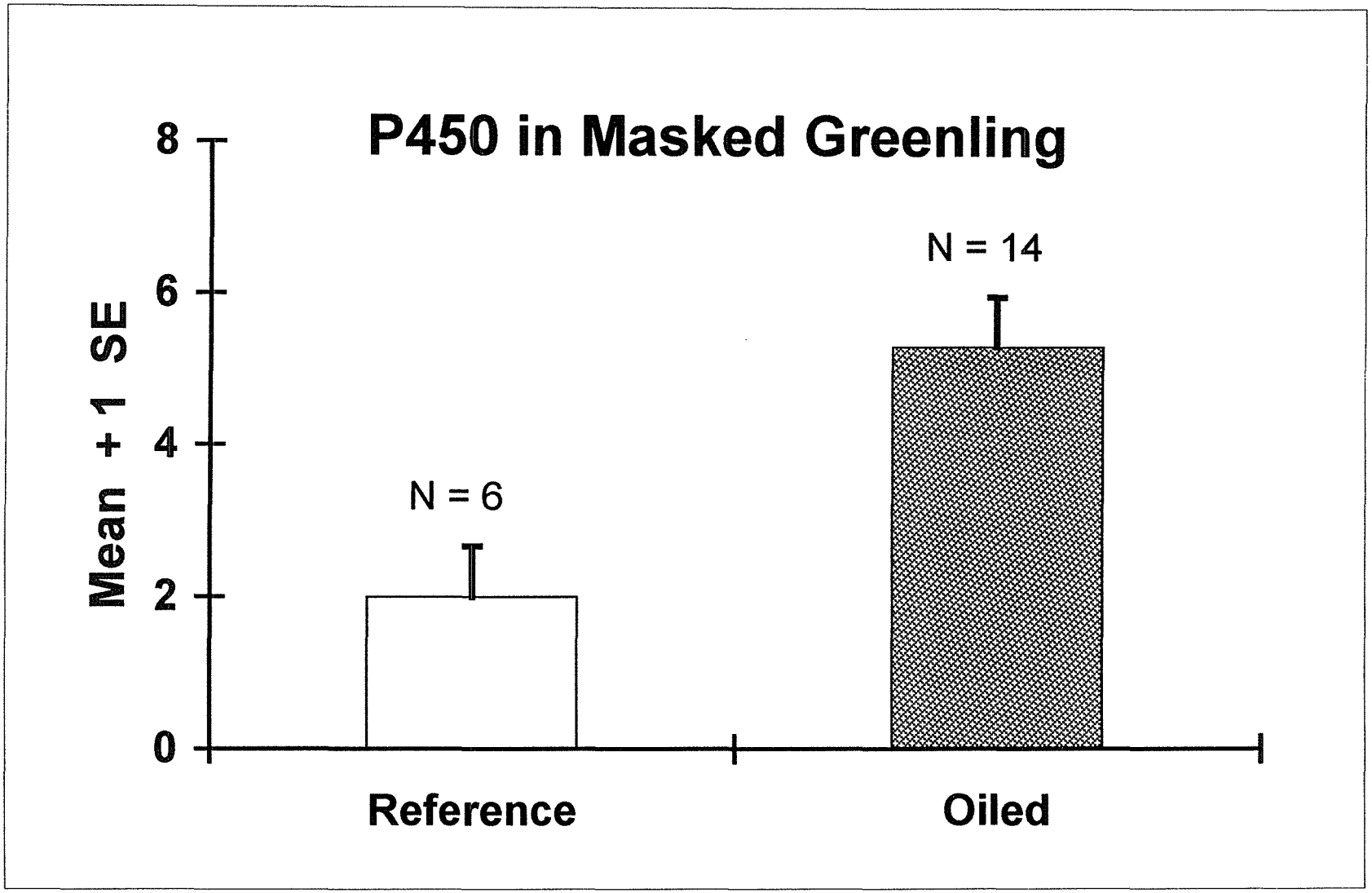

Figure 1. Comparison of cytochrome P450 (CYP1A) in masked greenling from oiled Herring Bay and unoiled (reference) Jackpot Bay, Prince William Sound, 1996.

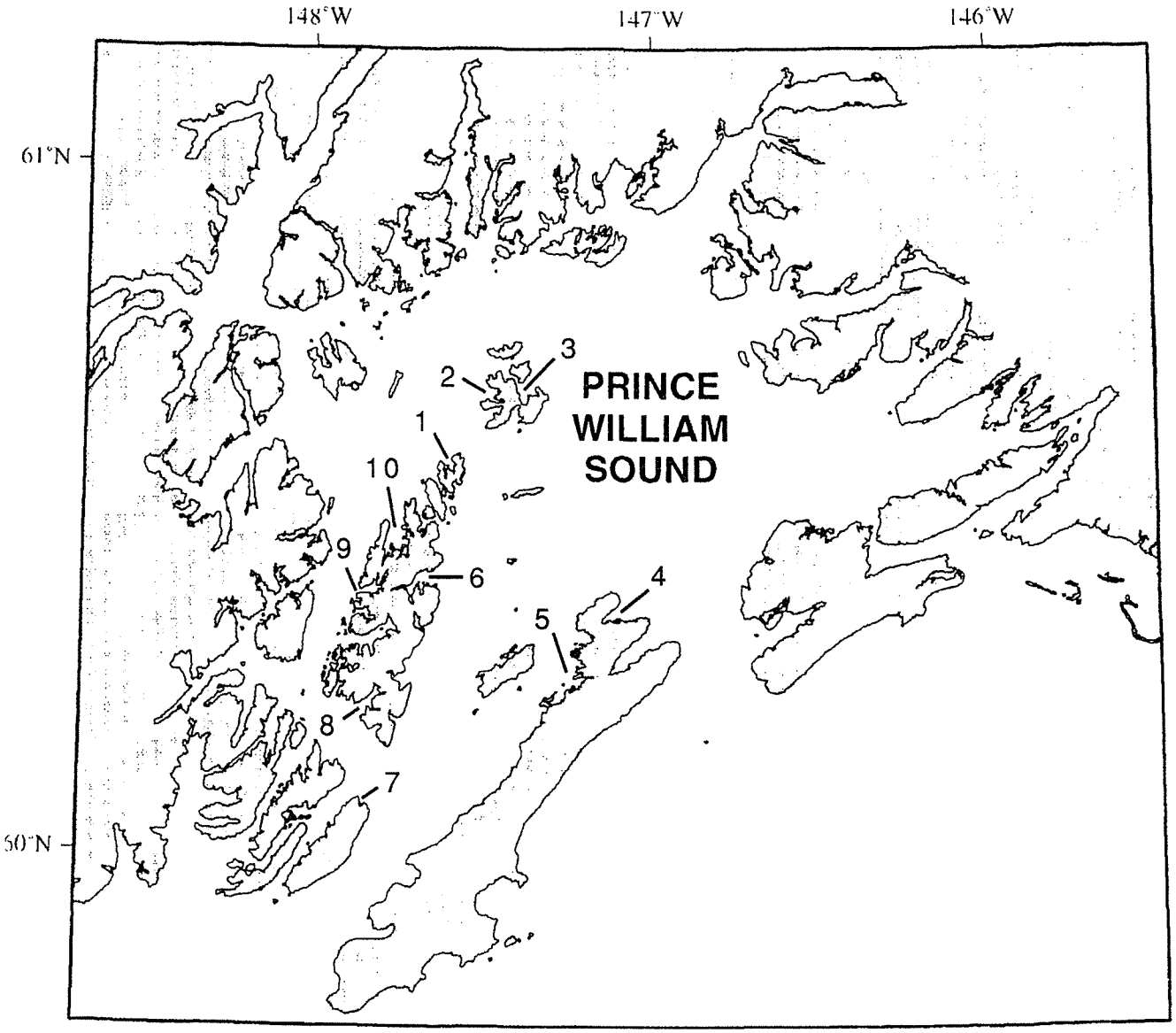

Figure 2. Fish sampling locations for P450.
1 = Northwest Bay, 2 = Cabin Bay, 3 = Clammy Bay, 4 = Rocky Bay,
5 = Port Chalmers, 6 = Bay of Isles, 7 = Sleepy Bay, 8 = Mummy Bay,
9 = Lower Herring Bay, 10 = Herring Bay.

PRINCIPAL INVESTIGATOR

Stephen C. Jewett

Dr. Jewett has been a research associate at the School of Fisheries and Ocean Science, University of Alaska Fairbanks, since 1975. During this time he has been involved in numerous benthic and intertidal assessment and/or monitoring investigations throughout Alaska. He has authored more than 30 publications in scientific journals and books. He has also been the coordinator of the federal/state EVOS shallow subtidal investigations in Prince William Sound (1989–1996) and an investigator on the EVOS Near-shore Vertebrate Predator research (1995–present).

OTHER KEY PERSONNEL

Merav Ben-David

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Dr. Ben-David has conducted extensive research on intertidal organisms in southeast Alaska. She has developed the application of stable isotope analysis to the study of individual diet selection and has published five manuscripts on stable isotope ratios of intertidal and subtidal organisms.

Thomas A. Dean

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Dr. Dean is president of the ecological consulting firm Coastal Resources Associates, Inc. (CRA) in Vista, California. He has over 20 years of experience in the study of near-shore ecosystems, and has authored more than 20 publications, including several dealing with impacts of the *Exxon Valdez* oil spill on subtidal populations of plants and animals. Dr. Dean has extensive experience in long-term monitoring studies, and has played a major role in both intertidal and subtidal EVOS investigations since 1989.

John Stegeman

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Dr. Stegeman is a research scientist at Woods Hole Oceanographic Institution. He is internationally recognized as an expert in the area of cytochrome P450 biomarkers of hydrocarbon exposure.

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1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$36.8
Travel		$3.1
Contractual		$52.6
Commodities		
Equipment		
Subtotal		$92.5
Indirect		$20.9
Project Total		$113.4
Full-time Equivalents (FTE)		0.6
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		

Dollar amounts are shown in thousands of dollars.

Comments:

The indirect rate is 25% TDC (5% for subcontract amounts over $25,000), as negotiated by the *Exxon Valdez* Oil Spill Trustee Council with the University of Alaska.

FY 99

Project Number: 99379
Project Title: Assessment of Risk to Residual *Exxon Valdez* Oil in PWS Using P450 Activity in Fishes
Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

Prepared: 4/10/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 1999
	Jewett, S.	Principal Investigator/Research Associate	2.0	8.5		17.0
	Hoberg, M.	Technician	2.0	5.1		10.2
	Ben-David, M.	Research Associate	1.0	5.4		5.4
	TBN	Technician	2.0	2.2		4.4
		Adjustment to recognize rounding				-0.2
		Subtotal	7.0	21.2	0.0	
					Personnel Total	$36.8

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1999
	Fairbanks to Anchorage – EVOS meeting	0.3	2	10	0.1	1.6
	Boston to Anchorage – EVOS meeting	0.8	1	5	0.1	1.3
	Adjustment to recognize rounding					0.2
					Travel Total	$3.1

FY 99

Project Number: 99379
Project Title: Assessment of Risk to Residual *Exxon Valdez* Oil in PWS Using P450 Activity in Fishes
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 4/10/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Contractual Costs:	Proposed
Description	FY 1999
Subcontract to Coastal Resources Associates, Inc. – participation of researcher T. Dean in project	15.2
Subcontract to Woods Hole Oceanographic Institution – participation of researcher J. Stegeman and processing of 280 P450 samples @ $130 each	36.4
Isotope sample analyses – 60 samples @ $15 each	0.9
Communications	0.1
Contractual Total	$52.6

Commodities Costs:	Proposed
Description	FY 1999
Commodities Total	$0.0

FY 99

Project Number: 99379
Project Title: Assessment of Risk to Residual *Exxon Valdez* Oil in PWS Using P450 Activity in Fishes
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities DETAIL

Prepared: 4/10/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 1999
Description			
Those purchases associated with replacement equipment should be indicated by placement with an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number of Units	
Description		

FY 99

Project Number: 99379
Project Title: Assessment of Risk to Residual *Exxon Valdez* Oil in PWS Using P450 Activity in Fishes
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

Prepared: 4/10/98

STATUS OF SEABIRD COLONIES IN NORTHEASTERN PRINCE WILLIAM SOUND

Project Number:	99381
Restoration Category:	Monitoring
Proposer:	Pacific Northwest Research Station, U.S. Forest Service
Lead Trustee Agency:	U.S. Forest Service
Cooperating Agencies:	U.S. Fish and Wildlife Service
Duration:	1 year
Cost FY 99:	$13.0
Cost FY 00:	$ 1.0
Geographic Area:	Prince William Sound
Injured Resource:	Black oystercatcher, pigeon guillemot

ABSTRACT

In northeastern Prince William Sound, existing documentation on seabird colonies is either inadequate or outdated. With the most recent colony data from 6-24 years old, current documentation may not reflect recent changes in size, species composition, and location that may have occurred since the *Exxon Valdez* oil spill. Areas around northeastern Prince William Sound (Port Gravina to Orca Inlet) are pending purchase by the Trustee Council to aid in the restoration of injured species. These lands, however, may be subject to increased human pressure in three ways: 1) increased wildlife and fishing tours generated by newly scheduled cruise ship stopovers in Cordova, 2) greater access to Prince William Sound due to the construction of the road from Portage to Whittier, and 3) the conversion of acquired parcels from private land to public land. All of these factors may increase human/wildlife interactions. We intend to establish current population data for the seven known colonies in these areas and survey the coastline for suspected and unknown seabird colonies. Acquisition of this information is necessary to minimize human disturbance of injured species.

INTRODUCTION

The purchase of fee simple lands and conservation easements by the *Exxon Valdez* Oil Spill (EVOS) Trustee Council will conserve lands and aid in the recovery of injured species. In particular, the pending purchase of land in the northeastern part of the Prince William Sound (PWS) around Sheep Bay and Port Gravina are considered among the most valuable lands in the Sound for the recovery of injured species (EVOS 1997). However, the conversion from private lands to public lands will also increase recreational opportunities and public access. The road under construction from Portage to Whittier, as well as guided fishing and wildlife tours for cruise ship passengers visiting Cordova, will create additional use of these lands and their adjacent waters. This elevated activity may lead to increased human/wildlife interactions. It is important to understand where wildlife is at risk of disturbance to make sound management decisions.

In northeastern Prince William Sound, there have been no systematic surveys for seabird colonies, and existing documentation is inadequate or outdated. For many seabird species, colonies may change size and location from year to year in response to food availability, food quality, and disturbance. For example, Irons et al. (1998) found substantial changes in black-legged kittiwake (*Rissa tridactyla*) colonies over time in Prince William Sound, probably due to changes in forage fish composition and abundance. Arctic terns (*Sterna paradisaea*) have been known to abandon colonies in response to disturbance and/or habitat degradation (Hawksley 1957). Terns are particularly susceptible to human disturbance because they often nest in flat, grassy areas that are attractive to campers and picnickers.

Currently there are seven known seabird colonies from Port Gravina to Simpson Bay (U.S. Fish and Wildlife Service 1998a), and an eighth suspected pigeon guillemot colony in Nelson Bay (northern Orca Inlet; Sanger and Cody 1994). At least four of these colonies support two injured species (black oystercatchers, *Haimatopus bachmani,* and pigeon guillemots, *Cepphus columba*), but only two of these colonies have been surveyed since the *Exxon Valdez* oil spill. The other five were surveyed either 14 or 26 years ago (U.S. Fish and Wildlife Service 1998a). Of these colonies, four have high potential for human disturbance: two that are situated near commonly used anchorages (Lethcoe and Lethcoe 1985), one that is near a popular sport fishing area, and one that is near a commercially owned weatherport. Because seabird colonies can be negatively affected by human disturbance (Gillet et. al 1975, Ellison and Cleary 1978, Anderson and Keith 1980), current knowledge of colony locations is important to lessen the impact of increased demand on public land in this area.

NEED FOR THE PROJECT

A. Statement of Problem

Existing documentation for seabird colonies is limited or outdated. With most recent surveys conducted 6-24 years ago, colonies may have changed in size, species composition, and location. At the same time, increases in human activity in PWS are expected in the future. The Alaska

Department of Transportation (ADOT) has estimated that human activity in PWS will increase 600% by 2015 (ADOT 1995). Seabird colonies are often susceptible to human disturbance (Gillet et. al 1975, Ellison and Cleary 1978, Anderson and Keith 1980). For this reason it is important to document where colonies exist to safely handle the expected increase in human activities.

B. Rationale/Link to Restoration

Lands in northeastern PWS are being purchased for the recovery of injured species. This recovery could be offset by increased human activity on these lands, especially recreational fishing and wildlife viewing. At least two injured species (black oystercatcher and pigeon guillemot) nest in these areas. Knowledge of seabird colony locations will allow management agencies to reduce human pressure on sensitive areas.

C. Location

The study area consists of the shoreline, islands and offshore rocks in northeastern PWS. This includes Port Gravina, Sheep Bay, Simpson Bay, the Narrows (Channel Islands), and Nelson Bay (northern Orca Inlet). This area coincides with lands being purchased from the Eyak Corporation by the *Exxon Valdez* Oil Spill Trustee Council.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Through the Chugach School District Youth Area Watch program, we will attempt to involve one or two high school students from Cordova or eastern Prince William Sound in the collection of data.

PROJECT DESIGN

A. Objectives

FY99.

1. Determine the status, species composition, and population of known seabird colonies in northeastern PWS.

2. Systematically survey northeastern PWS shoreline, islands, and offshore rocks for undocumented seabird colonies.

3. Incorporate local community members in the collection of data through the Youth Area Watch program.

B. Methods

Surveys will be conducted 1-20 June. This coincides with breeding activity for most species of seabirds and is the recommended time to survey for pigeon guillemots (Sanger and Cody 1994). We will use a 5.2-m skiff traveling at approximately 5 knots to survey shoreline, islands, and offshore rocks for seabirds and black oystercatchers. Upon encountering a colony, location will be recorded on 1:64,000 aerial photographs, and GPS coordinates will be taken. We will determine the number of birds present using protocols developed by U.S. Fish and Wildlife Service for the Alaska Seabird Colony Database. Depending on species, counts will be conducted from the boat offshore, from land by walking within the colony, or from land by using a viewpoint outside the colony (U.S. Fish and Wildlife Service 1998b). Counts of pigeon guillemot colonies will be conducted on the morning high tide (K. Kuletz, U.S. Fish and Wildlife Service, pers. comm.).

We will attempt to count entire colonies, recording for each species the number of individual birds (or pairs) and the number of nests (for black-legged kittiwakes and cormorants). If the entire colony cannot be counted, we will count a portion and estimate the entire size, or where appropriate, use plots or transects. We will also record the stage of breeding and signs of predators and other marine species. Habitat information will include area (length and width), substrate, vegetation type, height of cliff, and aspect, and means to access (U.S. Fish and Wildlife Service 1998b).

C. Cooperating Agencies, Contracts, and Other Agency Assistance

During FY99 the Pacific Northwest Research Station will contribute resources in the form of personnel costs for the Principal Investigator (1/2 month in-kind) and Assistant Project Leader (1 week in-kind) as well as field equipment (17-ft Boston Whaler with motor, camping supplies). Other agency contributions to this project include equipment loans from the Copper River Delta Institute and Cordova Ranger District, Chugach National Forest. Cooperation for community involvement will be sought through the EVOS Restoration Office and the Youth Area Watch Program.

SCHEDULE

A. Measurable Project Tasks for FY99

May 1-15:	Coordination with Youth Area Watch Program
June1-20:	Conduct Surveys and Colony Counts
July 1-15:	Prepare Report, Distribute Data

B. Project Milestones and Endpoints

June 20:	Complete Survey and Colony Counts
September 30:	Submission of Final Report, Distribution of Data

C. Completion Date

The final report for this project will be submitted to the Restoration Office before April 15 2000.

PUBLICATIONS AND REPORTS

The final report for this project will be submitted to the Restoration Office before 15 April 2000. Information from this project will be published in the Alaska Seabird Colony Catalog and Database, published and maintained by the U.S. Fish and Wildlife Service, Anchorage, AK.

PROFESSIONAL CONFERENCES

No conferences are anticipated in FY99. We will present a poster at the annual EVOS conference in 2000.

NORMAL AGENCY MANAGEMENT

The work proposed here is not part of normal agency management and is related specifically to research addressing oil spill restoration concerns. The need for this work is generated by the purchase of lands by the Trustee Council and the presence of injured species on these and nearby lands. No similar work has been conducted, is currently being conducted, or is planned using agency funds. Ultimately, management of these lands will require coordination between native corporations and federal agencies. This project will provide useful information for all parties.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Data will be shared with the Human Use and Wildlife Disturbance Model (EVOS project 98339) for their eastern Prince William Sound database. We also will provide our data to the EVOS contractor for the revision of the NOAA Environmentally Sensitive area maps that will be updated in FY99. Data will be shared with the U.S. Fish and Wildlife Service, Migratory Bird Management, for inclusion in the Alaska Seabird Colony Catalog and Database. We will also share this data with local land management agencies, including the Chugach National Forest, Eyak Corporation, the Tatitlek Corporation, Alaska Department of Fish and Game, and Alaska Department of Natural Resources. Information from this data will aid in management decisions that will increase the chances for recovery of injured species. Finally, cooperation for community involvement will be sought through the EVOS Restoration Office and the Chugach School District Youth Area Watch Program.

PROPOSED PRINCIPAL INVESTIGATORS

Mary Anne Bishop
Pacific Northwest Research Station
U.S. Forest Service
P.O. Box 1430
Cordova, AK 99503
Ph: 907/424-7212
Fax: 907/424-7214
email: mbishop@eagle.ptialaska.net

PRINCIPAL INVESTIGATORS

Mary Anne Bishop: Oversees the project and coordinates with other agencies involved. Is responsible for project design, contract management, and completion of final products. Will conduct some field work. Bishop received a B.B.A. from University of Wisconsin in 1974, a M.S. in Wildlife and Fisheries Sciences from Texas A & M University in 1984, and her Ph.D. in Wildlife Ecology from the University of Florida in 1988. Dr. Bishop has been principal investigator for studies on cranes, swans, and shorebirds. She is the Principal Investigator for EVOS Sound Ecosystem Assessment 320Q- Avian Predation on Herring Spawn (FY 94-96, 99), and the EVOS Nearshore Vertebrate Predator Project 025- Avian Predation on Blue Mussels Component (FY 95-97). Since 1990, Dr. Bishop has worked in Cordova Alaska as the research avian ecologist for the Pacific Northwest Research Station, U.S. Forest Service both as an employee and through a cooperative agreement between the Center for Streamside Studies, University of Washington (1994-1997). Bishop also served as the Institute's Acting Manager from May 1992 through April 1993.

OTHER KEY PERSONNEL

Paul M. Meyers: Oversees field work and logistics, is responsible for community involvement, data analysis, and writing of final report. Meyers received his B.S. degree in General Biology from Colorado State University in 1988, and his M.S. in Wildlife Ecology from Utah State University in 1994. He worked as a seabird wildlife biologist with USGS-BRD in Anchorage for two years and is currently working as an ecologist for the Pacific Northwest Research Station, US Forest Service in Cordova. He was lead biologist for EVOS 95021, Seasonal Movements and Pelagic Habitat Use of Murres and Puffins Determined by Satellite Telemetry. He has also conducted studies on upland birds and mammals.

Jim Sedell: U.S. Forest Service, Pacific Northwest Research Station, Corvallis Forestry Sciences Laboratory. Ensures that project deadlines are met by the project leader. Jim Sedell is the Program Manager for the Aquatic/Land Interaction program of the Pacific Northwest Research Station, U.S. Forest Service. The Copper River Delta Institute and its research program is a major component of the Aquatic/Land Interaction program.

Wildlife Technician. Will assist with field work.

Student Volunteer. Will assist with field work.

LITERATURE CITED

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FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$10.4
Travel		$0.0
Contractual		$0.0
Commodities		$1.0
Equipment		$0.0
Subtotal	$0.0	$11.4
General Administration		$1.6
Project Total	$0.0	$13.0
Full-time Equivalents (FTE)		0.3
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$1.0				

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared: 4/15/98

Project Number: 99381
Project Title: Status of Seabird Colonies in NE Prince William Sound
Agency: USFS-Pacific Northwest Research Station

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
M. Bishop	Principal Investigator	GS-12-02	0.9	5.7		5.1
P. Meyers	Biologist	GS-09-01	1.0	3.2		3.2
Vacant	Biological Technician	GS-05-01	0.9	1.8		1.6
Vacant	Student Volunteer		0.9	0.6		0.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		3.7	11.3	0.0	
					Personnel Total	$10.4

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
					0.0
					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

FY 99

Prepared: 4/15/98

Project Number: 99381
Project Title: Status of Seabird Colonies in NE Prince William Sound
Agency: USFS - Pacific Northwest Research Station

FORM 3B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 1999
Description	
field supplies: aerial photos, mylar, data supplies	0.2
fuel (gasoline 250 gal@1.60)	0.4
field camp food ($45 @ 8 days)	0.4
Commodities Total	$1.0

FY 99

Prepared: 4/15/98

Project Number: 99381
Project Title: Status of Seabird Colonies in NE Prince William Sound
Agency: USFS-Pacific Northwest Research Station

FORM 3B
Contractual & Commodities DETAIL

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
			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
Whaler 17'	1	USFS

FY 99

Prepared: 4/15/98

Project Number: 99381
Project Title: Status of Seabird Colonies in NE Prince William Sound
Agency: USFS-Pacific Northwest Research Station

FORM 3B
Equipment
DETAIL

Exxon Valdez Oil Spill Information-Transfer Workshop for Managers

Project Number:	99382
Restoration Category:	General Restoration
Proposer:	Dave Gibbons
Lead Agency:	USFS
Cooperating Agencies:	DOI, NOAA, ADF&G, ADNR
Alaska Sea Life Center:	no
Duration:	1st year, 2 year project
Cost FY99:	$35.3
Cost FY00:	$19.7
Geographic Area:	Entire EVOS area
Injured Resource/Service:	All

ABSTRACT

Communicating the results of the EVOS restoration program has been an on-going activity for the Restoration Office. Scientists conducting restoration funded projects are encouraged to publish their results in peer reviewed literature, present their results at professional conferences and at the annual EVOS symposium. These activities are essential in coordinating and integrating restoration projects, and in making information available to the scientific community. The Trustee Council also works to communicate information to the public. One audience that has not been the focus of these efforts are the mid-level managers who make daily decisions in the management of injured resources and services throughout the oil spill area. These individuals are often informed about restoration activities conducted by their own agencies, but are often unaware of information gathered by other agencies which could benefit their management activities. This information is also important for communities, private-land and corporation land managers. This project would facilitate communication of the restoration program with managers through a two-three day workshop specifically designed for management purposes. An interagency coordination group would direct the focus of the workshop presentations by developing questions to be addressed in each of the presentations and through facilitating an extended question and answer period.

INTRODUCTION

The *Exxon Valdez* Oil Spill (EVOS) restoration effort has been greatly enhanced by the level of communication with the public that has been promoted by the Trustee Council. Considerable effort has been made through public meetings, newsletters and radio shows to inform people of the type of work being conducted, and of opportunities to participate, in the restoration program. In addition, the annual EVOS symposium facilitates the communication between the principal investigators that are conducting restoration projects throughout the oil spill area. These efforts have demonstrated the importance of communication in the restoration effort. This project is designed to increase communication between the EVOS program and the individuals who make daily decisions in the management of the oil spill area. The project would further enhance the usefulness of the restoration program by targeting mid-level managers in agencies and corporations. These managers generally have direct responsibility for the management of land and resources throughout the EVOS area. The focus of the managers' information-transfer workshop would be to facilitate the understanding of how the research and restoration efforts can be utilized in the daily management of the EVOS area. This would be valuable for interested private land owners as well as for agency and corporation employees.

NEED FOR THE PROJECT

A. Statement of Problem

Although the EVOS Trustee Council has recognized the need for communication as part of its restoration efforts, emphasis has not been placed on an important audience. Presentations designed for mid-level managers falls between the information presented to the general public and the technical information geared towards the EVOS principal investigators. These managers are often the individuals who are responsible for making the daily management decisions that affect the resources injured by the oil spill, or affect the way people use the oil spill area. Because management responsibilities are often carried out by different individuals than those conducting the research and restoration activities, it has been difficult to ensure that these managers are informed about applicability of the restoration efforts that have been undertaken. All of the injured resources and services are managed in some capacity by the different Trustee agencies or by Native Alaskan or private land owners. Providing the opportunity for these managers to interact directly with the principal investigators from all the agencies and universities conducting the restoration efforts would expand opportunities for the information to be applied in the daily management of the EVOS area.

B. Rationale/Link to Restoration

During the annual EVOS symposium in 1997, a panel of managers was asked to speak about the type of information that they needed to better manage the land and resources within the spill area. One of the speakers asked for assistance in understanding how to use the newly acquired information in the daily management of the resources. This information-transfer workshop would provide the assistance to allow managers to make informed decisions that can facilitate the restoration of all of the injured resources. Because this workshop would address the management of these resources and services, it would enhance the restoration of all of the resources and services in the spill area.

C. Location

The information-transfer workshop would be held in Anchorage; however, the entire oil spill area would be included in the focus of the presentations.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Management decisions made by communities, Alaskan Native Corporations and individuals are equally important as those made by agencies. Therefore this workshop would be designed to benefit communities as well as agencies. Communities would be invited to attend the workshop. In addition, at least one presentation or session would be requested to be focused on the incorporation of traditional ecological knowledge in the restoration effort and its potential for inclusion in the normal daily management by agencies. Non-government organizations interested in natural resource management within the oil spill area will be invited to attend the workshop. Preliminary discussions with a few organizations and Alaskan Native Corporations indicate interest in attending this workshop and potentially in participating on a panel to discuss management opportunities.

PROJECT DESIGN

A. Objectives

1. To facilitate the ability of managers to apply the information and techniques gained in the restoration program.

2. Provide the opportunity for principal investigators to discuss their project results with managers from all agencies who could apply the information in the daily management of the EVOS area.

B. Methods

An interagency group would develop the agenda and focus for a two or three-day information-transfer workshop. This group would evaluate which restoration projects may have the most immediate interest to managers. Request for papers would be sent to the associated principal investigators along with a series of questions designed to focus the presentation to the information needs of managers. Presentation format would be similar to that of the annual EVOS symposium with an extended question/answer period. Presenters would be asked to respond to the questions submitted by the workshop coordinators. These questions would be designed to focus the conclusion of the presentations on how the information benefits the management of the resources or services being described. The presenters also would be asked to submit a two-page summary of their presentation. These summaries would be compiled for distribution at the workshop to serve as a reminder of the management application of the restoration projects as well as to provide contacts for future discussion. In addition to presentations by principal investigators who have worked on restoration projects, a panel discussion of non-government organizations would be convened at the end of the workshop to discuss how these groups view the application of the restoration information into daily management. The interagency coordinating group would also consider the opportunity to

incorporate information valuable to the ecotourism industry either through the questions addressed in the presentations or through a session specifically focused on ecotourism. A key-note speaker would be identified by the coordinating group and invited to participate in the workshop.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

As with the overall restoration program, it would be important to have all of the EVOS Trustee Agencies involved in this information-transfer workshop. Although the USFS would take the primary responsibility for the coordination of this workshop, all of the agencies would be involved in designing the workshop so that it meets the needs of managers throughout the EVOS area. Each agency would also take responsibility to ensure that managers are informed about the workshop and are encouraged to attend. They would also ensure that principal investigators are encouraged to participate.

The information-transfer workshop would be held at a conference facility in Anchorage and would include a contract to rent space and provide beverages and snacks to the participants. Lunch could be provided if it would not substantially change the costs of the workshop.

SCHEDULE

A. Measurable Project Tasks for FY99

November:	Convene organizing committee to develop draft agenda
January 31:	Finalize workshop focus and contact principal investigators
February 1–April 1:	Recruit presentations and participants, distribute first invitation
March 23-27:	Attend 10th Anniversary Symposium
April 30:	Finalize logistics and agenda, receive expanded abstracts
September 1-15:	Distribute second invitation to managers
September 1-30:	Print presentation summaries, prepare workshop materials

FY00

October-November:	Two or three-day Managers' Information-transfer workshop

B. Project Milestones and Endpoints

This project has two objectives: 1) to facilitate the ability of managers to apply the information and techniques gained in the restoration program; 2) provide the opportunity for principal investigators to discuss their project results with managers from all agencies who could apply the information in the daily management of the EVOS area. Both of these objectives would be met when the information-transfer workshop is completed in late October or November, 1999. The following milestones are identified to track the progress of the workshop development:

FY99

February 1–April 1:	Recruit presentations and participants, distribute first invitation
April 30:	Finalize logistics and agenda, receive expanded abstracts
September 1-15:	Distribute second invitation to managers

FY00
October-November: Two or three-day Managers' Information-transfer workshop

C. Completion Date

This project would be completed when the information-transfer workshop has been held in October or November 1999.

PUBLICATIONS AND REPORTS

A compilation of expanded abstracts (two pages/presentation) would be distributed at the workshop. This document would be designed to remind managers of the management application identified in the presentations as well as to provide contacts for future coordination of management and restoration efforts.

PROFESSIONAL CONFERENCES

Not applicable.

NORMAL AGENCY MANAGEMENT

This information-transfer workshop would cover all of the EVOS area as well as have participants from each of the Trustee Agencies. Therefore, the scope of this workshop is well beyond the normal management jurisdiction of the Forest Service or any individual trustee agency. This workshop is similar to the annual EVOS symposium sponsored by the Restoration Office, except that it would be targeting a different audience.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This information-transfer workshop would be designed to bring information from EVOS funded restoration projects to managers in the different Trustee Agencies. Each agency would be contributing to the workshop by encouraging and allowing participation of their employees. Travel expenses, per diem and miscellaneous expenses for participants would be paid for by the agencies as part of their normal agency management. These expenses would likely exceed those requested of the EVOS Trustee Council to coordinate the information-transfer workshop.

The timing of the information-transfer workshop is proposed to reduce conflicts with scientific reviews of the large ecosystem projects, the 10th Anniversary Symposium and the field season. In addition, completion of the proposed synthesis work on the ecosystem projects in FY99 would be beneficial to this workshop. Coordination with other efforts to improve communication between agencies and to agency and non-agency managers will be important. For instance, the ongoing effort by ADF&G in the lower Cook Inlet and Kachemak Bay area would provide important information in focusing this workshop on management needs. The Prince William sound – Copper River Natural and Cultural Resources Cooperative will be an important link in coordinating this workshop.

PROPOSED PRINCIPAL INVESTIGATOR

Douglas Stockdale
Public Affairs Officer – Chugach National Forest
3301 C Street Ste 300
Anchorage, Alaska 99503
(907) 271-2500
(907) 271-3992 (FAX)

PRINCIPAL INVESTIGATOR

Douglas Stockdale

Douglas B. Stockdale is the Public Affairs Officer for the Chugach National Forest. He was also the Public Affairs Officer for the Chatham Area of the Tongass National Forest from 1989 to 1998, and the Yuma District Office of the Bureau Of Land Management in Yuma, Arizona from 1985 to 1989. He received a B.S. in Forest Management from Washington State University in 1975 and completed course work towards an M.S. in Range Management. Over a 20+ year Federal resource management career, he has worked in Washington State, Montana, Arizona and Alaska and has held positions as a Biological Technician surveying for rare, threatened or endangered plants, a Range Conservationist, and as a Wild Horse and Burro Specialist. As a member of the Chugach National Forest Leadship Team, Doug's responsibilities include media and legislative affairs, public involvement and management and supervision of the award winning and nationally recognized Chugach Design Group.

OTHER KEY PERSONNEL

NOAA, DOI, ADF&G and ADNR have all agreed to participate in an interagency coordination group. Specific personnel have not yet been identified for ADF&G, DOI and ADNR. Karen Murphy or Lowell Suring, both wildlife biologists, would participate on the coordination group for the USFS. Linda Shaw, wildlife biologist, would participate for NOAA.

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999	PROPOSED FY 1999 TRUSTEE AGENCY TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
				$3.2	$4.1	$19.7	$3.2	$5.1
Personnel	$0.0	$29.6						
Travel	$0.0	$1.3						
Contractual	$0.0	$0.0						
Commodities	$0.0	$0.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$30.9		Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
General Administration	$0.0	$4.4						
Project Total	$0.0	$35.3		$19.7	$0.0	$0.0		
Full-time Equivalents (FTE)	0.0	0.3						
			Dollar amounts are shown in thousands of dollars.					
Other Resources	$0.0	$0.0		$0.0	$0.0	$0.0		

Comments:

FY 99

Prepared:

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Lead Agency: USFS

FORM 2A
MULTI-TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$17.1
Travel		$0.0
Contractual		$0.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$17.1
General Administration		$2.6
Project Total	$0.0	$19.7
Full-time Equivalents (FTE)		0.3
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
$12.0				

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: USFS

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared:

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
D.Stockdale	Project Leader	GS-12/7	1.0	5.7		5.7
D.Allen	Graphic Designer	GS-11	0.5	5.4		2.7
C.Lindemuth	Graphic Artist	GS-11	0.5	4.9		2.5
L.Suring	Wildlife biologist	GS-12/8	1.0	6.2		6.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		3.0	16.5	0.0	
					Personnel Total	$17.1

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
					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

FY 99

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: USFS

FORM 3B
Personnel
& Travel
DETAIL

Prepared:

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

FY 99

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: USFS

FORM 3B
Contractual & Commodities DETAIL

Prepared:

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
			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

FY 99

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: USFS

FORM 3B
Equipment
DETAIL

Prepared:

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$2.8
Travel		$0.0
Contractual		$0.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$2.8
General Administration		$0.4
Project Total	$0.0	$3.2
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$1.6				

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: ADF&G

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
To Be Determined	Fish Biologist III	18E	0.5	5.6		2.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		0.5	5.6	0.0	
					Personnel Total	$2.8

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
					0.0
					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

FY 99

Prepared:

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: ADF&G

FORM 3B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

FY 99

Prepared:

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: ADF&G

FORM 3B
Contractual & Commodities DETAIL

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 1999
			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	Inventory
Description	of Units	Agency

FY 99

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: ADF&G

FORM 3B
Equipment
DETAIL

Prepared:

FY 99 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$3.6
Travel		$0.0
Contractual		$0.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$3.6
General Administration		$0.5
Project Total	$0.0	$4.1
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$2.0				
Dollar amounts are shown in thousands of dollars.					

Comments:

FY 99

Prepared:

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: ADNR

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
To Be Determined	Natural Resource Manager	20	0.5	7.2		3.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		0.5	7.2	0.0	
					Personnel Total	$3.6

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
					0.0
					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

FY 99

Prepared:

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: ADNR

FORM 3B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

FY 99

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: ADNR

FORM 3B
Contractual & Commodities DETAIL

Prepared:

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 1999
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		

FY 99

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: ADNR

FORM 3B
Equipment
DETAIL

Prepared:

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$2.8
Travel		$0.0
Contractual		$0.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$2.8
General Administration		$0.4
Project Total	$0.0	$3.2
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$1.6				

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: DOI

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
TBD	TBD	GS 12/4	0.5	5.6		2.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		0.5	5.6	0.0	
					Personnel Total	$2.8

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
					0.0
					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

FY 99

Prepared:

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: DOI

FORM 3B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

FY 99

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: DOI

FORM 3B
Contractual & Commodities DETAIL

Prepared:

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 1999
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	Inventory Agency
Description		

FY 99

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: DOI

FORM 3B
Equipment
DETAIL

Prepared:

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$3.3
Travel		$1.3
Contractual		$0.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$4.6
General Administration		$0.5
Project Total	$0.0	$5.1
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$2.5				

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	Proposed FY 1999
Name	Position Description					
L.Shaw	Wildlife Biologist	GS-12/3	0.5	6.6		3.3
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		0.5	6.6	0.0	
					Personnel Total	$3.3

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1999
Description					
RT Anchorage - Juneau	0.5	2	3	0.1	1.3
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.3

FY 99

Prepared:

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: NOAA

FORM 3B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

FY 99

Prepared:

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: NOAA

FORM 3B
Contractual & Commodities DETAIL

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
			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

FY 99

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: NOAA

FORM 3B
Equipment
DETAIL

Prepared:

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$0.0
Contractual		$0.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$0.0
General Administration		$0.0
Project Total	$0.0	$0.0
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	Proposed FY 1999
Name	Position Description					
						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 Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1999
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
				Travel Total	$0.0

FY 99

Prepared:

Project Number: 99382
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: NOAA

FORM 3B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

FY 99

Project Number:
Project Title: EVOS Information-Transfer Workshop for Managers
Agency: NOAA

FORM 3B
Contractual & Commodities DETAIL

Prepared:

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
			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

FY 99

Project Number:
Project Title: EVOS Information-Transfer Workshop for Managers
Agency:

FORM 3B
Equipment
DETAIL

Prepared:

Distribution Study of Cutthroat Trout and Dolly Varden Char in Prince William Sound

Project Number:	99383
Restoration Category:	Monitoring
Proposer:	USFS
Lead Trustee Agency:	USFS
Cooperative Agencies:	None
Alaska Sea Life Center:	No
Duration:	1st year, 3-year project
Cost FY 99:	$25.6
Cost FY 00:	$26.0
Cost FY 01:	$5.0
Geography Area:	Prince William Sound
Injured Resource / Service:	Cutthroat Trout and Dolly Varden char

ABSTRACT

Cutthroat trout and Dolly Varden char are currently listed as a resource injured from the *Exxon Valdez* Oil Spill and their recovery is unknown. Significant gaps in knowledge exist regarding the distribution of these species, particularly in western Prince William Sound (PWS). Without such basic information, determining the effect of the spill or implementing prudent management techniques for recovery is very difficult. In this study, we will investigate watersheds that have a high likelihood of containing these species to further describe the population distributions. This project is designed to integrate with past and current research on cutthroat and Dolly Varden in PWS. The results of this study, when combined with these other findings, will provide a more complete picture of these species in PWS and will greatly assist managers in future restoration and conservation efforts.

INTRODUCTION

Both the coastal cutthroat trout, *Onchorhynchus clarki,* and the Dolly Varden char *Salvelinus malma*, are known to occur in Prince William Sound (PWS; Howse 1975). The cutthroat trout found here represent the northern most extremes of their range in North America (Morrow 1980). Although relatively little is known in PWS, these populations are considered to be small, sensitive, few in number, and relatively isolated from one another. Dolly Varden are more common than cutthroat, but knowledge is also limited on this species (ADF&G 1996). Both Dolly Varden and cutthroat are important ecological and recreational resources described as injured by the *Exxon Valdez* Oil Spill (EVOS) and their recovery is currently unknown (Hepler 1993).

The purpose of this study is to gain an understanding of basic distribution for these two species in PWS. A larger perspective is needed to accurately define the scope of impacts and recovery relating to the oil spill. Sampling would be coordinated with any additional field sampling for project 98145 (the Relation among and within populations of anadromous and resident forms of cutthroat trout and Dolly Varden char), and with the proposed cutthroat trout growth rate study if it is funded in FY99. Summarization of all existing data will also be integrated with results from EVOS project 97302 (Inventory of cutthroat trout and Dolly Varden char in eastern PWS). Additionally, data from this study will establish population baselines for the Prince William Sound human use and wildlife disturbance model (EVOS project 98339) designed to provide a management tool to protect injured, recovering and sensitive fish and wildlife populations.

NEED FOR THE PROJECT

A. Statement of Problem

Limited information is available on the distribution of both cutthroat trout and Dolly Varden char within PWS, particularly within the western region. There is strong evidence suggesting the existence of other populations not currently documented in the *Anadromous Waters Catalog* (ADF&G 1982). With minimal sampling effort, the Glacier Ranger District located cutthroat in the upper portions of three watersheds during the summer of 1994. It appears that previous surveys lacked the rigor needed to determine presence of these species. Insufficient information regarding distributions of cutthroat trout and Dolly Varden char has made it difficult to determine recovery and impacts from the oil spill.

B. Rationale/Links to Restoration

In the *Exxon Valdez* Restoration Plan, the EVOS Trustee Council recommends an ecosystem approach to restoration. Ecosystem restoration can be described as the reestablishment of processes, functions, and related biological, chemical, and physical linkages between the biotic and abiotic features. This includes the interactions between organisms with their environment as well as interactions between and among populations of the same species.

There is considerable evidence in the literature of conservation and population biology suggesting that large-scale spatial structure and dispersal mechanisms are critical to the persistence of many species (Gilpin 1987; Shaffer 1987; Hanski 1991; Hanski and Gilpin 1991; Boyce 1992; Rieman et al. 1993). Large groups of interacting populations in this context are termed as metapopulations (Shaffer 1987; Hanski and Gilpin 1991). These groups are more likely to interact and interbreed among themselves than with other groups, but exchange of individuals occurs through different dispersal mechanisms (Rieman et al. 1993). The diversity of groups can provide stability to the metapopulation in the event of local extinctions and larger catastrophic disturbances.

Salmonids exhibit many characteristics of metapopulations. Homing and spawning fidelity create isolation among groups and represent the basis for the stock concept (Ricker 1972). Dispersal of individuals is maintained through straying of migrating adults (Simon 1972; Labell 1992), density-dependent displacement of individuals, and maintenance of colonizing phenotypes (McMahon and Tash; Northcote 1992).

Metapopulation dynamics are important considerations in conservation planning and species maintenance and recovery efforts (Murphy and Noon 1992; Noon and McKelvy 1992). By understanding the uniqueness of populations, their distribution, and degree of isolation, managers can develop more efficient and prudent conservation and recovery plans. Such information is very limited for cutthroat trout and Dolly Varden char in PWS.

The results of this project will help to fill existing gaps in knowledge regarding the distribution of these species. Combining these results with other existing data (including EVOS projects 97302 and 98145), will provide managers with a better understanding of the population dynamics for cutthroat trout and Dolly Varden char in PWS. Such knowledge is necessary to determine the relative impact of the oil spill and to guide managers with recovery efforts.

Further benefits would be realized by providing this distribution data to efforts of EVOS project 98339 (Prince William Sound Human Use and Wildlife Disturbance Model). With the construction of the Whittier road, the number of angler days are predicted to increase from an average of 9,800 days to 81,750 days in the year 2015 in PWS (Alaska Department of Transportation and Public Facilities 1995). Anadromous cutthroat trout are highly susceptible to over harvest (Gresswell and Harding 1997) and it is likely that they will be a highly sought after recreational resource because of limited opportunities to catch cutthroat elsewhere in south central Alaska. Hence, recovery could be hampered by over exploitation. Baseline data is needed for comparing existing and potential human use patterns with sensitive fish populations to effectively manage these species and to ensure recovery.

C. Location

Distribution studies would occur in streams and lakes of western PWS. Exact sampling locations would be determined by a coarse filter analysis using variables that have strong associations with cutthroat presence elsewhere in PWS. In preliminary investigations, we found approximately 60 watersheds that have a high probability of cutthroat trout occurrence. Benefits of this project would be realized by all recreational and subsistence users of the Sound, but particularly by the

residents of Whittier, Chenega, Valdez, and Tatitlek.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Community leaders and local interest groups would be contacted to solicit traditional and local knowledge regarding fish populations and recreational and subsistence use patterns.

PROJECT DESIGN

A. Objectives

1. Determine the distribution of cutthroat trout and Dolly Varden char in streams and lakes in western PWS.

2. Coordinate with researchers of project 97302 on the compilation of distribution data from this and other studies for inclusion in the Alaska Department of Fish and Game Anadromous Catalog.

3. Coordinate with project 98145 to provide locations of other populations and to aid in collection of genetic samples.

4. Provide results for researchers of EVOS project 98339 for incorporation in the PWS human use model.

B. Methods

To locate sampling sites with high probabilities of occurrence, the Alaska Department of Fish and Game (ADF&G), Native villages and corporations, local sport groups, and other sources will be solicited for information on the location of known populations. Secondly, the Geographical Information System (GIS) will be used to query possible sample locations based on watershed area, channel type, and other variables strongly associated with presence of these species.

Presence and absence sampling for cutthroat trout and Dolly Varden char will occur in lakes and streams. Lakes will be sampled using minnow traps and hook and line at a variety of depths and locations dependent on lake characteristics. Stream reaches will be stratified based on channel (USDA 1992) and macro habitat type (Hawkins et al. 1993) with approximately 20 percent of the available habitat sampled using minnow traps, hook and line, or snorkeling. Previous surveys indicate that cutthroat trout in PWS have a patchy distribution and are generally found in upper reaches with more confined channel types (Dan Gillikin and Gordy Reeves personal communications). Therefore, sampling effort will be more intense in these areas.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

This project will be implemented entirely by the U.S. Forest Service (USFS). Ken Hodges,

USFS, would be contacted for information regarding EVOS project 97302 for possible sampling sites and to coordinate assimilation of all available cutthroat data for PWS. The Alaska Department of Fish and Game would be asked to provide any other available data. Additionally, we will coordinate sampling with Gordy Reeves, USFS, to collect needed genetic samples for EVOS project 99145 and provide baseline data to Karen Murphy, USFS, for the Prince William Sound human use and wildlife disturbance model (EVOS project 98339).

SCHEDULE

A. Measurable Project Task for FY 99 (October 1, 1999 - September 30, 1999)

October 1 - March 1:	Contact ADF&G, Native groups, community leaders, and use GIS query to locate possible sampling areas.
March 23 - 27:	Attend 10th Anniversary Symposium
March 1 - May 1:	Finalize sampling areas, arrange logistics and hire personnel.
May 15 - August 31:	Conduct surveys.
September 1 - 30:	Compile results and write progress report.

B. Project Milestones and Endpoints

March 1 - May 1:	Finalize sampling areas, arrange logistics and hire personnel.
May 15 - August 31:	Conduct surveys.
September 2000:	Finish sampling and write progress report.
April 15, 2001:	Compile results and write final report. Send update to Alaska Department of Fish and Game for inclusion in the Anadromous Catalog.

C. Completion Date

The final report summarizing the project results will be provided for peer review in the year 2001.

PUBLICATIONS AND REPORTS

No professional publications are planned for at this time. However, the final report and all data will be made available to other researchers and managers to aid in the development of a more ecologically based management plan.

PROFESSIONAL CONFERENCES

At this time there are no plans to present this project at professional conferences. However, a poster board display is planned in 2001 Restoration Workshop and for presentations on the Chugach National Forest.

NORMAL AGENCY MANAGEMENT

Although such information can greatly aid in management decisions, general distribution surveys for fish and wildlife populations are not mandated by statute or regulation as responsibilities of the USDA Forest Service.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This study was designed to integrate with other EVOS research on the distribution of cutthroat trout and Dolly Varden char, the relationship between populations, and their sensitivity to human impacts. We will be cooperating with USFS with other research efforts on cutthroat trout and Dolly Varden char in PWS. This includes providing genetic samples and population locations for the proposed cutthroat trout growth study(if funded) as well as coordinating with researchers responsible for the inventory of these species in eastern PWS (EVOS project 97302). Data from this project will also provide baseline information for the PWS human use and wildlife disturbance model (EVOS project 98339).

PROPOSED PRINCIPAL INVESTIGATOR

Robert Spangler
U.S. Forest Service
P.O. Box 129
Girdwood, AK 99587
(907) 783-3242
FAX: (907) 783-2094

PRINCIPAL INVESTIGATOR

Robert Spangler is a fisheries biologist with the U. S. Forest Service, Glacier Ranger District, Chugach National Forest. He obtained his B. S. degree in Fisheries from Oregon State University and a M. S. Degree in Fisheries Science from the University of Idaho. He has worked primarily with cold water fishes of the western U. S. and has a total of ten years of fisheries experience in Oregon, Idaho, Montana, and more recently, Alaska. Relevant investigations include distribution, abundance, and seasonal habitat utilization of westslope cutthroat trout, *O. clarki lewisi*, and bull char, *S. confluentus*, as well as distribution and habitat studies of the interior redband trout, *O. mykiss gairdneri*, and westslope cutthroat trout in the Kootenai Basin of Montana and Idaho.

OTHER KEY PERSONNEL

Dan Gillikin is a fisheries technician with the U. S. Forest Service, Glacier Ranger District, Chugach National Forest. He has eight years of experience with Private and Federal Agencies in Washington and Alaska and has spent six years working with dolly varden and cutthroat trout in PWS. His responsibilities include GIS modeling and the logistical aspects of project implementation.

LITERATURE CITED

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PERSONAL COMMUNICATIONS

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FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$15.8
Travel		$0.8
Contractual		$0.0
Commodities		$6.6
Equipment		$0.0
Subtotal	$0.0	$23.2
General Administration		$2.4
Project Total	$0.0	$25.6
Full-time Equivalents (FTE)		0.5

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$26.0	$5.0			

Dollar amounts are shown in thousands of dollars.

Other Resources								

Comments: New project

FY 99

Project Number: 99383
Project Title: Distribution Study of CT/DV in PWS
Agency: U S Forest Service

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared:4/7/98, KEH

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 1999
R. Spangler	PI - Fish Biologist	GS-9	1.5	4.0		6.0
Vacant	Fish Tech	GS-7	1.5	2.5		3.8
Vacant	Fish Tech	GS-5	1.5	2.0		3.0
Vacant	Fish Tech	GS-5	1.5	2.0		3.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		6.0	10.5	0.0	
					Personnel Total	$15.8

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
Train ticket personal	0.01	18			0.2
Train ticket truck	0.05	12			0.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.8

FY 99

Prepared:

Project Number: 99383
Project Title: Distribution Study of CT/DV in PWS
Agency: U S Forest Service

FORM 3B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:		Proposed FY 1999
Description		
When a non-trustee organization is used, the form 4A is required.	**Contractual Total**	$0.0

Commodities Costs:		Proposed FY 1999
Description		
Field food	120 days@ $18/day	2.1
boat rental	30 days @ $150/day	4.5
	Commodities Total	$6.6

FY 99

Prepared:

Project Number: 99383
Project Title: Distribution Study of CT/DV in PWS
Agency: U S Forest Service

FORM 3B
Contractual & Commodities DETAIL

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
			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
The following U.S. Forest Service equipment (not purchased by EVOS) are being contributed to this project. Total estimated value is approximately $12.3K. Landing craft ($200/day) for 30 days = $6 K Inflatable or skiff and O/B for 30 days = $3.5 K Camp and supplies = $2.8 K		

FY 99

Project Number:99383
Project Title:Distribution Study of CT/DV in PWS
Agency:U S Forest Service

FORM 3B
Equipment
DETAIL

Prepared: