Approved TC 8-13-98

Sound Ecosystem Assessment (SEA)

Project Number:	99320-CLO
Restoration Category:	Research
Proposer:	T. Cooney, et al/UAF
Lead Trustee Agency:	ADFG
Cooperating Agencies:	USFS
Alaska SeaLife Center:	No
New or Continued:	Cont'd
Duration:	6th yr. 6 yr. project
Cost FY 99:	$738.3
Cost FY 2000:	
Cost FY 01:	$0.0
Cost FY 02:	$0.0
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pink salmon, Pacific herring

ABSTRACT

This project is an integrated, multi-component study of processes influencing the annual survival of juvenile pink salmon and herring rearing in Prince William Sound. Support in FY 99 provides the means to close out the program. Program closeout includes the submittal of a single, integrated final report and a synthesis volume written as a single journal volume for the journal *Fisheries Oceanography*. Project support will also provide the means for individual principal investigators to address revisions to reports and manuscripts in FY 99. A nominal amount is signaled to the Trustee Council for clean up of revisions and page charges that hang over into FY 00. These tasks will be supervised by an in-house editor and the SEA lead scientist.

INTRODUCTION

The SEA program (320) was designed in 1993 and funded in April 1994, as a five-year, multi-project investigation of factors influencing the production of pink salmon and herring in Prince William Sound, Alaska. The herring and salmon literature suggested at the time that most of the mortality occurs in the earliest life stages of these species, the larval and juvenile forms. During this critical time, both species are resident in the region, are sustained primarily by energy arising from plankton populations, and are believed to undergo high rates of loss associated primarily with predation and starvation. SEA argued that any understanding of the dynamics of recovery for these important commercial and ecological components of the Prince William Sound ecosystem must account for the combined affects of oil-induced change and limits placed on production by oceanographic and other natural variability in the marine environment. In the absence of any substantial knowledge about how historical trends in pink salmon and herring production reflect environmental limitation, SEA developed a multi-year program of study to define the process of loss in juvenile populations of pink salmon and herring. The intent of the research has been to provide information about these processes so that Alaska Department of Fish and Game might better enhance, manage or otherwise restore pink salmon and herring production in the region.

After five years of intense field and modeling activity, the SEA program is being closed out in FY99. This primarily writing activity will produce a single, integrated Final Report of all results obtained by each individual project in the multi-year study. In addition to the Final Report, SEA investigators will also produce a bundle of professional manuscripts for a single volume of the prestigious journal, Fisheries Oceanography. The report and synthesis volume will document project results relative to the major hypotheses guiding the field and modeling studies, and will describe potential management applications for pink salmon and herring populations in Prince William Sound. The numerical products developed by SEA will also be documented in these reports and manuscripts.

NEED FOR THE PROJECT

A. Statement of Problem

Injured and non-recovering pink salmon and herring populations in 1993 suggested that something other than oil might be constraining their recovery. SEA proposed that some aspect of ocean climate, perhaps temperature and/or food for juveniles might be responsible for the perceived limitation, or that an oil-induced shift or other change in the composition of large fish predators was the cause for reduced production. These conditions can only be examined comprehensively within the framework of a multi-disciplinary program designed specifically to define the processes of loss to juvenile pink salmon and herring populations in relation to bottom-up (oceanographic) and top-down (predation) control each year.

A vast amount of information has been gathered by the SEA program since its initiation in the spring of 1994. This information has been reported in previous annual reports of the investigators (the SEA single, integrated annual report series), and is now entering the peer-reviewed literature. The information to date is primarily that arising from the individual projects. A SEA synthesis volume has been designed specifically as the appropriate vehicle to integrate selected

results across the boundaries of the individual projects, particularly where results have bearing on complex hypothesis testing and model development and validation. As such, preparation of the SEA synthesis volume is central to the orderly close-out of SEA and the products that it has been developing since 1994.

B. Rationale/Link to Restoration

The SEA approach to pink salmon and herring restoration is to formulate a series of interacting numerical models designed to simulate the dynamic processes influencing the survival of juvenile pink salmon and herring rearing in Prince William Sound each year. Because pink salmon and herring populations are managed for a commercial fishery, there is a mandated means for manipulating stock size each year in response to levels of production and the commercial, sport and subsistence needs of the region. SEA models will ultimately assist the managers of these important fisheries to understand how environmental factors affect production from year to year and possibly on longer decadal-level time scales. Because they encompass both food-web dynamics and atmospherically forced ocean physics, these simulations will also allow retrospective analyses of past stock performance, now-casting (current status of juveniles in the system), and improved forecasting. By more fully understanding the factors that regulate juvenile herring and pink salmon survival, appropriate levels of harvest can be applied to allow stock response in the face of continually changing natural conditions in the region—some minor, some major.

The final step in the maturation of the SEA program is the assembly of results in forms that can be accessible to the Trustees and their agencies, to the academic marine science community, and to the general public, particularly the users of pink salmon and herring resources. In this regard, the close-out activities planned by SEA will ensure documentation of the results in reports and scientific papers available to resource users and managers.

C. Location

The SEA program has been conducted in Prince William Sound and adjacent shelf and ocean waters.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Program 320 grew out of active regional community involvement which continues to the present time. Part of the study originates from the Prince William Sound Science Center, Cordova, Alaska and requires local services in that community. Prince William Sound vessels and aircraft have been routinely chartered for much of the SEA research. Each year SEA provides the citizens of the region with an update of research findings and current and planned studies. During the first two years of the program, SEA circulated a newsletter of accomplishments. Commercial fishermen in the region also learn about SEA results through a lecture series sponsored by the Prince William Sound Science Center. In FY97, SEA expanded the herring work to include incorporation of traditional ecological knowledge for this species (97320-T supplement). A most recent annual report of SEA progress was presented to the Prince William Sound Aquaculture Corporation and the public at the PWSAC spring meeting, March 1998, in Cordova.

PROJECT DESIGN

A. Objectives

1. Produce a single, integrated Final Report of SEA accomplishments following the format established for this purpose. This report will document all progress by individual projects in SEA toward goals established by the multi-disciplinary program. The single, integrated volume will be prepared by the Lead Scientist and will be submitted as the final volume of the report series from SEA (previous volumes include SEA94, SEA95, SEA96 and SEA97). All previous results, and results from FY98 will be included in this volume. However, unlike the previous series, there will be no extensive "synthesis chapter" in this document. That information is the subject of a second volume—a series of scientific manuscripts being submitted as a single journal volume to Fisheries Oceanography (see 2 below).

2. Produce an integrated series of synthesis papers for the journal, Fisheries Oceanography and the Trustee Council. These co-authored manuscripts will present multi-disciplinary assessments of factors influencing the survival of juvenile pink salmon and herring in Prince William Sound, will document tests of hypotheses that have guided SEA research, and will suggest ways in which the observed and modeled results can be used to manage these valuable resources in the region.

B. Methods

Report writing and synthesis activities leading to the preparation of close-out documentation of SEA results will proceed along several tracks. First, individual investigators are responsible for publishing results that apply to their projects alone. Priority is given to results that have bearing on the broader issues in SEA. These activities are presently underway. Secondly, small subgroups, focused by synthesis manuscript titles and authorship, will collaborate through data sharing and writing tasks to produce drafts of all papers destined for the journal volume. These papers will be distributed and read internally, then returned for revisions before becoming bundled in the submission package for Fisheries Oceanography and the Trustee Council in April 1999. The SEA Lead Scientist will be responsible for assuring that the SEA Final Report is prepared and submitted as a single, integrated document at that time as well. A SEA in-house editor will be responsible (in consultation with the Lead Scientist) for tracking, assembling, and submitting the synthesis bundle to Fisheries Oceanography. This individual will also be responsible for seeing that future revisions are addressed and that (possibly in FY00) page charges are cleared and the volume is published.

Close-out activities will be facilitated by small-group workshops, by meetings of all SEA investigators, by conference calls, by e-mail and by web tools designed for the purpose of sharing manuscripts and data. Project Z-1 will provide travel for investigators to most workshops/meetings. However, each project is also budgeting travel for one small-group workshop. These activities have been refined within the SEA workgroups and proven to work. Alaska Department of Fish and Game personnel outside of SEA have been invited to participate as co-authors on manuscripts in their areas of speciality. Two SEA investigators who concluded their work prior to FY98 are being invited to participate in the synthesis activities to strengthen the perspective of the overall team (M. A. Bishop and D. Scheel).

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Program 98320 is one of three ecosystem approaches sponsored by the EVOS Trustee Council in Prince William Sound. The integrated SEA study is administered by two agencies - ADF&G for projects housed at the University of Alaska Fairbanks and within ADF&G, and NOAA for projects conducted from the Prince William Sound Science Center, Cordova, Alaska, and at the Copper River Delta Institute (U.S. Forest Service).

SCHEDULE

A. Measurable project tasks for FY 99 (October 1, 1999 – September 30, 1999)

October:	SEA synthesis workshop – rough drafts of all papers
January:	SEA synthesis workshop – second drafts of all papers
January–March 20:	Papers and Final Reports prepared in final form
March 24-27:	Synthesis presented at the EVOS public workshop (SEA technical session)
April 15:	Submit the SEA Final Report and SEA synthesis volume to the Trustees and Fisheries Oceanography
April 15–September 30:	Respond to revisions to the Final Report and SEA synthesis volume

B. Project Milestones and Endpoints

April 15:	Submit the SEA Final Report
April 15:	Submit the SEA synthesis volume

After the submission of these documents, SEA investigators will respond to revisions. It is intended that these revisions will be completed in FY99, but that cannot be guaranteed. Nominal funds are signaled for FY00 in budget 99320-Z-2 for publication tasks that extend into that year.

C. Completion Date

The SEA program will close out in FY99. To the extent possible, all revisions to reports and manuscripts will be addressed in FY99. However, it seems unlikely that all responses can be addressed by September 30. We are therefore proposing a small close-out fund for a designated in-house SEA editor (Project Z-2) to facilitate cleaning up any report and manuscript business hanging over into FY00. Editorial activity will include tracking the status of papers/reports, routing revisions and galleys, and paying page charges. Most individuals who have been associated with SEA will be available locally to interact with the in-house editor to expedite these tasks, but we feel it is necessary to have an identified person on site to guide this effort. The SEA Lead Scientist expects to retire from the University in the summer of 1999, and will reside outside Alaska after that. Dr. Cooney will remain associated with the project through the FY99 funding year, and will be available for assistance with the final close-out tasks as needed in FY00.

PUBLICATIONS AND REPORTS

As its close-out package, SEA will submit two (2) volumes: 1) the single, integrated Final Reports of all the projects assembled in the manner of previous SEA annual reports by the Lead Scientist; 2) a bundle of manuscripts prepared as a single journal volume for both the Trustees and Fisheries Oceanography (series of synthesis papers for the reviewed literature).

At present, the synthesis volume features the following manuscripts (exact titles and authorship subject to change). These manuscripts were agreed upon at a meeting of all project investigators in September 1997, in Valdez:

1. Introduction: What is SEA? (Cooney, et al.)

2. SEA Summary: What have we learned about the survival of pink salmon and herring? (SEA executive committee and others as invited)

3. The observed and modeled physical oceanography in Prince William Sound (Vaughan, et al.)

4. The response of plant and animal communities to physical conditions in Prince William Sound (Eslinger, et al.)

5. Physical and biological factors influencing juvenile pink salmon survival in Prince William Sound (Willette, et al.)

6. Physical and biological factors influencing the herring life cycle in Prince William Sound (Norcross, et al.)

7. The role of pollock in the Prince William Sound ecosystem (Stokesbury, et al.)

8. Linked physical–plankton–nekton models for Prince William Sound (Patrick, et al.)

9. Information services and numerical products supporting SEA research in Prince William Sound (Allen, et al.).

10. Management implications for SEA results in Prince William Sound (ADF&G designee, et al.)

This volume is intended to serve as the synthesis chapter to the SEA Final Report. It will be submitted to the Trustee Council at the same time it is also submitted for review to Fisheries Oceanography. Co-authors expect to respond to critical reviews from journal and EVOS peer reviewers.

PROFESSIONAL CONFERENCES

SEA will participate in the March 1999 EVOS public workshop. We expect to present the results of the SEA synthesis volume in a special technical session devoted to our ecosystem approach. Individual authors will also present the results of their projects at other national meetings in

FY99. In some cases, Principal Investigators have requested funds to allow additional participation at national meetings. Some are requesting that graduate students and research staff be permitted to present papers or posters at conferences, such as those for the American Fisheries Society, American Society of Limnology and Oceanography, and the American Geophysical Union. All requests for travel are for presenters of results. There are no requests to merely support observers at these meeting. Much of the work of SEA has been undertaken and completed by young professionals seeking careers in the marine and fisheries sciences. Their presentations at national meetings will provide additional exposure for SEA results.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

SEA program efforts are coordinated by a Lead Scientist (Ted Cooney) with assistance from an executive committee composed of David Eslinger, Vince Patrick, Mark Willette and Brenda Norcross (Kevin Stokesbury substituting for Norcross in 1997/98). Each of the SEA modeling subgroups is chaired by a Principal Investigator with responsibility for coordination and integration within and between subgroups. SEA interacts with other EVOS-sponsored studies through collaborative research and analysis of data arranged primarily at the investigator level. To assist with close-out activities, SEA is proposing to appoint a senior staff person to serve as an on-site editor to see that the synthesis volume is competed in a timely manner. Dr. Jennifer Allen at the Prince William Sound Science Center has agreed to serve in this capacity.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

The work proposed by SEA for FY99 is specifically for the purpose of bringing the SEA program to an orderly close. The level of this activity has been negotiated with the EVOS Science Coordinator and SEA program managers.

PROPOSED PRINCIPAL INVESTIGATOR

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PRINCIPAL INVESTIGATOR

Robert (Ted) Cooney serves as the Lead Scientist for SEA. Dr. Cooney has extensive experience with zooplankton in the Gulf of Alaska and Prince William Sound. His studies began in 1976 in response to questions from the local aquaculture corporation about the carrying capacity of the region to support enhanced populations of pink and other salmon species in the region. He initiated a program of Cooperative Fisheries and Oceanographic Studies (CFOS) prior to the *Exxon Valdez* oil spill that yielded important information to initiate SEA studies of juvenile pink salmon survival. Dr. Cooney is professor of marine science at the University of Alaska Fairbanks, and an affiliated scientist with the Prince William Sound Science Center, Cordova.

OTHER KEY PERSONNEL

The interdisciplinary aspects of the FY98 SEA program are led by the following Principal Investigators:

Mark Willette	Alaska Department of Fish and Game, Cordova
Peter McRoy	Institute of Marine Science, University of Alaska Fairbanks
Ted Cooney	Institute of Marine Science, University of Alaska Fairbanks
Brenda Norcross	Institute of Marine Science, University of Alaska Fairbanks
David Eslinger	Institute of Marine Science, University of Alaska Fairbanks
A. J. Paul	Institute of Marine Science, University of Alaska Fairbanks, Seward
Vince Patrick	Prince William Sound Science Center, Cordova
Gary Thomas	Prince William Sound Science Center, Cordova
Thomas Kline	Prince William Sound Science Center, Cordova
Shari Vaughan	Prince William Sound Science Center, Cordova
Jennifer Allen	Prince William Sound Science Center, Cordova

These investigators are assisted by staff and students in Fairbanks, Cordova, and Seward, and at several institutions outside Alaska. The investigators will be joined by Mary Anne Bishop and David Scheel (former SEA investigators) to assist with the SEA synthesis.

LITERATURE CITED

None

Revision - 10-98
Approved - 13-98

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel	$244.1	$77.8
Travel	$3.1	$1.0
Contractual	$20.0	$1.0
Commodities	$14.9	$0.2
Equipment	$0.0	$0.0
Subtotal	$282.1	$80.0
General Administration	$0.0	$11.7
Project Total	$282.1	$91.7
Full-time Equivalents (FTE)		1.1
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
$0.0	$0.0	$0.0

Dollar amounts are shown in thousands of dollars.

Comments:

At a Sea Grant workshop on Ecosystem Considerations in Fisheries Management a paper entitled 'An Evaluation of Some Factors Affecting Mortality of Juvenile Fish During the Spring Bloom in Prince William Sound, Alaska' will be presented.

FY 99

Prepared:

Project Number: 99320E
Project Title: SEA: Salmon Predation
Agency: ADF&G

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
						0.0
Mark Willette	Fishery Biologist III	18F	5.0	6.6		33.0
Mark Clapsadl	Fishery Biologist II	16E	4.0	5.6		22.4
Karen Hyer	Biometrician I	17C	4.0	5.6		22.4
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
Subtotal			13.0	17.8	0.0	
					Personnel Total	$77.8

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
					0.0
Attend annual EVOS workshop	0.2	1	3	0.1	0.5
Attend Sea Grant workshop on ecosystem considerations in fisheries management	0.2	1	3	0.1	0.5
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.0

FY 99

Prepared:

Project Number: 99320E
Project Title: SEA: Salmon Predation
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 FY 1999
Description	
Publication costs: T.M. Willette, R.T. Cooney, K. Hyer. Some processes affecting piscivory among pelagic fish during the spring bloom in a subarctic embayment. Anticipated publication CJFAS 10/98 M.D. Clapsadl, T.M. Willette, G.L. Thomas, K. Hyer. An evaluation of predation as a mechanism resulting in anomalous survival rates of juvenile pink salmon in Prince William Sound, Alaska in 1994. Anticipated publication CJFAS 2/99. T.M. Willette, K. Hyer, M. Clapsadl. Intra- and Inter-annual changes in predation rates on juvenile pink salmon in nearshore habitats of Prince William Sound, Alaska 1995-1997. Anticipated publication CJFAS 3/99.	1.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$1.0

Commodities Costs:	Proposed FY 1999
Description	
Office & computer supplies (copier toner, printer toner cartridges, color printer paper, computer diskettes and RAM)	0.2
Commodities Total	$0.2

FY 99

Prepared:

Project Number: 99320E
Project Title: SEA: Salmon Predation
Agency: ADF&G

FORM 3B
Contractual & Commodities DETAIL

FY 99 EXXON VALDEZ TRUS, 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: 99320E
Project Title: SEA: Salmon Predation
Agency: ADF&G

FORM 3B
Equipment
DETAIL

Prepared:

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		
Travel		
Contractual	$99.7	$70.0
Commodities		
Equipment		
Subtotal	$99.7	$70.0
General Administration	$7.0	$4.9
Project Total	$106.7	$74.9
Full-time Equivalents (FTE)	2.6	2.1
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
$0.0	$0.0	$0.0

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Project Number: 99320-G
Project Title: SEA Plankton Dynamics: Phytoplankton and Nutrients
Agency: ADFG

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel	$67.5	$47.3
Travel	$5.1	$6.7
Contractual	$0.9	$1.2
Commodities	$2.1	$0.8
Equipment	$4.2	
Subtotal	$79.8	$56.0
Indirect	$19.9	$14.0
Project Total	$99.7	$70.0
Full-time Equivalents (FTE)	2.6	2.1
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, as negotiated by the *Exxon Valdez* Oil Spill Trustee Council with the University of Alaska.

Personnel costs for P. Simpson include two semesters of resident tuition ($2,916).
Personnel costs for K. Tamburello include two semesters of non-resident tuition ($5,616).

In accordance with the Federal Office of Management and Budget Circular A-21, including Cost Accounting Standards, the School of Fisheries and Ocean Sciences has gone to considerable effort to assure that all expenditures, regardless of source, are in compliance with federal law. These standards specify which costs are to be directly charged, and which are included in Facilities and Administration (sometimes referred to as Indirect, Overhead Recovery, or General or Administrative Costs). Project specific communications costs such as postage, photocopying, telephone and fax tolls, express package services, and audio conferencing charges are considered direct charges to projects. Project specific supplies including software, and laboratory and field supplies are direct charges as well.

FY 99

Project Number: 99320-G
Project Title: SEA Plankton Dynamics: Phytoplankton and Nutrients
Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

Prepared: 7/9/98

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
	McRoy, C. P.	Principal Investigator/Professor	1.0	12.3		12.3
	Simpson, P.	Ph.D. Student	12.0	1.4		16.8
	Tamburello, K.	M.S. Student	12.0	1.5		18.0
		Adjustment to recognize rounding				0.2
		Subtotal	25.0	15.2	0.0	
					Personnel Total	$47.3

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1999
	Fairbanks to Anchorage – EVOS annual meeting	0.2	3	15	0.1	2.1
	Fairbanks to Cordova – SEA synthesis	0.3	3	15	0.1	2.4
	Fairbanks to Santa Fe – presenters at ASLO meeting in February	0.7	2	6	0.1	2.0
	Adjustment to recognize rounding					0.2
					Travel Total	$6.7

FY 99

Project Number: 99320-G
Project Title: SEA Plankton Dynamics: Phytoplankton and Nutrients
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
Communications	0.2
Publication costs for following expected journal articles:	1.0
"The case for bottom-up control of food web dynamics in Prince William Sound, Alaska"	
Authors: McRoy, Cooney, Simpson, Ward, Tamburello & Cameron; Journal: Fisheries Oceanography	
"Observed and modeled plankton dynamics in Prince William Sound, Alaska"	
Authors: McRoy, Eslinger, Cooney & Vaughan; Journal: Fisheries Oceanography	
"Seasonal patterns of phytoplankton and nutrients in Prince William Sound, Alaska"	
Authors: Simpson, McRoy, Eslinger, Ward & Cameron; Journal: Continental Shelf Research	
"The spring phytoplankton bloom in Prince William Sound, Alaska"	
Authors: Ward & McRoy; Journal: Limnology and Oceanography	
Contractual Total	$1.2

Commodities Costs:	Proposed FY 1999
Description	
Project supplies (computer disks, laboratory supplies and chemicals)	0.8
Commodities Total	$0.8

FY 99

Project Number: 99320-G
Project Title: SEA Plankton Dynamics: Phytoplankton and Nutrients
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities
DETAIL

Prepared: 7/9/98

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: 99320-G
Project Title: SEA Plankton Dynamics: Phytoplankton and Nutrients
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999	LONG RANGE FUNDING REQUIREMENTS					
				Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
Personnel								
Travel								
Contractual	$99.2	$51.2						
Commodities								
Equipment								
Subtotal	$99.2	$51.2						
General Administration	$6.9	$3.6						
Project Total	$106.1	$54.8		$0.0	$0.0	$0.0		
Full-time Equivalents (FTE)	1.0	0.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY 99

Project Number: 99320-H
Project Title: The Role of Zooplankton in the Prince William Sound Ecosystem
Agency: ADFG

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel	$69.6	$35.1
Travel	$5.4	$3.3
Contractual	$2.9	$2.6
Commodities	$1.5	
Equipment		
Subtotal	$79.4	$41.0
Indirect	$19.8	$10.2
Project Total	$99.2	$51.2
Full-time Equivalents (FTE)	1.0	0.3
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, as negotiated by the *Exxon Valdez* Oil Spill Trustee Council with the University of Alaska.

In accordance with the Federal Office of Management and Budget Circular A-21, including Cost Accounting Standards, the School of Fisheries and Ocean Sciences has gone to considerable effort to assure that all expenditures, regardless of source, are in compliance with federal law. These standards specify which costs are to be directly charged, and which are included in Facilities and Administration (sometimes referred to as Indirect, Overhead Recovery, or General or Administrative Costs). Project specific communications costs such as postage, photocopying, telephone and fax tolls, express package services, and audio conferencing charges are considered direct charges to projects. Project specific supplies including software, and laboratory and field supplies are direct charges as well.

FY 99

Project Number: 99320-H
Project Title: The Role of Zooplankton in the Prince William Sound Ecosystem
Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

Prepared: 7/9/98

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
Cooney, R. T.	Principal Investigator/Professor		2.1	11.7		24.6
Coyle, K.	Research Associate		1.9	5.5		10.5
		Subtotal	4.0	17.2	0.0	
					Personnel Total	$35.1

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
Fairbanks to Anchorage – SEA workshop	0.3	1	5	0.1	0.8
Fairbanks to Anchorage – Annual EVOS meeting	0.3	1	5	0.1	0.8
Fairbanks to Cordova – Synthesis organization	0.4	2	10	0.1	1.8
Adjustment to recognize rounding					-0.1
				Travel Total	$3.3

FY 99

Project Number: 99320-H
Project Title: The Role of Zooplankton in the Prince William Sound Ecosystem
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 – September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
Publication page charges for "Ecosystem Controls of Fish Production in Prince William Sound, Alaska" R. T. Cooney and selected SEA authors; for submission to Fisheries Oceanography	1.0
Academic Services – manuscript preparation (30 hr @ $40/hr)	1.2
Communications – phone, mail	0.4
Contractual Total	$2.6

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

FY 99

Project Number: 99320-H
Project Title: The Role of Zooplankton in the Prince William Sound Ecosystem
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities
DETAIL

Prepared: 7/9/98

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: 99320-H
Project Title: The Role of Zooplankton in the Prince William Sound Ecosystem
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

Prepared: 7/9/98

FY 99 EXXON VALDEZ TRUS. COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$8.4
Travel		$1.4
Contractual		$0.0
Commodities		$0.2
Equipment		$0.0
Subtotal	$0.0	$10.0
General Administration		$1.3
Project Total	$0.0	$11.3
Full-time Equivalents (FTE)		0.1
Other Resources		

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

Dollar amounts are shown in thousands of dollars.

Comments:
Prepare publications including synthesis papers for SEA closeout

FY 99

Project Number: 99320-Q
Project Title: SEA-Avian Predation on Herring Spawn
Agency: USFS-Pacific Northwest Research Station

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: 25 Mar98/MAB
revision - 7 July98 - wjh

FY 99 EXXON VALDEZ TRUS 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	1.3	5.7		7.4
P. Meyers	Biologist/Statistitian	GS-09-01	0.3	3.2		1.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.6	8.9	0.0	
					Personnel Total	$8.4

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
					0.0
Cordova to Anchorage - EVOS Workshop - March 1999	0.3	1	5	0.1	0.8
SEA - small group synthesis workshop - Fairbanks	0.3	1	3	0.1	0.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.4

FY 99

Prepared:

Project Number: 99320-Q
Project Title: SEA-Avian Predation on Herring Spawn
Agency: USFS-Pacific Northwest Research Station

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		
Poster materials		0.1
Computer-Generated Slides	(20@$5)	0.1
	Commodities Total	$0.2

FY 99

Prepared:

Project Number: 99320-Q
Project Title: SEA-Avian Predation on Herring Spawn
Agency: USFS-Pacific Northwest Research Station

FORM 3B
Contractual & Commodities DETAIL

FY 99 EXXON VALDEZ TRUS. . 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: 99320-Q
Project Title: SEA-Avian Predation on Herring Spawn
Agency: USFS-Pacific Northwest Research Station

FORM 3B
Equipment
DETAIL

Prepared:

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999						
Personnel								
Travel								
Contractual	$150.0	$70.0						
Commodities								
Equipment			LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$150.0	$70.0		Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
General Administration	$10.5	$4.9						
Project Total	$160.5	$74.9		$0.0	$0.0	$0.0		
Full-time Equivalents (FTE)	2.6	0.4						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY 99

Project Number: 99320-R
Project Title: SEA Trophodynamic Modeling and Remote Sensing
Agency: ADFG

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel	$81.5	$33.7
Travel	$12.2	$9.9
Contractual	$24.0	$10.9
Commodities	$2.3	$1.5
Equipment		
Subtotal	$120.0	$56.0
Indirect	$30.0	$14.0
Project Total	$150.0	$70.0
Full-time Equivalents (FTE)	2.6	0.4
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, as negotiated by the *Exxon Valdez* Oil Spill Trustee Council with the University of Alaska.

The purpose of the second trip to Cordova is to recover the C-LAB mooring and includes truck rental ($1,000).
Per diem for Anchorage includes car rental ($261).
Per diem for national meetings includes car rental ($261) and registration for two meetings ($600).

In accordance with the Federal Office of Management and Budget Circular A-21, including Cost Accounting Standards, the School of Fisheries and Ocean Sciences has gone to considerable effort to assure that all expenditures, regardless of source, are in compliance with federal law. These standards specify which costs are to be directly charged, and which are included in Facilities and Administration (sometimes referred to as Indirect, Overhead Recovery, or General or Administrative Costs). Project specific communications costs such as postage, photocopying, telephone and fax tolls, express package services, and audio conferencing charges are considered direct charges to projects. Project specific supplies including software, and laboratory and field supplies are direct charges as well.

FY 99

Project Number: 99320-R
Project Title: SEA Trophodynamic Modeling and Remote Sensing
Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Personnel Costs: Name	Position Description		Months Budgeted	Monthly Costs	Overtime	Proposed FY 1999
Eslinger, D.	Principal Investigator/Assist. Professor		3.5	7.4		25.9
Allen, D.	Marine Technician		1.0	4.6		4.6
Chu, C.	Programmer		0.6	5.4		3.2
	Adjustment to recognize rounding					
	Subtotal		5.1	17.4	0.0	
					Personnel Total	$33.7

Travel Costs: Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1999
Fairbanks to Cordova – SEA synthesis meeting	0.4	1	7	0.1	1.1
Fairbanks to Cordova – Recover C-LAB mooring	0.4	1	7	0.2	1.8
Fairbanks to Anchorage – EVOS meeting	0.3	3	15	0.1	2.4
Fairbanks to Lower 48 – presenter at national meetings (ERIM Coastal Remote Sensing and AGU)	0.9	2	10	0.2	3.8
Adjustment to recognize rounding					0.8
				Travel Total	$9.9

FY 99

Project Number: 99320-R
Project Title: SEA Trophodynamic Modeling and Remote Sensing
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 – September 30, 1999

Contractual Costs:	Proposed
Description	FY 1999
Communications	0.5
Publishing/page charges for "Three dimensional modeling of plankton dynamics in Prince William Sound, Alaska" Authors: D.L. Eslinger, N. Pintchouk & S.J. Thornton; Expected date: 8/99; Journal: Fish. Oceanogr. or Cont. Shelf Res.	1.0
ARGOS servicing	3.5
Ship time	2.5
Shipping	3.4
Contractual Total	$10.9

Commodities Costs:	Proposed
Description	FY 1999
Project supplies – diskettes, DAT tapes, software upgrades	0.5
Color printing supplies	1.0
Commodities Total	$1.5

FY 99

Project Number: 99320-R
Project Title: SEA Trophodynamic Modeling and Remote Sensing
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities DETAIL

Prepared: 7/9/98

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: 99320-R
Project Title: SEA Trophodynamic Modeling and Remote Sensing
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

Prepared: 7/9/98

Revised 9-1. 3

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		
Travel		
Contractual	$523.7	$150.0
Commodities		
Equipment		
Subtotal	$523.7	$150.0
General Administration	$23.0	$10.5
Project Total	$546.7	$160.5
Full-time Equivalents (FTE)	9.6	1.9
Other Resources		

LONG RANGE FUNDING REQUIREMENTS			
Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	
$0.0	$0.0	$0.0	

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Project Number: 99320-T
Project Title: Juvenile Herring Distribution and Habitats
Agency: ADFG

FORM 3A TRUSTEE AGENCY SUMMARY

Prepared: 8/27/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel	$354.4	$82.9
Travel	$19.0	$10.6
Contractual	$35.0	$23.6
Commodities	$10.5	$2.9
Equipment		
Subtotal	$418.9	$120.0
Indirect	$104.8	$30.0
Project Total	$523.7	$150.0
Full-time Equivalents (FTE)	9.6	1.9
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Dollar amounts are shown in thousands of dollars.

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		

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 R. Foy include two semesters of resident tuition ($2,916).

FY 99

Project Number: 99320-T
Project Title: Juvenile Herring Distribution and Habitats
Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

Prepared: 8/27/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Personnel Costs: Name	Position Description		Months Budgeted	Monthly Costs	Overtime	Proposed FY 1999
Norcross, B.	Principal Investigator/Assoc. Professor		3.0	8.5		25.5
Brown, E.	Program Manager		0.5	6.1		3.1
Frandsen, M.	Laboratory Technician		3.5	5.1		17.9
Vallarino, M.	Programmer		3.5	5.1		17.9
Foy, R.	Ph.D. Student		12.0	1.6		19.2
	Adjustment to recognize rounding					-0.7
	Subtotal		22.5	26.4	0.0	
					Personnel Total	$82.9

Travel Costs: Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1999
Fairbanks to Anchorage – EVOS meeting	0.3	4	20	0.1	3.2
Fairbanks to Anchorage – Technical review session	0.3	4	8	0.1	2.0
Fairbanks to Lower 48 – presenters at AFS meeting (location TBN)	0.7	4	16	0.1	4.4
Adjustment to recognize rounding					1.0
				Travel Total	$10.6

FY 99

Project Number: 99320-T
Project Title: Juvenile Herring Distribution and Habitats
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 8/27/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 – September 30, 1999

Contractual Costs:	Proposed
Description	FY 1999
Reprint charges for published manuscripts	2.0
Communications	1.0
Copying and duplicating	1.0
Page charge for publication of research results	1.0
Postage and shipping for samples and data	0.4
University of Massachusetts (K. Stokesbury)	18.2
Contractual Total	$23.6

Commodities Costs:	Proposed
Description	FY 1999
Presentation supplies – slides, overheads, video tape, poster supplies, etc.	1.3
Project supplies – laboratory supplies and chemicals, shipping supplies	0.6
Computer supplies – disks, software upgrades	1.0
Commodities Total	$2.9

FY 99

Project Number: 99320-T
Project Title: Juvenile Herring Distribution and Habitats
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities DETAIL

Prepared: 8/27/98

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: 99320-T
Project Title: Juvenile Herring Distribution and Habitats
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

Prepared: 8/27/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		
Travel		
Contractual	$71.0	$23.5
Commodities		
Equipment		
Subtotal	$71.0	$23.5
General Administration	$5.0	$1.6
Project Total	$76.0	$25.1
Full-time Equivalents (FTE)	1.0	0.3
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$0.0	$0.0	$0.0		

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Project Number: 99320-T Supplement
Project Title: Documenting Forage Fish Natural History through Local and Traditional Ecological Knowledge
Agency: ADFG

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999	LONG RANGE FUNDING REQUIREMENTS					
				Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
Personnel	$38.0	$15.4						
Travel	$12.0	$2.0						
Contractual	$5.6	$1.2						
Commodities	$1.2	$0.2						
Equipment								
Subtotal	$56.8	$18.8						
Indirect	$14.2	$4.7						
Project Total	$71.0	$23.5						
Full-time Equivalents (FTE)	1.0	0.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

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 J. Seitz are actually 5 hours per day for 3 months.

In accordance with the Federal Office of Management and Budget Circular A-21, including Cost Accounting Standards, the School of Fisheries and Ocean Sciences has gone to considerable effort to assure that all expenditures, regardless of source, are in compliance with federal law. These standards specify which costs are to be directly charged, and which are included in Facilities and Administration (sometimes referred to as Indirect, Overhead Recovery, or General or Administrative Costs). Project specific communications costs such as postage, photocopying, telephone and fax tolls, express package services, and audio conferencing charges are considered direct charges to projects. Project specific supplies including software, and laboratory and field supplies are direct charges as well.

FY 99

Project Number: 99320-T Supplement
Project Title: Documenting Forage Fish Natural History through Local and Traditional Ecological Knowledge
Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Personnel Costs: Name	Position Description	Months Budgeted	Monthly Costs	Overtime	Proposed FY 1999
Brown, E.	Principal Investigator/Program Manager	0.5	6.1		3.1
Seitz, J.	Technician	1.9	4.6		8.7
TBN	GIS Technician	1.0	2.5		2.5
Frandsen, M.	Laboratory Technician	0.3	5.1		1.5
	Adjustment to recognize rounding				-0.4
	Subtotal	3.7	18.3	0.0	
				Personnel Total	$15.4

Travel Costs: Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1999
Cordova to Anchorage – EVOS annual meeting	0.2	1	5	0.1	0.7
Cordova to Anchorage – SEA synthesis or TEK meeting	0.2	1	4	0.1	0.6
Fairbanks to Anchorage – SEA synthesis or TEK meeting	0.2	1	4	0.1	0.6
Adjustment to recognize rounding					0.1
				Travel Total	$2.0

FY 99

Project Number: 99320-T Supplement
Project Title: Documenting Forage Fish Natural History through Local and Traditional Ecological Knowledge
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 – September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
Communications	0.2
Publication costs for "Historical Observations of Forage Fish and Herring by Resource Users of the Southern Kenai Peninsula and Prince William Sound"; Author: J. Seitz; to be submitted to Arctic. Page cost is $75/page. Estimated total cost is ~$1,200, including graphics, postage, and communications regarding submission.	1.0
Contractual Total	$1.2

Commodities Costs:	Proposed FY 1999
Description	
Project supplies – disks, software upgrades	0.2
Commodities Total	$0.2

FY 99

Project Number: 99320-T Supplement
Project Title: Documenting Forage Fish Natural History through Local and Traditional Ecological Knowledge
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities DETAIL

Prepared: 7/9/98

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: 99320-T Supplement
Project Title: Documenting Forage Fish Natural History through Local and Traditional Ecological Knowledge
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		
Travel		
Contractual	$98.9	$70.0
Commodities		
Equipment		
Subtotal	$98.9	$70.0
General Administration	$6.9	$4.9
Project Total	$105.8	$74.9
Full-time Equivalents (FTE)	1.3	0.7
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$0.0	$0.0	$0.0		

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Project Number: 99320-U
Project Title: Fish Energetics
Agency: ADFG

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel	$75.0	$53.6
Travel	$2.1	$1.8
Contractual	$1.2	$0.4
Commodities	$0.8	$0.2
Equipment		
Subtotal	$79.1	$56.0
Indirect	$19.8	$14.0
Project Total	$98.9	$70.0
Full-time Equivalents (FTE)	1.3	0.7
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, as negotiated by the *Exxon Valdez* Oil Spill Trustee Council with the University of Alaska.

Travel to Anchorage is by personal vehicle at the UAF rate of $0.31 per mile.

In accordance with the Federal Office of Management and Budget Circular A-21, including Cost Accounting Standards, the School of Fisheries and Ocean Sciences has gone to considerable effort to assure that all expenditures, regardless of source, are in compliance with federal law. These standards specify which costs are to be directly charged, and which are included in Facilities and Administration (sometimes referred to as Indirect, Overhead Recovery, or General or Administrative Costs). Project specific communications costs such as postage, photocopying, telephone and fax tolls, express package services, and audio conferencing charges are considered direct charges to projects. Project specific supplies including software, and laboratory and field supplies are direct charges as well.

FY 99

Project Number: 99320-U
Project Title: Fish Energetics
Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Personnel Costs: Name	Position Description	Months Budgeted	Monthly Costs	Overtime	Proposed FY 1999
Paul, A. J.	Principal Investigator/Assoc. Professor	2.7	8.6		23.2
McDonald, J.	Technician	6.0	5.1		30.6
	Adjustment to recognize rounding				-0.2
	Subtotal	8.7	13.7	0.0	
				Personnel Total	$53.6

Travel Costs: Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1999
Seward to Anchorage – Annual EVOS meeting	0.1	1	5	0.2	1.1
Seward to Anchorage – SEA synthesis meeting	0.1	1	5	0.2	1.1
Adjustment to recognize rounding					-0.4
				Travel Total	$1.8

FY 99

Project Number: 99320-U
Project Title: Fish Energetics
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 – September 30, 1999

Contractual Costs:	Proposed
Description	FY 1999
Communications	0.4
Contractual Total	$0.4

Commodities Costs:	Proposed
Description	FY 1999
Project supplies (laboratory supplies, computer disks)	0.2
Commodities Total	$0.2

FY 99

Project Number: 99320-U
Project Title: Fish Energetics
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities DETAIL

Prepared: 7/9/98

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: 99320-U
Project Title: Fish Energetics
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

Prepared: 7/9/98

Revision 7-17-98
Approved TC. 8-98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		
Travel		
Contractual	$0.0	$10.0
Commodities		
Equipment		
Subtotal	$0.0	$10.0
General Administration	$0.0	$0.7
Project Total	$0.0	$10.7
Full-time Equivalents (FTE)	0.0	0.1

LONG RANGE FUNDING REQUIREMENTS			
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
	$0.0	$0.0	$0.0

Dollar amounts are shown in thousands of dollars.

Other Resources

Comments:

FY 99

Project Number: 99320-Y
Project Title: Bird Predation on Salmon Fry
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: 7/9/98

1999 EXXON VALDEZ TRUS. COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999						
Personnel		$7.1						
Travel		$1.0						
Contractual		$0.2						
Commodities								
Equipment			LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$8.3		Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
Indirect		$1.7						
Project Total	$0.0	$10.0						
Full-time Equivalents (FTE)		0.1						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:The PWS Science Center Cost Policy Statement was submitted with prior proposals and should be on file at the Trustee Office.

Our Federal Indirect Cost Rate proposal includes a Cost Policy Statement that specifically details what we charge as Direct Costs and what is charged as Indirect Cost. This was done to insure that the manner in which we charge out costs are fair and equitable to all projects and to insure that indirect costs are distributed so that federally funded projects do not bear more than their fair share. The Prince William Sound Science Center charges communication and copying costs to each project according to project codes utilized when using the service and charges supplies that are used specifically for and directly to that individual project. Indirect Cost communications, copying and supplies relate to those costs assumed for managing and administering the entire Science Center and not an individual project. To charge these costs for our EVOS projects as an Indirect Cost would create an inequity in our system that could cause the Center to be penalized in other federally funded projects .

The EVOS Trustee Council has capped the Science Center with a reduced Indirect Cost rate of 20% TDC instead of the 28.6%MTDC rate that has been determined to be fair and equitable by our federal cognizant agency .To have us assume additional cost under that reduced 20% rate would be inappropriate.

FY 99

Project Number: 99320-Y
Project Title: Bird Predation on Salmon Fry
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4A
Non-Trustee
SUMMARY

Prepared: 7/9/98

1999 EXXON VALDEZ TRUS. COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 1999
	Scheel, D.	Co-author	1.10	6.44		7.1
		Subtotal	1.1	6.4	0.0	
					Personnel Total	$7.1

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1999
	Ogdensburg, NY to Anchorage, AK – EVOS meeting/SEA synthesis	1.0	1	3		1.0
					Travel Total	$1.0

FY 99

Project Number: 99320-Y
Project Title: Bird Predation on Salmon Fry
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 7/9/98

1999 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET
October 1, 1998 – September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
Services (photocopies, phone, mail, etc).	0.2
Contractual Total	$0.2

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

FY 99

Project Number: 99320-Y
Project Title: Bird Predation on Salmon Fry
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Contractual & Commodities DETAIL

Prepared: 7/9/98

1999 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET
October 1, 1998 – September 30, 1999

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

Existing Equipment Usage: Description	Number of Units

FY 99

Project Number: 99320-Y
Project Title: Bird Predation on Salmon Fry
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Equipment
DETAIL

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999	LONG RANGE FUNDING REQUIREMENTS					
				Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
Personnel								
Travel								
Contractual	$59.8	$84.0						
Commodities								
Equipment								
Subtotal	$59.8	$84.0						
General Administration	$4.2	$5.9						
Project Total	$64.0	$89.9		$0.0	$0.0	$0.0		
Full-time Equivalents (FTE)	0.2	0.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY 99

Project Number: 99320-Z-1
Project Title: Sound Ecosystem Assessment (SEA): Synthesis and Integration
Agency: ADFG

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel	$28.7	$35.1
Travel	$15.0	$29.6
Contractual	$4.1	$2.5
Commodities		
Equipment		
Subtotal	$47.8	$67.2
Indirect	$12.0	$16.8
Project Total	$59.8	$84.0
Full-time Equivalents (FTE)	0.2	0.3
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, as negotiated by the *Exxon Valdez* Oil Spill Trustee Council with the University of Alaska.

In accordance with the Federal Office of Management and Budget Circular A-21, including Cost Accounting Standards, the School of Fisheries and Ocean Sciences has gone to considerable effort to assure that all expenditures, regardless of source, are in compliance with federal law. These standards specify which costs are to be directly charged, and which are included in Facilities and Administration (sometimes referred to as Indirect, Overhead Recovery, or General or Administrative Costs). Project specific communications costs such as postage, photocopying, telephone and fax tolls, express package services, and audio conferencing charges are considered direct charges to projects. Project specific supplies including software, and laboratory and field supplies are direct charges as well.

FY 99

Project Number: 99320-Z-1
Project Title: Sound Ecosystem Assessment (SEA): Synthesis and Integration
Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 – September 30, 1999

Personnel Costs: Name	Position Description		Months Budgeted	Monthly Costs	Overtime	Proposed FY 1999
Cooney, R. T.	Principal Investigator/Professor		3.0	11.7		35.1
	Subtotal		3.0	11.7	0.0	
					Personnel Total	$35.1

Travel Costs: Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1999
All travel is for SEA synthesis workshops.					
Fairbanks to Cordova	0.4	10	50	0.1	9.0
Fairbanks to Anchorage	0.3	10	50	0.1	8.0
Miami to Fairbanks	1.2	2	10	0.1	3.4
Cordova to Anchorage	0.1	10	50	0.1	6.0
Charleston to Anchorage	1.1	2	10	0.1	3.2
				Travel Total	$29.6

FY 99

Project Number: 99320-Z-1
Project Title: Sound Ecosystem Assessment (SEA): Synthesis and Integration
Name: University of Alaska Fairbanks

FORM 4B Personnel & Travel DETAIL

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
Communications – mail, conference call	1.1
Document copying	0.6
Academic Services – manuscript preparation (20 hr @ $40/hr)	0.8
Contractual Total	$2.5

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

FY 99

Project Number: 99320-Z-1
Project Title: Sound Ecosystem Assessment (SEA): Synthesis and Integration
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities DETAIL

Prepared: 7/9/98

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: 99320-Z-1
Project Title: Sound Ecosystem Assessment (SEA): Synthesis and Integration
Name: University of Alaska Fairbanks

FORM 4B Equipment DETAIL

Prepared: 7/9/98

FY 99 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$0.0
Travel		$0.0
Contractual		$65.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$65.0
General Administration		$4.6
Project Total	$0.0	$69.6
Full-time Equivalents (FTE)		0.5

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$60.0	$0.0	$0.0		

Dollar amounts are shown in thousands of dollars.

Other Resources

Comments:

FY 99

Prepared:

Project Number: 99320-Z-2
Project Title: SEA Synthesis and Integration (editor)
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUS. COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999						
Personnel		$35.8						
Travel		$1.7						
Contractual		$16.6						
Commodities		$0.1						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$54.2		Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
Indirect		$10.8						
Project Total	$0.0	$65.0		$60.0				
Full-time Equivalents (FTE)		0.5						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: The PWS Science Center Cost Policy Statement was submitted with prior proposals and should be on file at the Trustee Office.

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FY 99

Prepared:

Project Number: 99320-Z-2
Project Title: SEA Synthesis and Integration (editor)
Name: Jennifer R. Allen
Agency: NOAA

FORM 4A
Non-Trustee
SUMMARY

FY 99 EXXON VALDEZ TRUS. COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 1999
Jennifer Allen	Synthesis Coordinator & Editor		5.0	6.6		33.0
TBN	Clerical Assistant		1.0	2.8		2.8
	Subtotal		0.5	9.4	0.0	
					Personnel Total	$35.8

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
Cordova-Fairbanks	350.0	2	10	100.0	1.7
				Travel Total	$1.7

FY 99

Prepared:

Project Number: 99320-Z-2
Project Title: SEA Synthesis and Integration (editor)
Name: Jennifer R. Allen
Agency: NOAA

FORM 4B
Personnel
& Travel
DETAIL

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

Contractual Costs:	Proposed
Description	FY 1999
Postage	0.4
Telephone	1.0
Photocopying	0.2
Network connectivity	10.0
Software licenses	5.0
Contractual Total	$16.6

Commodities Costs:	Proposed
Description	FY 1999
Office supplies	0.1
Commodities Total	$0.1

FY 99

Prepared:

Project Number: 99320-Z-2
Project Title: SEA Synthesis and Integration (editor)
Name: Jennifer R. Allen
Agency: NOAA

FORM 4B
Contractual & Commodities DETAIL

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
None			
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
Prince William Sound Science Center network, workstation, personal computer and associated hardware	1

FY 99

Project Number: 99320-Z-2
Project Title: SEA Synthesis and Integration (editor)
Name: Jennifer R. Allen
Agency: NOAA

FORM 4B
Equipment
DETAIL

Prepared:

Approved TC 8-13-98

Sound Ecosystem Assessment (SEA): Observational Oceanography in Prince William Sound and the Gulf of Alaska

Project Number:	99320M-CLO
Restoration Category:	Research
Proposer:	S. Vaughan/PWSSC
Lead Trustee Agency:	NOAA
Cooperating Agencies:	None
Alaska SeaLife Center:	No
New or Continued:	Cont'd
Duration:	6th yr.
Cost FY 99:	$62.5
Cost FY 2000:	$0.0
Cost FY 01:	$0.0
Cost FY 02:	$0.0
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pink salmon, Pacific herring

ABSTRACT

The model validation portion of 97320M/SEA - Observational Oceanography has not been completed. Model validation is required before the model can be used for hypothesis testing by any of the other SEA subprojects. Funds were remaining in the 97320M budget at the end of the year. This proposal is for funding, in the amount remaining in FY 97, to cover salaries of personnel responsible for circulation model validation and zooplankton seeding/flushing hypothesis testing.

Informed management decisions will enhance the restoration of pink salmon and Pacific herring, as well as other marine resources.

The SEA Observational Oceanography project has responsibilities in 3 main areas:

1. Large scale (Sound wide) physical and biological descriptive oceanography, relating phytoplankton and zooplankton distributions to physical processes.
2. Nearshore physical and biological descriptive oceanography, relating juvenile herring distributions to physical processes.
3. Numerical circulation model validation and testing.

The first 2 items in the SEA FY97 DPD (page 129)) under 'Physical field measurements', continuing ADCP velocity measurements at Hinchinbrook Entrance and Montague Strait and calculating transports, and continuing large scale hydrographic and velocity measurements, have been completed. The 1997 May cruise data have been processed, and we retrieved the ADCP mooring from Hinchinbrook Entrance and processed the data. We also completed a Sound-wide survey of zooplankton distributions using the OPC (item 5). The last 2 items, about critical regions and times, and designing a cost-effective monitoring scheme, are addressed in a recent FY99 DPD submitted to EVOS.

The third and fourth items in FY97 DPD, about assimilating data into the model, and identifying 'river' and 'lake' conditions, are only partially completed. The version of the model that is running now has freshwater input distributed uniformly over the surface. The model temperature profiles agree with the observations, but the modeled and observed salinities are not in agreement, especially in September (highest freshwater runoff).

The version of the model being constructed now (under SEA 320-J) will have freshwater input distributed around the periphery of the Sound, which is much more realistic. This version will also have more realistic inflow/outflow at Hinchinbrook Entrance, provided by the ADCP mooring time series. The current model version has inflow at all levels. After this newer model version is validated, it will be used to test hypothesis about zooplankton seeding and flushing in PWS.

The newer version of the model was scheduled for completion in January 1998. Because of personnel changes (in 320-J), this work is only now nearing completion. It is the validation of this newer model version, and finalizing our 'river/lake' analysis that remains to be done. This proposal is for funds to cover salaries of personnel responsible for completing these tasks.

NEED FOR THE PROJECT

A. Statement of the Problem

Pink salmon and Pacific herring resources continue to be listed as injured and non-recovering. SEA is an interdisciplinary ecosystem approach to understand which biological and physical factors in the environment might be constraining the recovery of these species. Predicting the impact of physical

processes on the biological components requires the coupling of a numerical ocean circulation model with a biological model. Other projects in SEA are working toward developing such a coupled model for PWS, but these models need observations for validation. This project will contribute the oceanographic data and analytic techniques for validation and refinement of the numerical circulation model, and for hypothesis testing.

B. Rationale/Link to Restoration

Without understanding how environmental and ecological factors might be influencing the recovery of injured species, there is no clear means for interpreting the past and present production status of pink salmon and herring in Prince William Sound. Further, restoration activities undertaken in the absence of knowledge about ecosystem function could conceivably cause more damage than they are intended to remedy. In the short term, development of improved stock assessment techniques and their application to building and evaluating numerical models of the herring and pink salmon ecosystem will improve the tools available for harvest management. Over the long term, as the SEA program obtains a better understanding of ecosystem form and function in Prince William Sound, the risks associated with proactive restoration activities will become much less uncertain. The numerical models developed by SEA will allow a variety of "what if" restoration options to be evaluated prior to their implementation as a measure for protecting all resources in the region.

Physical processes (tides, storms, inflow from the GOA, etc.) determine the water mass properties (temperature and salinity) and the circulation of PWS. Water mass properties and circulation influence the abundance and distribution of phytoplankton and zooplankton. Since zooplankton are the major food source for juvenile fish, their availability directly impacts the abundance and distribution of pink salmon and herring in PWS. Describing the character and evolution of the water mass properties and circulation in PWS, and identifying which physical processes are primarily responsible for changes in the water mass properties and circulation, will ultimately lead to correlations between those physical processes and fish abundance.

C. Location

This project has been designed for Prince William Sound. All communities that utilized the marine resources of Prince William Sound will benefit from this research.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

This project has contributed to the EVOS Youth Area Watch by designing a low cost program for high school students to monitor coastal oceanographic and meteorological variables at several locations in PWS. EVOS students participated in an oceanographic research cruise in 1996. This collaboration is expected to continue. Local fishing vessels and ships were chartered for oceanographic cruises in FY94 through FY97. Coast Guard and SERVs vessels have also been used for oceanographic surveys. This project has contributed information to local news letters, newspaper articles, seminars, and the Sound Waves radio program, and will continue to do so. Scientific results have been posted on the SEA web page, and are accessible to the public.

PROJECT DESIGN

A. Objectives

The main objective of this proposal is to complete tasks scheduled for FY97 so that the SEA project will close-out on schedule. These task are:

1. Validate the newest version of the numerical circulation model.

2. Use the model and the observations to test hypothesis about zooplankton seeding and flushing rates ('river/lake' hypothesis) in PWS.

B. Methods

1. Model generated horizontal fields of temperature, salinity, and current velocity at several standard depths (surface, 20m, 50m, 100m, etc.) for the months where cruise data exist will be compared to the observations. Vertical sections of modeled temperature, salinity, and current velocity will be compared sections created from the data. Success of the model simulations will be judged by the level of agreement between predicted and actual magnitudes of the variables, horizontal and vertical distributions of the variables, the seasonal variability (stratification formation, warming, and freshening), and the ability of the model to simulate large scale, robust features of the circulation and hydrographic structure of PWS (e.g. basin scale cyclonic circulation in September).

2. A passive tracer concentration, simulating zooplankton, will be placed at some location and depth in the model, for example mid-depth at Hinchinbrook Entrance, or deep in the 'black hole'. The model will be allowed to run, forced by seasonal meteorological fields, predicting the evolution (both horizontally and vertically) of the tracer field. The wind forcing, the inflow at Hinchinbrook Entrance, and the amount of freshwater input, for example, may be varied in the model runs to examine the effects of each. The spreading and evolution of the tracer field will be used to infer zooplankton distribution under different conditions. The model predictions will be compared to the observations.

C. Cooperating Agencies, Contracts and Other Agency Assistance

In previous years, vessel charters have been contracted to the private sector through competitive bid.

SCHEDULE

A. Measurable Project Tasks for FY 99

March 1999: EVOS Workshop - 10th Anniversary, and SEA Review
April 15, 1999: Submit SEA FY98 Draft Annual Report

April 15, 2000: Submit SEA FY99 Draft Final Report

B. Project Milestones and Endpoints

FY99: Submission of publication to peer reviewed journal.

D. Completion Date

The completion date will be September 30, 1999.

PUBLICATONS AND REPORTS

One manuscript will be submitted on comparisons between model simulations and observations in PWS.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Efforts in Observational Physical Oceanography are coordinated with all components of the SEA program. Research cruises and much of the data collected are shared with other SEA investigators. SEA will also cooperate with APEX and other EVOS-sponsored programs to provide the most efficient means for investigating biological and environmental factors common to all projects.

PROPOSED PRINCIPAL INVESTIGATOR

Shari L. Vaughan, Ph.D.
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Revision 11/4/98
Approved TC 8-13-98

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		$58.4
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$58.4
General Administration		$4.1
Project Total	$0.0	$62.5
Full-time Equivalents (FTE)		8.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$0.0	$0.0	$0.0		

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:

Project Number: 99-320M
Project Title: SEA: Observational Oceangraphy in PWS and GOA
Agency:

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$48.7						
Travel		$0.0						
Contractual		$0.0						
Commodities		$0.0						
Equipment		$0.0						
Subtotal	$0.0	$48.7		Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
Indirect (20.0%)		$9.7						
Project Total	$0.0	$58.4						
Full-time Equivalents (FTE)		8.5						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY 99

Project Number: 99-320M
Project Title: SEA: Observational Oceangraphy in PWS and GOA
Agency:

FORM 4A
Non-Trustee
SUMMARY

Prepared:

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
Shari Vaughan	Physical Oceanographer (PI)		2.90	7100.0		20.6
Shelton Gay	Physical Oceanographer		2.80	5300.0		14.8
Loren Tuttle	Biological Oceanographer		2.78	4800.0		13.3
Kenric Osgood	Biological Oceanographer		0.0	5170.0		0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		8.5	22370.0	0.0	
					Personnel Total	$48.7

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: 99-320M
Project Title: SEA: Observational Oceangraphy in PWS and GOA
Agency:

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	
Contractual Total	$0.0

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

FY 99

Prepared:

Project Number: 99-320M
Project Title: SEA: Observational Oceangraphy in PWS and GOA
Agency:

FORM 4B
Contractual & Commodities DETAIL

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	
Description		

FY 99

Prepared:

Project Number: 99-320M
Project Title: SEA: Observational Oceangraphy in PWS and GOA
Agency:

FORM 4B
Equipment
DETAIL

99320N

Approved TC 8-13-98

Acoustic Assessment of Pink Salmon Predators, Macrozooplankton Prey and Juvenile Herring in Prince William Sound

Project Number:	99320N-BAA
Restoration Category:	Research
Proposer:	G. Thomas/PWSSC
Lead Trustee Agency:	NOAA
Cooperating Agencies:	None
Alaska SeaLife Center:	No
New or Continued:	Cont'd
Duration:	6th yr.
Cost FY 99:	$51.1
Cost FY 2000:	$0.0
Cost FY 01:	$0.0
Cost FY 02:	$0.0
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pink salmon, Pacific herring

ABSTRACT

This project will support the processing, analysis and reporting of FY 96-97 surveys of salmon predators, macrozooplankton prey and juvenile herring in Prince William Sound. This request is consistent with other projects (/320M, Oceanography and /320I, Isotopes) which have been compensated for additional field and analytical work that occurred with the expansion of the Juvenile Herring Growth and Habitats project (/320T). Scheduled analysis and reporting of the Nekton and Plankton Acoustics project (/320N) has been delayed because of this increased work load. Also, the funds that are requested were originally budgeted for the Nekton and Plankton Acoustics project but were underspent in FY 96-97. We were asked to submit a new proposal to recapture these funds after requesting a no-cost extension.

Science Foundation group of scientists working on the Ocean Ecosystem Dynamics Program (GLOBEC) concluded that our inability to predict changes in marine fish populations prevented us from separating natural and anthropogenic impacts (Cullen 1991). Acknowledging this situation, the EVOS Trustee Council initiated ecosystem-level studies to develop a better ecological understanding of these populations and improve the existing predictive tools. In 1993, the Sound Ecosystem Assessment science plan was developed by a group of scientists, fishermen and concerned citizens using the GLOBEC program as a guide. Funding of research began in the spring of 1994.

This is the fourth year of the Sound Ecosystem Assessment program (SEA), which is a long-term (5-8 years) ecosystem study to improve prediction of changes in abundance of pink salmon and Pacific herring in Prince William Sound. The pink salmon survival study focuses, but not exclusively, on hatchery fish since they represent over 90% of the juvenile salmon in the Sound during the spring. The herring in Prince William Sound are assumed to be a distinct stock. Both stocks are part of the EVOS Trustee Council restoration program.

The SEA program is developing (1) a subecosystem numerical model that predicts returning number of adult pink salmon spawners by indirectly estimating marine mortality of juvenile pink salmon in the spring and, (2) a subecosystem, numerical model that predicts recruitment of juvenile herring into the adult spawning population by directly estimating over-summer and over-winter mortality of sub-adult Pacific herring (ages 0, 1,2, 3 and 4) from fall and spring stock assessment surveys.

The development and operation of numerical models and the testing of hypotheses requires accurate assessment information on the distribution, density and size of specific animal populations. The nekton-plankton acoustics project (96320-N) is evaluating and applying acoustic measurement technology to collect this information. The assessment problem is complex for the development and operation of ecosystem-based models because they require estimates of dominant nekton and plankton predators and prey populations, which are often found in mixed aggregations. The measurement problem is simplified for juvenile herring in the winter when a time series of stock assessment surveys on the target species are possible, and mixed predator and prey assemblages are minimal.

To date, we have made significant progress toward our goals. For the ecosystem-based, numerical model for pink salmon we have: (1) identified adult walleye pollock as the dominant pelagic fish predator of nekton and plankton in the Sound, (2) made quantitative estimates of adult pollock biomass in the winter (in cooperation with commercial fishermen, Alaska Draggers Association and Alaska Department of Fish and Game, ADF&G), (3) made quantitative estimates of the distribution and density of adult walleye pollock in mixed layers of plankton prey in the spring, (4) made a first estimate of zooplankton distribution and

density. Tasks we are working on in 1996-98 are: (1) continue adult pollock biomass estimation with the fishing industry and ADF&G, (2) evaluate error in the estimate of spring-feeding adult pollock biomass, (3) evaluate the accuracy of zooplankton distribution and density estimates as a surrogate for prey availability, (3) determine the feasibility of assessing the spring salmon fry density and distribution along the shoreline, (4) determine the feasibility of assessing the spring density and distribution of subadult pollock biomass along the shoreline and their role as salmon fry predators and, (5) determine the feasibility of assessing the fall and winter biomass of subadult pollock distribution and abundance. Annual estimates of adult pink salmon returning each year are provided by ADF&G.

For the population-based numerical model for herring we have: (1) made quantitative estimates of adult herring biomass in the fall and spring (in cooperation with commercial fishermen, Cordova District Fishermen United (CDFU) and ADF&G) and, (2) made first run estimates of fall juvenile herring distribution and abundance. Tasks that we are working on in 1996-98 are: (1) continue making estimates of the adult herring biomass in the fall and/or spring with the fishing industry and ADF&G and (2) evaluate the accuracy of fall and spring, juvenile herring distribution and abundance estimates.

NEED FOR THE PROJECT

Statement of the Problem

Pink salmon were damaged by the spill but are now listed as a recovering resource, while herring is still listed as non-recovering. However, we do not have the ability to tie the changes observed in these populations to natural or anthropogenic impacts. Thus, the justification to continue SEA remains to develop better predictive tools. SEA has made significant progress in two years towards developing a better understanding of the ecosystem, improving the data management, analysis and modeling tools and maintaining communication and cooperation amongst a diverse group of organizations and researchers. In addition, some byproducts of the SEA program have already made important contributions, such as the application of acoustic survey techniques to make estimates of adult Pacific herring in 1993, 1994 and 1995 and adult walleye pollock in 1995.

Pacific herring were damaged by the spill and were showing some signs of recovery until this spring when only 24,000 tonnes were measured on the acoustic-purse seine survey. The ecological, economic and cultural importance of Pacific herring to PWS and the North Gulf of Alaska is unparalleled. The Tlingit called herring the "grass of the sea." Herring are the main source of prey for numerous fish, birds, and mammals in PWS. Without understanding how environmental and ecological factors, including climatic changes, might be influencing the

recovery of Pacific herring, there is no clear means for predicting changes in production. Furthermore, restoration activities undertaken in the absence of knowledge about ecosystem function could conceivably cause more damage than they are intended to remedy. Over the long term, as understanding of the Prince William Sound ecosystem improves, the risks associated with proactive restoration activities will become much less uncertain.

B. Rationale

Baseline data on animal abundance is limited when used for determining the impact of and recovery of anthropogenic disruptions on dynamic populations. This is because animal population abundance is seldom stable. In contrast, it is often in a state of fluctuation, either increasing or decreasing as a result of purely natural events. Therefore, the development of models that predict animal population change as a result of natural conditions is mandatory to accurately assess recovery from an anthropogenic disturbance. The Nekton-Plankton Acoustics project is providing the baseline data on animal abundance that is also essential data for developing and evaluating the predictive models.

In addition, restoration activities undertaken in the absence of the ability to predict change are controversial because they could cause more damage than they are intended to remedy. Almost every biological remedy fits into this class: fish hatcheries, animal rehabilitation, bioremediation, etc. However in the short-term, the Nekton-Plankton Acoustics project development of improved stock assessment techniques and their application to building and evaluating numerical models of the herring and pink salmon ecosystem has already improved our knowledge of the stocks and provided new tools for harvest management. Over the long term, as the SEA program obtains a better understanding of ecosystem form and function in Prince William Sound, the risks associated with proactive restoration activities will be reduced.

C. Summary of Major Hypotheses and Objectives

The underlying mechanisms of the ecosystem-based, numerical models are the coupled hypotheses: river-lake and prey-switching. River-lake hypothesizes that the climate-forced flushing rates of the Sound are negatively correlated with the availability of zooplankton prey to fishes in the spring. Prey-switching hypothesizes that during years of low zooplankton prey availability (a river year), the predators switch to feed on the age 0 fishes rearing in the Sound and age 0 fish survival is low. The combination of age 0 fish survival being positively correlated to lake year conditions and negatively correlated to predation is proposed as the mechanism that produces large year classes of fishes in the Sound.

The Nekton-Plankton Acoustics project is contributing to the testing of the river-lake and

prey-switching hypotheses by providing zooplankton and fish distribution and density information. After two years of SEA research, there is increasing evidence to support that these hypotheses are mechanisms that dominate the Sound's production processes. With dominant mechanisms providing the framework for the modeling effort, there is an excellent chance to develop better predictive models for pink salmon and herring recruitment.

D. Completion Date

1. Phase I (FY94-95): Infrastructure development, implementation of standard fisheries measurement technologies to study population-level predator-prey relationships, stock assessment of dominant fish species (a cooperative program with industry and management), initiation of zooplankton measurement program using digital echosounders and the development of new 4D visualization techniques with acoustic data.
2. Phase II (FY96-98), Continued stock assessment of dominant fish species (a cooperative program with industry and management), model development to describe predator-prey dynamics relative to physical conditions, advancement of quantitative 4D visualization techniques with acoustic data, implementation of a new zooplankton measurement program, refinement of measurement and estimation techniques. Initiation of synthesis.
3. Phase II (FY99-2001): Completion of synthesis and implementation, testing and training for the monitoring phase in the transition from research and development to application. Researchers cannot be expected to become locked into the routine monitoring phase so education and training of post-graduate personnel will be necessary to bring them up to speed on the new measurement and analytical technologies and their application.

COMMUNITY INVOLVEMENT

The SEA Science Plan was developed using local knowledge from the community to establish goals for the science program. The Nekton-plankton acoustics project has integrated local knowledge of the fish populations into: (1) the design and implementation of fish stock assessment surveys, (2) the choice of procedures to subsampling specific acoustic targets, and (3) in the safe and effective operation of vessels used as sampling platforms. Several community presentations on different aspects of the project are presented to the local public in both invited and public seminars each year.

The PWS Science Center initiated a SEA newsletter, the Sound Waves radio program, established a home page on the world-wide web (http://www.pwssc.gen.ak.us/sea/sea.html) and is building a local area network to disseminate information throughout the Sound and to interested parties around and outside Alaska. Locally, we also use our Science Club, Science Discovery Room, Science outreach program and Science Summer Camp programs to disseminate information to the public. Although, the EVOS funding for this has been

discontinued, the Center is seeking other sponsors to continue the dissemination of research information to the public via presentations, newsletters, wide- and local-area networks, radio and possibly video communications. The Nekton-Plankton Acoustics Project has contribution to all of the above communications on research findings and acknowledges the EVOS Trustee Council for its generous support.

Location

This project has been designed for Prince William Sound. All communities that utilized the marine resources of Prince William Sound will benefit from this research.

PROJECT DESIGN

In the summers of 1996 and 1997, acoustic measurements of juvenile herring were collected in four bays and fjords around PWS (Whale, Eaglek, Simpson, and Zaikof) by SEA Nekton and Plankton Acoustics Project (320-N) in support of the SEA Herring project (320-T). It was hypothesized (SEA project) that condition at the onset of winter would play an important factor in the over-winter survival of the fish. These studies were designed to study the processes that affected the pre-winter condition of the herring.

The goal of the Nekton and Plankton Acoustics projects was to determine the site fidelity and the possible carrying capacity of winter refuge for juvenile herring. Also, to work with SEA Oceanographers (320M) to identify retention mechanisms in the nearshore regions and potential losses from PWS to the outer Kenai areas. Both of these mechanisms are supported by broad scale acoustic observations in the fall of 1995. We dedicated a full time acoustician to the juvenile herring project for the last two years to accomplish this task. We need to recapture unspent funds in the FY96-97 budgets to finish the analysis and processing that was postponed to collect the additional juvenile herring data.

Objectives

We are currently working on the macrozooplankton, predator and herring observation data bases for use in hypothesis testing of mechanisms that are the backbone of the SEA modeling development. We need to finish these so we can play an effective role in the synthesis of SEA data.

For our project 'deliverables', an easy way to separate tasks in fiscal years might be the resulting publications. So, first are the deliverables already completed by April 15, 1998:

1. The assessment of co-occurring predator and plankton densities submitted to the Canadian bulletin for publication (1994-95) and EVOS TC 1997 annual report.
2. The determination of errors in acoustic assessment of adult herring and pollock biomass (1993-1996), the dominant predators of salmon fry in PWS, and their implications towards multiple species management that was published in the Proceedings of the 2nd World Fisheries Congress and 1997 EVOS TC annual report.
3. The repeatability and accuracy of acoustic assessment of the adult herring and pollock in PWS (1993-1997), and implications in the 1997 annual report to the EVOS TC,
4. The assessment of the predation of salmon fry at AFK hatchery (1992-93) published in the 1995 annual report to the EVOS Trustee Council,
5. Broadscale distributions of juvenile herring in PWS in the fall of 1995 reported in the 1996 EVOS Trustee annual report.
6. Walleye pollock abundance and distribution along the outmigration route of pink salmon fry, PWS, (1994-95) that was published in the 1994-95 annual reports to the EVOS TC.
7. The preliminary assessment of the use of acoustics, optics and nets in the measurement of plankton density and distribution in PWS in the 1997 report to EVOS TC.

Second are the deliverables to be completed by April 1999 if extension is authorized:

1. A manuscript to a journal on the repeatability and accuracy of acoustic biomass estimation for herring and pollock in PWS (1993-1998) and their implications to inseason management, salmon fry model input and validation publication (latest version of the model). This includes incorporation of 1997-1998 data and analyses that are underway.
2. A manuscript submitted to a journal on the acoustic estimation of plankton density and distribution in PWS (1994-1996). This includes new processing of data that were just received from Ted Cooney.
3. A manuscript submitted to a journal on the broadscale distribution of juvenile herring in PWS (1993-1997). This includes new analyses that were just completed for the 1997 review and a merging of findings with the herring habitat project.
4. A manuscript on the pollock prey switching relative to plankton densities (1994-1996). This includes new high resolution spatial analysis that is being designed after the completion of the pollock and plankton co-occurrence paper.
5. A manuscript describing the SEA program and the synthesis of findings, which are being developed by the SEA P.I.'s.

Methods

The Nekton-Plankton Acoustics project is a multidisciplinary study that will rely on: (1) cooperative, model development to assist in sampling design, data analysis and interpretation,

(2) shared vessel and facilities for data collection and logistical support, (3) data sharing with the agency and university principal investigators, and (4) remote sensing with acoustical and optical technologies.

Synoptic sampling of both the biological and physical characteristics of the water column using samplers that operate on quasi-continuous, spatial and temporal scales are essential if SEA is to link small scale process measurements to population and ecosystem parameters (Thomas 1992, GLOBEC 1991b). In response to this, three core SEA projects (oceanography, nekton-plankton acoustics and data management and modeling) were designed to incorporate the necessary acoustical and optical measurement technologies and computer intensive analytical and communication tools. Recognizing the rapid evolution of technologies, a small component of each of these SEA projects will be used to match other funding sources to research and develop new techniques.

The SEA field program used the conceptual experimental design of GLOBEC (1991c), which involves the nesting of fine scale measurement programs within large scale ecosystem monitoring efforts. Ocean state monitoring required large scale surveys in the coastal buoyancy current and throughout the Sound, and fine scale monitoring along the western shorelines. Trophic state monitoring required large scale monitoring throughout the Sound for macrozooplankton, and finer scale monitoring in the central-western Sound and along its shorelines for nekton. Monitoring is concentrated in the western Sound because this area contains the primary migration route and feeding areas of juvenile and adult pink salmon and Pacific herring.

Macrozooplankton:

The primary temporal and spatial characteristics of the macrozooplankton bloom that are important to measure are: (1) the timing, (2) the amplitude and, (3) the horizontal distribution around the Sound. Finer scale measurements of inshore-offshore and vertical distribution of the prey relative to diel and tidal conditions are important to the development of the bioenergetics and foraging mechanisms. Understanding mechanisms is critical to making believable predictions.

Historically, the timing of the macrozooplankton bloom has been determined by systematically sampling with a vertical net at hatcheries over the season. Acoustic and optical measurement procedures are being used to make a more representative estimate of the macrozooplankton population in time and space.

In 1994-95, we developed more appreciation for the importance of the spring macro-zooplankton bloom to the juvenile fishes rearing in PWS. Measurement of the temporal and

spatial characteristics of the macrozooplankton bloom (timing, amplitude and geographic distribution) is a key aspect of 1995 SEA studies. The integrated volume of this distribution could positively correlate with flushing rate (river to lake conditions) and explain the majority of interannual variability in pink survival. Also, 1994-95 surveys suggested that the abundance of the primary salmon predator, walleye pollock, can be made coincidentally with macro-zooplankton assessment. Thus, one survey may provide the annual estimates of prey and predators affecting juvenile fish survival. Thus, some variation of the spring macrozooplankton survey could be the future monitoring tool used to estimate annual carrying capacity of PWS.

In 1996, the large scale distribution and information on density of the macrozooplankton was measured using multiple-frequency, digital, dual-beam echosounders, an optical plankton counter (OPC) and various plankton nets (Cooney, 320H). A four frequency (120, 420, 720 kHz and 1 MHz) echosounder system were used for offshore sampling and a two frequency system will be deployed inshore (120 and 420 kHz). Interactive Data Language (IDL) code and Advanced Visualization Systems (AVS) flowgrams were developed on a workstation for processing (including target strength and absolute density estimation), data integration and visualization.

The macrozooplankton catch in the closing net were used to sea truth the higher frequency acoustics and the optical measurements. The closing net, acoustic and optical measurements were taken at the same depth and time interval. The acoustics and optics will be cross calibrated, or size and density estimates of macrozooplankton will be compared between acoustics and optics to develop best sampling protocols. These analyses are ongoing.

The timing of the bloom may be of very short duration in river years (only three weeks) so the selection of sampling time is critical. The long term averages suggest that the peak macrozooplankton abundance is plus or minus a week around the 12th of May. Thus, the timing of the large scale surveys will be conducted to bracket this period.

Nekton:

Large scale measurements of fish distributions were made using 120 kHz (38 and 70 kHz if available) digital echosounders. The BioSonics ESP and DT software was be used to integrate the backscatter and isolate individual targets. IDL code and AVS flowgrams were developed on a workstation for processing (target strength and density), data integration and visualization. The sonars were deployed from surface vessels in the western Sound for salmon work and throughout the Sound for herring. Aerial surveys will help stratify acoustic survey efforts for nearshore herring assessment. During late spring and summer months sidelooking sonar was used in addition to downlooking echosounders to collect information

on nearsurface salmon fry and herring concentrations. These analyses are ongoing.

In 1994, we observed large variability in seasonal in- and offshore distribution of fish along the outmigration corridor of the pink salmon fry. In 1995, we conducted shoreline and offshore sampling at sites where juvenile pink salmon fry were concentrated to determine in- and offshore changes over diel and tidal cycles. Acoustic transects will be run perpendicular to the shoreline site and repeated several times during these surveys. In 1994 and 1995, the salmon fry tended to be patchily distributed, at the surface, and so tightly distributed against the shoreline that they were inside of the acoustic surveys of fry predators. In 1996, we explored the feasibility of measuring the distribution of salmon fry along the shoreline with sidelooking sonar. These analyses are ongoing.

Actual field sites will be determined by the Principal Investigators during field prelogistic meetings.

Data Acquisition and Processing

Acoustic Data Acquisition: Acoustic signals are currently acquired by the Echo Signal Processor software (version 3.0) from BioSonics. Two data sets are generated from each transect; a list of individual targets whose voltage peaks could be isolated from the transducer signals (via dual-beam), and a 2-dimensional array of relative density (via echo-squared integration) whose cells will be georeferenced with GPS information.

For the 120 kHz system, a noise threshold is determined which will remove smaller targets not of interest. For higher frequencies that are used to measure zooplankton, the noise level will establish the threshold. A TS of -70 dB typically marks the beginning of Rayleigh scattering for a 120 kHz system. We also perform passive listening so as to characterize the sonar's noise performance.

The number of echo integrator cell sizes is limited by hardware and software constraints. New software with the digital sonars are expected to reduce these limitations. The vertical size of cells was smaller near the surface to provide higher resolution (0.5 m). The horizontal size of cells was determined by the minimum number of pings which ranged from 8 to 60 pings (higher resolution was used for inshore surveying). Ping rates are logged so that individual targets can be referenced to their appropriate cell.

Geographical Logging: Each sonar system is equipped with a Magellan DX5000 GPS receiver and external antenna to indicate current position. We connect the GPS's NMEA0183 data output to the computer's COM1 input, after which the position data is read to the echo-integration files, yielding georeferenced density arrays. BIOMAP software is used as a realtime navigational aid. Maps are made by postprocessing data using the pwsplot procedure

in IDL. This data link is feasible only during minimal CPU use and often causes Windows to crash. This problem is under investigation by BioSonics and will be solved by next spring's field season.

Species verification with biological sampling: Fish are caught to determine species, measure physical lengths (to compare to acoustic measurements), and to analyze stomach contents. Over 1300 hundred purse seine, herring trawl and tucker trawl hauls were made in the summer of 1994 and 1995. Classification of acoustic targets by species using the composition of these net catches is ongoing.

Data Management and analysis

An acoustic tool box of software utilities have been developed in IDL and AVS for processing and analysis.

a) IDL - The Interactive Data Language (IDL) is an array-oriented programming environment which has been chosen for processing of electronic data. The PWS Science Center has hosted a number of acoustic R&D projects which have contributed to the development of a library of software procedures for expediting acoustic data analysis. Compiled versions of these routines are shared with cooperating researchers for specific projects as a service offered by the PWS Science Center.
b) AVS - Advanced Visualization System is a tool which allows scientists to connect block-diagram modules into flowgram networks. These modules include visualization, data I/O, and statistical functions, as well as any C programs written in-house. This makes it simple to use as well as expandable. Modules for data integration and geographical transformation have been developed at PWS Science Center on a number of R&D projects. Executable files for these routines are available for use by cooperating researchers.

Processing: An IDL data file is generated for each pass on a transect, and includes individual targets, spatial arrays of absolute density and average backscatter, georeferencing, bottom, and calibration information. The acoustic values are all recalculated from the raw voltage data, so that calibration parameters can be adjusted during post processing if necessary. .
a) Targets - A power function (Traynor and Ehrenberg, 1979) is currently used to simulate a transducer's beam pattern (ideally a Bessel function) so as to estimate TS. The target strengths are therefore compensated for off-axis location, and targets with angles greater than the mode in the angle distribution (usually about 3 degrees) are excluded so as to remove size bias (since off-axis targets require higher noise thresholds).

Some of the parameters in dual-beam estimation have a degree of variability which can cause error in TS. In particular, the wide beam dropoff is determined by a regression, and the range

of angles to include in its computation has not been standardized. We will investigate the use of the beam pattern as a discrete vector instead of a simulation. During processing, this will be more computationally expensive than a power function although much less than a Bessel function, and the cost in CPU time will be offset by the additional accuracy.

b) Densities - Absolute density is calculated spatially by dividing the relative density array (v^2) by the average target backscatter (sigma), then applying calibrations (SL, RG, PW, B^2).

Biological Analysis:

a) Problem definition - Classification of targets is a problem in Prince William Sound because of the diversity of marine life. While pollock, salmon, cod and herring are the dominant fish species, other organisms including zooplankton, squid, and jelly plankton are plentiful and capable of reflecting sound. Some separation of these species is possible because they often arrange themselves in layers but these layers have fuzzy boundaries relative to the sharp boundaries of discrete fish schools. This may be a function of the single-frequency analysis and should be resolved by multifrequency analysis. Also, different species can overlap in space and time, which we may use in predation analysis.
b) People and machines - Our first step in target classification is to develop criteria for interactively classifying species. An editor has been written in IDL which allows the user to select an aggregation of targets within an electronic echogram, and tag them based on TS, known spatial and temporal behavior of each species. Data from these are referenced to seine and trawl catches that were either directed at the targets or conducted in the vicinity of the acoustic transecting. Other classifications such as noise, bubbles, jellies, and false bottom can also be used so as to exclude those targets from the analysis.

Automation technology is often assumed to be an ultimate solution, without considering all of its implications. Quality control and assurance can easily suffer degradation when high quantity is the priority and automation is the primary tool. Although the volume of data collected is often immense (hundreds of transects per year), it is still to our advantage to use interactive techniques, as opposed to "faster" automated techniques. An interactive technique is one in which powerful computers and software allow the intelligent user to make decisions efficiently, with the labor performed by the CPU under the scientist's supervision. It is also faster than pure manual techniques. Automatic techniques to classify targets also require extensive parameterization and ground truthing, which although possible, will take a few years to develop fully.

c) N-dimensional signal processing - Work has been done in using 1-dimensional signals (individual pings) to determine school content (Rose and Leggett, 1988, Ramani and Patrick,

1992). However, the second spatial dimension (ping number) is relevant to species classification. Thus, the entire image will be analyzed as well as single ping information. We are currently using the electronic echograms mentioned above. We plan to expand earlier signal processing techniques to the distance dimension, so that image processing (2-dimensional signal processing) will direct our classification schemes.

Multifrequency Analysis:

Our plan for summer 1996 is to deploy, measure, and analyze multiple frequencies and to use inverse techniques (Greenlaw and Johnson, 1983) to determine biomass as a function of species. We have purchased 70kHz, 120kHz, 420kHz, 720kHz, and 1MHz systems. We plan to operate up to four of these frequencies simultaneously. Inversion is a mathematical technique where matrix algebra is employed to solve for several unknowns, given several equations. The fundamental equation states that acoustic scattering at a particular frequency is the total of the multiple of biomass per species by each species response at that frequency. Thus, by dividing the measured acoustic scattering matrix by the known frequency dependence of all species of interest, the result is the scattering as a function of species. This technique requires frequency response of each species to be accurately known, which is another justification for upgrading our calibration facilities to allow known targets to be tethered and ensonified. These mathematical techniques have been expanded to constrain solutions to be non-negative (Lawson and Hanson) , and to find solutions even when given fewer equations than unknowns. A portion of these inversion algorithms has been coded in IDL, and will be complete by summer 1996.

Estimation routines:

Estimates of fish biomass will be made from systematic transect designs and where replication is possible estimates of precision will be made. Procedures for estimation and sources of error are presented in MacLennan and Simmonds (1992). Hypotheses testing will be an integrated analysis step with the Numercial Modeling project (320J).

C. Discussion

Pink Salmon and Pacific herring models

The indirect estimation of marine mortality for the juvenile life history stage of pink salmon is necessary because they migrate to sea and are not seen until they return 12-14 months later as adults to spawn (Forester 1967). Since about 90% of marine mortality of pink salmon occurs as juveniles in the spring (Thomas and Mathisen 1992), we are attempting to model ocean and trophic state conditions as a surrogate to a direct measurement of the number of fish and

result in an estimate of survival. Ocean state conditions (water temperature and current velocities) directly affect the juvenile pink salmon survival via the bioenergetics mechanism (Beauchamp et al. 1989) and are postulated to indirectly affect the trophic structure by altering the distribution and abundance of prey, competitor and predator specie. Since climate forcing (cyclonic storms, El Nino events, etc.) results in significant annual variability in ocean state conditions, the survival of juvenile pink salmon fry are expected to fluctuate in a like manner (Thomas and Mathisen 1992).

The survival of herring larvae from egg deposition to recruitment as four year olds into the adult spawning population has been a topic of intensive investigations. Since the studies of herring eggs and larvae have not produced a reliable model to predict herring recruitment (reference), we are evaluating the capability to directly measure ages 0, 1, 2, 3 and 4 juvenile herring in the fall and spring to estimate survival over the summer and winter periods. Critical to this capability is the assumption that the subadult herring distribution is relatively stable within the Prince William Sound survey area. It is important to note that this is not a mechanistic model so it cannot tell you why the mortality has occurred.

The development of an ecosystem-based, numerical model that predicts herring recruitment by indirect estimation of over-summer and over-winter juvenile herring mortality is needed to assess why the mortality has occurred. Also, the over-summer and -winter model subcomponents may be useful if the stock assessment of juvenile herring proves not to be feasible. Between these two subcomponents, the over-winter survival model is most tractable since the predation and feeding/growth effects are minimal. The development of an over-summer survival model for herring is problematic since predation and feeding/growth effects are dominant processes and mortality rates are precipitous. Also, if the survey approach is successful at estimating survival from a time series of direct measurements, the development of the ecosystem-based, Numercial model will be more robust, if the ocean and trophic state conditions are known. Since there is a time lag and spatial separation between when age 0 pink salmon and herring are present in the Sound, additional ocean and trophic state measurements for herring are needed.

Since juvenile mortality rates for both pink salmon and Pacific herring are eventually used to estimate adult recruitment, accurate stock assessment of the adults is essential for the final testing of numerical models. Stock assessment of the returning adult pink salmon is a major management program that is conducted annually by ADF&G. Adults are counted in the catch and adult escapement into the streams is estimated by visual inspection via aerial overflights. To conduct stock assessment of herring, ADF&G relies on virtual population analyses, egg deposition surveys and aerial estimates of the length of shoreline that is discolored by herring milt. Working with the fishermen and ADF&G through grants from CDFU, we have developed an acoustic stock assessment survey that has tracked the population since fall 1993.

Since adult stock assessment is essential to the success of SEA but not a SEA task, we must continue to collaborate with management and industry to collect this information using acoustic techniques developed between 1993-95.

Multi-species exploitation rate model

Since the ecosystem-based models are long-term products, a short-term solution to restoration that has developed as an offshoot of the SEA and related stock assessment efforts is the development of a multiple-species (pink salmon, herring, walleye pollock) exploitation rate model. Again, this is a non-mechanistic approach to restoration and is offered only to consolidate and standardize ongoing single-species management efforts that independently set exploitation rates for these co-existing stocks.

Logistics of measurement and future monitoring

These endeavors are considered logistically possible only because: (1) the Sound is assumed to be a semi-enclosed, rearing area for the young salmon and herring, which places spatial limits to the extent of our study area, (2) it is assumed over ninety percent of the juvenile pink salmon mortality occurs in the spring, which places temporal limits on our study, (3) subadult herring are assumed to rear overwinter in the Sound or close by, and (4) we are implementing a synoptic large and small scale measurement program with quasi-continuous samplers (optics and acoustics) that allows us to simultaneously measure ocean and trophic state conditions.

C. Cooperating Agencies, Contracts and Other Agency Assistance

Vessel charters will contracted to the private sector through competitive bid.

SCHEDULE

A. Measurable Project Tasks for FY 99

October 1998:	Analyze field data
March 1999:	EVOS Workshop - Anchorage
April 1999:	Annual Report submitted

B. Project Milestones and Endpoints

FY99

September 1999: Complete observations and analysis

C. Completion Date

The completion data of this project is September 30, 1999.

PUBLICATIONS AND REPORTS

Manuscripts submitted by the end of FY01: see objectives

PROFESSIONAL CONFERENCES

Travel is requested to present results at the EVOS Workshop in January 1998 in Anchorage.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This research will be coordinated with all components of the SEA program. This project will also cooperate with APEX, NVP, and other EVOS-sponsored programs to provide the most efficient means for investigating biological and environmental factors common to all projects.

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OTHER KEY PERSONNEL

Jay Kirsch, EE: Data processing and analysis
Geoff Steinhart:. Data processing and analysis

Revisio 7/14/98
Approved TC 8-13-98

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		$47.8
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$47.8
General Administration		$3.3
Project Total	$0.0	$51.1
Full-time Equivalents (FTE)		3.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
$0.0	$0.0	$0.0

Dollar amounts are shown in thousands of dollars.

Comments:

FY 99

Prepared:

Project Number: 99320N
Project Title: Acoustic Analysis
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$34.6
Travel		$2.6
Contractual		$0.6
Commodities		$0.4
Equipment		$0.0
Subtotal	$0.0	$38.2
Indirect		$9.6
Project Total	$0.0	$47.8
Full-time Equivalents (FTE)		3.5

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

Dollar amounts are shown in thousands of dollars.

Other Resources								

Comments:

FY 99

Project Number: 99320N
Project Title: Acoustic Analysis
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4A
Non-Trustee
SUMMARY

Prepared:

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
G.L. Thomas	co-Principal Investigator		1.5	13.6		20.4
Jay Kirsch	co-Principal Investigator		2.0	7.1		14.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		3.5	20.7	0.0	
					Personnel Total	$34.6

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 1999
ICES Fish Acoustic Meeting		1.0	1	8.0	0.2	2.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$2.6

FY 99

Prepared:

Project Number: 99320N
Project Title: Acoustic Analysis
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed
Description	FY 1999
tele, communications, fax, etc.	0.5
maintenance	0.1
Contractual Total	$0.6

Commodities Costs:	Proposed
Description	FY 1999
supplies	0.4
Commodities Total	$0.4

FY 99

Prepared:

Project Number: 99320N
Project Title: Acoustic Analysis
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Contractual & Commodities DETAIL

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	
Description		

FY 99

Project Number: 99320N
Project Title: Acoustic Analysis
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Equipment
DETAIL

Prepared:

Approved TC 8-13-98

Assessment of Injury to Intertidal and Nearshore Subtidal Communities Following EVOS: Preparation of Manuscripts for Publication

Project Number:	99325-BAA
Restoration Category:	Research
Proposer:	T. Dean/Coastal Resources Associates, Inc.
Lead Trustee Agency:	NOAA
Cooperating Agencies:	ADFG
Alaska SeaLife Center:	No
New or Continued:	Cont'd
Duration:	2nd yr. 2 yr. project
Cost FY 99:	
	$41.1
Cost FY 2000:	$0.0
Cost FY 01:	$0.0
Cost FY 02:	$0.0
Geographic Area:	All
Injured Resource/Service:	Intertidal and subtidal communities

ABSTRACT

This project will prepare manuscripts for publication in scientific journals based on previous Trustee Council funded evaluations of injury to, and restoration of, coastal habitats (intertidal and subtidal communities).

INTRODUCTION

The *Exxon Valdez* Oil Spill Trustee Council (hereafter referred to as the EVOS Trustees) has funded a number of projects that examined the injury to, and recovery of intertidal and nearshore subtidal systems. These include Coastal Habitat Study 1A: Comprehensive Assessment of Coastal Habitat; Restoration Project 94086: Herring Bay experimental monitoring studies; and several projects dealing with nearshore subtidal communities (Air/Water Project ST2A, and Restoration Projects 93047 and 95106). The final reports for these projects have been submitted to the Trustees (Highsmith *et al.* 1994, 1995; Jewett *et al.* 1995; and Jewett and Dean 1996) and several aspects of this work have either been published or are submitted for publication in the peer reviewed scientific literature (see Literature Cited). However, there are still several important scientific aspects of this work that have not been published.

In April 1997, a proposal was submitted to the EVOS Trustees to prepare manuscripts based on past EVOS work. The project (98325) was funded, with separate contracts awarded to Coastal Resources Associates, Inc. and WEST, Inc. (through NOAA under BAA) and to the University of Alaska (through ADF&G). Unfortunately, funding for the project was delayed and did not become available until February, 1998. As a result, there has been slower progress toward manuscript submittal than originally proposed. However, substantial progress has been made. One manuscript proposed for submission in FY 1998 was submitted in February 1998 and is in review. A draft of another has been completed and is under internal review, and for three others, manuscripts have been outlined and progress made toward gathering and analyzing data. This proposal seeks additional funding for FY 1999 to complete additional manuscripts as proposed in April of 1997. We anticipate that funding will of course be contingent upon submittal of manuscripts for which funds have already been received.

NEED FOR THE PROJECT

A. Statement of Problem

Publication of past Trustee sponsored studies of coastal habitats is important because these studies serve as a critical foundation for future injury assessment and restoration efforts. These studies are the most thorough and comprehensive investigations of a major oil spill that have been conducted to date, and should serve as cornerstone for future oil spill studies. Some of the Trustee sponsored work has recently been criticized (e.g. Paine *et al.* 1996) and a timely publication of coastal habitat studies is needed in order to correct some current misconceptions.

B. Rationale/Link to Restoration

The lessons learned from studies of coastal habitats following the *Exxon Valdez* oil spill, both about the ecology of the nearshore environment and about the process of assessing impacts from a major oil spill, are valuable ones that need to be applied to future restoration efforts.

C. Location

There are no field studies to be conducted. Past studies, on which publications will be based, were conducted in Prince William Sound, Kenai/Cook Inlet, and Kodiak/Alaska Peninsula.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

The projects are based on data gathered throughout the damage assessment and restoration phases of the *Exxon Valdez* Oil Spill studies funded by the Trustees. Past work has been presented at various public meetings sponsored by the council. It is anticipated that manuscripts produced will be the basis of future presentations at Trustee sponsored restoration workshops.

One of the manuscripts that is to be produced as part of this project, "Comparison of Study Designs for Assessment of Shoreline Impacts of the *Exxon Valdez* Oil Spill" will critique study designs utilized by the Trustee sponsored work, studies sponsored by NOAA, and studies by Exxon. An obvious shortcoming of all of these works is the failure to address subsistence issues, and the failure to utilize traditional ecological knowledge in the study design. A discussion of how these shortcomings might be addressed in future studies will be developed in consultation with the Oil Spill Restoration Office, and will be included as part of the manuscript.

PROJECT DESIGN

A. Objectives

The objective of the proposed study is to produce a minimum of 8 manuscripts for publication in the peer reviewed scientific literature. Six are slated for completion in FY 1998. This proposal requests funding for additional manuscripts to be submitted in FY99.

B. Methods

The manuscripts will be prepared by a team of scientists who have been directly involved in the coastal habitat studies funded by the Trustees. The work will be coordinated by Coastal Resources Associates, Inc. (CRA). Dr. Thomas Dean, President of CRA will serve as project leader. Key individuals in the Coastal Habitat Injury Assessment program will serve as authors of manuscripts to be prepared. These will include Drs. Ray Highsmith and Mike Stekoll of the University of Alaska. Dr. Dean will also serve as a lead author, and will be assisted by Dr. Larry Deysher of CRA who has had extensive involvement in the CHIA program.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

This proposal is being submitted under BAA by Coastal Resources Associates, Inc. However, it is anticipated that a portion of the funding will be directed to the University of Alaska, with contract administration for that portion of the contract conducted by Alaska Department of Fish and Game.

SCHEDULE

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

A total of two manuscripts will be prepared for publication during FY99. A description of these is given under "Publications and Reports" below.

B. Project Milestones and Endpoints

All manuscripts slated for preparation in FY99 will be in draft form and available for internal review by March 31, 1999. At that time, a progress report will be submitted to the Trustees that includes the draft manuscripts. All manuscripts will be submitted by April 30, 1998. The schedule for publication will depend on the length of the review period, and on the extent of revisions (if any) required. It is anticipated that all manuscripts will be ready for final acceptance by August 1999.

C. Completion Date

It is anticipated that all ten manuscripts proposed will be submitted and accepted by September 1999. Some carry over of funds may be required to cover page charges incurred in FY00.

PUBLICATIONS AND REPORTS

It is anticipated that a minimum of eight manuscripts will be produced. Six of these are slated for submission in FY98, with an additional 2 proposed for FY99. A listing of anticipated authors, titles, journals selected for submission, and a brief description of the content of each manuscript follows. For manuscripts to be submitted in FY 1998, an assessment of the progress made toward publication is included.

Manuscripts to be prepared in FY 1998

1. Comparison of Study Designs for Assessment of Shoreline Impacts of the *Exxon Valdez* Oil Spill

Proposed Authors: Lyman L. McDonald, Wallace P. Erickson, M. Dale Strickland, and Charles Peterson. (Order to be determined by relative contribution and amount written)

Possible Journals: Marine Pollution Bulletin or Oecologica

This manuscript will contrast the design of the Coastal Habitat Injury Assessment (Highsmith *et al.* 1996, Jewett *et al.* 1995, McDonald *et al.* 1995, Stekoll et al 1996) to study designs used in assessment of shoreline impacts of the spill by Exxon supported scientists (Page *et al.* 1995) and NOAA scientists (Mearns 1996, Houghton *et al.* 1996). The objectives of these studies will be contrasted and the designs will be evaluated in terms of how well project objectives were met, the

relative ability of each design to quantify impacts of the Exxon spill, and the relative strengths and weaknesses of each design. The role of the following will be assessed in each of the studies:

1) random selection of study sites,
2) subjectively selected study sites,
3) interspersion of study sites,
4) definition and selection of reference sites,
5) levels of statistical inference,
6) power to detect important ecological effects (and specifically trade offs one must make with respect to power and ability to make broader statistical inferences),
6) the role of experiments (as contrasted to surveys) in injury assessment,
7) statistical analyses, and
8) definitions for recovery.

Progress: Dr. McDonald has outlined this manuscript and has solicited comments from co-authors regarding its content.

2. *Fucus* and the *Exxon Valdez* Oil Spill: Injury and Recovery

Proposed Authors: Michael S. Stekoll, Lawrence E. Deysher, and Mandy R. Lindeberg

Possible Journals: Marine Ecology Progress Series or Marine Environmental Research

Analysis of injury to *Fucus* will be presented for all areas (Prince William Sound, Kenai/Lower Cook Inlet, and Kodiak/Alaskan Peninsula) and habitats (Sheltered Rocky, Exposed Rocky, Coarse Textured, and Estuarine) for the period 1991-1994. The focus will be on *Fucus gardneri* populations (abundance, biomass. reproductive state, injury to plants, extent of fouling, percent cover), and will contrast the patterns observed at the three areas representing different levels of oiling and cleanup, and different physical regimes. The discussion will draw on previously published studies of experimental evaluations on the recovery and recolonization of *Fucus* in Herring Bay (Stekoll and Deysher 1996, Van Tamlen and Stekoll 1995, 1996; and Van Tamlen *et al.* 1997) to help explain differences in patterns observed in different areas and habitats.

Progress: Dr. Stekoll has produced a draft manuscript and it is currently being reviewed by co-authors. Dr. Stekoll is planning on revising this manuscript and submitting it for publication by August 1998.

3. Injury to, and Recovery of Rocky Intertidal Communities in Prince William Sound Following the *Exxon Valdez* Oil Spill

Proposed Authors: Raymond C. Highsmith, Thomas A. Dean, and Susan M. Saupe.

Possible Journals: Marine Ecology Progress Series or Marine Environmental Research

This manuscript will assess injury to dominant taxa of intertidal plants and animals in Prince William Sound in sheltered rocky, exposed rocky, and coarse textured habitats. The paper will utilize data from a broad geographic examination of injury based on studies carried out throughout the Sound (Coastal Habitat Injury Assessment Studies), and from a longer time series of observations in Herring Bay (Herring Bay Population Dynamics Studies) to evaluate injury and recovery of dominant taxa (*Fucus*, ephemeral algae, barnacles, limpets, mussels and littorines). We will examine how the Herring Bay and CHIA data correlate with one another and attempt to use the Herring Bay data to infer mechanisms of impact and processes of recovery for communities throughout the Sound. For example, the paper will related algal species composition and abundance following the spill and potential relationships to subsequent invertebrate distributions, and vice versa.

Progress: The has been no progress on this manuscript.

4. Factors Limiting Recovery of Limpet Populations following the *Exxon Valdez* Oil Spill

Proposed Authors: Thomas A. Dean, Anthony J. Hooten, and R. Highsmith. (Order to be determined by relative contribution and amount written)

Possible Journals: Marine Ecology Progress Series or Marine Environmental Research

This paper will focus on limpets. The evidence for injury (based mostly on CHIA data), and recovery (based mostly on the Herring Bay population dynamics data) will be reviewed. The bulk of the paper will examine experimental data from fencing and caging experiments on the effects of oiled substrates as well as other factors (e.g. algal density and limpet density) on the recovery process. A preliminary examination of the data suggest that limpets (especially *T. persona* in the upper intertidal) were severely injured, that most populations perhaps recovered by 1993 or 1994, and that oiled substrates apparently did not inhibit recovery. Experimental data indicate that limpets graze on algae and provide a mechanism that might explain why cover by filamentous algae increased following the spill. Experimental data also suggest some interesting biology regarding density dependence in limpets, and the potential effects of predators on survival of limpets. Population dynamics data indicate that there was a large increase in the abundance of limpets at both oiled and control sites in Herring Bay between 1990 and 1994. We can speculate that this might have been natural temporal variation, or a result of a release from predation pressure throughout Herring Bay because of an oil related reduction in oystercatchers, harlequin ducks and other potential predators.

Progress: Dr. Dean has obtained databases with algal and invertebrate data necessary for manuscript preparation from the University of Alaska and Mr. Andy Hooten. Some preliminary analyses have been conducted, especially with respect to extracting needed algal data from existing coastal habitat injury assessment databases.

5. Effects of the *Exxon Valdez* Oil Spill and Non-Anthropogenic Factors on the Distribution and Abundance of Nearshore Benthic Fishes in Prince William Sound, Alaska

Proposed Authors: T.A. Dean, L. Haldorson, D. Laur, and S. Jewett. (Order to be determined by relative contribution and amount written)

Possible Journals: Fisheries Bulletin, Environmental Biology of Fishes

This paper will examine the factors affecting the distribution and abundance of nearshore benthic fishes including a variety of habitat characteristics (vegetation type, slope, substrate type, exposure) as well as oiling of adjacent shorelines. We will examine community response (MDS and PCA analysis) as well as responses of dominant taxa (using non-linear models and/or PCA analysis). A previous publication (Laur and Haldorson 1996) examined only the differences between fish abundance at oiled and control sites, by species and habitat. This manuscript will present a more community based approach, that also examines the influence of factors other than oil on distribution and abundance. Data are from the 1990 subtidal surveys, with a few other data from eelgrass habitat surveys in subsequent years . A draft of this manuscript is in preparation.

Progress: An outline has been produced and analysis of fish community data has been initiated. Initial multivariate analysis (MDS and principal component analyses) were completed, and further analyses are underway. It is anticipated that a draft manuscript will be prepared by May 1998.

6. Impacts of the *Exxon Valdez* Oil Spill on Benthic Communities in Eelgrass Habitats

Proposed Authors: S.J. Jewett, T.A. Dean, A. Blanchard, and R.O. Smith.

Possible Journals: Marine Ecology Progress Series

Examination of impacts to subtidal benthic infauna and small epifauna based on subtidal studies. This is a manuscript that comes directly from sections of the report of Jewett and Dean (1996) on eelgrass communities that deal with dredge sample data.

Progress: This manuscript was submitted to Marine Ecology Progress Series in January 1998.

Manuscripts to be prepared in FY99

7. Algal Community Function Following the *Exxon Valdez* Oil Spill

Proposed Authors: Michael S. Stekoll, Lawrence E. Deysher, and M.R. Lindeberg.

Possible Journals: Marine Ecology Progress Series or Marine Environmental Research

An examination of community level responses following the EVOS, based on algal data from Coastal Habitat Injury Assessment studies conducted in Prince William Sound, Kenai/Cook Inlet, and Kodiak/Alaskan Peninsula. Community similarity (MDS), diversity, functional group analysis

(e.g. leafy blades, filamentous algae), higher order taxa analysis (red vs. green algae), and life history groupings (annuals vs. perennials, widely dispersed vs. not so widely dispersed, etc.) will be presented.

8. A Summary of Impacts of the *Exxon Valdez* Oil Spill on Nearshore Subtidal Communities

Proposed Authors: T.A. Dean and S.J. Jewett.

Possible Journals: Ecological Applications, Annual Reviews of Ecology and Systematics

A summary of available information on the injury and recovery of subtidal communities including (but not necessarily limited to) studies of impacts and recovery of subtidal communities (Armstrong *et al.* 1995; Dean *et al.* 1996a, 1996b; Jewett and Dean 1997; Jewett et al 1995, 1996; Laur and Haldorson 1996); hydrocarbon data (Bence and Burns 1995; Carlson and Kvenvolden 1996; O'Clair *et al.*, 1996; Page *et al.* 1995; Short and Babcock 1996; Short *et al.* 1996a, 1996b; Wolfe *et al.* 1994); bacteria data (Braddock and Richter 1994; Braddock *et al.* 1995, 1996); toxicity data (Armstrong *et al.* 1995; Wolfe *et al.* 1996), and biomarker data in subtidal fishes (Armstrong *et al.* 1995; Collier *et al.* 1996). Salmon and herring data will be not be reviewed. This manuscript is in preparation.

PROFESSIONAL CONFERENCES

No funding is being requested for attendance at professional conferences in FY99.

NORMAL AGENCY MANAGEMENT

This project has been developed through collaboration of private sector and University of Alaska scientists. None of the proposers have management responsibility. However, it is anticipated that publications produced will be widely utilized in future management decisions.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The scientists involved in the preparation of manuscripts have worked collaboratively in previous Trustee funded investigations of injury and recovery in coastal habitats. Authors will serve as internal reviewers of each of the manuscripts while these manuscripts are in preparation.

Several of the authors are also participants in other large ecosystem studies funded by the Trustees. Thomas Dean and Stephen Jewett are principal investigators for the Nearshore Invertebrate Predator Project and Lyman McDonald serves as consulting statistician for both the Nearshore Vertebrate Predator and APEX projects. The APEX and especially the Nearshore Vertebrate Predator Project have large components that deal with coastal habitats, and new findings produced by these studies will be considered when preparing manuscripts. It is also

anticipated that information presented in the manuscripts, along with the information gained in ongoing research and monitoring efforts, will be integrated and utilized in developing future monitoring plans for coastal habitats.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

A review of impacts on intertidal communities that was originally proposed for inclusion in the FY 1999 budget is currently being developed under separate contract to Dr. Charles Peterson, and is not included in this renewal proposal. As a result, the budget for FY 1999 is less than originally anticipated.

PROPOSED PRINCIPAL INVESTIGATORS

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Approved TC 13-98

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		$21.1
Commodities		$0.0
Equipment		$0.0
Subtotal		$21.1
General Administration		$1.5
Project Total		$22.6
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.

PROJECT TOTAL:

$22.6 NOAA (CRA)
18.5 ADFG (UAF)
$41.1

FY 99

Project Number: 99325
Project Title: Injury to Intertidal and Nearshore Subtidal: Manuscripts
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Revision 7/27/98
Approved TC 8-13-98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel	$14,662	$11,132
Travel	$0	$528
Contractual	$1,400	$0
Commodities	$1,740	$400
Equipment	$0	$0
Subtotal	$17,802	$12,060
Indirect	$13,318	$9,025
Project Total	$31,120	$21,085
Full-time Equivalents (FTE)	2.2	1.60
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	Estimated FY 2003
$800	$0	$0	$0

Dollar amounts are shown in thousands of dollars.

Comments: 1. Contractual changes are as follows:

1. CRA, Inc. Indirect Rates calculated as follows: Overhead = 59.5% of salaries and fringe.
General Administrative = 12.065% of total direct costs.
Fee = 0% of total direct and indirect

1999

Prepared:

Project Number: 99325
Project Title: Assessment of Injury to Intertidal and Nearshore Subtidal Communities Following the Exxon Valdez Oil Spill: Preparation of Manuscripts for Publication "Submitted under BAA"
Name: Coastal Resources Associates, Inc.

FORM 4A
Non-Trustee
SUMMARY

7/27/98

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
Dean, Thomas A.	Project Coordinator-Lead Author		1.00	$7,604	0.0	7,604
Deysher, Lawrence E.	Co-author		0.35	$7,604	0.0	2,661
Jung, Dennis	Graphical/Production Assistant		0.25	$3,469	0.0	867
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.6	$18,677	0.0	
					Personnel Total	$11,132

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
					0.0
One round trip					0.0
San Diego to Anchorage	$368	1	2	$80	$528
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$528

1999

Prepared:

Project Number: 99325

Project Title: Assessment of Injury to Intertidal and Nearshore Subtidal Communities Following the Exxon Valdez Oil Spill: Preparation of Manuscripts for Publication "Submitted under BAA"

Name: Coastal Resources Associates, Inc.

FORM 4B
Personnel
& Travel
DETAIL

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed FY 1999
Description	
Contractual Total	$0

Commodities Costs:	Proposed FY 1999
Description	
Journal Page Charges	$400
Commodities Total	$400

1999

Prepared:

Project Number: 99325

Project Title: Assessment of Injury to Intertidal and Nearshore Subtidal Communities Following the Exxon Valdez Oil Spill: Preparation of Manuscripts for Publication "Submitted under BAA"

Name: Coastal Resources Associates, Inc.

FORM 4B
Contractual & Commodities DETAIL

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
None			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

1999

Prepared:

Project Number: 99325
Project Title: Assessment of Injury to Intertidal and Nearshore Subtidal Communities Following the Exxon Valdez Oil Spill: Preparation of Manuscripts for Publication "Submitted under BAA"
Name: Coastal Resources Associates, Inc.

FORM 4B
Equipment
DETAIL

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		$17.3
Commodities		$0.0
Equipment		$0.0
Subtotal		$17.3
General Administration		$1.2
Project Total		$18.5
Full-time Equivalents (FTE)		0.0
	Dollar amounts are shown in thousands of dollars.	
Other Resources		

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

FY 99

Project Number: 99325
Project Title: Injury to Intertidal and Nearshore Subtidal: Manuscripts
Agency: ADFG

FORM 3A
TRUSTEE
AGENCY
SUMMARY

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

Budget Category:	Authorized FY 1997	Proposed FY 1998
Personnel		$13,055.0
Travel		$0.0
Contractual		$0.0
Commodities		$1,000.0
Equipment		$0.0
Subtotal	$0.0	$14,055.0
Indirect		$3,289.0
Project Total	$0.0	$17,344.0
Full-time Equivalents (FTE)		1.50
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	
	$25,000.0				

Dollar amounts are shown in thousands of dollars.

Comments:

1998

Prepared:

Project Number: 99325
Project Title: Assessment of Injury to Intertidal and Nearshore Subtidal Communities Following the *Exxon Valdez* Oil Spill: Preparation of Manuscripts for Publication "Submitted under BAA"
Name: University of Alaska, Southeast

FORM 4A
Non-Trustee
SUMMARY

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

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 1998
	Stekoll, Mike	Lead Author	1.5	$8,703	0.0	13,055
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	1.50	$8,703	0.0	
					Personnel Total	$13,055

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 1998
	None					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

1998

Prepared:

Project Number: 99325
Project Title: Assessment of Injury to Intertidal and Nearshore Subtidal Communities Following the Exxon Valdez Oil Spill: Preparation of Manuscripts for Publication "Submitted under BAA"
Name: University of Alaska, Southeast

FORM 4B
Personnel
& Travel
DETAIL

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

Contractual Costs:	Proposed FY 1998
Description	
None	
Contractual Total	$0.0

Commodities Costs:	Proposed FY 1998
Description	
Office and computer supplies	$500
Page charges - manuscript	$500
Commodities Total	$1,000

1998

Prepared:

Project Number: 99325
Project Title: Assessment of Injury to Intertidal and Nearshore Subtidal Communities Following the Exxon Valdez Oil Spill: Preparation of Manuscripts for Publication "Submitted under BAA"
Name: University of Alaska, Southeast

FORM 4B
Contractual & Commodities DETAIL

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1998
None			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	

1998

Prepared:

Project Number: 99325
Project Title: Assessment of Injury to Intertidal and Nearshore Subtidal Communities Following the Exxon Valdez Oil Spill: Preparation of Manuscripts for Publication "Submitted under BAA"
Name: University of Alaska, Southeast

FORM 4B
Equipment
DETAIL

Approved TC 8-13-9

Pigeon Guillemot Restoration Research at the Alaska SeaLife Center

Project Number:	99327
Restoration Category:	Research
Proposer:	D. Roby/Oregon State Univ.
Lead Trustee Agency:	DOI
Cooperating Agencies:	None
Alaska SeaLife Center:	Yes
New or Continued:	Cont'd
Duration:	2nd yr. 4 yr. project
Cost FY 99:	$166.1
Cost FY 2000:	$167.7
Cost FY 01:	$95.1
Cost FY 02:	$0.0
Geographic Area:	Lower Cook Inlet
Injured Resource/Service:	Pigeon guillemot

ABSTRACT

This project will test the feasibility of direct restoration techniques for pigeon guillemots (e.g., installation of artificial nest sites, use of social attractants, captive propagation and release). While raising young guillemots in captivity, it will also be possible to conduct controlled experiments crucial to two other restoration objectives: (1) development of nondestructive biomarkers of petroleum hydrocarbon contamination, and (2) understanding how dietary factors (prey species composition, prey size, lipid content, feeding frequency) constrain growth, development, and condition at fledging in guillemots.

STUDY HISTORY

This study is beginning its first field season in May 1998. Considerable progress has been made in setting up the Research Work Order from USGS-BRD to Oregon State University that will fund this project, selecting a graduate student for the project, designing and constructing artificial nest sites, exploration of potential sites for collecting guillemot eggs and young chicks, and obtaining the necessary permits (NEPA, Scientific Collecting) and approvals (IACUC) to conduct the work.

INTRODUCTION

The Pigeon Guillemot (*Cepphus columba*) population in Prince William Sound has failed to recover from declines that occurred both before and after the *Exxon Valdez* Oil Spill (EVOS). Post-spill studies of Pigeon Guillemot reproductive success have identified three primary factors preventing recovery:
1) In Prince William Sound (Naked and Jackpot islands) and Kachemak Bay, predation on eggs and chicks was a major source of nesting failure (Hayes 1996, Prichard 1997).
2) There has been a decline in the proportion of sand lance in the diet at some guillemot colonies in Prince William Sound (e.g., Naked Island), and the proportion of high-quality schooling forage fish in the diet seems to be a key factor in guillemot reproduction. The Alaska Predator Ecosystem Experiment (APEX) Project components F (Factors Limiting Pigeon Guillemot Recovery), G (Seabird Energetics), and M (Seabird/Forage Fish Studies in Lower Cook Inlet) are investigating the relationship between a lack of recovery and the availability and quality of forage fish. A decline in availability of high-lipid forage fishes (sand lance, herring, capelin) in the last two decades may be responsible for lower growth rates, fledging weights, post-fledging survival, and adult recruitment.
3) The Nearshore Vertebrate Predator (NVP) Project (River Otter and Pigeon Guillemot component) is testing the hypothesis that exposure to residual oil from the spill continues to limit recovery of Pigeon Guillemots. Pigeon Guillemots feed on a diversity of nearshore demersal fishes and schooling forage fish that use the substrate to avoid predators (e.g., sand lance), prey that were likely injured by EVOS. The approach of the NVP study is to measure certain biomarkers in blood and compare biomarker levels in nestlings from oiled and nonoiled areas. These blood biomarkers still need to be calibrated to known doses of weathered Prudhoe Bay Crude Oil (PBCO) in a controlled, laboratory setting.

The proposed research will be conducted at the Alaska SeaLife Center in Seward and will address all three of the above limiting factors. Experimental studies using captive subjects will be integrated with raising Pigeon Guillemot nestlings in captivity in order to establish free-ranging guillemot breeding colonies in the vicinity of the SeaLife Center. Predator-free nest sites will be built in the vicinity of the SeaLife Center and, in association with the use of decoys and audio playbacks of guillemot calls, will be used to attract and recruit prospecting guillemots to breed. Guillemot populations are frequently nest-site limited (Storer 1952) and Pigeon Guillemots readily breed in anthropogenic structures, such as docks and breakwalls, at many locations throughout the species' range. Like most seabirds, guillemots are philopatric to their natal location, and the cohorts that are raised in captivity at the SeaLife Center and released there can be expected to return and attempt to breed at the surrounding area. Although guillemots only rarely breed before three years of age, prospecting 2-year-olds that are raised in the first year of this three-year study can be expected to visit the SeaLife Center in the last year of this study. For the first two years of the study, immigration from nearby natural colonies will provide recruits to the colonies of free-ranging guillemots that we seek to establish near the SeaLife Center.

Providing artificial nest sites has the potential to restore guillemot populations through enhancing both local recruitment of adults and nesting success. Our success in recruiting prospecting adult guillemots to use artificial nest sites and the proportions of captive-reared and immigrant guillemots that utilize artificial nest sites will allow us to test the feasibility of this direct restoration technique for enhancing recovery of guillemot populations in the EVOS area.

The proposed work is intended to result in the establishment of breeding colonies of free-ranging Pigeon Guillemots near the SeaLife Center. By banding immigrants to the colony and young that are raised and released at the SeaLife Center, we can establish a breeding colony comprised of known-age individuals whose breeding history is known. Accessibility of nest sites can be a major obstacle for studies of factors influencing nesting success and demographics of guillemots, and artificial nests sites can provide investigators with unique opportunities. A dockside Black-legged Kittiwake colony in Great Britain has been studied for the past 30 years and provided most of what is known about that species in the northeastern Atlantic (i.e., Coulson 1988). Establishment of Pigeon Guillemot colonies near the SeaLife Center has the potential of providing a similar resource, in addition to providing opportunities for integration with ASLC's public education program.

Besides providing recruits for the breeding colony of free-ranging guillemots to be established at ASLC, raising chicks in captivity will also provide the opportunity to conduct controlled experiments that are relevant to two major issues in Pigeon Guillemot restoration: (1) the effect of prey type, size, quality, and frequency of delivery on nestling growth rates and condition of young at fledging and (2) the utility of biomarkers in blood and excreta as indicators of exposure to crude oil and other environmental contaminants. Research on these two topics can best be conducted using captive subjects whose environment and diet can be carefully controlled to avoid confounding variables so common in natural populations. In the first year of this study (1998), chicks will be raised on different diet regimes to determine the effects of the proportion of schooling forage fishes (sand lance, capelin, herring) vs. nearshore demersal fishes (gunnels, pricklebacks, sculpins) on growth rates. In the subsequent two years of the study (1999 & 2000), controlled feeding experiments will be conducted that are designed to reveal the tradeoffs inherent in meal size, meal frequency, and meal quality (energy density) as they influence nestling growth performance. The results from this study will complement continuing studies on the role of diet for productivity of nesting guillemots that are part of the APEX Project.

In the second and third years of the study, some chicks that are raised in captivity will be fed small, sublethal doses of weathered Prudhoe Bay crude oil (PBCO). Subsequent to dosing, samples of blood and excreta will be collected at prescribed intervals for measurement of biomarkers of health status. These results will allow us to define the dose-response relationship between ingested PBCO and each biomarker of exposure. Such results are essential for evaluating the efficacy of particular biomarkers and the utility of these biomarkers for assessing the exposure of free-ranging guillemots to oil.

Of particular value for interpretation of the results of captive feeding trials and crude oil dose-response experiments will be the subsequent release of these subjects and measurements of their return rates in subsequent years. Although it can not be assumed that all young guillemots that are fledged from the ASLC and survive to breeding age will return to breed near ASLC, the return rates of nestlings raised on various diets, plus return rates of oil-dosed and control nestlings, will provide valuable information on the long term effects of prey composition and oil exposure for guillemot fitness.

NEED FOR THE PROJECT

A. Statement of Problem

In the last two decades the Pigeon Guillemot population in Prince William Sound has declined from 15,000 to 5,000 individuals (Laing and Klosiewski 1993). While this decline apparently began prior to the EVOS, an estimated 10-15% of the population in the spill area died as a direct result of the spill. Post-spill censuses have not detected an increase in numbers, suggesting no appreciable recovery has occurred in the aftermath of the spill. Reasons for the lack of recovery are unclear, but may be related to changes in prey resource availability, continuing exposure of

guillemots or their prey to oil, or nesting failure due to predation on guillemot eggs and/or nestlings.

Predation on Pigeon Guillemot eggs and chicks was apparently minimal before EVOS, but post-spill studies have frequently recorded high levels of predation from river otters and mink (Hayes 1995). High predation rates could be reducing production of local birds, increasing breeding dispersal (lack of fidelity to a previously used nest site or location) of established breeders, and decreasing the immigration of guillemots from other colonies. While Pigeon Guillemots typically have high fidelity to their breeding site, disturbance and lack of breeding success can increase the rate and distance of breeding dispersal. Populations suffering high levels of disturbance, such as persistent nesting failure due to terrestrial predators, will decline due to a lack of production of new recruits, dispersal of breeding birds, and/or decreased immigration.

Two ongoing EVOS projects have identified potential reasons for a lack of recovery by Pigeon Guillemots in the EVOS area. The APEX Project has identified a major shift in the nearshore ecosystem that has apparently resulted in fewer schooling fish, particularly sand lance (*Ammodytes hexapterus*) fed to chicks (Oakley and Kuletz 1994, Golet et al. unpubl. ms.). Pre-spill studies found sand lance, a nearshore schooling fish with a high lipid content, to be the dominant prey returned to chicks. Post-spill studies have found gadids and nearshore demersal fish to constitute the majority of the diet. The NVP project has attempted to determine if blood biomarkers can be used to monitor level of exposure to oil and if blood from individuals in wild populations currently indicates exposure to oil is occurring. Both of these projects have examined wild populations that are exposed to numerous sources of variability that confound the examination of factors affecting chick growth or blood biomarkers.

This study is relevant to EVOS Restoration Work because it is designed to develop direct restoration techniques for Pigeon Guillemots, a species injured by the spill that is failing to recover. Techniques developed during this study will be relevant to restoration of other alcid species. Also, dose-response experiments with guillemot nestlings fed small, sublethal amounts of weathered Prudhoe Bay crude oil will provide crucial validation and calibration results for interpretation of on-going studies of biomarkers as indicators of crude oil exposure. Experimental studies with captive-reared guillemots will also provide a better understanding of how shifts in the diet of guillemots and other seabirds breeding in EVOS area affects growth, development, fledging condition, and, ultimately, fitness. By monitoring the growth and development of nestlings raised on controlled rations, the relative nutritional quality of various prey can be assessed. Also, fitness tradeoffs between prey size/quality and provisioning rate can be assessed through monitoring of subsequent survival in the wild of captive-reared chicks. Understanding the constraints imposed on guillemots by diet composition, oil exposure, and nest site quality will be crucial for designing management initiatives to enhance productivity in this and other seabird species that are failing to recover from EVOS.

B. Rationale/Link to Restoration

Artificial nest sites have the potential to increase the size of both guillemot breeding colonies and populations. A Black Guillemot colony in arctic Alaska increased from 10 to 225 pairs in 17 years through provision of artificial nest sites (Divoky et al. 1974 and in prep.). In Washington State 27% of the 33 Pigeon Guillemot colonies are in piers or other anthropogenic structures (Speich and Wahl 1989). Establishment of a Pigeon Guillemot colony near the Alaska SeaLife Center will demonstrate the utility of direct restoration in assisting the recovery of Pigeon Guillemot populations in the northern Gulf of Alaska. If artificial nest sites are successful in attracting breeding adults and if successful reproduction ensues, artificial nest sites can be used in Prince William Sound to enhance productivity, recruitment, and immigration, all of which will facilitate recovery. Clusters of artificial nest sites similar to those at the ASLC can be installed near natural colonies that suffer from chronically high nest predation rates. Nests could be placed on pilings or "dolphins" constructed specifically for colony development.

Aside from providing prototypes for artificial colonies in other parts of the EVOS area, a breeding colony of free-ranging guillemots at the ASLC will allow investigators to conduct research on Pigeon Guillemots that would not be possible at natural colonies. Loss of eggs or chicks to predation has been a major source of nest failure in post-spill studies of Pigeon Guillemots in Prince William Sound (Hayes 1995). In addition, marked adults and returning young will allow an examination of demographics that has not been possible in Prince William Sound studies. A lack of recovery could be due to demographic parameters (e.g., adult survival, subadult survival, immigration/emigration rates) not evident in studies of nesting success or colony censuses. Guillemot demographics are much more easily studied at a colony of artificial nest sites where the banding of chicks and adults entails far fewer problems than at natural colonies. Should the proposed work result in the deployment and use of artificial nest sites in Prince William Sound, investigators will be able to obtain demographic information for that area that could explain the lack of recovery of local populations.

While the proposed colonies of Pigeon Guillemots to be established near the ASLC will have the benefit of captive-reared chicks returning to their natal location and assisting in establishment of the colony, immigration is obviously the source of adults founding new colonies. Immigrants can also be the primary source of recruits to established and expanding colonies (Petersen 1981). Unlike many seabirds, guillemots are semi-colonial and able to breed as single pairs as well as colonially. Prospecting guillemots can be expected to search for nesting opportunities more extensively than more colonial seabirds, which require minimum numbers of conspecifics for successful breeding. Nest sites at ASLC are likely to attract nonbreeding prospectors from the approximately 100 pairs of Pigeon Guillemots breeding between Aialik Cape and Cape Resurrection (Nishimoto and Rice 1987), as well as more distant colonies. An expanding colony of Black Guillemots in arctic Alaska drew most of its recruits from colonies more than 400 km distant (Divoky, in prep.).

A Pigeon Guillemot colony could also have the potential of attracting other seabird species to nest in the area of ASLC. Some of these other species may also be recruited by providing nest sites. A Black Guillemot breeding colony that utilized artificial nest sites in arctic Alaska also attracted Horned Puffins (*Fratercula corniculata*), some of which used the artificial nest sites (Divoky 1982 and unpubl.).

The research component of this study will allow evaluation and validation of the use of nondestructive biomarkers (in blood and excreta) to assess the health status of individual guillemots and potential exposure to petroleum hydrocarbons. There is evidence that certain acute phase proteins (i.e., haptoglobin) in blood and porphyrins in excreta are induced by ingestion of sublethal doses of weathered crude oil (Prichard et al. 1997). The results of a dose-response experiment with wild guillemot nestlings in their natural nest sites, however, were ambiguous because of among-site variability in baseline values for biomarkers (Prichard et al. 1997). Also, guillemot nestlings were fed small doses (0.05-0.2 ml) of highly weathered PBCO in that study; the doses were not sufficient to cause a significant decline in growth rates of nestlings. Finally, blood samples for measuring biomarker levels were not collected until five days post-dosing, when any induction of an acute phase response had likely passed. While the use of blood and fecal biomarkers for monitoring oil exposure and general population health of guillemots is promising, more research under controlled, captive conditions is required to validate the techniques and provide a sound basis for interpretation of results from wild guillemots.

There is a definite need for information on the relationship between diet and reproductive success for Pigeon Guillemots, a seabird species that is failing to recover from EVOS at an acceptable rate (1994 *Exxon Valdez* Oil Spill Restoration Plan). Guillemots are the most neritic members of the marine bird family Alcidae (i.e., murres, puffins, and auks), and like the other members of the family, capture prey during pursuit-dives. Pigeon Guillemots prey on a wide variety of fishes, including schooling forage fish (e.g., sand lance, herring, pollock) and subtidal/nearshore demersal fish (e.g., blennies, sculpins; Drent 1965, Kuletz 1983). There is

strong evidence of a major shift in diet composition of guillemot pairs breeding at Naked Island. Sand lance were the predominant prey fed to young in the late 1970s (Kuletz 1983), but currently sand lance is a minor component of the diet (G. Golet, unpubl. ms.). In contrast, guillemots breeding in Kachemak Bay continue to provision their young predominately with sand lance, and sand lance is particularly prevalent in the diet at sites that support high densities of breeding pairs (Prichard 1997). Also, young of breeding pairs that provision their nestlings with mostly sand lance have higher growth rates (Prichard 1997, Golet et al. unpubl. ms.). Jackpot Island in southwestern Prince William Sound supports the highest nesting densities of guillemots anywhere in the Sound and growth rates of nestlings are correspondingly high. The high availability of juvenile herring to guillemots nesting at Jackpot Island may be responsible for both the high nesting density and high growth rates. Thus availability of high-quality schooling forage fishes (herring, sand lance) may be crucial for maintaining high nesting densities of highly productive guillemots.

C. Location

Pigeon Guillemot nestlings will be raised in captivity at the Alaska SeaLife Center in Seward. Guillemot nestlings will be hatched from eggs obtained from source colonies on the Kenai Peninsula or at other appropriate northern Gulf of Alaska colonies. Eggs that fail to hatch will be replaced with young nestlings (< 7 days post-hatch) collected from other colonies. Impact of these collections on the productivity of source colonies will be minimal as eggs lost during the first half of incubation are usually replaced during renesting and the majority of guillemot nesting attempts in the NGOA fail to produce fledglings because of high nest predation rates. Most of the captive-reared fledglings will be banded and released at ASLC to assist in efforts to establish local breeding colonies of free-ranging guillemots near ASLC. Artificial nest sites will be constructed near ASLC on an adjacent breakwall and other sites to enhance the prospects for colony establishment. Colonies in Resurrection Bay that may serve as sources of immigrants or may recruit captive-reared guillemots will be censused and checked for banded adults annually during the three years of the project. The information obtained from this project will benefit Pigeon Guillemot populations in the Gulf of Alaska, especially Prince William Sound. An understanding of the affect of prey type on chick growth will help explain the role of ecosystem shifts in continuing declines of Pigeon Guillemot populations. Assessing the utility of blood biomarkers for detecting and quantifying exposure to crude oil will benefit efforts to monitor the health status of Pigeon Guillemot populations throughout the spill zone without resort to lethal sampling procedures.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

All research will be conducted at the Alaska SeaLife Center, which will allow the community in and around Seward to observe progress in the establishment of guillemot colonies in both artificial and natural nest sites. Wild breeding colonies near ASLC have the potential for involving science classes from local schools. The location of colonies will potentially permit easy viewing by the public and allow science teachers to use the colony for instruction about seabird breeding biology and restoration. Science classes could conduct observations on the occurrence and activities of prospecting and breeding guillemots. Some of these (timing of arrival in the spring and sightings of color banded adults) could provide important information for the period when the investigators are not in Seward. Local science teachers can receive annual summaries of information about local colonies (e.g., timing of clutch initiation, breeding success) that can provide the basis for lessons on regional climate change and annual variability in the marine environment. The Seaquest Program of the Chugach School System would be a logical avenue for presenting this material to students.

PROJECT DESIGN

A. Objectives

This research project has three primary objectives listed below. During the second year of the project (CY 99), the emphasis will be on achieving all three objectives.

1. Determine the feasibility of using direct techniques for restoration of Pigeon Guillemots, including:
   a) providing artificial nest sites
   b) use of social attraction, such as decoys and playbacks of vocalizations
   c) release of captive-reared young

2. Determine the response of particular biomarkers of crude oil exposure (acute phase proteins, plasma sodium, fecal porphyrins) to variables of exposure in guillemot nestlings, and the survival of exposed nestlings post-fledging. Exposure variables that will be examined include:
   a) dose of ingested oil
   b) degree of weathering of ingested oil
   c) time since ingestion of dose
   d) frequency of exposure

3. Determine the effect of diet variables on growth performance, development, fledging condition, and post-fledging survival of Pigeon Guillemots, including:
   a) types of forage fish consumed, with emphasis on schooling forage fishes vs. nearshore demersal fishes
   b) lipid content of the diet
   c) size of prey items
   d) frequency of prey delivery

B. Methods

The proposed work will test the following three basic hypotheses, which relate to each of the three primary objectives listed above:

Hypothesis 1. Artificial nest sites, decoys, and playbacks of vocalizations can be used to establish new Pigeon Guillemot breeding colonies and enhance breeding success over that experienced at natural colonies using natural nest sites.

Hypothesis 2. Biomarkers from the plasma and excreta of nestling Pigeon Guillemots can be used as indicators of exposure to weathered crude oil in the food supply, and the subsequent survival probabilities of young guillemots post-fledging.

Hypothesis 3. Growth performance, fledgling condition, and post-fledging survival of Pigeon Guillemot nestlings are sensitive to differences in prey type, prey size, feeding frequency, and lipid content of prey.

Methodology employed during the second year of the study (CY 99) will consist of the following:

Objective 1: Testing Feasibility of Direct Restoration Techniques

a. Installation of Artificial Nest Sites and Use of Social Attraction

Pigeon Guillemot nest sites will be constructed and installed at two additional locations in the vicinity of the Alaska SeaLife Center. A minimum of five nest sites and three to five decoys will be placed at each new location. Additional nest sites will be provided at each location if the number of breeding birds and prospecting adults exceeds the number of available nest sites. Design of the artificial nest sites is based on the sites developed by Dr. Divoky for Pigeon Guillemots in Puget Sound, with modifications based on studies of nest site characteristics that

are associated with nesting success in Kachemak Bay (Prichard 1997). Sites will have two entrances with a central nesting cavity. Baffles in the entryways to the nest cavity will prevent avian predators from viewing nest contents. Based on the locations of Pigeon Guillemot nest sites associated with docks and piers, it appears that placing the sites beneath an overhang will increase their attractiveness to guillemots prospecting for nest sites. Sites under an overhang apparently have the advantage of decreased avian predation. Sites will be large enough to accommodate monitoring devices (such as a closed circuit camera, platform scale, or activity monitor) that may be used in future research.

Guillemot decoys will be made from molds produced by Mad River Decoy in Vermont. A CD player with external speakers will be used to play adult Pigeon Guillemot calls from May to mid August. Because prospectors may make recruitment decisions based on local breeding productivity (Boulinier et al. 1996), from late June to late August the calls of chicks in nest sites will also be played during the early morning and evening, when colony attendance can be expected to be highest. Similar combinations of decoys and audio playbacks have been used successfully for other seabird species, including alcids (Kress and Nettleship 1989, Kress 1983), but have never before been used to attract guillemots to nest at new locations.

Guillemots may begin prospecting for nest sites as early as March and nest sites and decoys will be deployed in March 1999. Personnel from this project will not be present at ASLC during most of March and April and staff from ASLC will be asked to make incidental observations of any guillemots associating with the artificial nest sites or decoys during our absence. We will attempt to assure that artificial nest sites and decoy placements are visible from ASLC. We will begin systematic observations of artificial nest sites and decoy sets in early May. Daily observations will be conducted at the times expected to have maximum colony attendance (0200-0900 and 1600-2000 Alaska Daylight Time, high tides). Initially observations will be recorded every 15 minutes on the number of Pigeon Guillemots visible from the roof of ASLC and their distance from artificial nest sites. Once guillemots begin associating with decoys and nest sites, we will conduct detailed observations on the behavior of prospecting birds. The location and activities of prospectors will be recorded during 15-minute periods. Behavioral observations will be similar to those conducted by Preston (1968) on Black Guillemot social behavior. In the initial stages of the study, when the sighting of any guillemots associating with artificial nest sites will be important, we will attempt to use a closed-circuit television camera to monitor activity while project personnel are in the SeaLife Center.

b. Monitoring of Pigeon Guillemot Breeding Biology and Demographics

Should breeding occur in the artificial nest sites in 1999, we will obtain information on the breeding biology of birds using the nest sites. To reduce the chances of nest site abandonment, no adults will be captured during 1998, but if successful breeding takes place in 1998, we will attempt to noose breeding adults for banding in 1999. In 1999 the following breeding parameters will be monitored:

- date of clutch initiation
- egg weight and volume
- egg color and pattern
- date of hatching
- weight at hatching
- hatching success
- growth rate (measured every two-four days)
- fledging weight
- fledging age
- fledging success

The observations on breeding chronology and success can be compared with ongoing field studies of Pigeon Guillemot nesting in Prince William Sound and Kachemak Bay. Additionally

the information on egg size and color can be used in future years to assess the potential of using egg characteristics to measure female survival and recruitment.

During the nestling period we will conduct observations on the prey types delivered to chicks. These observations will determine the taxonomic composition of nestling diets at each nest and collectively. These observations will be compared with diet data collected at natural colonies in Prince William Sound and Kachemak Bay (Golet unpubl. ms., Prichard 1997).

c. Captive-rearing of Chicks

Guillemot eggs will be collected in late May and early June, during the laying period or early in incubation. Eggs will be collected from nests on the Kenai Peninsula or other locations in the northern Gulf of Alaska. Collection will occur as soon as possible after clutch completion. Guillemots frequently relay when a clutch is lost within a few days of clutch completion (Divoky, unpubl.), and taking eggs early in incubation would minimize the impact on productivity of the host colony. Additionally, the sensitivity of embryos to lapses in incubation increases during development, and transporting eggs in the early stages of development should increase hatching success. Eggs will be transported to the ASLC and incubated in a large cabinet incubator operated by ASLC until they hatch or it becomes clear the eggs are infertile or addled. We prefer to collect and transport eggs rather than chicks partly so that all the conditions influencing post-natal growth can be controlled in the lab. However, if hatching success is low or hatchling survival poor, we will substitute guillemot chicks removed from nests shortly after hatching in order to meet target sample sizes for numbers of chicks raised in captivity and released at ASLC. Chicks translocated later in the nestling period display philopatry to the location of hatching, instead of fledging (Serventy 1967, Fisher 1971).

The source colonies for eggs or hatchling guillemots will be primarily on the Kenai Peninsula, and will be selected based on the numbers of breeding pairs at each colony and the accessibility of individual nests. The outer coast of the Kenai peninsula from Port Bainbridge in the east to Port Graham in the west has more than an adequate breeding population of Pigeon Guillemots to support the collections we propose without a detectable impact on existing colonies. We will collect 110 guillemot eggs early in the 1999 breeding season with the goal of successfully hatching 100 chicks and releasing at least 80 captive-reared fledglings into the wild at ASLC. When two-egg clutches are encountered in the field, we will collect both eggs in the clutch in order to enhance the incidence of clutch replacement at source colonies. If hatching success of eggs placed in the incubator is less than 90%, we will collect sufficient young nestlings guillemots to bring the sample of captive-reared chicks up to 100. If two-chick broods are encountered in the field, we will remove only one of the two chicks in order to increase the chances of the other chick successfully fledging. Assuming a level of philopatry similar to that observed for Black Guillemots (Divoky, in prep.), 35% of fledging guillemot chicks should ultimately return to ASLC from the 1999 cohort, providing >28 potential recruits to local breeding colonies. If all surviving captive-reared guillemots recruit at the natal location, a colony of > 40 breeding pairs should be present by 2004, even if the sites do not attract immigrants from other natural colonies before that time.

d. Release of Captive-reared Chicks

Guillemots fledge at night as early as 30 days after hatching, with most fledging after 35 days (Hayes 1995). Fledglings are able to fly at the time of nest departure, are close to adult size, and are independent of parental care after they fledging. When captive-reared chicks reach 32 days of age, they will be moved in their containers to the roof of ASLC. The covers will be removed from the buckets after sunset and chicks provided the opportunity to fledge. To insure that no predation by gulls or other avian predators occurs, project personnel will attend the chicks whenever they are on the roof. Fledglings will be taken to the roof nightly until all have fledged. Fledglings will be banded with a stainless steel U.S. Fish and Wildlife band and a unique

combination of color polyvinyl chloride bands to allow individual identification at a distance. The latter will be sealed with an adhesive to reduce band loss.

e. Assessment of Size and Productivity of Pigeon Guillemot Colonies in Resurrection Bay

A census of guillemot colonies in Resurrection Bay and adjacent areas will facilitate understanding of the conditions contributing to the establishment of artificial colonies near ASLC. Immigration constituted the majority of recruits at a colony of Black Guillemots in arctic Alaska that was enhanced using artificial nest sites, and Pigeon Guillemots fledging from local natural colonies in Resurrection Bay that have yet to breed can be expected to prospect the sites near ASLC. To assess the size of these potential source populations and their annual productivity we will attempt to census as many local colonies as possible and, when possible, determine breeding productivity. We have not budgeted for transportation to these sites but will attempt to visit them on tour boats, National Park Service vessels, or on foot (Caine's Head). Personnel from the Kenai Fjords National Park have indicated they will provide space on their vessels for this purpose.

If Pigeon Guillemot nests at these colonies are accessible, we will band nestlings. Resightings of these guillemots at ASLC will provide information on dispersal distance for this species. Intercolony visits are common for pre-breeding alcids (Harris 1983, Kress and Nettleship 1989), and in 1999 we will search these colonies for banded individuals that were raised in captivity at ASLC in 1998.

Objective 2. Validation and Calibration of Nondestructive Biomarkers for Monitoring the Health and Exposure to Oil of Guillemots

a. Measurement of Certain Blood Biomarkers of Petroleum Hydrocarbon Exposure

In the second year of this study (CY 99), research on blood biomarkers of oil exposure will include controlled dose-response experiments with weathered Prudhoe Bay crude oil (PBCO). A range finding experiment will be conducted to determine the no-effect dose for guillemot chicks consuming weathered PBCO. We will also determine the time course of biomarker response to ingestion of PBCO, including the time post-ingestion when biomarker induction is no longer detectable. At 20, 25, and 30 days post-hatch, we will feed guillemot chicks small, sublethal doses of weathered PBCO in number 2 gelcaps that are inserted into the abdominal cavity of a fish that is then fed to the nestling. Five to six guillemot nestlings from each of the four diet treatments (see below) will be assigned to each of the following oil ingestion treatments: control, 0.25 ml of weathered PBCO, 0.5 ml of weathered PBCO, and 1.0 ml of weathered PBCO. Control chicks will receive 1 ml of corn oil in a number 2 gelcap inserted in a food fish. We know from previous experiments (Prichard et al. 1997) that a dose of 0.2 ml of weathered PBCO ingested three times during the latter part of the nestling development period does not have a significant effect on growth of Pigeon Guillemots. Consequently, these doses are designed to identify the "no-effect" dose for weathered PBCO.

Just before and following ingestion of the oil dose, we will collect 1 ml of blood in heparinized vials by puncturing the brachial vein. Blood samples will be collected at 0 h, 12 h, 24 h, and 48 h post-injestion of oil. Previous experiments (Prichard 1997) indicate that there is no significant difference in blood biomarker levels five days after oil dosing, so this time course of blood samples is designed to reveal the time course of biomarker induction from crude oil injestion. Blood samples will be kept cool and centrifuged at 3,000 rpm for 20 minutes. Plasma will then be removed with a pipette and stored in snap-top plastic vials at -20oC for laboratory analysis at the University of Alaska Fairbanks. In the lab, we will measure haptoglobin and other acute phase protein levels in plasma samples in order to determine dose-response and time course of the response. Assays for blood biomarkers will be conducted in the laboratory of Dr. Larry Duffy at the University of Alaska Fairbanks. Dose-response will be compared among the four diet groups (see below) to assess the role of diet in determining biomarker induction in blood in response to PBCO ingestion.

b. Measurement of Biomarkers in Excreta

In addition to collection of blood samples, samples of excreta will be collected over 24-h intervals each day after the initial dosing of PBCOin order to measure fecal porphyrin levels and determine dose-response and time course of response. As with blood biomarkers, responses in fecal porphyrin levels will be compared among the four diet groups. Measurements of fecal porphyrins in excreta will be conducted in the laboratory of Dr. Larry Duffy at the University of Alaska Fairbanks.

Objective 3. Captive Feeding Trials to Assess the Relationship between Diet and Postnatal Development in Guillemots

a. Comparison of Guillemot Growth Performance on Diets of Nearshore Demersal Fish vs. High-lipid or Low-lipid Schooling Forage Fish

In CY 99, 20-25 guillemot chicks will be raised on each of four diets: (1) 160 g of crescent gunnels per day, (2) 160 g of herring per day, (3) 160 g of sand lance per day, 160 g of juvenile pollock per day. All of these prey species are major components of guillemot chick diets at certain sites and the four species are representative of the two primary prey types in guillemot diets: nearshore demersal fishes and schooling forage fishes. These daily rations are designed so as to provide a variety of caloric and lipid consumption rates that are within the normal range experienced by guillemot nestlings, but biomass consumption rates would be the same for each diet group. Herring and sand lance are representative of high-lipid forage fishes with relatively high energy densities. Juvenile walleye pollock are representative of low-lipid forage fishes with relatively low energy densities. Crescent gunnels are typical on nearshore demersal fishes with intermediate lipid content and energy density. Each chick will be kept in a separate cage so that food consumption can be monitored individually. The daily rations will be provided to most chicks in four daily feedings of 40 g each at about 10:00, 13:00, 16:00, and 19:00 ADT. Each day prior to the first feeding the body mass, wing length, and outer primary length of each chick will be measured until each captive-reared chick fledges into the wild, at about 35-40 days post-hatch. Return rates of subadults in the third and fourth year of this study will allow us to assess the role of prefledging nutrition and fledging mass on subsequent post-fledging survival.

CY 2000

In 2000 all of the direct restoration activities listed above for 1999 will be conducted. Additionally, after 1999 we will attempt to locate guillemots that were raised at the Alaska SeaLife Center at regional colonies during our surveys.

Also in 2000, we will conduct additional dose-response experiments with captive-reared guillemot chicks that build on the results of 1999 experiments to validate the use of certain biomarkers for assessing the health status and oil exposure of wild guillemot chicks. These experiments will emphasize acute phase proteins, such as haptoglobin and hemaplexin, which are known to be induced in birds in response to disease, trauma, or other stress. Finally, we will investigate the role of weathering in reducing the toxicity of PBCO by comparing results of dose-response experiments using PBCO that has been weathered for different periods. Small sample sizes of dosed and undosed (control) chicks will be sacrificed for measurement of CP-450 levels in liver tissues and to examine nasal gland tissues for hypertrophy.

Captive feeding trials in 2000 will continue to investigate the relative quality of various prey types commonly fed to guillemot chicks by their parents. Additional experiments will be designed to explore the tradeoffs for guillemot nestlings of meal size, meal frequency, and meal quality. This will be accomplished by raising guillemot chicks on isocaloric rations (same number of calories ingested per day) of large or high energy density prey fed infrequently vs. small or low energy density prey fed frequently. The growth rates and fledging condition of

chicks raised on these various diets will be compared, and subsequent survival post-fledging will be assessed from return rates of captive-reared adults to the natal site. Small samples of chicks raised on the different diet regimes will be sacrificed to measure body composition using proximate analysis techniques. The results of these captive feeding trials will enable us to interpret guillemot diet data that are collected as part of long-term monitoring activities and assess the availability and quality of forage fishes for breeding guillemots.

Approval of the field protocols for work with live birds described in this DPD have been obtained from the Institutional Animal Care and Use Committee at Oregon State University and are pending from ASLC. Any take of eggs or incidental/unintentional take of nestling or adult guillemots will be covered by relevant Federal and State Scientific Collecting permits. All fledgling, captive-reared guillemots released to the wild will be banded with USFWS stainless steel leg bands and polyvinyl colored leg bands under a Master Station banding permit held by the Oregon Cooperative Fish and Wildlife Research Unit.

C. Contracts and Other Agency Assistance

Laboratory analyses of the biochemical composition and energy content of forage fishes fed to captive guillemots and the proximate composition of chick carcasses will be conducted in the laboratory of the PI at Oregon State University.

Analyses of biomarkers in blood plasma and fecal samples will be conducted in the lab of Dr. Lawrence K. Duffy at the University of Alaska Fairbanks, where the expertise is available to perform this task.

SCHEDULE

A. Measurable Project Tasks for CY 99 (February 1, 1999 - January 31, 2000

March 1 - May 15:	Install artificial nest sites, decoys, and playback sound equipment at SeaLife Center.
May 15 - August 31:	Collect field data on guillemot use of artificial nest sites, raise guillemot nestlings in captivity, conduct captive rearing experiments, and release captive-reared fledglings.
Sept. 1 - Dec. 31:	Enter, analyze, and interpret field data and data collected from captive-reared chicks. Conduct laboratory analyses of plasma samples, diet samples, and chick carcass samples.
January 1 - 14:	Prepare for Annual Restoration Workshop
January 15 - 24:	Attend Annual Restoration Workshop and present FY 99 results to peer reviewers.
Jan. 24 - April 14:	Prepare 1999 annual report of findings.
April 15:	Submit annual report (FY 99 findings) Submit FY 00 DPD to Trustee Council
March 16 - April 30:	Arrange logistics and prepare for FY 00 field season and captive-rearing experiments.

B. Project Milestones and Endpoints

CY 99

May 15, 1999	Installation of artificial nest sites, decoys, and audio equipment near the Alaska SeaLife Center
August 31, 1999	Completion of second field season, release of second cohort of captive-reared nestlings, collection of blood and fecal biomarker samples for dose-response experiment, completion of captive-feeding trials comparing nestling growth performance on schooling forage fish and nearshore demersal fish.
April 30, 1999	Completion of second annual report of findings
CY 00	
August 31, 2000	Completion of second year of a two-year experimental study of the role of diet on nestling growth performance and dose-response experiments with ingested crude oil Completion of field work and Objective 1
CY 01	
June 30, 2001:	Completion of M.S. thesis
September 30, 2001	Completion of Objectives 2 and 3 and submission of manuscripts addressing these objectives

C. Completion Date

The anticipated completion of this project will be early in FY 02, at the end of calendar year 2001. This will allow adequate time to complete data analysis, thesis preparation by the Masters student, and manuscript preparation and submission following the last field season in 2000 and completion of laboratory analysis early in 2001.

PUBLICATIONS AND PROJECT REPORTS

The following publications are projected for this research project (this is a rough projection and by no means complete):

An annual report for the second year of this project will be submitted by 15 April 2000. The final report for this project will be submitted 15 December 2001. At least three manuscripts will be generated from this research, and all will be published in the peer-reviewed scientific literature. Each of these three manuscripts will address one of the three major objectives/hypotheses of this study: (1) guillemot colony establishment as a direct restoration technique, (2) biomarkers as a means of assessing exposure of guillemots to crude oil, and (3) diet as a factor in nestling growth and post-fledging survival. A portion of the final report will be excerpted from the thesis of the M.S. student on this project. This student will be strongly encouraged and directly assisted by the PI to submit for publication in the peer-reviewed scientific literature the results from this research.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The research described in this proposal takes advantage of the new research facilities and potential represented by the Alaska SeaLife Center and dove-tails nicely with continuing research as part of the APEX and NVP projects that assesses factors limiting recovery of Pigeon Guillemot populations damaged by EVOS. It is also relevant to efforts toward developing seabird models as upper trophic level sentinels of oil pollution in nearshore ecosystems. The proposed research approach utilizes growth performance, fledgling body condition, and blood

and fecal biomarkers to assess the health status of guillemot nestling exposed to oil and raised on different diet rations. These data are essential for developing techniques for long term monitoring of the health and status of guillemot populations in the EVOS area.

Studies of foraging, reproduction, and population recovery following the EVOS are on-going for pigeon guillemots. This proposal complements and enhances other studies on pigeon guillemots, without duplication of effort. The PI on the present proposal has been and will continue to work closely with David Irons and Greg Golet (PIs on APEX Component 99163 F "Factors Affecting Recovery of PWS Pigeon Guillemot Populations"), Dave McGuire (Co-PI on NVP studies of biomarkers of oil exposure in guillemot nestlings), and John Piatt (PI on APEX Components 99163 M "Lower Cook Inlet Forage Fish Studies" and 99163 N "Black-legged Kittiwake Feeding Experiment") in developing protocols for collecting data.

PRINCIPAL INVESTIGATOR

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Revision 10-1 8
Approved TC 8-13-98

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1998	Proposed FY 1998
Personnel		$0.0
Travel		$0.0
Contractual		$150.1
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$150.1
General Administration		$10.5
Project Total	$117.4	$160.6
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	Estimated FY 2003	
	$168.8	$95.1			

Dollar amounts are shown in thousands of dollars.

Comments:
Prepared by Lisa Thomas USGS-BRD See forms 4A&B for detail.

Note: Estimates for years 2000-'01 are based on calculations done by the EVOS Restoration Office and have been inserted above.

TOTAL PROJECT FUNDING:

$160.6
5.5 ASLC bench fees
$166.1

1999

Project Number: 99327
Project Title: Pigeon Guillemot Restoration Research at the Seward Sealife Center
Lead Agency: USGS-BRD

FORM 3A
TRUSTEE
AGENCY
SUMMARY

10/1/98

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 1998
						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 1998
					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

Prepared:

Project Number: 99327
Project Title: Pigeon Guillemot Restoration Research at the Seward Sealife Center
Lead Agency: USGS-BRD

FORM 3B
Personnel
& Travel
DETAIL

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

Contractual Costs:	Proposed FY 1998
Description	
Linkage with forms 4A&B	150.1
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$150.1

Commodities Costs:	Proposed FY 1998
Description	
Commodities Total	$0.0

1999

Project Number: 99327
Project Title: Pigeon Guillemot Restoration Research at the Seward Sealife Center
Lead Agency: USGS-BRD

FORM 3B
Contractual & Commodities
DETAIL

Prepared:

10/1/98

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

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 1998
			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

1999

Project Number: 99327
Project Title: Pigeon Guillemot Restoration Research at the Seward Sealife Center
Lead Agency: USGS-BRD

FORM 3B
Equipment
DETAIL

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Budget Category:	Authorized FY 1997	Proposed FY 1998
Personnel		$31.1
Travel		$19.0
Contractual		$50.7
Commodities		$17.4
Equipment		$0.0
Subtotal	$0.0	$118.2
Indirect		$31.9
Project Total	$0.0	$150.1
Full-time Equivalents (FTE)		15.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Dollar amounts are shown in thousands of dollars.

	Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	
	$149.1	$157.8	$88.9		

Comments:

Indirect rate for OSU is 42.5% of Modified Total Direct Cost (MTDC=Direct cost- assistanship and equipment) on-campus research rate and 26% of MTDC off-campus research rate.

Not included in this budget is bench fees for the Alaska SeaLife Center estimated at 5.5K

Prepared by Lisa Thomas USGS-BRD 10/01/98

1999

Project Number: 99327
Project Title: Pigeon Guillemot Restoration Research at the Seward Sealife Center.
Name: Oregon State University
Agency: USGS-BRD Contractor

FORM 4A
Non-Trustee
SUMMARY

1998 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1997 - September 30, 1998

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 1998
	Graduate Student (Ph.D.) stipend		9.0	1.6		14.4
	Graduate Student salary- field season		3.0	1.8		5.4
	Research Assistant-field season		3.0	1.6		4.8
	Graduate Student (Ph.D.) benefits					0.1
	Graduate Student summer hire benefits					0.3
	Research Assistant-benefits					0.5
	Tuition PhD					5.6
	Subtotal		15.0	5.0	0.0	
					Personnel Total	$31.1

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1998
Corvallis/Seward/Corvallis	0.7	4			2.8
Travel in Alaska for egg collections(air fare, boat charter, air charter)	0.5	4			12.0
Per diem en route to egg collections			24	0.1	2.4
Restoration Workshop Corvallis/Anchorage/Corvallis	0.5	2			1.0
per diem while at Restoration Workshop			8	0.1	0.8
				Travel Total	$19.0

1999

Project Number: 99327
Project Title: Pigeon Guillemot Restoration Research at the Seward Sealife Center.
Name: Oregon State University
Agency: USGS-BRD Contractor

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 10/1/98

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

Contractual Costs:	Proposed
Description	FY 1998
Personal Services Contract to Dr. George Divoky	27.5
Housing in Seward for 3 persons (4 mo @78.75$/day)	9.4
Lab/Office space estimated at 5.5K	
duplication/computer fees	1.0
lab analyses of blood and excreta samples for biomarkers (L. Duffy, UAF)	7.5
samples shipping	0.7
publication/presentations- reports and visual aids	0.9
vehicle rental Anchorage to Seward	1.0
field equipment maintenance	1.2
phone services- long distance charges	1.5
Contractual Total	$50.7

Commodities Costs:	Proposed
Description	FY 1998
chick rearing cages	0.5
nest boxes/sites	2.0
decoys, playbacks, other social attractants	2.0
binoculars, spotting scopes, tripods for observing guillemots at Sealife Center	2.5
egg collecting equipment	0.5
incubators	0.3
blood sample collection supplies	2.0
food for personnel at Seward (3 persons, 15 wk@$210/wk)	3.1
Ohaus top-loading balance, battery-powered	0.6
food for chicks	2.0
bands and banding supplies	0.4
miscellaneous supplies for captive rearing	1.5
Commodities Total	$17.4

1999

Project Number: 99327
Project Title: Pigeon Guillemot Restoration Research at the Seward Sealife Center.
Name: Oregon State University
Agency: USGS-BRD Contractor

FORM 4B
Contractual & Commodities DETAIL

Prepared: 10/1/98

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

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 1998
			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
Description	of Units
analytical balance	1
drying ovens	3
Soxlet apparatus	2
muffler furnace	1
freezers	2
zodiac and motor (from APEX project we hope)	1

1999

Prepared:

Project Number: 99327
Project Title: Pigeon Guillemot Restoration Research at the Seward Sealife Center.
Name: Oregon State University
Agency: USGS-BRD Contractor

FORM 4B
Equipment
DETAIL

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		$5.1
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$5.1
General Administration		$0.4
Project Total	$0.0	$5.5
Full-time Equivalents (FTE)		0.0
	Dollar amounts are shown in thousands of dollars.	
Other Resources		

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

Comments:

FY 99

Project Number: 99327
Project Title: Bench Fees - Pigeon Guillemot Research at ASLC
Agency: ADFG (for USGS-BRD)

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Approved 8-13-98

Synthesis of the Toxicological and Epidemiological Impacts of the Oil Spill on Pacific Herring

Project Number:	99328
Restoration Category:	Research
Proposer:	M. Carls/NOAA
Lead Trustee Agency:	NOAA
Cooperating Agencies:	None
Alaska SeaLife Center:	No
New or Continued:	New
Duration:	1st yr. 1 yr. project
Cost FY 99:	$46.1
Cost FY 2000:	$0.0
Cost FY 01:	$0.0
Cost FY 02:	$0.0
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pacific herring

ABSTRACT

This project will synthesize results of toxicological and epidemiological damage to Pacific herring (but not the ecological research still in progress), and compare Trustee-sponsored conclusions to those of Exxon investigators. EVOS researchers concluded that exposure to oil caused egg mortality, morphological and cytogenetic abnormalities, reduced growth, and immunosuppression in adults, but that effects on the population level were unknown. Exxon investigators concluded that the spill had a minor impact on herring eggs, and that the population did not decrease. A monograph for publication will be prepared and presented at the 10 Years After symposium.

INTRODUCTION

Two very different interpretations of results emerged from the *Exxon Valdez* oil spill impact studies, divided along industry and Natural Resource Damage Assessment (NRDA) lines. These divided conclusions form a common theme among various species (including herring, salmon, and birds), ecosystems (such as recovery of intertidal biota), and sediment chemistry. Exxon investigators consistently concluded that oil effects were smaller in magnitude, spatial, and temporal extent than did NRDA investigators. We propose to explore this dichotomy for just one species, Pacific herring.

Did the *Exxon Valdez* oil spill impact herring in 1989 and 1990? Pearson et al. (1995a,b) concluded effects of the *Exxon Valdez* oil spill on Pacific herring in Prince William Sound (PWS) were generally negligible. Pearson et al. (1995a,b) argue that 1) very few spawned herring eggs were exposed to *Exxon Valdez* oil (4%), 2) effects on eggs were minor in 1989, even in oiled areas, 3) spill effects were not evident in 1990, and 4) herring population levels did not decrease. The NRDA studies draw very different conclusions: 1) the oil trajectory overlapped 41-52% of the total herring egg population in PWS (Brown et al. 1996a), 2) effects on eggs and larvae were significant in 1989 (McGurk and Brown 1996a; Hose et al. 1996; Norcross et al. 1996; Marty et al. 1997), 3) eggs may have been impacted by residual oil as late as 1992 (Kocan et al. 1996a,b), 4) population effects were unknown (EVOSTC). Also at issue is the toxicity of *Exxon Valdez* oil: Pearson et al. (1995a,b), based on previous water-soluble fraction (WSF) literature, argue that aromatic concentrations in PWS were generally far below toxic levels, but current NRDA studies indicate that PAH composition is an important factor in determining toxicity, and conclude that concentrations in PWS were in the toxic range (Carls et al. submitted [a]; Heintz et al. submitted).

What caused the collapse of the herring fishery in 1993 in Prince William Sound? Elston et al. (1997) argue that poor nutritional condition, coupled with cold winter temperatures, and possibly a cyclical density-dependent downturn in population numbers could have caused the collapse of the herring population. In contrast, Brown et al. (1994) suggested a linkage between the previous oil spill and the population collapse, and hypothesized that recruitment of an immunologically damaged 1989 year class may have been responsible for the collapse.

Were herring affected by oil in 1989? Were they affected by oil in 1993? These questions illustrate the need for a synthesis study that examines the Trustee and industry evidence.

Many research projects have been completed or are nearing completion concerning impacts of the *Exxon Valdez* oil spill on Pacific herring in Prince William Sound. These projects fall into three broad topic areas: toxicological, epidemiological, and ecological. Investigative progress in each of these areas has varied. Toxicological questions were addressed beginning immediately after the spill, and most of this research has been completed and published. Disease research was stimulated by the 1993 herring population collapse, and is nearing completion. Ecological research concerning herring, which has been associated with several Trustee-sponsored programs, is the least complete at present. For this reason, and because of the potentially very broad context of a single synthesis effort, we recommend that synthesis efforts be split into at least two main topics: toxicological and epidemiological (FY99), and ecological or

oceanographic (FY00). Principal investigators for these two separate syntheses will not be the same. The current synthesis proposal is limited to toxicology and disease, and limited to a one year effort.

NEED FOR THE PROJECT

A. Statement of Problem

Conflicting interpretations of the extent of injury emerged from Natural Resource Assessment Studies and those by Exxon investigators. Exxon investigators concluded that the spill had a minor impact on herring eggs, and that the population biomass was not reduced (Pearson et al. 1996). State and Federal researchers concluded that exposure to oil caused egg mortality, morphological and cytogenetic abnormalities, reduced growth, and immunosuppression in adults (Brown et a. 1996; Carls et al. submitted [b]; Hose et al. 1996; Kocan et al. 1996ab; Marty et al. 1997; McGurk and Brown 1996; Norcross et al. 1996; Thomas et al. 1997), but that the effects on the population level were unknown (EVOSTC 1996). However, herring were placed on the injured species list. Of particular concern was the population collapse in 1993, viewed as a possible delayed consequence of prior spill damage. The proposed synthesis will review published papers and reports pertinent to Pacific herring and the *Exxon Valdez* oil spill, and will integrate Trustee-sponsored toxicological and epidemiological research. The synthesis will also discuss Exxon investigator findings, and attempt to resolve differences.

B. Rationale/Link to Restoration

This project relates directly to the Oil Spill Restoration Plan objective to recover healthy and productive Pacific herring populations to pre-spill abundance. The significance and causes of long term damage will be evaluated; restoration and management strategies need this information.

C. Location

Prince William Sound is the geographic focus, but this synthesis project does not require additional field or laboratory work.

COMMUNITY INVOLVEMENT

Because all field work has been completed, opportunity for community involvement is very limited.

PROJECT DESIGN

A. Objectives

1. Synthesize results of Trustee-sponsored toxicological and epidemiological studies relating to long-term injury and recovery of Pacific herring. All major hypotheses from contributing studies would be examined in the synthesis manuscript.

2. Evaluate and incorporate into the synthesis all of the relevant Exxon-funded research, and attempt to reconcile differences with Trustee-sponsored research where possible.

B. Methods.

A minimum of 20 toxicological and epidemiological papers related to Pacific herring and the *Exxon Valdez* oil spill will be reviewed as the primary focus of the synthesis. Other peripheral papers and the Trustee hydrocarbon database will be utilized as needed. Writing will begin October 1, 1998, and continue into March 1999. The synthesis will be ready for presentation at the 10th anniversary symposium, and for submission to a peer-reviewed journal by June 1999. There will be one author meeting to review the scope of the paper, refine the outline, and determine writing assignments. Most other author interaction will take place by email or phone. Research considered in this effort would include NRDA and Restoration research funded by the *Exxon Valdez* Oil Spill Trustee Council and research published by *Exxon* investigators.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Coauthors will include Dr. Gary Marty (University of California, Davis), Dr. Jo Ellen Hose (Occidental University), and Dr. Richard Kocan (University of Washington). Dr. Stan Rice (Auke Bay Lab) will have management oversight, and will serve as a major reviewer and quality control.

SCHEDULE

A. Measurable Project Tasks for FY98 (October 1, 1998 - September 30, 1999)

We propose to start this project in FY99. Some subjects for the review are in hand now, others will be completed in FY99. Egg and larval work relating to genetics and morphology have been completed, but some disease research and papers have not yet been completed (e.g., Marty et al.; Kocan et al.).

Oct 98:	Begin writing synthesis paper
Nov 98:	Author meeting; discuss subject matter and organization, and assign writing.
Jan 99:	Toxicological section complete for review by other authors
Feb 99:	Disease section complete for review by other authors
Mar 99:	Complete oral presentation of synthesis; present at symposium
May 99:	Complete internal review
Jun 99:	Complete manuscript; submit to peer-reviewed journal
Sept 99:	Respond to reviewers; return edited manuscript for publication.

Target journal: Canadian Journal of Fisheries & Aquatic Sciences

B. Project Milestones and Endpoints

Jan 99:	First section of manuscript complete
Mar 99:	First draft complete and available for review
	Present synthesis at symposium
Sept99:	Synthesis in press.

C. Completion Date

This project would be completed in Fiscal Year 1999.

PUBLICATIONS AND REPORTS

This project would produce a publication that would synthesize results of the separate Trustee-sponsored studies on toxicological and epidemiological impacts of the *Exxon Valdez* oil spill on Pacific herring, and compare these results to those published by Exxon investigators. It would begin in FY99, and be submitted for publication in a peer-reviewed journal in September 1999.

A summary synthesis would be presented at the 10th Anniversary Symposium in March 1999.

PROFESSIONAL CONFERENCES

The synthesis product could be presented at the 1999 SETAC conference.

NORMAL AGENCY MANAGEMENT

NOAA/NMFS has statutory stewardship for most living marine resources; however, if the oil spill had not occurred NOAA would not be conducting this project. NOAA/NMFS proposes to make a significant contribution (as stated in the proposed budget) to the operation of this project, making it truly cooperative.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project will be coordinated with other projects conducted by ABL and ADF&G.
This project is dependent on the completion of the Trustee projects relevant to toxicological and epidemiological impacts on Pacific herring.

PROPOSED PRINCIPAL INVESTIGATOR

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revision 2

Revis 7-8-98
approved TC 8-13-98

Budget Category:	Authorized FFY 1998	Proposed FFY 1999						
Personnel	$0.0	$21.0						
Travel	$0.0	$3.7						
Contractual	$0.0	$17.1						
Commodities	$0.0	$0.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$41.8	Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2002	Estimated FFY 2003	Estimated FFY 2004	Estimated FFY 2005
General Administration	$0.0	$4.3						
Project Total	$0.0	$46.1	$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					

Comments:

Personnel cost assumes salary coverage of 3-4 weeks per contributing author (contractual), plus 2 additional man-months for the coordinator (salary).

Other Resources:
NOAA contribution is estimated:

1999

Prepared:

Project Number: 99328
Project Title: HERRING SYNTHESIS MANUSCRIPT
Agency: National Oceanic & Atmospheric Administration

FORM 3A AGENCY PROJEC

Personnel Costs:			GS/Range/	Months	Monthly		Proposed
PM	Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 1999
	Mark Carls	Fishery Biologist	12/5	3.0	7,000		21.0
	Dr. Stan Rice	Program Manager	14	0.0	11,000		0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
		Subtotal		3.0	18,000	0	
Those costs associated with program management should be indicated by placement of an *.						**Personnel Total**	$21.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
PM	Description	Price	Trips	Days	Per Diem	FFY 1999
	Anchorage, Symposium, 2 trips, 3 days/person	255	2	6	150	1.4
	Car Rental/Miscellaneous for above					0.5
	ticket price reflects average price					
	total days assumes 3 day workshop for 2 people					
	per diem is based on federal rate					
	Sacramento, Planning meeting, 3 trips, 1 day/person	220	3	4	150	1.3
	Car Rental/Miscellaneous for above					0.5
						0.0
Those costs associated with program management should be indicated by placement of an *.					**Travel Total**	$3.7

1999

Project Number: 99528
Project Title: HERRING SYNTHESIS MANUSCRIPT
Agency: National Oceanic & Atmospheric Administration

FORM 3B Personnel

Contractual Costs:				Proposed
Description				FFY 1999
		man-months	rate	
	Dr. Gary Marty	1	9600	9.6
	Dr. Jo Ellen Hose	0.75	10000	7.5
	Dr. Dick Kocan	0	7000	0.0
When a non-trustee organization is used, the form 4A is required.			**Contractual Total**	$17.1

Commodities Costs:		Proposed
Description		FFY 1999
	Commodities Total	$0.0

1999

Project Number: 99328
Project Title: HERRING SYNTHESIS MANUSCRIPT
Agency: National Oceanic & Atmospheric Administration

FORM 3B Contractual & Commodit

New Equipment Purchases: Description		Number of Units	Unit Price	Proposed FFY 1999
				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 in Equipment Total				$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
Computers & printers	2	NOAA
Slide scanner	1	NOAA
Camera	1	NOAA
Photo output device	1	NOAA

1999

Project Number: 99328
Project Title: HERRING SYNTHESIS MANUSCRIPT
Agency: National Oceanic & Atmospheric Administration

FORM 3B Equipment

Approved TC 8-13-98

Synthesis of the Toxicological Impacts on Pink Salmon

Project Number:	99329
Restoration Category:	Research
Proposer:	S. Rice/NOAA
Lead Trustee Agency:	NOAA
Cooperating Agencies:	ADFG
Alaska SeaLife Center:	No
New or Continued:	Cont'd
Duration:	2nd yr. 2 yr. project
Cost FY 99:	$44.4
Cost FY 2000:	$0.0
Cost FY 01:	$0.0
Cost FY 02:	$0.0
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pink salmon

ABSTRACT

This project will synthesize results of all Trustee Council sponsored studies related to the toxicological damage to pink salmon. Since 1989, five separate Council-sponsored projects have individually advanced understanding of the effects of the oil spill on pink salmon: past and present potential for oil exposure (Project /194), effects on egg/embryo survival (Project /191A&B), juvenile feeding and growth (Project FS4B), marine survival and straying of returning adults (Project /076). Data from these studies will be drawn upon in order to construct synthetic conclusions regarding the injury to and subsequent recovery of pink salmon. The results of contracted studies by Exxon Corporation will be compared with the Trustee Council studies.

INTRODUCTION

The *Exxon Valdez* oilspill caused several toxicological effects on pink salmon (*Oncorhynchus gorbuscha*), including increased mortality, reproductive impairment, and possible long-term genetic damage in pink salmon eggs and embryos that incubated in oiled intertidal sections of freshwater streams. Short-term effects were measured in 1989 and 1990, but to the surprise of the scientific community, negative impacts to developing embryos continued through 1993. The value of the pink salmon resource in Prince William Sound stimulated the gathering of the best pre-spill information; the long-term impacts stimulated a suite of field and laboratory studies to document the slow rates of recovery and to investigate mechanisms of the long-term damage. The Trustee Council funded seven separate studies to examine possible consequences to pink salmon populations. These studies by both ADFG and NOAA examined the past and present potential for oil exposure (Project 194), effects on egg/embryo survival (Project 191A and 191B), juvenile feeding and growth (NRDA Project 4), marine survival and straying of returning adults (Projects 076 and 209), and the possibility that effects are heritable (Project 228).

The pink salmon studies are the best evidence of continued long-term damage in any fish species following an oil spill. Long-term damage is a rare event that has not been documented in many species following an oil spill. The Trustee emphasis on this question has stimulated EXXON to fund independent studies of toxicological impacts on pink salmon in Prince William Sound. Some interpretations from these studies have been counter to the Trustee studies on several major issues; collectively, the two groups of studies have been controversial.

This synthesis effort would focus on the issue of long-term damage: is it real, is it significant, what are the mechanisms? Although the individual studies have greatly advanced our understanding of the effects of the *Exxon Valdez* oilspill on pink salmon, each when considered separately presents an incomplete picture of the long-term impacts. Considered together, these studies would provide a complete and comprehensive analysis of the toxicological impacts on pink salmon. Further, contradictory conclusions reached by EXXON contractors and Trustee-sponsored studies need to be reviewed and resolved.

NEED FOR THE PROJECT

A. Statement of Problem

Seven separate Trustee-sponsored studies and several EXXON-contracted studies have examined the toxicological impacts of the *Exxon Valdez* oilspill on pink salmon. When considered separately, the studies present an incomplete and sometimes contradictory analysis of the impacts. When analyzed together, these studies would provide the data necessary to construct a synthetic argument about the toxicological impacts on pink salmon. This project would provide the synthesis needed to link the different pieces from these studies into a comprehensive whole picture of the impacts on and recovery of pink salmon after the *Exxon Valdez* oilspill. At the 1997 Restoration Workshop, keynote speaker Dr. Kai Lee emphasized the need for syntheses such as Project 329 to bring cohesiveness to the Trustee's multi-faceted research program.

B. Rationale/Link to Restoration

This project relates directly to the Oil Spill Restoration Plan objective to recover healthy and productive pink salmon populations to prespill abundance. The significance and causes of long-term damage would be evaluated; restoration and management strategies need this information.

C. Location

Prince William Sound. Field work has already been completed.

COMMUNITY INVOLVEMENT

As all field work has already been completed, only limited community involvement is envisioned for this project.

PROJECT DESIGN

A. Objectives

1. Synthesize results of all Trustee-sponsored studies relating to long-term toxicological injury to and recovery of pink salmon. All the major hypotheses from the various studies would be proposed and tested as part of a synthetic argument developed for this project.

2. Evaluate and incorporate into a synthesis all of the relevant EXXON-funded results, and reconcile differences where possible.

B. Methods

Data from all Trustee-sponsored studies have been collected. Project 329 will produce a synthesis that will test the major hypotheses about the toxicological effects of the oil spill on pink salmon. We would work together with the principal investigators to jointly review results and derive conclusions. Some of the hypotheses that would be considered include

H1: Persistent elevated egg/alevin mortality until 1994 was due to genetic damage incurred during the first incubation period after the oil spill.

H1a: Alternatively, persistent egg/alevin mortality was due to continued oil exposure until 1993.

H2: The mechanism of persistent egg/alevin mortality was reproductive impairment in adults incurred by toxicological effects during incubation.

H2a: Alternatively, the mechanism of elevated egg/alevin mortality was genetic impairment.

H3: Toxicological effects included increased egg/alevin mortality, increased marine mortality, increased straying, and decreased fecundity.

H4: Toxicological effects have disappeared at all life-history stages, and population dynamics have recovered.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Principal investigators (Bue and Seeb) from ADFG have agreed to take part in working meetings to assist in constructing a synthesis from their individual studies. The proposed budget includes funds for 0.5 months of Bue's time and 0.5 months of Seeb's time in FY99. No other contracts or agency assistance is required.

SCHEDULE

A. Measurable Project Tasks for FY 99

This project started in FY 98 because delaying the start to FY 99 would not allow enough time to provide a product and presentation in FY 99. The focus in the first half of FY98 is to complete various component parts of manuscripts from other projects. The sythesis will start in the second half of FY98 and continue into FY99. Some subjects for the review are in hand now; others will be completed in FY 99. Results from the oiled stream sediment project (Project 194) are available and are currently being evaluated. The data evaluation phase of the straying project (Project 076) is nearing completion and will be available by mid FY 98 to be incorporated into this synthesis project.

Completed:

October-December 1997:	Collated data from final reports from all Trustee-sponsored studies and all appropriate EXXON studies related to toxicological impacts on pink salmon. Made presentations at SETAC meetings by Rice, Heintz, Short, (and Exxon). Met with principal investigators, including Brian Bue and Mark Willette of ADFG, to evaluate the status of past studies, reports, and manuscripts. Reviewed the Brannon/Maki EXXON review; developed some partial critiques.

To be completed in FY 98:

April - September 1998:	Meet with principal investigators; formulate outline and schedule for the monograph; develop component parts to the synthesis. Focus in last half of FY 98 would be the final report from the straying project, (the last significant unfinished component part), and the development of specific themes. Present material during a joint Trustee/EXXON panel at AFS meeting in Sept. 1998 in Anchorage.

To be completed in FY 99:

October- December 1998:	First draft of monograph completed; co-author reviews.
January - March 1999:	Complete the Murphy stream sediment paper and final report, submit by March (important component of synthesis). Complete second draft of Manuscript. Prepare for symposium presentation.
March 1999:	Present synthesis at the 10th Anniversary Symposium.
April 1999:	Submit synthesis monograph to journal for publication.

B. Project Milestones and Endpoints

January 1998:	Data from final reports collected and tabulated.
June 1998:	Outline of monograph prepared.
December 1998:	Draft monograph synthesis completed and available for co-author review.
March 1999:	Synthesis presented at the 10th Anniversary *Exxon Valdez* Oil Spill Symposium.
April 1999:	Monograph synthesis completed and submitted for publication.

C. Completion Date

This project would be completed in Fiscal Year 1999 (March 1999).

PUBLICATIONS AND REPORTS

Project 329 will produce a monograph publication that will synthesize results of the separate Trustee-sponsored studies on toxicological impacts on pink salmon. It began in FY 98, and if this proposal is funded, it would be finished in FY 99. The synthesis monograph would be submitted for publication in a peer-reviewed journal in April 1999.

The synthesis would be presented at the 10th Anniversary Symposium in March 1999.

NORMAL AGENCY MANAGEMENT

NOAA/NMFS has statutory stewardship for most living marine resources; however, if the oil spill had not occurred, NOAA would not be conducting this project. NOAA NMFS proposes to make a significant contribution (as stated in the proposed budget) to the operation of this project, making it truly cooperative.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project would be coordinated with other projects conducted by ABL and ADFG. This project depends on the completion of the Trustee projects relevant to toxicological impacts on pink salmon. Several of these will be finished in FY 98 (straying, oiled stream sediments, etc.).

PROPOSED PRINCIPAL INVESTIGATOR

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E-mail: jeep.rice@noaa.gov

Cooperating Investigators (Co-authors)

ABL	ADFG
Alex Wertheimer	Jim Seeb
Mike Murphy	Brian Bue
Jeff Short	
Ron Heintz	

PRINCIPAL INVESTIGATOR

GM-14 Physiologist - Stanley D. Rice

Dr. Stanley D. Rice received a BA (1966) and MA (1968) in Biology at Chico State University, and Ph.D. (1971) in Comparative Physiology at Kent State University. Employed at the Auke Bay Laboratory since 1971 as a research physiologist and task leader, Dr. Rice has been Habitat Program Manager since 1986. He has researched oil effects since 1971 and has published over 80 papers on the subject, and over 20 papers on other pollution/physiological subjects. Dr. Rice was the lead editor for the *Exxon Valdez* Symposium published in 1997. His studies have ranged from field to lab tests, behavioral to biochemical studies, and salmonids to invertebrates. Dr. Rice has conducted and managed cooperative projects since 1974, including the Auke Bay Laboratory's *Exxon Valdez* damage assessment studies. Activities since the oil spill include management of more than 10 damage assessment projects, more than 25 restoration projects, establishment of chemistry lab and analyses, and establishment of hydrocarbon database management. Dr. Rice has provided reviews and critical input to principal investigators and managers in NOAA and other agencies to support agency decisions, and he has interacted closely with other agencies on logistics coordination, study design review, and data interpretation. Over 100 publications.

Revision 12-9-98
Approved TC 12-15-98
(adds to funds approved 8-13-98)

FY 99 EXXON VALDEZ TRU.. E COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$16.9
Travel		$4.1
Contractual		$0.0
Commodities		$1.0
Equipment		$0.0
Subtotal	$0.0	$22.0
General Administration		$2.5
Project Total	$0.0	$24.5
Full-time Equivalents (FTE)		0.2
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

	Estimated FY 1999	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	
	$0.0	$0.0	$0.0		

Dollar amounts are shown in thousands of dollars.

Comments:

These additional funds ($44,400 was approved for this project in August 1998) will cover costs not anticipated at the time the original proposal was submitted. The new costs relate to analysis of original data from Exxon-sponsored studies and an increased effort to disseminate study results.

TOTAL PROJECT FUNDING:

approved 8-13-98	44.4
approved 12-15-98	24.5
	$68.9

FY 99

Project Number: 99329 (am.)
Project Title: Synthesis of Toxicological Impacts on Pink Salmon
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

12/9/98

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 1998
Jeff Short	Senior Research Chemist	13	1.0	8.4		8.4
Ron Heintz	Fishery Research Biologist	12	1.0	6.6		6.6
Stanley Rice	Physiologist	14	0.2	9.6		1.9
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		2.2	24.6	0.0	
					Personnel Total	$16.9

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1998
Jnu-Cordova-Anch-Jnu for public meeting (Rice, Short, Heintz)	0.5	3	11	225.0	4.0
Rental car					0.1
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$4.1

FY 99

Project Number: 99329 (am.)
Project Title: Synthesis of Toxicological Impacts on Pink Salmon
Agency: NOAA

FORM 3B
Personnel
& Travel
DETAIL

FY 99 EXXON VALDEZ TRU[illegible]E COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Contractual Costs:	Proposed FY 1998
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0
Commodities Costs:	Proposed FY 1998
Description	
Page charges	1.0
Commodities Total	$1.0

FY 99

Project Number: 99329 (am.)
Project Title: Synthesis of Toxicological Impacts on Pink Salmon
Agency: NOAA

FORM 3B
Contractual & Commodities DETAIL

FY 99 EXXON VALDEZ TRU. .E COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 1998
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: 99329 (am.)
Project Title: Synthesis of Toxicological Impacts on Pink Salmon
Agency: NOAA

FORM 3B
Equipment
DETAIL

12/9/98

Approved TC 8-13-98

Mass-Balance Models of Trophic Fluxes in EVOS-Impacted Areas

Project Number:	99330-BAA
Restoration Category:	Research
Proposer:	D. Pauly/UBC, S. Pimm/U. Tenn
Lead Trustee Agency:	NOAA
Cooperating Agencies:	None
Alaska SeaLife Center:	No
New or Continued:	Cont'd
Duration:	2nd yr. 2 yr. project
Cost FY 99:	$149.8
Cost FY 2000:	$0.0
Cost FY 01:	$0.0
Cost FY 02:	$0.0
Geographic Area:	Prince William Sound, Lower Cook Inlet
Injured Resource/Service:	All

ABSTRACT

This project will construct, validate, and disseminate whole food-web models of Prince William Sound and adjacent marine areas affected by the oil spill. These mass-balance models of flows among trophic levels and among ecosystem components are ideally suited to synthesize the extensive information gathered by various research groups since the spill. The second year of this project will consist of two main components: (1) the production of a CD-ROM for the public domain, incorporating an interactive graphic version of the Prince William Sound trophic model developed during year 1 as well as user-friendly databases on the biology and local/traditional knowledge of the marine organisms of Prince William Sound and beyond; and (2) refinements of the shelf model based on preliminary application and user suggestions.

INTRODUCTION

Our ongoing project, *Mass Balance Model of Trophic Fluxes in Prince William Sound* (Project # 98330), is primarily designed to help fulfill the often-stated need of integrating and synthesizing what is being learned from the various research and monitoring projects within Exxon Valdez Oil Spill (EVOS) restoration programs, and thus to enable the Trustee Council "to view the effects of the oil spill and the long-term restoration and management of injured resources and services from an ecosystem-level perspective" (EVOS Trustee Council, 1996, p. 53). This current proposal is focused on year 2 of our two-year project (Option Period I). It can be titled *Mass-Balance Models of Trophic Fluxes in Impacted Areas: Option Period I--Trophic Fluxes Along the Kenai Shelf and Outer Cook Inlet.*

Our proposal of April 10, 1997, which was approved, outlined a program in which we would construct trophic models, based on the well-documented and used ECOPATH software (Christensen and Pauly 1992a, b, 1995, Pauly and Christensen 1993, Pauly and Christensen 1995, and other authors in Christensen and Pauly 1996). One model would cover the period prior to the oil spill and be based largely on published or pre-existing information. The structure of a second post-spill model would be based on inputs by researchers who are authorities on the ecosystem components of Prince William Sound (PWS) and adjacent areas, most of which have received EVOS funding and have yet-unpublished data. In particular, this latter model would incorporate information from APEX, SEA, and NVP programs--three large EVOS programs which incorporate efforts to model particular segments of the PWS ecosystem.

By working with these various experts, we would seek a broad and inclusive ecosystem synthesis of the larger Prince William Sound and adjacent segments of the Gulf of Alaska (affected shelf areas) and the complex changes within them. We envisioned that this broad participation, and the collaborative process used for model specification, would ensure that the product would be perceived as a useful compliment to existing EVOS research. We went on to suggest that this different level of analysis would provide ecosystem-level insights into both the structure and function of these systems and the effects of EVOS and other perturbations on the systems in question.

The pre-spill model of Prince William Sound is completed and available from the Fisheries Centre (Dalsgaard and Pauly 1997), and it is posted on our project web page at <http://fisheries.com/project.pwsound.htm>. A well-attended initial working lunch was held in conjunction with the 1998 EVOS restoration workshop at which principal investigators and other researchers attended. Construction of the post-spill ECOPATH model was initiated during a 3-day workshop held in Anchorage on March 2-4, at which representatives from the three major EVOS ecosystem programs were present and contributed. Construction of this collaborative post-spill model of Prince William Sound is well underway, as is the development of the corresponding report (see the above project web page for more information on this workshop and the overall project). As a corollary to these efforts, an e-mail network has been established among the PWS ECOPATH model contributors[1].

[1] Note: it is our perception, as well as the communicated perception of participants and others, that there now exists a higher degree of enthusiasm and acceptance of the ECOPATH approach for this setting than generally expected based on previous skepticism and reluctance within the overall EVOS community. We also believe that this exercise has spawned increased interaction and discussion among research groups.

The second year of this project will consist of 3 main components:

1) Production of a CD-ROM for the public domain, incorporating an interactive graphic version of the PWS trophic model developed during year 1 as well as the inclusion of user-friendly databases on the biology and local/traditional knowledge of the marine ecosystem and organisms of PWS and beyond (to be ready for initial presentation and distribution at the 10th Annual Restoration workshop in March of 1999);
2) The option of a 2-day workshop in late January of 1999 devoted to constructing an Ecopath model of the Kenai shelf and outer Cook Inlet, attended by researchers from the Gulf of Alaska region (the alternative to this workshop is individual meetings between the project coordinator and identified contributors where necessary);
3) Development of shelf model through extended study and coordination with experts.

To ensure the acceptability and wide dissemination of the model among the public as well as among managers, the CD-ROM product will be made available for distribution through the Trustee Council and appropriate trustee agencies to interested organizations and institutions, including schools. This CD-ROM will comprise a locally-enriched, customized version of "FishBase", the global, computerized encyclopedia of fishes. (see MacCall and May 1995).

NEED FOR THE PROJECT

A. Statement of Problem

The EVOS Trustee Council stated the need for our project quite precisely on page 53 of its invitation for 1997 proposals: "... many data sets [generated by EVOS projects] on the distribution, abundance and productivity of many species and ecological communities ... need to be integrated in a simple model to benefit long-term resource management." Also , "the restoration program will increasingly focus on an integrated, ecological approach. To that end, the Trustee Council has identified a possible need for a simple cost-effective ecosystem model". This goal (request) is now emphasized more strongly than ever in the invitation for 1999 proposals (Page 31).

Several EVOS-funded projects, notably APEX, NVP, and SEA, are devoted to the biology and ecology of distinct groups of organisms, sometimes including their prey, their predators, or both. A great deal of information has been collected about these segments of the ecosystem, and in some cases the resolution of this information is high. The goal of the ECOPATH model is to use measures of central tendency and their ranges to explore the relationships among the best estimates of biomass, productivity, consumption, and diet composition to reveal patterns of energy flow among the components. The precision of these estimates varies among ecosystem components, but since all components of the defined ecosystem are included and balanced (while accounting for imports and exports) the approach enables learning, modification, and verification of distinct components as well as insights into whole ecosystem structure and function. The precision of estimates for a particular group incorporates the resolution of information collected for that group. Within the ECOPATH framework then, the precision gained from the large investments in some programs enables increased knowledge of less-understood components. In addition to

gaining a better understanding of individual resource components and their potential trajectories in an ecosystem context, as well as ecosystem structure and function, trophic flow models can provide the tools and information for studies of contaminant fate and transport, though this study does not focus on the latter application.

The ECOPATH models being developed during this project will provide useful and explicit insights into most of the injured resources and all of the services listed in Table 4 on page 42 of the invitation for 1999 proposals. The following two boxes contain questions that can be addressed by the ECOPATH approach.

Initial Questions - Our initial-year proposal listed the following possible specific questions that could be addressed using the ECOPATH approach.

1. What will be the consequences of loading hatchery raised salmon into the system given the complex interactions between juvenile salmon, large copepods and pollock?
2. What other components of the ecosystem will the decline of Pacific herring stocks affect? What effect does this have on marine bird and mammal populations?
3. In what species groups will the consequences of fishing become apparent? Is there likely a strong connection between fishing, marine bird, and marine mammal populations?
4. What are the consequences of changes in harbor seal populations?
5. Should we expect sea-otters, harlequin ducks, guillemots and other oil-affected near-shore species to recover in the near-term, given the observed ecosystem changes?
6. How should the change from an ecosystem dominated by shrimp to one dominated by pollock and cod affect seabirds, marine mammals, and other species groups?
7. How do changes in one ecosystem -- say, the near-shore – affect processes in other ecosystems?

Additional Questions - These "what if" scenarios were contributed by EVOS and NMFS program scientists (B. Spies, B. Wright, A. Gunther) during the PWS model specification workshop to be used as possible perturbations to the model PWS model.

1. What if fishing pressure on herring increases or decreases; what if there is one stock of herring? two? three?
2. What if somebody decides to fish sandlance or capelin? this is probably far-fetched, but model simulations would likely show important trophic impacts of removing important forage fishes.
3. What if an earthquake raises the upper 10m of intertidal above sea level?
4. What if PWSAC goes broke and the hatcheries close?
5. What if there is another oil spill?
6. What if human impacts from the road to Whittier result in damage to intertidal habitats in the western part of PWS?
7. What if recreational fishing pressure removes 90% of the rockfish from PWS?
8. What if there is a major warm-water episode for 2 years with the upper 200 m of water over the shelf in the GOA is elevated by 2 degrees C ?
9. What if the bloom and sustained productivity lasts only for 3 weeks instead of the usual 12 weeks in PWS ?
10. What if the harbor seals continue to decline at 8% per year ?
11. What if dungeness crab return to PWS?
12. What if salmon prices drop or increase?
13. What if pollock disappear from PWS?
14. What if salmon farming were allowed in PWS?
15. What if a road were established to Cordova?
16. What if cruise ship traffic increases into Cordova?

B. Rationale/Link to Restoration

A quantitative description of the whole trophic structure of PWS and adjacent waters and the relationships between the different species and groups that inhabit the area will place the results of individual EVOS projects into a realistic context and enable marine resource policy planning on an ecosystem level (multi-species as opposed to single species). Such a description and management approach does not exist. For example, an ECOPATH model of PWS will enable analysis of shifts in the trophic structure in the wake of the oil spill that might be hindering the recovery of seabirds and marine mammals. Likewise, a quantitative analysis of the relationships between seabird foraging and hatchery-released fish will help to identify problems in the restocking program. Another subject potentially resolvable through ECOPATH is the complex interactive relationship between the impacts of fishing and the

impacts of the oil spill. Numerous other examples exist. The versatility of the ECOPATH system allows it to produce a fast and cost-effective overview of any part of the system. The basic idea of this project is that the use of a mass balance model such as ECOPATH will allow easy identification of areas of trophic flux that will be of interest to those involved in policy making and restoration.

Rationale for mass-balance trophic models

Biological production (expressed as energy or carbon) in a given ecosystem must be either exported or consumed locally. Furthermore, the biological production of a given group that is not exported must be equal to the amount of that group consumed in the system. Such simple mass-balance constraints, when explicitly formulated for each of the major species or functional groups of an ecosystem, can be used to validate (or correct) independent standing stock and flux estimates, and to reveal thermodynamically "possible" trophic models of ecosystems. Models of this sort can then be used to make inferences on the structure of ecosystems, and the interactions among their components (Christensen and Pauly 1992a, b, 1995, Pauly and Christensen 1993, Pauly and Christensen 1995).

To gain realistic insights into the ecosystem-level effects of a perturbation like a catastrophic oil spill, some understanding of interactions among ecosystem components is necessary. Indeed, counter-intuitive indirect effects may appear several trophic linkages away from their cause (Abrams 1992, also see Vanni 1987a, 1987b). In the Bering Sea, for example, a locally concentrated pollock fishery may have caused the decline of pollock-eating sea-lions, murres, and kittiwakes, but more distantly, caused an increase in auklets -species that feed on the plankton on which the pollock feed (Springer 1992). The ECOPATH approach provides a quantitative framework for tracking such indirect, ecosystem-level, effects.

But beyond these tremendously useful static representations of ecosystems, the data in ECOPATH files can be directly used in simulation models of the system (ECOSIM). A quasi-static sequence of ECOPATH models can provide insights into ecosystem changes, but many questions require investigation of the dynamic behavior of the system. Dynamic ECOSIM models allow rapid exploration of the predicted consequences of various intervention or events (e.g. restocking, selective harvesting, or changes in some physical forcing functions). Once the PWS ECOPATH model is constructed, balanced, and ready, perturbations can be tailored to resemble real anthropogenic disturbances, such as the EVOS oil spill. Management actions and strategies can likewise be simulated.

In addition to the present integral features of ECOSIM, we will specifically tailor a dynamic model for each of the two major areas of interest. The additional modeling effort will resolve deeper issues often vital to the understanding and wise management of the system. These include questions of the resistance and persistence of the system, system stability under a wide range of situations, vulnerability of individual species and even whole subwebs, the sensitivity and characteristic response modes to changes, and estimates of recovery times. We aim to derive direct indicators potentially saving thousands of model runs in Monte Carlo simulations.

ECOSIM simulation models

To study indirect effects, or ecosystem-level effects, of a perturbation, the system of linear equations underlying mass-balance models can be re-expressed as a system of coupled differential equations using a new module (ECOSIM) of the ECOPATH software (Walters et al., 1997). This allows, once mass-balance has been established, the rapid construction of a simulation model for any ecosystem. Thus, the proposed project will also generate a simulation model of trophic interactions in PWS and adjacent waters, allowing e.g. "...examination of the potential impacts of large-scale perturbations such as the major decline in the population of Pacific herring." (EVOS Trustee Council, 1996, p.53.)

This is done by linearizing the dynamic models and applying the powerful methods of linear systems analysis to answer basic questions about stability and response. Monte Carlo

experiments will be important for investigating "what if" questions, but doing so with the *a priori* knowledge of the basic system characteristics will sharpen the process and make it far more efficient.

Ongoing analysis of data and model updating will also provide a means of incorporating new information from the various EVOS projects and also a route for identification of possible gaps in current research. In this way, the work of project staff is tailored to requirements identified during the specification workshops and through interaction with contributors.

A great deal can be learned from Ecosim simulation models to aid resource managers in making decisions that affect the development of these communities. Perhaps even more importantly, the outputs and implications of Ecosim model runs are easily graspable to anyone because of the friendly user interface and graphics that are clear and intuitive. Indeed, we believe that the accuracy, precision and ease of use of the PWS model will be more than adequate to reveal and predict functional and structural responses to virtual manipulations

The newest development to the Ecopath approach is a spatially explicit component of Ecosim called Ecospace. The Ecospace approach may well revolutionize the modeling of ecosystems. It is clear that organisms, or components, in an ecosystem are distributed spatially, and thus organize and concentrate their interactions within and according to particular spatial distributions. With this reality in mind, ecosystem models that do not incorporate spatially explicit analysis seem woefully inadequate. Already, contributors of the PWS post-spill model were asked during the workshop held in Anchorage to provide information on the spatial distribution of their components according to a diagrammatic representation of PWS that was then incorporated into the graphical Ecospace routines. This new approach was demonstrated at the PWS workshop on March 2-4 by enabling the different ecosystem components to "interact' and thus re-distribute themselves in space, within the context of trophic flow.

Production of interactive software displaying temporal changes resulting from the direct or indirect effects of management interventions will allow for novel approaches for explaining basic ecological principles and species interactions in PWS to the general public, schoolchildren, and various special interest groups. The public impact of the proposed project will be strengthened by embedding its main output, the Ecopath/Ecosim model of PWS, into a database on the fish of the PWS region in which coverage of Alaskan fishes will be enriched by incorporation of biological and local/traditional knowledge of all marine biotic resources of the study regions.

C. Location

The area covered by Prince William Sound was defined during our PWS workshop held in Anchorage on 2-4 March, and it was graciously represented by the Alaska Biological Science Centre, USGS, using a GIS package with which J. L. Bodkin and colleagues also provided areal estimates for different depth zones for PWS (see this color map at the project web site at <http://fisheries.com/project.pwsound.htm>). This area closely corresponds to the area used in the PWS pre-spill model (report found at project web site). The area to be included in the second post-spill model includes the marine areas adjacent to PWS, the Kenai

Peninsula, and the outer Cook Inlet, but final definition of area will be made by consensus among contributors. The biological and local/traditional knowledge to be incorporated into FishBase will pertain to the wider PWS region, i.e., include information from outside PWS proper. Thus, the benefits will accrue across the areas of the Gulf of Alaska and Prince William Sound that harbor APEX, SEA, or NVP communities.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

The ultimate goal of community involvement and input into the models constructed for PWS and adjacent areas is that the experience of fishers and hunters will be considered when specifying the models. The proximate task for achieving this ultimate goal will begin by developing a database based on the local names of fishes and other marine organisms within the study area. All accessible names in all appropriate native languages will be the basis for this database. The next step will be to focus on traditional knowledge of life history and interactions for each of the organisms. This database will be incorporated into the report as a separate section, but more importantly it will be incorporated into the Alaska-region FishBase and other databases on the CD-ROM. We hope that this will provide access of this information to the whole spectrum of communities and age groups that might be interested and inclined to contribute. All local/traditional knowledge on the fishes and other organisms of the PWS region to be included in FishBase will rely on published sources, as the project does not include a field component. A project extension phase to deepen this specific aspect of the database, and which would include a field work component, may eventually be proposed, given an expression of interest by the Trustee Council.

PROJECT DESIGN

A. Objectives

Previously stated objectives for this project were:

1. Prepare and hold a one-week model specification workshop;
2. Build a food web model of the interactions of the APEX community members;
3. Build a food web model of the interactions of the NVP community members;
4. Build a food web model of the interactions of the SEA community members;
5. Integrate the three food webs into two, large-scale models of the interactions of the communities;
6. Interact with experts and modify ECOPATH mass-balance model until consensus on trophic interactions in PWS and adjacent waters is reached;
7. Enter biological information, local names in local languages, and local knowledge (so far published) on PWS region fishes and other Alaskan fishes into FishBase;
8. Modify ECOPATH such that seasonal changes are explicitly considered when establishing mass balance;
9. Link the ECOSIM module of the PWS model with an existing model of PWS capable of predicting primary production, and thus drive the trophic interactions in ECOSIM;

10. Prepare a CD-ROM with ECOPATH/ECOSIM model(s) of PWS, and a database on the fishes of the PWS region;
11. Prepare and hold a workshop to present and disseminate the final product (in 10), and teach its use;
12. Present the project and its products at every opportunity, especially at conferences and in the primary literature.

These objectives were either accomplished, or are underway and will be completed during FY 99. In the case of objectives 2-5, however, development and integration of separate models was not necessary. Ecosystem components were defined and partitioned and then individuals from each of the groups mentioned contributed information about the components to which they were assigned. Two additional components proposed for FY 99 are:

13. Use essentially the same method to construct an ECOPATH model of the Kenai Shelf and the Outer Cook Inlet;
14. Enable the models to be run in a spatially-explicit manner using ECOSPACE by expressing spatial distributions of all organisms.

B Methods

Please refer to our initial project proposal of 10 April 1997 for an outline and discussion of the specific methodologies of developing an ECOPATH model. The following paragraphs focus on the basic methods of accomplishing the three project components specified in the introduction section of the current proposal.

Component 1 - The CD-ROM product proposed for production (proposed here and in our accepted initial proposal) will serve as a receptacle and a vehicle for much of the work in this project. Project products to be made accessible through this CD-ROM include the working PWS ECOPATH model including ECOSIM and ECOSPACE features and databases of Alaskan fishes and other marine organisms with accessibility through native languages. The completion of this CD-ROM in time for the 10th annual EVOS workshop will be accomplished through the following tasks:

- Construction, analysis, and presentation of the PWS ECOPATH model during year 1;
- Development of the database of local names and traditional knowledge of organisms;
- Development of a database on Alaska Fishes within FishBase, through contract;
- Incorporating and enabling use of databases that include other taxa (eg. Whiskers);
- Development of user-friendly packaging of included components, through contract;
- Physical production of the CD-ROM product, through contract;
- Arrangement for dissemination at the 10th annual EVOS meeting, and elsewhere.

Component 2 - The goal of this component is to develop an Ecopath model of some of the areas outside of PWS affected by the EVOS. Based on our experience constructing ECOPATH models, we consider that this component will proceed most efficiently if our team maintains options for two scenarios for collecting information for development of this additional model. The first scenario is to hold a 2-day workshop in late January of 1999 similar to the successful workshop held for the PWS model specification. The second scenario is for

project staff to coordinate with experts and researchers for these areas using the same type of collaborative approach where each expert would contribute to the model through an edited report and participants would be part of a list-server group. Meetings between the project coordinator and individual experts would be arranged opportunistically or where necessary. Justification for the second scenario includes: 1) our existent contact with some of the researchers who we would invite to be contributors for this additional model; 2) many of these researchers will already be familiar with the ECOPATH approach; and 3) individual meetings may be more convenient for these researchers than a workshop in January of 1999. We have not decided on either scenario at this point; we consider that it will be far more appropriate to make this decision in November of 1998 rather than now. Either scenario will lead to the same outcome, and we predict that the budget would be the same for either of these scenarios.

Component 3 - A considerable amount of work is involved in producing the content of the deliverables for this project. This work consists mainly of (1) constructing and balancing the models, 2) analysis of the ecosystems using the models (including simulations which follow the questions outlined in Section A above); (3) editing and producing the multi-authored model reports; and (4) coordinating with contributing experts and others. Thus, extended work and study is needed by project staff to accomplish these goals. Most of this work can be done at the respective universities of the involved staff, but some travel and field interaction may be necessary, especially given the second scenario of component 2 above.

C Cooperating Agencies, Contracts and Other Agency Assistance

The PIs and other investigators of all EVOS-funded projects devoted to studying PWS and Gulf of Alaska organisms have been contacted and invited to participate, along with other experts, in the PWS model specification workshop, and the subsequent validation process. This process is ongoing, and we consider the initial stages to have been successful.

In year two, the Fisheries Centre, UBC, will subcontract item 7 under "Objectives" (see above) to the FishBase Project of the (non-profit) International Center for Living Aquatic Resources Management (ICLARM), Manila Philippines, both because data encoding in the Philippines is extremely cost-effective, and more importantly, because data entry for FishBase is done only centrally, by FishBase project staff. (Note that creating local alternative to FishBase would not be cost effective, due to the major international investment that has already gone into FishBase). Additionally, in year two, the Fisheries Centre will subcontract item 10 to an off-campus consultant who is an affiliate of the Fisheries Centre and has experience with fisheries related projects. All other items will be handled by Fisheries Center faculty, or affiliates, or project staff to be hired by the Fisheries Centre. The work done by Stuart L. Pimm will be done as a subcontract to him.

SCHEDULE

A. Measurable Project tasks for FY 98 (October 1, 1997 - September 30, 1998)

1) Oct. 1 - Dec. 31: Literature search on names in the local language and traditional knowledge of marine organisms in PWS and adjacent areas covered

	by the Shelf model. Identification and coordination with experts on ecosystem components of the Shelf model area.
2) Jan. 28-29:	Two-day workshop on construction of the Shelf model
3) March 10:	Completion of the CD-ROM containing the PWS Ecopath model and packaged, graphical simulation scenarios; an Alaska Fish database including local and traditional names; other databases covering other components of the ecosystem
3) March 23-26:	Attend 10th anniversary EVOS restoration workshop and present project results and progress focusing on presentation of the CD-ROM product containing some of the project results.

B. Project Milestones and Endpoints

FY 99 Milestones (besides required annual reports):

Nov. 1998:	Incorporation of explicit seasonally into PWS ECOPATH Model and submission of scientific paper on subject.
Jan. 1999:	Holding of PWS Model Specification Workshop;
March 1999:	Presentation of results at EVOS 10th anniversary conference;
May. 1999:	Publication of Shelf model report;
Jun. 1999:	Submission of scientific papers documenting key features and behavior of trophic mass-balance models including ECOSPACE paper;
September 1999:	Final dissemination of project results and products

C. Completion Dates

As for "Milestones;" project will be completed in September of 1999 (FY 99)

PUBLICATIONS AND REPORTS

The above project milestones identify anticipated publications, reports, and other deliverables. The publication record of the Principal Investigators are invoked here: we will document and publish our work in the primary literature.

PROFESSIONAL CONFERENCES

The principal investigators are often invited to present keynotes at various conferences (see resumes) and will use the opportunities this provides to present the results of the proposed work. The project work to date will be presented at the 16th Lowell Wakefield Fisheries Symposium in Anchorage Alaska on September 30 to October 3, 1998, just before a one day project presentation workshop on October 5.

COORDINATION AND INTEGRATION OF RESTORATION EFFORTS

The aim of the proposed work is to synthesize data from projects funded by the Trustee council (see above under "NEED FOR THE PROJECT")

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

Three main differences exist between the current DPD and the DPD approved by the Trustee Council for FY 98: (1) We are proposing to construct a model of areas outside of PWS affected by EVOS including the Kenai shelf and the outer Cook Inlet. The focus of the project has somewhat shifted from the before-after comparison to coverage of larger affected areas. This shift in focus enables additional analysis and is justified because uncertainties in the pre-spill model will likely remain relatively high. (2) Models and analysis will include a spatially-explicit component through the use of the Ecospace part of the Ecosim analyses. (3) Two different methodological scenarios are included as options for accomplishing the construction of the aforementioned shelf model. This option is necessary because the end of this calendar year is a more appropriate decision point for the shelf model strategy.

PROPOSED PRINCIPAL INVESTIGATORS

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PRINCIPAL INVESTIGATORS

Dr. Daniel Pauly - The key qualifications of Dr. Pauly are having initiated, while still at ICLARM, Manila, Philippines, the activities which led to the emergence of the ECOPATH approach and software, and of FishBase, and to have authored a large number of primary literature publications documenting these. Further, he has organized several workshops (including one in the Pacific Northwest) and training courses at which the ECOPATH approach was taught and used.

Dr. Stuart L. Pimm is on the editorial boards of Conservation Biology, Evolutionary Ecology, Journal of Animal Ecology, Oecologia, and Science. He has also participated on several major committees such as the National Research Council Committee on Preservation of the 'Alala; the Scientific Advisory Board, the Centre for Conservation Biology, Stanford University; the American Institute of Biological Sciences Task force for the 90s, and the National Research Council Committee on the Value of Biodiversity. He has also given Testimony to the Federal Senate Committee on the Environment; the re-authorization of the Endangered Species Act; July 13th 1995, and the House Committee on Resources; the re-authorization of the Endangered Species Act; September 20th 1995. He is the author of numerous scientific papers in distinguished journals and a book, among others, on food webs.

OTHER KEY PERSONNEL

Dr Carl Walters, Professor, Fisheries Centre, UBC, who developed the ECOSIM module of ECOPATH;

Dr Tony Pitcher, Director, Fisheries Centre UBC, who will serve as Project Manager, and a staff member to be hired by the project;

Robert D. Powell, Senior Research Associate, Department of Ecology and Evolutionary Biology, The University of Tennessee, who will develop models at the University of Tennessee;

Thomas A. Okey, M.S., Project Coordinator / Marine Ecologist, Fisheries Centre, UBC, who will continue development of the current, tailored collaborative process, coordinate the shelf Ecopath workshop in Year 2, and edit the PWS and shelf model reports.

Approved TC 8 3-98

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$0.0						
Travel		$0.0						
Contractual		$140.0						
Commodities		$0.0						
Equipment		$0.0						
Subtotal		$140.0		Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
General Administration		$9.8						
Project Total		$149.8						
Full-time Equivalents (FTE)		0.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

FY 99

Project Number: 99330
Project Title: Mass-Balance Model of Trophic Fluxes
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Revision 11/15/98
Approved TC 8-13-98

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel	$92,550	$89,500
Travel	$30,880	$10,090
Contractual	$2,800	$15,000
Commodities	$3,710	$0
Equipment	$9,680	$400
Subtotal	$139,620	$114,990
Indirect	$28,380	$25,011
Project Total	$168,000	$140,001
Full-time Equivalents (FTE)	29.5	21.1
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
$0.0	$0.0	$0.0

Dollar amounts are shown in thousands of dollars.

Comments: Indirect costs are for UBC Fisheries Centre, standard UBC contract overheads and cover general services, administration, space and buildings, computer facilities, basic office supplies and communications. They are calculated at the standrad UBC contract rates for ' non-commercial govemment and NGOs' of 30% of the cost of personnel and 2% or travel costs. Note: rates for S. Pimm and B. Powell are calculated at the UTC rate of 23%.

FY 99

Project Number: 330
Project Title: PWS Ecopath Model Component Only
Name: Fisheries Centre UBC, U of Tennessee, Knoxville

FORM 4A
Non-Trustee
SUMMARY

Prepared: 14 July 1998

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
Dr Daniel Pauly	PI - UBC Fisheries Centre		1.0	7500		7,500
Dr Stuart Pimm	PI - U. Tenn.		1.0	7500		7,500
Dr Carl Walters	numerical modeller - UBC Fisheries Centr		0.6	7500		4,500
Dr Tony Pitcher	ecologist, project manager, UBC -FC		0.5	7500		3,750
Robert D. Powell	research associate - U. Tenn.		5.0	4330		21,650
Thomas A. Okey, MS	project coordinator- UBC Fisheries Centre		10.0	4100		41,000
(to be appointed)	graduate student - Pauly		3.0	1200		3,600
						0
						0
						0
						0
						0
	Subtotal		21.1	39630.0	0.0	
					Personnel Total	89,500

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
UBC PI, modeller + proj. coordinator to 10th annual EVOS meeting	700	3	15	130	4,050
PI Pimm and Powell to 10th annual EVOS meeting	1000	2	8	130	3,040
PI Pimm and Powell to Vancouver to help coordinate modeling	850	2	10	130	3,000
					0
					0
					0
					0
					0
					0
					0
					0
				Travel Total	10,090

FY 99

Project Number: 330
Project Title: PWS Ecopath Model Component Only
Name: Fisheries Centre UBC, U of Tennessee, Knoxville

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 14 July 1998

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

Contractual Costs:	Proposed
Description	FY 1999
Report draft, editing, binding and delivery	2,500
Production of multi-cultural Alaska Ecopath / Fishbase CD-Rom	
Entry of Alaska Ecopath and fish information into Fishbase database	6,000
Database design and supervision by senior scientist	1,000
Database arrangement and physical production of CD-Rom	5,500
Contractual Total	15,000

Commodities Costs:	Proposed
Description	FY 1999
Commodities Total	$0.0

FY 99

Prepared: 14 July 1998

Project Number: 330
Project Title: PWS Ecopath Model Component Only
Name: Fisheries Centre UBC, U of Tennessee, Knoxville

FORM 4B
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
hard drive upgrade for laptop at UTK	1	400.0	400.0
			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**	$400.0

Existing Equipment Usage: Description	Number of Units	

FY 99

Project Number: 330
Project Title: PWS Ecopath Model Component Only
Name: Fisheries Centre UBC, U of Tennessee, Knoxville

FORM 4B
Equipment
DETAIL

Prepared: 14 July 1998

Approved TC 8-13-98

Survival of Adult Murres and Kittiwakes in Relation to Forage Fish Abundance

Project Number:	99338
Restoration Category:	Research
Proposed By:	U.S. Geological Survey (PI- John F. Piatt)
Lead Trustee Agency:	DOI-BRD
Cooperating Agencies:	DOI-FWS
Duration:	2nd year, 3-year project
Cost FY 99:	$57,900
Cost FY 00:	$45,000 (data analysis, reporting)
Cost FY 01	$0
Cost FY 02	$0
Geographic Area:	Cook Inlet, Gulf of Alaska
Injured Resource:	Multiple resources

ABSTRACT

Some seabird populations damaged by the *Exxon Valdez* oil spill continue to decline or are not recovering. In order to understand the ultimate cause of seabird population fluctuations, we must measure productivity, recruitment, and adult survival. Current APEX studies are focused on measuring productivity only. Recruitment measurement demands an unrealistic study duration. We propose to augment current studies in lower Cook Inlet that relate breeding success and foraging effort to fluctuations in forage fish density by using banding and resighting to quantify the survival of adult common murres and black-legged kittiwakes.

INTRODUCTION

Some seabird populations in the Gulf of Alaska have undergone marked fluctuations during the past few decades (Hatch and Piatt 1995; Piatt and Anderson 1996), including periods of decline or non-recovery. Ultimately, the ability of injured or declining seabird populations to recover depends on: 1) breeding success, or productivity; 2) fledgling survival and subsequent recruitment; and 3) overwinter survival of adults (Harris and Wanless 1988). Without concurrent measurement of at least two of these three parameters, it is difficult to determine which factor is most limiting to a population's recovery.

Mechanisms that regulate seabird populations by influencing productivity, recruitment, and adult survival are poorly understood, but food supply is clearly important (Cairns 1992). Studies sponsored by the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) in 1995-97 (APEX, project no. 99163) have shown linkages between food supply and population fluctuations. Exactly which parameters of reproductive strategy are driven by food supply, and so drive population fluctuations, remain unclear. To date, APEX has focused on forage fish availability and its relationship to productivity.

We propose to determine the overwinter survival of adult common murres (*Uria aalge*) and black-legged kittiwakes (*Rissa tridactyla*) using established banding and resighting techniques at two of the colonies (Fig. 1) currently being investigated by APEX (Project 99163M). Results of past work show clear differences in prey availability between the two colonies, with forage fish being scarce around Chisik Island and abundant around Gull Island. Both seabird species must work significantly harder at Chisik to provide food to their chicks (Fig. 2). This difference appears to be manifested in sharply reduced kittiwake production at Chisik Island (Fig. 2). Observing that kittiwake populations have been steadily declining at Chisik while increasing at Gull (Fig. 3), one might be tempted to conclude that weak productivity and recruitment are driving the Chisik kittiwake population declines. However, while murres (at least in recent years) have been similarly productive at Chisik and Gull (Fig. 2; J.F. Piatt unpubl. 1997 data), the Chisik Island murre population has historically declined at an even greater rate than the kittiwake population.

From these data we conclude that the murre population decline at Chisik Island and concurrent increase at Gull Island may be attributable to differences in adult survival rates. Measurement of survival rates, in coordination with APEX's focus on food supply and colony productivity, should help to more completely resolve the mechanisms underlying seabird population fluctuations, particularly for those species such as murres that are able to buffer against periods of food shortage by increasing foraging effort (Burger and Piatt 1990; Irons 1992).

Our continued research will measure adult survival of both murres and kittiwakes at Chisik and Gull Islands. We will use conventional banding/resighting methods to establish both species' adult survival rates. Working in collaboration with the CISeaFFS component of the APEX project, we will compare survival between colonies in relation to foraging stress, breeding

success, and forage fish abundance. Foraging stress from breeding effort is probably a major contributor to adult overwinter mortality (Golet et al. 1998). Our work will enhance understanding of the relationships among survival, reproduction, and foraging in kittiwakes and murres in lower Cook Inlet. In a broader context, our research will clarify the mechanisms and limiting parameters underlying natural population declines or the failure of injured populations to recover.

NEED FOR THE PROJECT

A. Statement of the Problem

Research has provided few clear examples of how seabird population biology is affected by changes in prey availability (Hunt et al. 1991). Consequently, it has been difficult to understand the non-recovery of some EVOS-damaged seabird populations because natural changes in forage fish stocks may have also contributed to their decline. The picture is further complicated by our inability to pinpoint which aspect of population biology ultimately drives population fluctuations. To determine the cause of population declines or non-recovery, the population's productivity, recruitment, and adult survival should be measured concurrent with evaluation of available food supply (Cairns 1992).

Current EVOSTC-funded work (APEX, project no. 99163M) measures productivity and foraging differences of seabirds in response to fluctuating prey availability. Preliminary results from research conducted in lower Cook Inlet show some correspondence between productivity and forage fish availability to breeders. There is no correspondence, however, in species such as the murre which are able to increase foraging effort in response to decreasing forage fish abundance (Burger and Piatt 1990). Differences in recruitment and/or adult survival are thus implicated as important determinants of population fluctuations. Yet their relative importance has not yet been established by EVOSTC researchers, despite past work which has shown that variation in either recruitment or adult survival could obscure or even offset population fluctuations apparently driven by productivity differences (Hudson 1985).

Since murres and kittiwakes do not commence breeding until they are several years old (Hudson 1985; Aebischer and Coulson 1990), it is not feasible to measure recruitment in Cook Inlet seabird populations within the time frame required by EVOSTC funding. Measurement of adult overwinter survival has not yet been studied within a complete ecological framework, and has been identified by APEX reviewers as an important topic for expanded research in pursuit of understanding population fluctuations and recovery.

B. Rationale

Population changes are continually being driven by natural ecosystem changes, and are occasionally driven by anthropogenic perturbations such as the *Exxon Valdez* oil spill. In order

to separate natural population fluctuations from anthropogenic population changes, we must have a complete understanding not only of the factors which drive population changes (e.g. change in prey availability) but also of the population biology parameter which is most altered by those driving forces. Chick productivity in relation to varying prey availability is currently being studied, but cannot explain all observed population trends. It is not feasible to measure chick survival and recruitment. Therefore, to assess the potential for recovery of seabirds affected by the *Exxon Valdez* oil spill by pinpointing the cause of population trends, a study of adult survival and its relationship to prey availability is required.

In collaboration with the ecosystem-based study of seabird foraging conditions and breeding biology currently being conducted by APEX in lower Cook Inlet (project no. 99163M), we have a unique opportunity to assess not only the role of adult survival in seabird population fluctuations, but also the suspected linkage between foraging effort during the breeding season and adult overwinter survival. By choosing species with different long-term breeding strategies (kittiwakes maintain investment in reproduction at relatively constant [high] levels despite variation in food supply; murres adjust reproductive effort in relation to prey availability by altering buffer or "loafing" time) we will address questions raised by ongoing APEX work that shows linkage between prey availability and population fluctuation in some species (kittiwake) but only implies a linkage in others (murre). Refined understanding of foraging effort in relation to food supply will further our understanding of the costs of breeding in murres and kittiwakes. Stress induced by increased foraging effort in response to poor foraging conditions may explain variation in adult survival.

C. Location

The proposed research will be undertaken in lower Cook Inlet, Alaska. The project's benefits will be realized throughout the EVOS area, in the form of enhanced understanding of seabird population trends and recovery mechanisms. Homer, Alaska is the only community that may be directly affected by the proposed research (as detailed below).

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Gull Island in Kachemak Bay is owned by the Seldovia Native Association (SNA). Limited subsistence use occurs during summer, with occasional egging and harvesting of juvenile birds (Fred Elvsaas, pers. comm.). It is also a major tourist attraction for visitors to Homer. Permission to work on and around the island has been obtained under the provision that annual reports of findings be made available to the SNA. We also plan to inform the local tour boat operators about our activities so that our presence at the island can be explained to visiting tourists. Chisik Island is managed by the Alaska Maritime National Wildlife Refuge, and we will employ charter vessels from Homer to support field work there. Chisik Island supports a small, seasonal fishing community and we will inform the summer residents about the nature and purpose of our activities. Every attempt will be made to include local.residents in the pool of

applicants considered for volunteer positions related to the project. Whenever possible, equipment and other resources will be acquired locally in the Homer area. Traditional and local ecological knowledge will be sought from fishermen and other residents, particularly on the topic of seabird population trends and foraging patterns.

PROJECT DESIGN

A. Objectives

1. To determine adult common murre and black-legged kittiwake overwinter survival rates, using conventional banding and resighting methods.

2. To relate differences in common murre and black-legged kittiwake overwinter survival to differences in prey availability and foraging effort during the breeding season.

3. To relate differences in common murre and black-legged kittiwake overwinter survival to differences in breeding success.

Background

To test our primary hypothesis- that adult common murre and black-legged kittiwake overwinter survival is related to prey availability and foraging stress during summer- we need to obtain measures of overwinter survival concurrent with measures of prey abundance and distribution. Data on prey (forage fish) abundance and distribution will be obtained via coordinated efforts with EVOSTC-funded projects 99163M (APEX) and 99306 (Sand Lance Ecology).

We will conduct the proposed research at Chisik and Gull Islands, lower Cook Inlet (Fig. 1). Chisik Island has relatively low prey availability within typical murre/kittiwake foraging ranges, while Gull Island has high prey availability (Piatt unpubl. data). The Chisik Island populations of both murres and kittiwakes have shown steady declines over the past two decades, in contrast to the Gull Island populations which are expanding (Fig. 3). Ongoing APEX work has shown a significant relationship between breeding success and foraging effort for kittiwakes, but not for murres (Fig. 2). Both species show increased foraging effort with decreased prey availability, but it appears that murres have a greater range of foraging effort within which they can still successfully produce chicks, as indicated by past studies (Burger and Piatt 1990). This raises the question: Is there a delayed or hidden cost to successful breeders that have had to "work harder" to raise their chicks? One way such a cost may be expressed is in decreased annual adult survival.

Measurement of survival:

Adult overwinter survival in seabirds has typically been measured by intensive banding and resighting programs (Harris and Wanless 1988; Aebischer and Coulson 1990; Hatchwell and Birkhead 1991; Hatch et al. 1993; Sydeman 1993). A suite of potential confounding factors (loss of bands, emigration, intracolony movement, observer failure to see marked birds) complicate survival estimates based on banding and resighting (Harris and Wanless 1988; Hatch et al. 1993). Models have been developed which account for some of these problems (Pollock et al. 1990); overcoming the remaining uncertainties depends directly on the amount of personnel effort that can be dedicated to banding and resighting work. Intensive effort will be required to resight banded birds, especially during the pre- egg-laying stage for kittiwakes (May) and murres (June). Adult common murres are particularly difficult to resight, due to the murre's compact body posture while at the nest site. Furthermore, precise survival estimates based on banding are ideally generated by multi-year studies, due to evidence that long-lived seabirds may sometimes skip one or more years of attempts at breeding (Hudson 1985; Golet et al. 1998).

Measurement of foraging effort:

Increased foraging effort may be the most important contributor to reduction in adult seabird survival (Golet et al. 1998), illustrating the trade-off between yearly reproductive output and longevity. The CISeaFFS study is currently measuring murre and kittiwake foraging effort (in terms of bird-hours spent away from the colony) using a series of four all-day nest (n= 8-12) watches, spread throughout the chick-rearing phase. All-day watches give information on nest-site attendance, foraging trip duration, and chick provisioning rate. Foraging data obtained concurrently with APEX forage fish abundance and distribution data will give insight into the mechanisms that reduce or influence adult survival as well as productivity, elucidating the forces that drive population fluctuations.

B. Methods

Resighting efforts to search for birds banded during FY98 work will commence in late May and early June 1999. Initial effort will focus on nest-sites at which birds were banded the previous year. Search coverage will then be expanded to include all visible nests, in order to document any intracolony movement. Coverage will also include roosting rocks and other gathering areas, to look for birds that may skip breeding in the year following banding, but continue to attend the colony. Resighted birds' position in the colony will be noted on archival plot photos or sketches.

Sample Size and Survival Statistics: Assuming a binomial distribution (sample unit being an individual murre, with survival being a yes or no), a power analysis of sample size in a two by two table (Steel and Torrie, 1980) predicts that a sample size of 47 marked birds per island would resolve a 6% difference in survival between colonies with acceptable statistical power and confidence (Table 1). To double the resolution (3%) would require a sample size nearly five times greater. A sample size of 125 is predicted to resolve a 5% difference with strong power

and significance at the 0.05 level. Previous studies have reported murre survival rates ranging from 87% to 98%, measured at stable colonies (Hudson 1985, Sydeman 1993). Given that our study colonies represent relative extremes of population expansion and decline, it is not unreasonable to expect their survival rates to also be at the extreme ends of the normal range. Therefore, detection of a 5% difference with statistical significance should adequately address our primary hypothesis. To allow calculation of resighting probabilities, potentially obviating the use of Jolly-Seber or related models, our goal will be to have a minimum of 200 individually marked birds of each species at each colony.

Cooperating Agencies, Contracts, and Other Agency Assistance

The proposed research will be conducted by a research student, under the PI's supervision. A Research Work Order or equivalent will provide funding for one MSc. student at a university yet to be determined. Personal Services contracts may be used for statistical consultation and programming assistance.

SCHEDULE

Measurable Project Tasks for FY 99

Oct. 1-Jan. 31:	Evaluate results of FY98 work; refine study design
Feb. 1-April 15:	Arrange logistics (resighting, capture and banding, nest monitoring, etc.)
March 23-27:	Attend 10th Anniversary Symposium
April 15:	Submit Annual Report (FY98 findings)
April 16-Sept. 10:	Conduct field work
Sept. 11-Sept. 30:	Compile resighting results; begin data analysis

Project Milestones and Endpoints

Dec. 31, FY 99:	Preliminary data analysis will be completed
April 14, FY 99:	Project design modifications (based on FY 98 results) will be completed
April 15, FY 99:	Submit annual report (FY 98 findings)
Sept. 10, FY 99:	Field work, as necessary based on FY 98 results, will be completed
April 15, FY 00:	Submit annual report (FY 99 findings)
Sept. 30, FY 00:	Preparation of research results for publication in peer-reviewed journals will be completed

Completion Date

Our proposed research takes advantage of a natural comparative system (failing vs. thriving colonies) to reduce the time required to test the hypothesis that increased foraging effort will decrease adult survival. We propose two field seasons (FY98 and FY99) to ensure an adequate

sample size and to allow for modification of project design based on initial results. The project will be completed by the end of FY 00, which is planned as a close-out year during which no new research will be undertaken. Efforts in FY 00 will focus on the graduate student's thesis completion and defense, and on publication of research results in peer-reviewed journals.

PUBLICATIONS AND REPORTS

The first planned product of the proposed research will be the annual report detailing FY 98 findings, due on April 15, 1999. Publication of project results in peer-reviewed journals will be pursued as soon as scientifically appropriate and logistically possible.

PROFESSIONAL CONFERENCES

Results of this project will be presented at the Annual Meeting of the Pacific Seabird Group, and at local professional meetings where appropriate.

NORMAL AGENCY MANAGEMENT

This research would not be conducted as a normal part of USGS research on seabirds.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The proposed research issues are related to management and conservation of seabirds in Alaska as addressed by the U.S. Fish and Wildlife Service (USFWS) 'Seabird Management Plan' (USFWS Region 7, Migratory Bird Management). The proposed work will complement and be coordinated with: i) long-term studies conducted by the Alaska Maritime National Wildlife Refuge (AMNWR, USFWS Region 7), which includes annual monitoring of seabird productivity at 9 major seabird colonies throughout Alaska; ii) related studies (APEX) of seabird-forage fish interactions being supported by EVOSTC in Prince William Sound; iii) EVOSTC-funded research on the Pacific sand lance; iv) ongoing studies of seabird populations in areas of oil and gas development conducted by the Minerals Management Service (MMS) in Alaska and the Biological Resources Division of the USGS and, v) ongoing studies of marine fish and oceanography conducted by the University of Alaska, Fairbanks out of the Kasitsna Bay Marine Lab in Kachemak Bay.

Logistic support from the USFWS and AMNWR will include vessel use, storage facilities, laboratory space, computer usage, and communications. Field sites and research platforms will be shared with the EVOSTC-funded APEX and sand lance projects.

PRINCIPAL INVESTIGATOR

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Table 1. Power analysis of sample size (in a two by two table). One minus beta is power; a power of <0.50 is typical in survival estimations. One minus alpha is the confidence interval. Ps and Pe are estimated survival fractions at two hypothetical colonies. Thus, with a sample size of 47 (transmitters per colony), we would expect to resolve a 6% difference (Ps minus Pe) with a power of 0.51 and 90% confidence intervals. With a sample size of 125, we would expect to resolve a 5% difference with a power of 0.75 and 95% confidence intervals. In general, as sample size doubles, variance is halved (Heisey and Fuller, 1985). Resolution of differences <5% demands unacceptably large sample sizes.

alpha	Zalpha	beta	Zbeta	Ps	Pe	n =
0.10	1.18	0.25	0.68	0.92	0.89	352.32
0.10	1.18	0.49	0.01	0.92	0.89	226.01
0.05	1.65	0.25	0.68	0.95	0.90	125.25
0.10	1.18	0.25	0.68	0.95	0.90	100.14
0.10	1.18	0.49	0.01	0.94	0.89	72.49
0.10	1.18	0.49	0.01	0.95	0.89	46.97

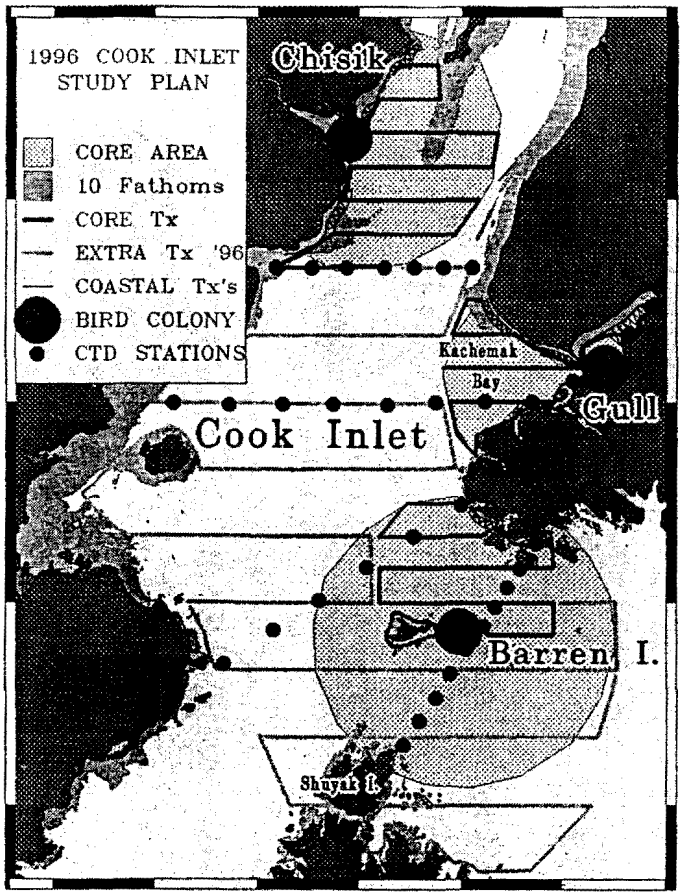
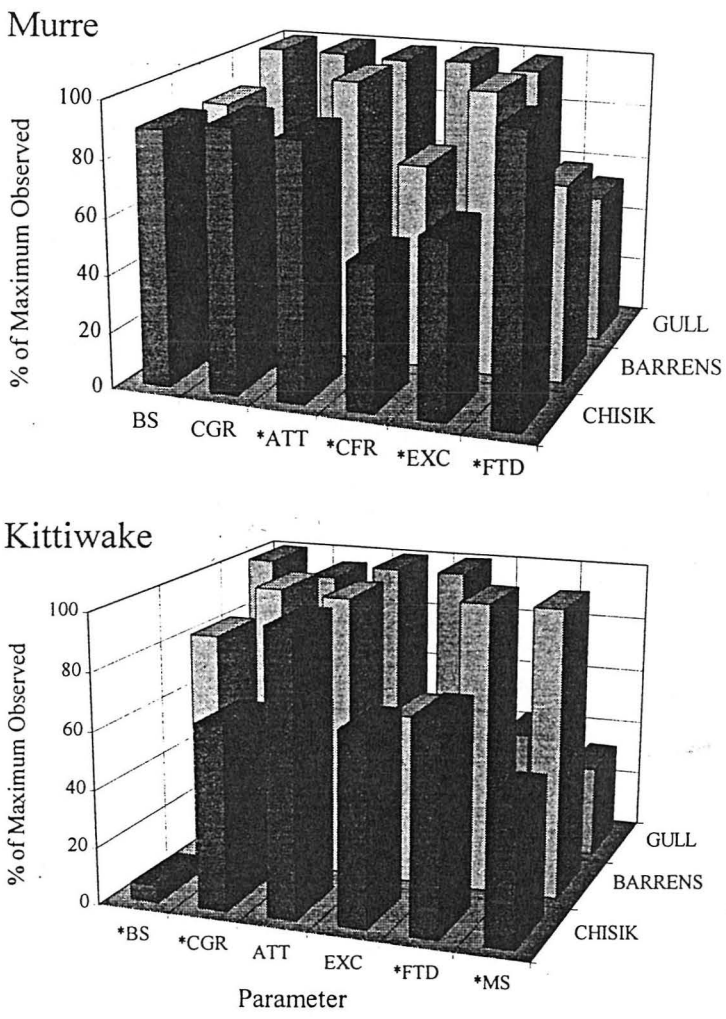


Figure 1. Study area in lower Cook Inlet. Colonies proposed for study of adult survival are located on Chisik and Gull Islands.



Parameters: BS- Breeding Success, CGR- Chick Growth Rate, ATT- Attendance by Adults, CFR- Chick Feeding rate, EXC- Exchange Rate of Brooding Adults, FTD- Foraging Time Duration, MS- Mean Meal Size. Asterisk (*) indicates significant difference in parameter values between colonies.

Figure 2. Variation in reproductive and behavioral parameters of seabirds at Chisik, Gull, and Barren Island colonies in 1996. Note high and similar breeding success of murres at Gull and Chisik, hypothetically made possible by increased foraging effort of Chisik murres. Chisik kittiwakes were apparently unable to compensate, and therefore failed to produce chicks.

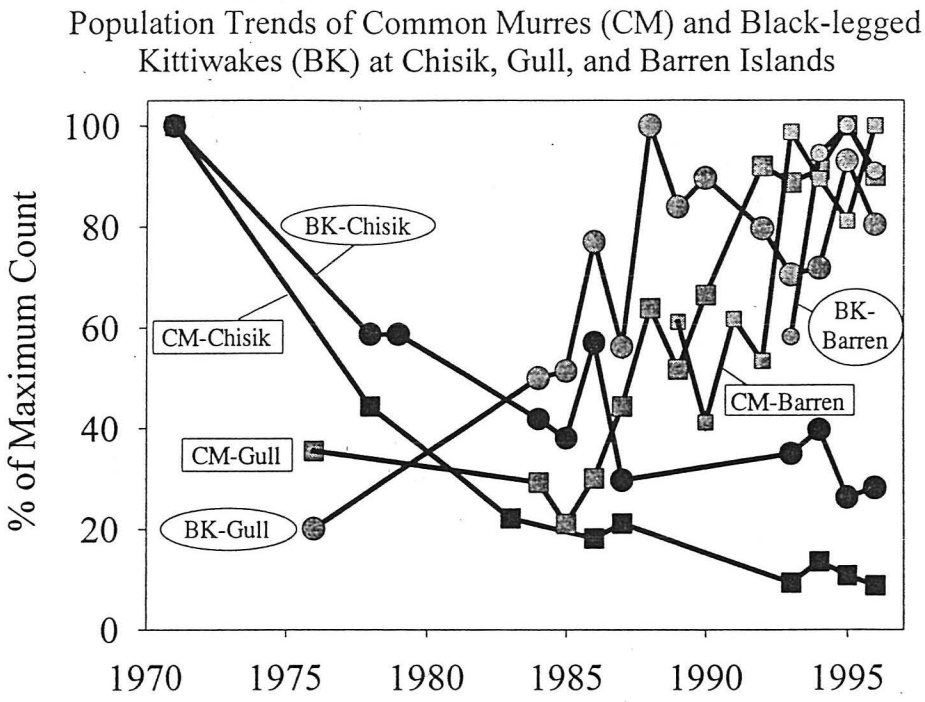


Figure 3. Population trends of murres and kittiwakes showing declines at Chisik Island and increases at Gull Island.

Approved TC 8-13-98

FY 99 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999	LONG RANGE FUNDING REQUIREMENTS					
				Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
Personnel		$11.0						
Travel		$1.2						
Contractual		$37.0						
Commodities		$4.1						
Equipment		$0.4						
Subtotal	$0.0	$53.7						
General Administration		$4.2						
Project Total	$56.2	$57.9		$45.0	$0.0	$0.0		
Full-time Equivalents (FTE)		0.4						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY 99

Prepared:

Project Number: 99338
Project Title: Survival of adult murres and kittiwakes
Agency: U.S. Geological Survey

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
vacant	Biotech	GS-5	2.5	2.2		5.5
vacant	Biotech	GS-5	2.5	2.2		5.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		5.0	4.4	0.0	
					Personnel Total	$11.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
Anc/Hom/Anc	0.2	6	0	0.0	1.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.2

FY 99

Prepared:

Project Number: 99338
Project Title: Survival of adult murres and kittiwakes
Agency: U.S. Geological Survey

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
Air charter Homer-Chisik (RT) (6 x $500/trip)	3.0
Boat charter (Camp support; Homer-Chisik RT 2 x $1500/trip)	3.0
Safety training	1.0
Research Work Order or euivalent (with University to be determined)	
RWO includes:	
Grad student stipend and tuition	28.0
Benefits	2.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$37.0

Commodities Costs:	Proposed
Description	FY 1999
Fuel (resighting from water, 15d @ 20gal/day @ $3.00/gal)	1.0
Misc. supplies	1.4
Color bands (300 sets per species per island)	1.2
Metal bands (300 per species per island)	0.5
Commodities Total	$4.1

FY 99

Prepared:

Project Number: 99338
Project Title: Survival of adult murres and kittiwakes
Agency: U.S. Geological Survey

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
Pelican case	2	0.2	0.4
			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**	$0.4

Existing Equipment Usage:	Number	Inventory
Description	of Units	Agency
Boston Whaler (camp and personnel support; @ $75K)	1	FWS
Laptop computer (@ $1.5K)	1	USGS
Zodiac inflatables (2 x $7.5K)	2	USGS

FY 99

Project Number: 99338
Project Title: Survival of adult murres and kittiwakes
Agency: U.S. Geological Survey

FORM 3B
Equipment
DETAIL

Prepared:

Approved TC 8-13-98

Western Prince William Sound Human Use and Wildlife Disturbance Model

Project Number:	99339
Restoration Category:	General Restoration
Proposer:	K. Murphy, L. Suring/USFS
Lead Trustee Agency:	USFS
Cooperating Agencies:	ADNR
Alaska SeaLife Center:	No
New or Continued:	Cont'd
Duration:	2nd yr. 2 yr. project
Cost FY 99:	$67.2
Cost FY 2000:	$0.0
Cost FY 01:	$0.0
Cost FY 02:	$0.0
Geographic Area:	Prince William Sound
Injured Resource/Service:	All

ABSTRACT

This project will use geographic information system (GIS) techniques to describe current human-use patterns in western Prince William Sound and to model potential changes in those use patterns as a result of additional development. Maps of present and projected human-use patterns will be incorporated with maps of the distribution of injured resources. This will provide a basis to identify areas where there may be conflicts between human use and wildlife concentrations resulting in disturbance. Disturbance of injured wildlife may result in decreased productivity exacerbating the effects of the oil spill and prolonging the time to recover. Identification of potential areas of disturbance will allow development of recommended management practices that may eliminate or minimize the negative effects of increasing human use. All injured resources and subsistence species will be addressed in a general approach but specific management recommendations will be developed for harbor seal, pigeon guillemot and cutthroat trout.

INTRODUCTION

In late December, 1997, the EVOS Trustee Council approved funding for a pilot project to develop a model of human use and wildlife disturbance in Western Prince William Sound (PWS). The project provides a foundation for displaying and understanding existing and future human use patterns in PWS, the potential disturbances on injured resources, and would make recommendations for management actions to minimize adverse effects of increased human use on injured resources. The project consists of three components:

1. Develop and evaluate a spatial computer model of existing human use patterns in PWS,
2. Use the model to project changes in human use patterns as a result of development and management actions in western PWS, and
3. Identify management actions for public lands to minimize potential future disturbance on injured resources.

The final product of this pilot project would be a report with management recommendations for State and Federal agencies and a geographic computer database. The report and computer model would be available to all agencies and to Chenega Bay to assist land owners and managers to better understand the potential human use of an area and make appropriate management decisions. While the project would generally take a broad-spectrum approach in describing potential disturbance patterns on injured resources and on subsistence species, we also propose a more in-depth analysis of three injured species: harbor seal, pigeon guillemot and cutthroat trout.

This project would provide a useful tool in many aspects of the EVOS restoration program. The model would help in the identification of appropriate research and monitoring sites to understand the effects of human disturbance on specific injured resources or services. It would help in identifying areas where subsistence harvests may be affected by increased recreation and other uses. In addition to benefiting restoration activities, the model and recommendations would benefit State and Federal agencies, and the Chenega Corporation, in land management planning and in the protection of resources.

In FY98 a draft GIS (Geographic Information System) model of existing human use patterns in western PWS is being developed. Obtaining data for this model has been a collaborative effort with tremendous support from the Whittier Harbor, Charter Operators and others. An initial draft model will be completed by May and model verification will begin using aerial survey techniques throughout the summer. This proposal describes the work to be accomplished in Fiscal Year 99.

NEED FOR PROJECT

A. Statement of Problem

Human activity in PWS is expected to increase significantly in the next decade (ADOT 1995). This project provides a management tool that would increase the effectiveness of management of resources and human use in PWS. The project has direct application under Habitat Protection

and General Restoration as described in the EVOS restoration plan (EVOS Trustee Council 1994), and has the potential to aid in the restoration of most of the identified injured resources and services. The pilot phase of this project places emphasis on describing potential disturbance effects and developing management recommendations for harbor seals, pigeon guillemots and cutthroat trout on public lands in PWS.

B. Rationale/Link to Restoration

The Trustee Council has made significant progress in understanding the effects of the EVOS and in restoring and protecting the resources and services injured by the spill. However, the recovery of these resources and services may be affected by a dramatic increase in human use in PWS. The ADOT has predicted that the Whittier access road will result in an increase of over 600% in recreational and tourism boat traffic in parts of western PWS by the year 2015 (ADOT 1995). However, the Whittier road is one of several changes that will affect human use in PWS. For example, in the last 5 years new glacier cruise tours have been established in Whittier, more State and Federal lands have been acquired in western PWS, and the number of recreational boaters in western PWS has increased. As more people recreate and work in PWS, there will be higher levels of interactions between people and injured resources. Research has shown that human disturbance can cause a wide range of problems for wildlife and fish populations. At its most severe levels, disturbance can cause mortality or reduced productivity (Knight and Cole 1991). As human use increases in PWS, the potential for problems related to human disturbance to delay recovery of injured species also increases. By identifying existing and potential human use patterns in western PWS, the Trustee Council would be providing a tool that would assist in habitat protection, general restoration, and would also provide valuable information for research and monitoring projects.

This pilot project would take a broad-spectrum approach in describing potential disturbance patterns on injured resources and on subsistence species. We also propose a more in-depth analysis associated with three injured species: harbor seal, pigeon guillemot and cutthroat trout. This analysis would compare known distribution patterns of these species with the predicted disturbance patterns to provide more specific management recommendations. Harbor seals were selected because their haulout sites are often approached by tourism and recreational boats. Richardson et al. (1995) provides a summary of effects of disturbance at haulout sites; such disturbance can result in site abandonment, shifts to nighttime haulout schedules, or injury and increased pup mortality. Pigeon guillemots are susceptible to human disturbance during nesting because they nest on or near beaches that may also provide good campsites and fishing areas for people. Of sportfish species, cutthroat trout may be at the greatest risk. PWS is the northern-most extent of the range for this species. Populations in western PWS are generally small and poorly understood. Increased harvest of this species could further reduce the population (Gillikin, D. pers. com.).

C. Location

This pilot project has focused on western PWS. The project will benefit all State and Federal agencies with management responsibilities in PWS. The project will also benefit other land owners, especially the Chenega Corporation and the community of Chenega Bay.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Involvement from the community of Chenega Bay and from the Chenega Corporation is an important component of this project. In order to fully understand human-use patterns in western PWS, the human use patterns to and from Chenega Bay must also be incorporated into the model. The Chenega Corporation has agreed to cooperate on this project by supplying information on historical and current use patterns, and to comment on the predicted human use patterns identified by the model. Residents of Chenega Bay have been asked to participate in identifying activity patterns near the village and in southwestern PWS.

PROJECT DESIGN

A. Objectives

There are three objectives associated with this pilot project:

1. Describe existing and potential human-use patterns in western PWS

2. Identify areas where human disturbance has a high potential to affect injured resources.

3. Develop management recommendations for public agencies to minimize or eliminate the effects of disturbance on injured resources.

B. Methods

These methods are identical to those described in the original project proposal (98339).

Model Construction

Only water-based transportation will be considered in the description of human-use patterns in PWS. Vessel classes will be established to more accurately describe use patterns. Classes will be based primarily on size and function (e.g., personal pleasure craft, charter, tour, commercial fishing). Current number, locations, and trips of vessels by class in western PWS will be determined through registration records, fuel records, and harbor master information on slip rental, moorage and launches. Additional information will be provided through a user survey.

The extent of human use in western PWS will be described through an analysis of accessibility of the area by water craft in association with preferred destinations (e.g., recreational and commercial fishing areas, mooring buoys, camping sites, recreation cabins). Accessibility will be defined as a function of the travel range of each vessel class. Average travel ranges will be assigned to vessel classes based primarily on fuel capacity. "Preferred" destinations will be described from existing information such as recreation sites maintained by land management agencies (e.g., U.S. Forest Service, Alaska Department of Natural Resources), commercial fishing areas (e.g., Alaska Department of Fish and Game, Prince William Sound Aquaculture Association), sport fishing areas (e.g., Alaska Department of Fish and Game), tour destinations (e.g., tour operators associations). Potential use levels of these sites will be determined from

existing survey information collected at the Whittier harbor (USDA Forest Service, unpublished data) and from a mail survey of the patrons of the Whittier harbor. The survey will be distributed to individuals and groups known to work and recreate in PWS. This survey will help to refine model parameters on frequency and duration of trips associated with different vessel classes.

Cell-based modeling using the GRID feature of the ARC/INFO geographic information system (GIS) will form the basis of our approach to evaluate human-use patterns in western PWS (Environmental Systems Research Institute, Inc. 1994). Weighted distance functions will be used to describe areas that are available to and may be used by vessel operators. Separate grids of the water portion of western PWS will be created for the analysis of dispersion of vessels in each class. For each vessel class a source grid will be created which will represent trip initiation points (e.g., marinas, launch sites). The PATHDISTANCE function will be used to determine the minimum accumulative-travel cost from the source to each cell location on the grid. This function allows for the control of factors that influence dispersion. First source cells will be identified. Then the cost to travel to each neighbor that adjoins a source cell will be determined. Next, each of the neighbor cells will be ordered from least costly to most costly. The cell location with the least cost will be removed. Finally, the least-accumulative cost to each of the neighbors of the cell just removed will be determined. This process will be repeated until all cells on the grid have been assigned an accumulative cost.

Corresponding cost grids will also be established for each vessel class. A cost grid will assign an impedance value to each cell that depicts the cost involved in moving through any particular cell. The value of each cell in the cost grid will represent the cost-per-unit distance of passing through the cell, where a unit distance corresponds to the cell width (Environmental Systems Research Institute, Inc. 1994:253). Each cell location will be given a weight proportional to the relative cost incurred by a vessel passing through a cell. The cost units will be established on a relative scale of energy units expended. Variations of the horizontal and vertical factor features of the PATHDISTANCE function will be used in the cost grids to represent attraction zones associated with preferred destinations (e.g., recreational and commercial fishing areas, mooring buoys, camping sites, recreation cabins).

ARC/INFO GRID functions will be used to create additional grids in which each cell is assigned the accumulative cost to the nearest source cell. Additional functions will be used to combine the accumulative cost grids and the attraction zone grids to develop grids that represent dispersion of water craft by vessel class in western PWS. These dispersion grids will be combined through map algebra to describe areas of western PWS by use class (e.g., low, medium, high vessel densities). The dispersion and density grids will be combined with grids of sensitive areas for injured species to identify those areas where conflict may occur.

Model Evaluation

The model will provide predictions of movements and concentrations of water vessels in the pilot study area. This information will be used to characterize areas of western PWS as having high, medium, and low densities of vessels by vessel class and total vessels on a monthly basis. Separate runs of the model will be made for each month from May through September. Actual vessel densities in representative areas will be determined, by month, through field surveys.

Three areas of western PWS within each of the high, medium, and low density classes (as predicted by the model) will be randomly selected. Counts of vessels present in each of the sample areas will be made each month from May through September during high-use (e.g., weekends) and low-use (e.g., mid-week) periods. Counts will be conducted from fixed-wing aircraft along line transects using the approach described by Anderson et al. (1979) and applied by Gasaway et al. (1986). Transects will be located 0.4 km apart and will traverse the sample areas. All vessels observed from transects during flights within the sample areas will be recorded by vessel class. Most vessels within sample areas are anticipated to have high sightability. However, small, nonmotorized vessels (e.g., kayaks) may not be obvious to the observers, especially if they are near the shoreline. A Sightability Correction Factor will be calculated for all vessel classes by conducting one intensive survey (e.g., following shorelines) each month in each density class while a standard survey is being conducted. The Sightability Correction Factors will be applied to the results of all transect surveys to provide an estimate of total number of vessels, by class, in the sample areas. The survey technique may be modified as experience in its application is gained.

Results of the field surveys will be used to determine if ranges of actual vessel densities in the sample areas correspond to the vessel density classes predicted by the model under current conditions. If model predictions are not corroborated by the results of the field counts, model parameters will be examined and modified to bring the model into compliance with field counts.

Model Application

Upon completion of the evaluation, the model will be used to estimate future use of western PWS under potential management changes (e.g., improved Whittier access, additional fuel sources provided). Analyses will be completed which will incorporate projections of increased use of western PWS to demonstrate expected temporal and spatial changes in use patterns. ARC/INFO grids of potential human-use patterns will be combined with existing GIS maps of the distribution and areas of essential habitat for injured wildlife and fish resources. Areas of potential conflict (e.g., high density human-use areas coinciding with essential habitat) will be identified.

Recommendations for management actions designed to minimize or eliminate potential conflict on public lands will be developed for all injured wildlife and fish resources based on information available in the published literature. More specific management recommendations will be developed to reduce potential risk to harbor seals, pigeon guillemot, and cutthroat trout. These recommendations will incorporate published literature and site-specific information available from ongoing studies in PWS.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Forest Service personnel will be responsible for the development and evaluation of the human use dispersion model and its attributes. Evaluation of the model will be based on the results of aerial surveys. The Forest Service will conduct the literature search on human disturbance effects on injured resources, and develop management recommendations in cooperation with the State. Forest Service personnel will incorporate the model with known information for three injured species. Coordination with other agencies will be the responsibility of the Forest Service.

The State of Alaska, Department of Natural Resources (ADNR) is a partner on this project. The Chugach National Forest, ADNR, and Chenega Corporation are responsible for most land management within the study area. An ADNR Natural Resources Manager will provide input and coordination with the Division of State Parks and Outdoor Recreation, and the Division of Lands. This partnership would ensure that relevant State activities are included in the model, and that the management recommendations are compatible with State management responsibilities. ADNR will also provide information on other activities related to State management, these will include, but are not limited to, human use patterns related to the State Marine Parks, Alaska Marine Highway System, and commercial fishing industry. The State will also conduct the user survey, and incorporate results of previous surveys, to refine the information about existing use patterns.

Contracts for this proposal include airplane costs associated with conducting the aerial surveys. Chenega Corporation will collaborate on this project by working with the principal investigators to ensure that the human use model accurately displays existing activities on Corporation lands and activities associated with the community of Chenega Bay.

SCHEDULE

A. Measurable Project Tasks for FY99

Oct. 1-Dec 15:	Analyze survey data; evaluate and adjust the existing use model
Oct. 1–Jan 31:	Synthesize literature on disturbance into draft management recommendations
Feb. 15–March 15:	Prepare preliminary results for presentation at 10th Anniversary Symposium
March 23-27:	Attend 10th Anniversary Symposium
Jan 1 – May 1:	Identify future use projections and apply to model
May 1:	Finalize management recommendations
April 1 – July 1:	Prepare final report and model

B. Project Milestones and Endpoints

Three objectives were identified for this project.

1. Describe existing and potential human-use patterns in western PWS.
2. Identify areas where human disturbance has a high potential to affect injured resources.
3. Develop management recommendations for public agencies to minimize or eliminate the effects of disturbance on injured resources

FY98

Oct. 1 - April 30:	Model development, Literature search
May 1 - Sept. 30:	Conduct aerial surveys and user surveys

FY99

Oct. 1-Dec 15:	Analyze survey data; evaluate and adjust the existing use model
Oct. 1–Jan 31:	Synthesize literature on disturbance into draft management

	recommendations
Feb. 15–March 15:	Prepare preliminary results for presentation at 10th Anniversary Symposium
March 23-27:	Attend 10th Anniversary Symposium
Jan 1 – May 1:	Identify future use projections and apply to model
May 1:	Finalize management recommendations
April 1 – July 1:	Prepare final report and model

C. Completion Date

This pilot project will be completed in 1999 and we anticipate submitting the final report before its required due date of April 15, 2000. This includes a final computer model and management recommendations. This does not include development of a user-based version of the dispersion model for direct use by land managers.

PUBLICATIONS AND REPORTS

The final report for this project will be completed in July 1999. The principal investigators hope to submit the results of this project for publication in FY99 or FY00.

PROFESSIONAL CONFERENCES

The principal investigators will request support to present the model at annual GIS and The Wildlife Society conferences in FY99.

NORMAL AGENCY MANAGEMENT

This project is outside the scope of normal management for the Chugach National Forest. Development of human dispersion models similar to the proposed project has not been done previously in the context of National Forest management. The Forest Service has conducted public use surveys in 1992 and 1995 on the Chugach National Forest to provide information for the Forest Plan Revision process. Additional surveys are not planned for PWS. This project is also outside of normal agency management because of the combination of species being addressed. Populations of species injured by the EVOS are potentially some of the most vulnerable to disturbance associated with increased human use. Many of these species, such as harbor seals, rarely occur on National Forest land; however, activities and management associated with National Forest land can affect these marine species.

Ultimately, managing human use in PWS will be an interagency responsibility which will require coordination between multiple agencies. This project will provide useful information for all of these agencies.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Opportunity exists to integrate this project with many of the other restoration projects. During the development of this proposal, three of the principal investigators who work with harbor seals, pigeon guillemots and cutthroat trout were contacted. All three have agreed to cooperate with this project to facilitate the emphasis on management of these species. The primary principal investigator for the APEX project also identified opportunities to link the dispersion model to GIS data layers on forage fish densities, and seabird foraging and nesting areas. The combination of the dispersion model and the model developed through APEX would provide important insights into managing seabird populations. In addition to these on-going restoration efforts, if the Trustee Council chooses to update the NOAA environmentally sensitive area maps for PWS, the GIS layers from this project would be available for the mapping effort and the digital information on resource concentration areas would be easily incorporated into this model.

The project would also be integrated into State and Federal agency management and would provide useful information to the Chenega Corporation and Chenega Bay in their ecotourism development plans for PWS. The Chugach National Forest will be continuing the revision of the 10 year Forest Plan during FY98. The information gathered for this project would be incorporated into the Forest planning process. Although the Forest Plan revision effort is anticipated to be completed before this project would be finalized, the principal investigators would work with the planning team to provide relevant information as it becomes available. The model and recommendations would also benefit biologists and recreation specialists who make project-level decisions for the Chugach National Forest. Many of these individuals would be involved in the development of this project and would have the opportunity to apply the information to other aspects of forest management. It is anticipated that other Federal agencies, such as National Marine Fisheries Service, would benefit from this project in their management activities.

The Alaska Department of Natural Resources is a partner on this project. This partnership will ensure that activities undertaken by State agencies are incorporated into the model and that the product would be beneficial to the State of Alaska.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

This proposal has changed from the original project proposal submitted for FY98 in two areas: cost and schedule. Because approval of this project was delayed until late December 1998, the schedule was rearranged to reflect the loss of three months during the model development stage of the project. This delay resulted in greater than anticipated costs to expedite data collection and processing in order to have a draft model of existing use completed by May 1998. The delay also results in a delay in the project completion date by three months. This delay means that we need to prepare a separate annual report and final report. Because the original completion date corresponded with the annual report date, only one report preparation period was included in the original budget. The revised budget reflects this additional time commitment and scheduled bi-annual salary increases. It also reflects a higher salary cost for the ADNR employee working on this project. When the initial budget was developed, an individual had not yet been identified and the budget estimate was low for salary costs in FY98.

PROPOSED PRINCIPAL INVESTIGATORS

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Revision 9-98
Approved 8-13-98

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

Budget Category:	Authorized FY 1998	Proposed FY 1999	PROPOSED FY 1999 TRUSTEE AGENCIES TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
					$15.0	$55.2		
Personnel	$0.0	$54.9						
Travel	$0.0	$4.0						
Contractual	$0.0	$0.0						
Commodities	$0.0	$0.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$124.6	$58.9		Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
General Administration	$14.6	$8.3						
Project Total	$139.2	$67.2		$0.0	$0.0	$0.0		
Full-time Equivalents (FTE)	0.0	0.9						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$0.0	$0.0		$0.0	$0.0	$0.0		

Comments:

1999

Prepared: 1 of [redacted] 9

Project Number: 99339
Project Title: PWS Human Use and Wildlife Disturbance Model
Lead Agency: US Forest Service

FORM 2A
MULTI-TRUSTEE
AGENCY
SUMMARY

7/6/98

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

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$43.2
Travel		$4.0
Contractual		$0.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$105.8	$47.2
General Administration	$12.2	$6.5
Project Total	$118.0	$53.7
Full-time Equivalents (FTE)		0.7
Other Resources		

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

Dollar amounts are shown in thousands of dollars.

Comments:

1999

Project Number: 99339
Project Title: PWS Human Use and Wildlife Disturbance Model
Agency: US Forest Service

FORM 3A
TRUSTEE
AGENCY
SUMMARY

7/6/98

1999 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
K.Murphy	Project Co-leader	GS-9	4.5	4.5		20.3
L.Suring	Project Co-leader	GS-12	3.7	6.2		22.9
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		8.2	10.7	0.0	
					Personnel Total	$43.2

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 1999
Travel to GIS and/or The Wildlife Society Conferences	1.0	2	10	0.2	4.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$4.0

1999

Project Number: 99339
Project Title: PWS Human Use and Wildlife Disturbance Model
Agency: US Forest Service

FORM 3B
Personnel
& Travel
DETAIL

7/6/98

1999 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

1999

Project Number: 99339
Project Title: PWS Human Use and Wildlife Disturbance Model
Agency: US Forest Service

FORM 3B
Contractual & Commodities DETAIL

Prepared: 4 of 13

7/6/98

1999 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

1999

Project Number: 99339
Project Title: PWS Human Use and Wildlife Disturbance Model
Agency: US Forest Service

FORM 3B
Equipment
DETAIL

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$11.7
Travel		$0.0
Contractual		$0.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$18.8	$11.7
General Administration	$2.4	$1.8
Project Total	$21.2	$13.5
Full-time Equivalents (FTE)		0.2
Other Resources		

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

Dollar amounts are shown in thousands of dollars.

Comments:

1999

Prepared: 6 of 13

Project Number: 99339
Project Title: PWS Human Use and Wildlife Disturbance Model
Agency: ADNR

FORM 3A
TRUSTEE
AGENCY
SUMMARY

7/6/98

1999 EXXON VALDEZ TRUSTEE 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					
A.Iliff	Natural Resource Manager	16	1.8	6.5		11.7
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.8	6.5	0.0	
					Personnel Total	$11.7

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

1999

Project Number: 99339
Project Title: PWS Human Use and Wildlife Disturbance Model
Agency: ADNR

FORM 3B
Personnel
& Travel
DETAIL

1999 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

1999

Project Number: 99339
Project Title: PWS Human Use and Wildlife Disturbance Model
Agency: ADNR

FORM 3B
Contractual & Commodities DETAIL

Prepared: 8 of 13

7/6/98

1999 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

1999

Project Number: 99339
Project Title: PWS Human Use and Wildlife Disturbance Model
Agency: ADNR

FORM 3B
Equipment
DETAIL

Approved TC 8-13-98

Toward Long-Term Oceanographic Monitoring of the Gulf of Alaska Ecosystem

Project Number:	99340
Restoration Category:	Monitoring
Proposer:	T. Weingartner/UAF
Lead Trustee Agency:	ADFG
Cooperating Agencies:	None
Alaska SeaLife Center:	No
New or Continued:	Cont'd
Duration:	2nd yr. 4 yr. project
Cost FY 99:	$91.4
Cost FY 2000:	$57.5
Cost FY 01:	$67.2
Cost FY 02:	$0.0
Geographic Area:	Lower Cook Inlet
Injured Resource/Service:	All

ABSTRACT

The 28-year time series of temperature and salinity data from hydrographic station GAK1 near Seward shows substantial interannual and interdecadal variability that could influence the Gulf of Alaska shelf ecosystem. This project will continue this time series and quantify the interannual and interdecadal variability of this shelf. A related goal is to better resolve the time and vertical structure of this variability at periods ranging from the tidal to the interannual. This information will aid in assessing progress in the recovery and restoration of resources and services affected by the oil spill, and will aid in designing a long-term, cost-effective ecosystem monitoring program for this shelf.

INTRODUCTION

This is a continuation proposal describing the second of a proposed four-year program to maintain the existing 28-year time series of conductivity–temperature versus depth (CTD) data collected at hydrographic station GAK1 on the north central Gulf of Alaska shelf. The first year's efforts began in November 1997 with monthly cruises to station GAK1. Thus, while the first year's collection and analysis has just begun, it has been instrumental in documenting the evolution of the anomalous ocean warming that began in the summer of 1997 and continues to the present. We have, for example, documented that the anomalous summer warming (amounting to 1–2°C above normal) was confined to the upper 40 m of the ocean. We propose to continue the monthly sampling which shows that, to date (March 1998), the abnormally warm water extends throughout the 250 m depth of the shelf water column. Temperatures are 1.5–2°C above normal, with these anomalies being the largest encountered within the GAK1 time series. We will continue this time series by monthly CTD sampling to provide vertical profiles of temperature and salinity, extending from the surface to the bottom, and hourly samples of temperature and salinity collected by instruments at several fixed depths. These instruments will be mounted on a subsurface mooring that will be deployed year-round. Our goals are to: 1) maintain the GAK1 sampling so that the substantial interannual variability in temperature and salinity in the Gulf of Alaska can be documented, and 2) assist in building an inexpensive, long-term, comprehensive monitoring program for this shelf. The GAK1 environmental data are representative of conditions in the northern Gulf of Alaska and the Bering Sea (Royer, 1993) and are being used to assess the role of environmental variability in the ecology of fisheries and marine mammals in these regions. Station GAK1 lies in 260 m of water at the mouth of Resurrection Bay, midway between Prince William Sound and Cook Inlet (Figure 1). GAK1 data should be helpful in placing many of the restoration studies sponsored by the Trustee Council in the context of interannual and interdecadal hydrographic variability. These data complement the goals of the Gulf of Alaska component of the U.S. Global Ocean Ecosystem Dynamics program (GLOBEC), which began in October 1997. GLOBEC is supported by the National Science Foundation (NSF) and the National Oceanic and Atmospheric Administration (NOAA). It consists of three components: monitoring, process studies, and modeling. Monitoring began in the Gulf of Alaska in October 1997, with modeling and process studies to follow in 2001. The proposal described here will encourage synthesis of the ecosystem studies supported by the Trustee Council and GLOBEC. In the following paragraphs we summarize the regional oceanography and the historical data from GAK1. This background information provides the context for understanding the rationale and the design of the project described in subsequent sections.

The circulation on the shelf and over the slope of the Gulf of Alaska is predominantly alongshore and cyclonic (counterclockwise) on average (Reed and Schumacher, 1986). Along the continental slope the flow consists of the Alaska Current, a relatively broad, diffuse current in the north and northeast Gulf which intensifies to become the swift and narrow western boundary current, the Alaskan Stream, in the west and northwest Gulf (Figure 2). Together these currents compose the poleward limb of the North Pacific Ocean's subarctic gyre and provide the oceanic connection between the Alaskan shelf and the Pacific Ocean.

The Alaska Coastal Current is the most striking shelf circulation feature in the Gulf, and station GAK1 is positioned along its inshore edge. The main axis of this swift (0.2–1.8 m s^{-1}) westward-flowing current is within 35 km of the coast (Royer, 1981; Johnson et al., 1988; Stabeno et al.,

1995). The coastal current is a perennial feature that circumscribes the Gulf of Alaska shelf for some 2500 km (at a minimum) from its origin on the northern British Columbia shelf (or possibly even the Columbia River depending on the season) to where it enters the Bering Sea in the western Gulf. The current is intimately connected to Prince William Sound, feeding the Sound through Hinchinbrook Entrance and draining it primarily through Montague Strait and the westernmost passes (Niebauer et al., 1994). It is also the source of shelf waters for Cook Inlet and transports inlet waters southwestward through Shelikof Strait (Muench et al., 1981). The Alaska Coastal Current transported much of the oil spilled by the *Exxon Valdez* along the south and west coasts of Alaska (Royer et al., 1990).

The dynamics of the Gulf of Alaska shelf are closely coupled to the Aleutian Low atmospheric pressure system. Storms propagate eastward into the Gulf and are blocked by the mountain ranges of Alaska and British Columbia. Consequently, regional winds are strong and cyclonic and precipitation rates are very high. On the shelf, these winds impel an onshore surface Ekman drift and establish a cross-shore pressure gradient that forces the Alaska Coastal Current. The high rates of precipitation, up to 8 m yr^{-1}, cause an enormous freshwater flux (~20 % larger than the average Mississippi River discharge) that feeds the shelf as a "coastal line source" extending from Southeast Alaska to Kodiak Island (Royer, 1982). The seasonal variability in winds and freshwater discharge (Figure 2) is large. (Winds are represented in Figure 2 as the upwelling index, a measure of the strength of cyclonic wind stress in the Gulf. Negative values mean coastal convergence and downwelling while positive values signify coastal divergence and upwelling. With respect to Alaska's south coast, negative values imply winds blowing to the west and positive values imply that the winds blow to the east.) The mean monthly "upwelling index" at locations on the Gulf of Alaska shelf is negative in most months, indicating the prevalence of coastal convergence. Cyclonic winds are strongest from November through March and feeble or even weakly anticyclonic in summer when the Aleutian Low is displaced by the North Pacific High (Royer, 1975; Wilson and Overland, 1986). The seasonal runoff cycle (Figure 2) exhibits slightly different phasing from the winds: it is maximum in early fall, decreases rapidly through winter when precipitation is stored as snow, and attains a secondary maximum in spring due to snowmelt (Royer, 1982).

Shelf hydrography and circulation vary in response to the annual cycles of wind and runoff. Figure 3 contrasts the cross-shore salinity structure in April and September 1983. (Density gradients are important in ocean dynamics and salinity is the predominant influence on ocean density in the Gulf of Alaska.) In April, the stratification and the offshore front (defined here to be the surface intersection of the 32.0 isohaline) are relatively weak. By contrast, in September a 25 km wide wedge of strongly stratified water lies adjacent to the coast and is bounded on the offshore side by a prominent front. The swiftest alongshore flows are found within and inshore of the front (Johnson et al., 1988), and most of the total transport is associated with the baroclinic component (Stabeno et al., 1995). The latter result probably accounts for Royer's (1979) finding that monthly coastal sea level variations at Seward are in phase with, and have nearly the same amplitude as, the upper ocean dynamic height at GAK1. (Dynamic height is a function of the vertically integrated ocean density. Horizontal gradients of dynamic height are proportional to the pressure gradients that accelerate ocean currents and provide an estimate of the oceanic transport.) Royer's finding is remarkable given the different nature of the sampling techniques: the sea level records were sampled hourly and then averaged into monthly means whereas the dynamic heights were from hydrographic measurements at GAK1 occupied several months apart. He also found that sea-level and precipitation anomalies were well correlated.

Both of Royer's results suggest that there might be a relationship between monthly (and perhaps shorter period) *cross-shelf dynamic height (or upper ocean density) gradients* and winds and/or freshwater discharge. Conceivably, the monthly anomalies of these variables are also correlated. If firm relationships among these parameters can be established, then the alongshelf (baroclinic) transport might be gauged from a conveniently located (e.g., GAK1) hydrographic station or mooring. Moreover, observations at a single location would probably reflect fluctuations in transport along vast portions of the shelf since variations in forcing (wind and runoff) are also coherent over a broad alongshore distance (Royer, 1982; Livingstone and Royer, 1980). Such a result would be enormously useful for model evaluation (and perhaps for data assimilation), retrospective studies, and monitoring.

It is very likely that transport variations in the Alaska Coastal Current affect the survival and/or condition of a number of marine organisms. This flow is apparently important in advecting zooplankton to important juvenile fish foraging areas. Napp et al. (1996) and Incze and Ainaire (1994) find that the major cohort of naupliar stage larvae available to first-feeding pollock larvae in Shelikof Strait originate in February–March on the shelf offshore of Prince William Sound and east of GAK1. Other studies indicate that the coastal current is an important feeding and migratory corridor for numerous species of marine mammals (Calkins, 1986) and sea birds (DeGange and Sanger, 1986).

Figure 3 also suggests that near-bottom salinities are higher in fall than in spring and this is the case on annual average. Xiong and Royer (1984) showed that maximum bottom salinities occur in fall and are nearly coincident with minimum surface salinities and maximum inshore stratification (Figure 4). Although surface waters are diluted by coastal discharge (which peaks in fall), the source of the high salinity water is the onshore intrusion of slope water (Figure 5) in response to the seasonal relaxation (or reversal) in downwelling (Royer, 1975; 1979). The deep water influx in summer from across the continental slope could be important in re-supplying nutrients to the Gulf of Alaska shelf and adjacent embayments and therefore, plays an important role in biological production.

The oceanographic description sketched above stems from research that began in 1970. Beginning that year research vessels from the University of Alaska and other organizations opportunistically sampled station GAK1 while in transit to and from the Seward Marine Center. This ad hoc sampling, conducted at nominally monthly intervals, was the beginning of what is now a 27-year time series for this station. Sampling became more routine (~monthly) in the past five years with support from NOAA and using a 25-foot vessel operated by the University of Alaska's Institute of Marine Science. As a result of these efforts the GAK1 data set comprises the longest ocean time series for the high-latitude North Pacific Ocean, and the only one that includes salinity (Royer, 1993). These data reveal substantial interannual and decadal scale variability in both temperature (Royer, 1993) and salinity (Royer, 1996).

For example, Royer (1993) showed pronounced interdecadal temperature variations that included colder water in the 1970s, followed by warmer conditions in the 1980s and a return to normal or cooling conditions in the 1990s. Coincidentally, the relative dominance of commercially important fish species changed in the mid-1970s; crab and shrimp declined while salmon and groundfish populations increased (Albers and Anderson, 1985; Blau, 1986; Hollowed et al., 1994; Thompson and Zenger, 1994; Francis and Hare, 1994). These population shifts coincided with the beginning of a decadal North Pacific change in the atmosphere and ocean (Trenberth

and Hurrell, 1994). Subsequent changes in this ecosystem followed in the 1980s with substantial declines in populations of sea lions (Merrick et al., 1987) and puffins (Hatch and Sanger, 1992).

Royer (1993) also showed that Sitka air temperature variability (for which records extend back to the mid-1800s) correlates with the GAK1 temperature anomalies at 200 and 250 m depths. He found that the 18.6 year lunar nodal tide accounts for a statistically significant fraction of the Sitka air temperature variability. Using the Sitka air temperatures as a proxy for shelf water temperatures, Parker et al. (1995) subsequently showed that the abundance of halibut and other commercially important species varies on a similar time scale and in conjunction with northern North Pacific Ocean temperatures. While these correlations do not imply causality, they underscore the possible significance of monitoring ocean climate to detect both periodic changes and more radical shifts in the marine environment.

There are also low-frequency variations in upper ocean salinities at what might be an 11–12 year period, which Royer (1996) ascribed to variations in runoff and precipitation. Much of the interannual variability in precipitation in the Gulf of Alaska is associated with changes in the strength and position of the Aleutian Low (Cayan and Peterson; 1989). Changes in upper ocean salinity could affect circulation in the Alaska Coastal Current and also influence biological production by varying frontal properties and the vertical stratification of the water column (Mann and Lazier, 1991). The GAK1 data also show substantial interannual variations in bottom water salinities, although these are not linearly correlated with variations in surface salinity. The absence of a correlation is not surprising because near-bottom salinities are linked to shelfbreak processes, while surface variations are associated with precipitation and runoff.

Salinities of deeper shelf water (depths $\geq$ ~125 m) are likely correlated with nutrient concentrations at these depths. This potentially valuable relationship is suggested in Figure 6, which shows the salinity–NO_3 relationship at stations within the Alaskan Stream and on the western shelf. The data come from the only synoptic deep ocean and shelf nutrient data available for the northern Gulf of Alaska, collected in May–June 1993, between 125 and 450 m depth during the WOCE (World Ocean Circulation Experiment) P17N section. This depth interval covers the range of bottom water salinities observed by Royer (1996) and Xiong and Royer (1984) and the correlation appears to be good. Note that a change in salinity from 32.0 to 33.0 involves a near doubling of the NO_3 concentration. Similarly tight relationships are apparent in plots of salinity versus phosphate and silicate. If salinity–macronutrient relationships can be statistically quantified for the shelf it might be possible to use the GAK1 salinity time series as a proxy for subsurface nutrient concentrations. This relationship could be exploited in retrospective studies and would aid in the design and maintenance of future monitoring programs because salinity can be accurately measured much more easily (and inexpensively) than nutrients.

In summary, several data sets now suggest that the Gulf of Alaska ecosystem is sensitive to environmental variations on time scales ranging from interannual to interdecadal. Other data sets suggest possible biophysical linkages that cause these ecological responses. However, we lack an adequate characterization of shorter period (seasonal to synoptic) variations that might impinge on the biological components of this ecosystem. Moreover, a mechanistic understanding of the physical dynamics of the Gulf of Alaska shelf and the processes linking environmental variability to ecosystem alterations is lacking. These are complex problems that require a concerted and interdisciplinary approach involving process-specific studies in addition to ecosystem monitoring. Some of these programs (APEX and SEA) are sponsored by the Trustee Council,

while a new initiative, the U.S. Global Ocean Ecosystem Dynamics program, began in the fall of 1997 on the Gulf of Alaska shelf. The GLOBEC program is specifically designed to elucidate details of the mechanisms underlying physical and biological environmental change on the shelf. For example, the nutrient cycles and concentrations on the Gulf of Alaska shelf are poorly understood at present (Reeburgh and Kipphut, 1986) but will be investigated in the GLOBEC program. Those results should benefit the monitoring proposed herein. In tandem, the GLOBEC- and Trustee-supported efforts will lead to improvements in ecosystem monitoring.

While the GAK1 time series has illuminated ocean variations having potentially significant ramifications for the marine ecosystem, the monthly sampling will not detect what might be important variations on shorter time scales. Present-day technology now allows inexpensive and accurate sampling at high temporal resolution of temperature and salinity from moorings deployed year round. In combination with monthly CTD sampling, this technology will enhance the value of the historical record, maintain the GAK1 time series, and contribute to the design of long-term ecosystem monitoring programs. The collection of these data form the basis of this proposal.

NEED FOR THE PROJECT

A. Statement of Problem

The GAK1 monthly time series portrays the very large interannual and interdecadal variability of the high latitude North Pacific. With a greater sampling rate, shorter period variations can be detected, revealing any temporal aliasing problems. The results will enhance interpretations of the historical data and place the magnitude of previous anomalies in a better statistical framework. Moreover, the time series could serve as a proxy for transport in the Alaska Coastal Current. Variability in the marine environment, as reflected in ocean temperatures and salinities, and, if possible, shelf circulation, need to be quantified to understand the structure of, and changes in, the northern Gulf of Alaska marine ecosystem. Such changes might influence the recovery of many of the marine species and marine services listed in Table 4 of the Proposal Invitation. In conjunction with the historical data set from GAK1, the monitoring program described below will provide a useful data set to EVOS investigators and others concerned with ocean climate variations.

B. Rationale/Link to Restoration

This monitoring proposal provides an information service to current and future investigators working in the Gulf of Alaska and adjacent waters who need information on environmental variability. The information will help assess recovery and restoration progress by allowing these issues to be analyzed within the context of the long-term variability of the physical environment. The GAK1 data set provides some of that information and the proposed measurements will enable continuation of these efforts by collecting time series at GAK1 of:

1. Monthly temperature and salinity at every meter throughout the water column using a conductivity–temperature–depth (CTD) instrument.

2. Hourly temperature and salinity at several fixed depths distributed throughout the water column.

This information will assist in:

1. Understanding thermohaline variability on time scales ranging from the tidal to the interdecadal.

2. Interpreting historical data sets for use in retrospective studies.

3. Configuring a cost-effective long-term monitoring program.

4. Designing process studies necessary to develop ecosystem models for this shelf.

C. Location

The field work will be conducted at Station GAK1 at the mouth of Resurrection Bay. Both the CTD work and the mooring deployment and recovery operations will be conducted from the Seward Marine Center using the 25-foot vessel, *Little Dipper*. All data collected as part of this program will be available to any who desire it via files on the internet. The monthly CTD data will be combined with the existing historical data that are on the Institute of Marine Science webpage, http://www.ims.alaska.edu:8000/gak1/gak.dat. A new homepage will be created for the hourly time series after mooring recovery and editing of the data. The homepages will be linked.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

We do not see any overt connection to traditional ecological knowledge. However, the most expedient way to share these data with both the public and scientific communities is via the internet. Such a link will allow easy access to the data for those working at the community level and with traditional ecological knowledge. The Principal Investigator is a member of the National Science Foundation's Partners in Science Program and is interested in sharing these data with the K–12 public school system. Again, this connection is primarily effected through the internet and broadens the public's ability to understand the marine environment and research. Through the Partners in Science Program, school children can explore marine science by accessing and using the data from GAK1. At this moment, the Partners program includes public schools (and home schoolers) in the Fairbanks, Grayling, Anchorage, and Juneau school districts. These data will form the basis of educational modules that explore ocean variability at time scales ranging from the interdecadal to the semi-diurnal. More importantly, student and teacher access to this data will allow them to explore it according to their own interests. Very likely these data will eventually contribute to displays at the Alaska SeaLife Center. We have had preliminary discussions with the executive and science directors of the center regarding this matter.

PROJECT DESIGN

A. Objectives

There are two overarching objectives of this multi-year program. First, we want to continue the 27-year time series at station GAK1 through a combination of monthly CTD measurements and year-long deployments of a mooring containing temperature and conductivity (T/C) recorders. Second, we want to contribute to the design of a monitoring program for the Gulf of Alaska shelf. The optimal system is one that is cost-effective yet minimizes contamination associated with spatial and/or temporal aliasing in sampling. (Aliasing results when the system or process is undersampled such that the real period or wavelength of the sampled phenomenon is not detected or it is misinterpreted as occurring at a longer period or wavelength.) It is unclear if aliasing is a problem and neither sampling procedure alone can adequately address this issue. The CTD measurements provide high vertical resolution but, with monthly sampling, they could lead to temporal aliasing. In contrast, the T/C data provide high temporal resolution but could be spatially aliased because they are distributed over a limited number of depths. The sampling schemes complement one another and can resolve these problems. We recognize that our generic goal of ecosystem monitoring is a long-term undertaking requiring incremental efforts. This proposal is one essential step toward that goal, and to guide our efforts we have formulated several project-specific objectives. These are:

1. Determine the within-month variance of temperature and salinity at a given depth. Such data are lacking and it is difficult to determine the significance of a single monthly measurement (as determined from the CTD data) relative to the variability observed within a given month. These basic statistics can be used to estimate the statistical significance of temperature or salinity anomalies observed in the past. This information will be placed on the GAK1 homepage so that users will have access to it as they use the historical data.

2. Determine the rate of change of water mass properties (temperature and salinity) and the phasing of these changes at different depths. Some of these features might be temporally aliased by monthly sampling. These changes need to be resolved to understand the dominant oceanic time scales and the relationship between low-frequency variations (monthly and longer) and shorter period fluctuations (synoptic scale events). The data files will be made available on the time series homepage for downloading and as a graphical display. Key events will be highlighted and discussed as part of the graphical display.

3. Determine how variance in temperature, salinity and dynamic height are distributed seasonally and over depth. Are there distinct vertical "modes" of variability that change with season? These results will also be summarized in a file containing textual, tabulated, and graphical information and will be accessible via the time series homepage.

4. If the temperature/conductivity recorders provide a useful estimate of dynamic height, then determine the joint effects on Seward sea level of dynamic height and winds. Over what time-scales are these variables coherent with one another and with Seward sea level? The results will be placed on the time series homepage.

The first three objectives will continue the historical data base and aid in monitoring design. The fourth objective is a feasibility study that will contribute to monitoring design.

B. Methods

Funds are requested to monitor Gulf of Alaska temperature and salinity through FY 01, at which time a restructuring of the program described here will probably occur. By this time, the APEX and SEA programs will be completed and preliminary results from the U.S. GLOBEC-sponsored Gulf of Alaska monitoring component will be available (U.S. GLOBEC, 1996). Accomplishments from these programs (and from the work proposed herein) will catalyze a reconsideration of the monitoring effort. In addition, researchers working at the Alaska SeaLife Center will probably have monitoring interests to be considered as well.

We propose to collect data monthly with the Institute of Marine Science's 25-foot *Little Dipper* using a Seabird SBE-25 internally-recording CTD deployed from the vessel's winch. The sensors on this CTD are calibrated annually by the manufacturer. Field checks on the conductivity sensor are made from bottle salinities collected during each cast and analyzed on the salinometer at the Seward Marine Center. This procedure allows detection of CTD drift between calibrations by the manufacturer. The historical salinity data have an accuracy of ~0.01 or better using this instrument and these procedures. Temperatures are accurate to within 0.005°C.

The monthly sampling will be complemented by hourly measurements from six temperature/conductivity recorders (Seabird MicroCats; SBE model 37-SM) incorporated in a taut-wire, subsurface mooring at GAK1. The mooring can be deployed and recovered by the *Little Dipper* during the CTD cruises. The instruments will make hourly measurements at nominal depths of 30, 50, 100, 150, 200, and 250 meters. This distribution covers the near-surface (30 m), the upper ocean (30–100 m), mid-depth (150–200 m) and bottom (200–250 m) of the water column. (Although observations at the surface would be useful, obtaining these would entail a mooring with substantially higher hardware and fabrication costs and the need for a larger vessel for servicing.) The MicroCat at 30 m depth includes a pressure sensor to measure mooring motion. (Strong currents can cause the mooring to lean with the flow, which results in instruments sampling at depths other than those desired. While we do not believe that this will be a severe problem at GAK1, the possibility needs to be assessed. Data from the uppermost instrument are most susceptible to contamination by mooring motion. The pressure data will identify suspect sections of the data record. These portions might be correctable using the monthly CTD data with the time record of instrument depth.)

Our prior experience with Seabird instruments similar to the MicroCats stems from nearly 25 year-long deployments in the Chukchi Sea. The maximum drift (and therefore uncertainty) in salinity over a one-year period was ~0.05. More often, salinity uncertainties were ~0.01, an order of magnitude smaller than anomalies reported by Royer (1996). Finally, the monthly CTD sampling will provide an additional check on MicroCat performance.

We request funds for the purchase of two sets of mooring equipment (MicroCats and acoustic releases) so that continual monitoring can be maintained while instruments are being serviced and/or calibrated annually. These procedures require that instruments be out of the water from 3 to 4 months. Therefore, reliance on a single set of equipment would mean that one-fourth to one-third of the annual cycle would not be acquired by the moored instruments. We purchased one mooring in FY 98 and will purchase a second in FY 99. Thereafter, only expendable parts would need to be purchased, as the instruments will be recycled. This procedure will leave data gaps of only a few hours' duration, at most.

The analyses of the data sets are straightforward.

Objective 1 will be achieved using univariate statistics. The effective number of degrees of freedom, based on the integral time scales for the temperature and salinity time series, will be used to construct confidence limits. The integral time scales are determined from the autocorrelation function (e.g., Kundu et al., 1975) and provide insights on the temporal characteristics of these variables at each depth.

Objective 2 is largely concerned with temporal aliasing issues associated with monthly sampling. Among the important processes that might be aliased are the summer onshelf influx of dense bottom water, changes in upper ocean stratification throughout the year as a consequence of winds and runoff, and the response of the thermohaline structure of the water column to synoptic scale forcing by the wind.

Objective 3 will be achieved by examining the empirical orthogonal functions (EOFs) of the temperature and salinity time series. The EOFs decompose the system variance into a set of linearly independent functions, with each describing a unique spatial and temporal structure. For the mooring data the system variance would be that computed from the salinity (or temperature) time series at all depths. Six EOF modes will result from the analysis because six depths are sampled. The modes are ordered by the proportion of the total system variance that each composes; the first mode accounts for the greatest fraction of system variance and the sixth mode accounts for the smallest proportion. Often, only a few modes are required to describe the system variance, and the significance of a given mode will be assessed following Overland and Preisendorfer (1982). The spatial structure of a mode describes the distribution of amplitude with depth, while its temporal structure describes how the mode varies through time. The EOFs are useful in consolidating large and complicated data sets into smaller correlated subsets that facilitate physical interpretation. They might also contribute to future monitoring design by suggesting times and/or depths that are either over- or under-sampled. In the latter case, the EOFs could identify potential temporal or spatial aliasing problems.

Objective 4 will correlate winds and upper ocean density (dynamic height) with Seward sea level. This motivation follows from Royer's (1979) observation of a statistically significant relationship between monthly dynamic height and Seward sea level. His findings suggest that a time series of sea level and/or dynamic height at a single location might provide an index of transport variability in the Alaska Coastal Current. To firmly establish the relationship between coastal transport and sea level will require making direct current measurements in the coastal current and comparing these with sea level. While such measurements are beyond the scope of this proposal, detection of significant relationships would provide compelling support to undertake a more ambitious transport measurement program. We regard this last objective as a feasibility study that will relate sea-level fluctuations to the two dominant forcing mechanisms for the shelf circulation: freshwater (which affects upper ocean density) and alongshore winds. The statistical analyses will entail multivariate spectral techniques (Groves and Hannon, 1968; Bendat and Piersol, 1971) to examine the multiple and partial coherences among the independent (winds and dynamic height) and dependent (sea-level) variables. This technique, analogous to partial and multiple correlation, identifies statistically significant relationships among these variables as a function of frequency (time period). Estimates of dynamic height using the MicroCats will depend upon the numerical technique used to perform the vertical integrations. The choice will

be guided by comparisons of dynamic height with high resolution CTD data and consideration of EOF results.

Our analysis will use wind measurements derived from gridded surface pressures available from NOAA's Pacific Fisheries Environmental Group (PFEG) on a 1° by 1° grid at six-hourly intervals. We will follow Luick et al.'s (1987) calculation procedure. These pressure fields are based on a blend of observations and forecasts from numerical models made by the U.S. Navy's Fleet Numerical Meteorology and Oceanography Center (FNMOC). Hourly sea levels for Seward are available from the Ocean and Lakes Level Division of NOAA and through their webpage. Atmospheric pressure for correcting sea level is collected from a weather package at the Seward Marine Center.

SCHEDULE

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

October 1:	Begin purchase of mooring equipment (MicroCats, etc.)
October 15:	Monthly CTD surveys, scheduled at mid-month; update homepage as CTD data are processed and edited; prepare wind fields and correct sea level for atmosphere pressure effects as the pressure data become available from PFEG
November–December:	Deploy mooring (the mooring will be deployed as soon as instruments can be delivered from the manufacturer) during this month's CTD sampling
September:	If FY 00 field monitoring is not funded then recover mooring, send MicroCats for post-calibrations, begin data processing. Otherwise mooring will be recovered in November or December of 1999 when replacement mooring is deployed

B. Project Milestones and Endpoints

The data collected as part of this project will be available to a broad community of users. We anticipate that some will want "immediate" access to it. This desire often conflicts with the goal (and required time) of producing data of the highest possible quality. In the past, the final CTD data have generally been placed online 1–2 months after collection. The final edited temperature and salinity data from the mooring should be ready three months after instrument recovery. The delays arise because of post-calibration requirements (performed by the manufacturer) and final editing of the data sets (performed at the Institute of Marine Science). We intend to make much of the data, along with preliminary results, available for rapid dissemination. From a practical point of view this approach is prudent because for many users the differences between the raw and the final edited product are insignificant. We will attach appropriate warnings concerning data quality to both preliminary and final data products. Thus we anticipate making most of the data available on the homepage one month after recovery of the mooring. However, we will not release any data for which there are severe concerns regarding quality unless and until these concerns are resolved. In addition to these general considerations we anticipate the following project milestones:

1. The first objective pertains to basic statistical results which will be made available in both preliminary and final fashion. When the final data product is ready we will update the GAK1 CTD homepage describing these statistics and their relevance to historical GAK1 data.

2. The second objective is to examine rates of change of water mass properties (temperature and salinity) and the phasing of these changes at different depths. This work is largely descriptive and will begin immediately after instrument recovery. Graphical data displays will be made available within 1–2 months of recovery. These will include textural information indicating features of interest. Displays will be updated periodically as new findings emerge. Eventually these results will be merged with those of the third objective.

3. The third objective provides the modal description of system variance. These calculations are straightforward and the results and preliminary interpretations would be made available within two months of mooring recovery. Further interpretation will entail more reflection and likely require completion of the last objective.

4. Four months after recovering the mooring, correlations among winds, corrected sea level, and upper ocean density will begin. We will first compare dynamic height determined from CTD data with that from the moorings. Combining these results with those from objective 3, we will perform the multiple coherence calculations. We estimate that this objective will be completed two months after it is begun.

If the mooring is recovered in September 1999, all objectives will be reached by early April 2000. If the mooring is recovered in November 1999, all objectives will be reached by early June 2000. Similar analyses and schedules will occur for each year of support. Comparison of the results among years will provide additional indications of statistical variability.

C. Completion Date

This project will be completed in FY 01.

PUBLICATIONS AND REPORTS

No manuscripts will be submitted in FY 99. Data and results will be provided via internet as indicated above.

PROFESSIONAL CONFERENCES

Conference presentations will be made in FY 99, probably at a national meeting such as that of the American Geophysical Union.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

We have discussed aspects of the GAK1 historical data with several investigators supported by the Trustee Council. Many have expressed interest in these data and know how to access it. Other

scientists are aware of these data through papers and meetings, (e.g., the American Geophysical Union which serves primarily the U.S. oceanographic community and the North Pacific Marine Science Organization [PICES] composed of marine scientists from around the Pacific Rim). Though we have discussed in previous sections how we would make these data available, we welcome advice from the Trustee Council on additional ways to share these data with other investigators and/or the public.

Several UAF scientists are co-investigators on a GLOBEC proposal whose results would complement this proposal. The UAF investigators (Coyle, Paul, Haldorson, Whitledge, Weingartner) along with Royer (Old Dominion University) have funding from the NSF NOAA GLOBEC program to examine the Gulf of Alaska shelf ecosystem for the period October 1997–December 2000. This work includes six R/V *Alpha Helix* cruises spaced throughout the year to examine the cross-shelf hydrography (including nutrients) and the distribution of phytoplankton, primary production, zooplankton and fish (mainly juvenile salmon and forage fish) in relation to the physical environment.

We see these programs as highly complementary in several ways. First, the cross-shelf hydrography will provide a basis for comparison with variations observed at GAK1. Second, a sufficient number of cross-shelf dynamic height *gradients* (proportional to the ocean transport) would be available (37 over the duration of the GLOBEC program) to examine the correlation between this gradient and dynamic height at GAK1. This result will help determine if dynamic height at a single station can provide an index of transport in the Alaska Coastal Current. Third, a comprehensive nutrient data set will be made available for establishing the type of correlations alluded to in the introduction. If significant correlations are obtained at several depths in the water column, then the GAK1 data would be a proxy indicator of historical variations in nutrient concentrations (for some depths).

The GLOBEC proposal makes connections with other investigators. For example, we have offered berth space on the *Alpha Helix* during our GLOBEC cruises to Robert Day of Alaska Biological Research, Inc., Fairbanks, for his sea bird and marine mammal studies. (Dr. Day is submitting a proposal to the Trustee Council for this project.) Thomas Kline of the Prince William Sound Science Center participated in the first GLOBEC cruise and plans to participate in this year's cruises also.

The effort described in this proposal takes a modest but important step toward achieving the goal of long-term, comprehensive ecosystem monitoring. There are compelling scientific and logistical reasons for believing that GAK1 will be a long-term site and that the sampling will eventually expand to include other disciplines. Resurrection Bay and the adjacent ocean are paradigmatic for much of the Gulf of Alaska shelf, and this area is easily accessible by marine scientists at Seward. Although our understanding of chemical cycling and biological processes on this shelf is limited at the moment, programs such as SEA, APEX, and GLOBEC will provide substantial new information for these disciplines. Results from these programs and those anticipated from the work proposed herein will contribute to the design of a comprehensive long-term monitoring strategy. Additional impetus for expanding the monitoring activities at GAK1 will occur as programs at the Alaska SeaLife Center evolve.

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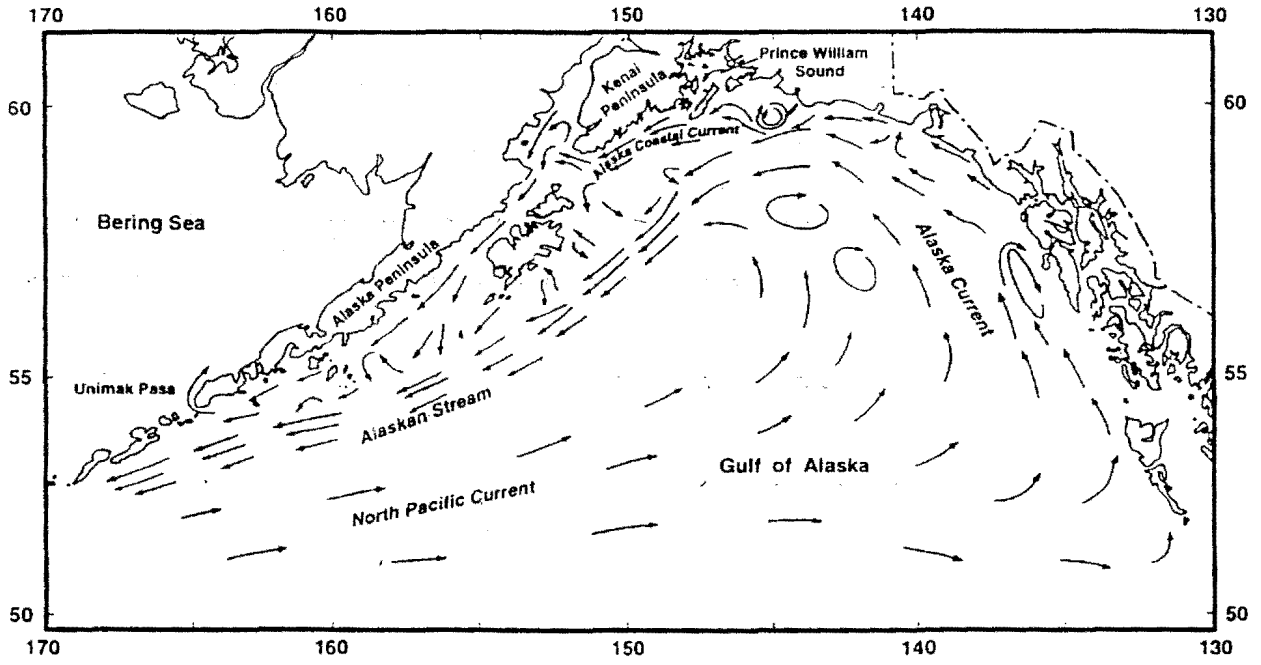

Figure 1. Schematic of the circulation of the Northeast Pacific and Gulf of Alaska (From Reed and Schumaker, 1986).

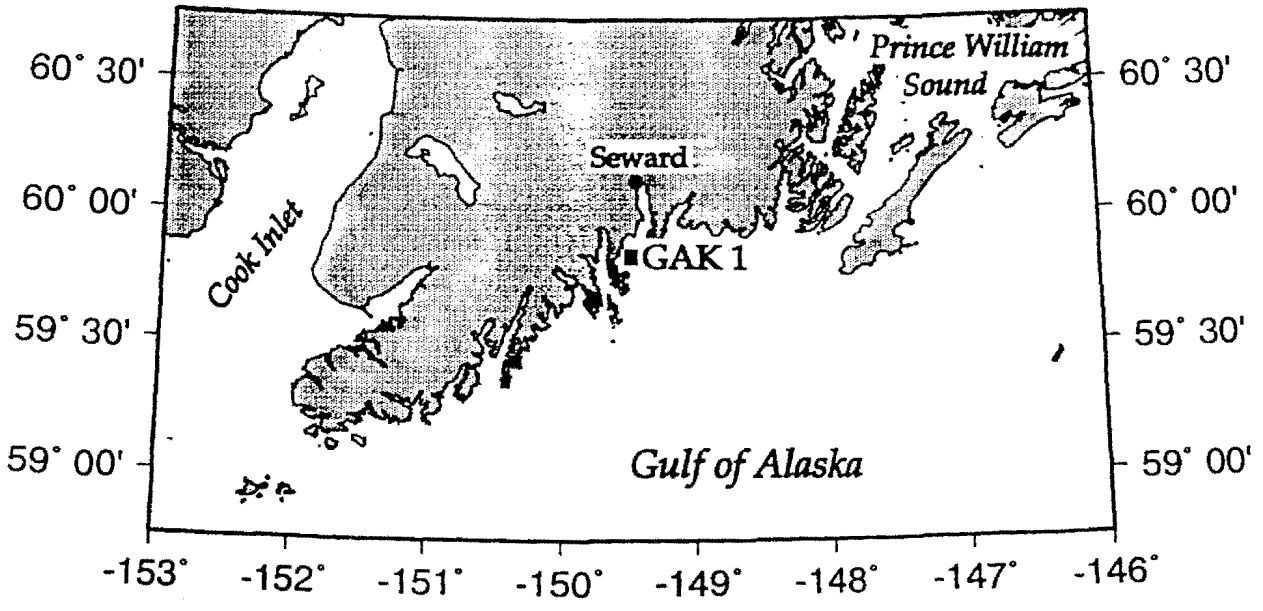

Figure 2. Map showing location of hydrographic station GAK1 in relation to Prince William Sound, Cook Inlet and Seward.

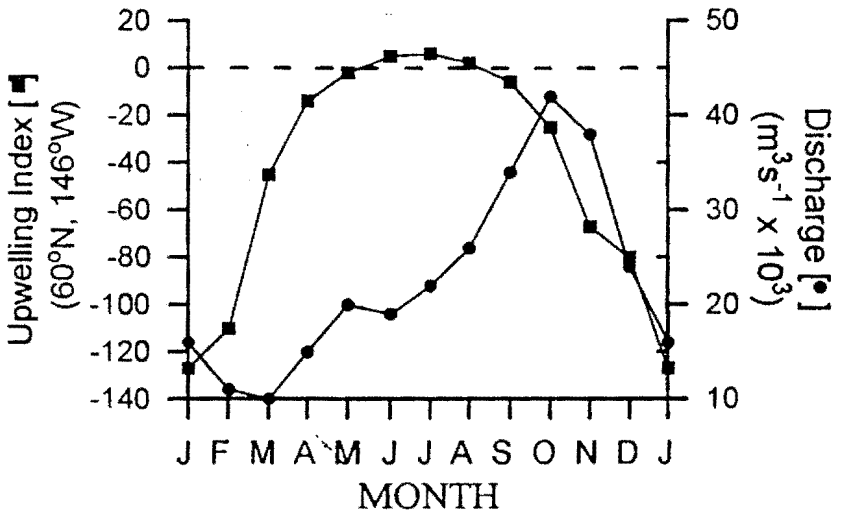

Figure 3. Mean monthly values of the upwelling index (from 1946–1995) and the estimated freshwater discharge (from 1930–1992) into the Gulf of Alaska using the hydrology model of Royer (1982).

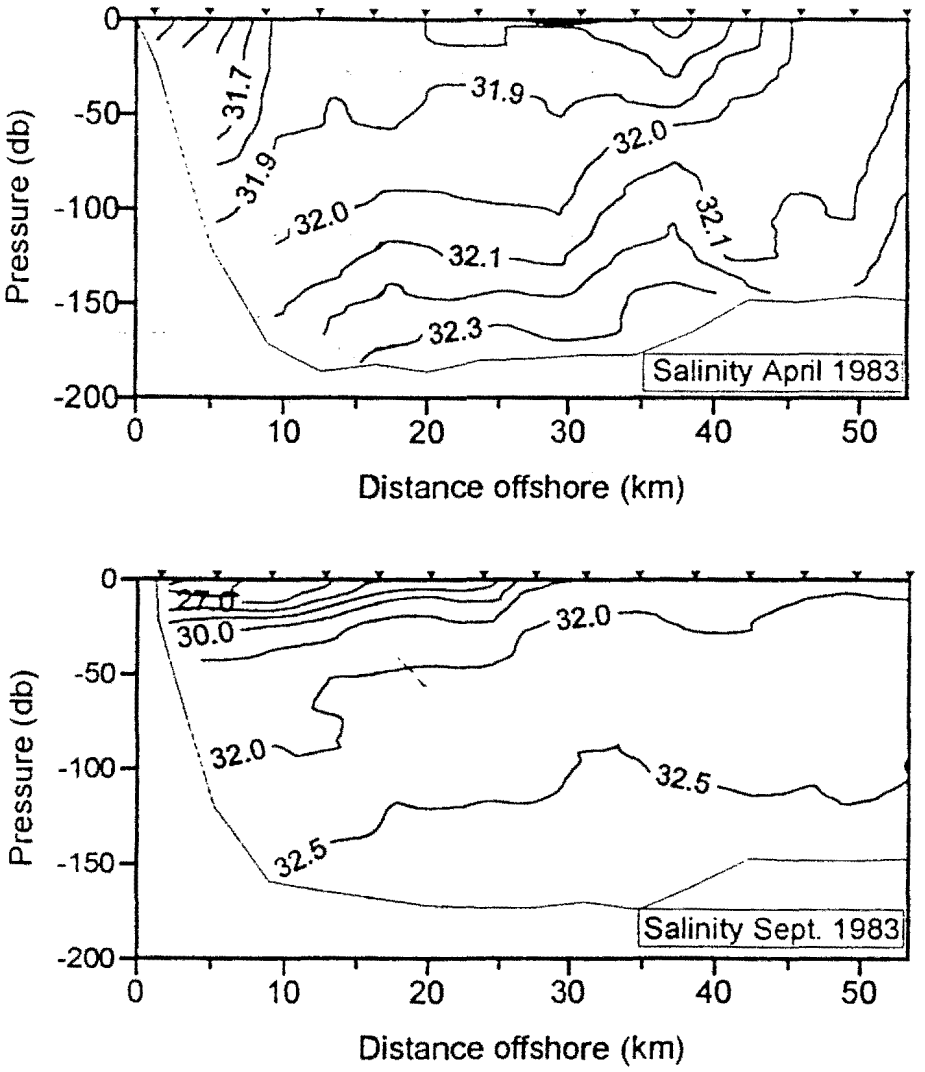

Figure 4. Contours of salinity as a function of depth and position in the Gulf of Alaska on a cross-shelf transect near GAK1. The upper panel is from April 1983 and the lower panel is from September 1993.

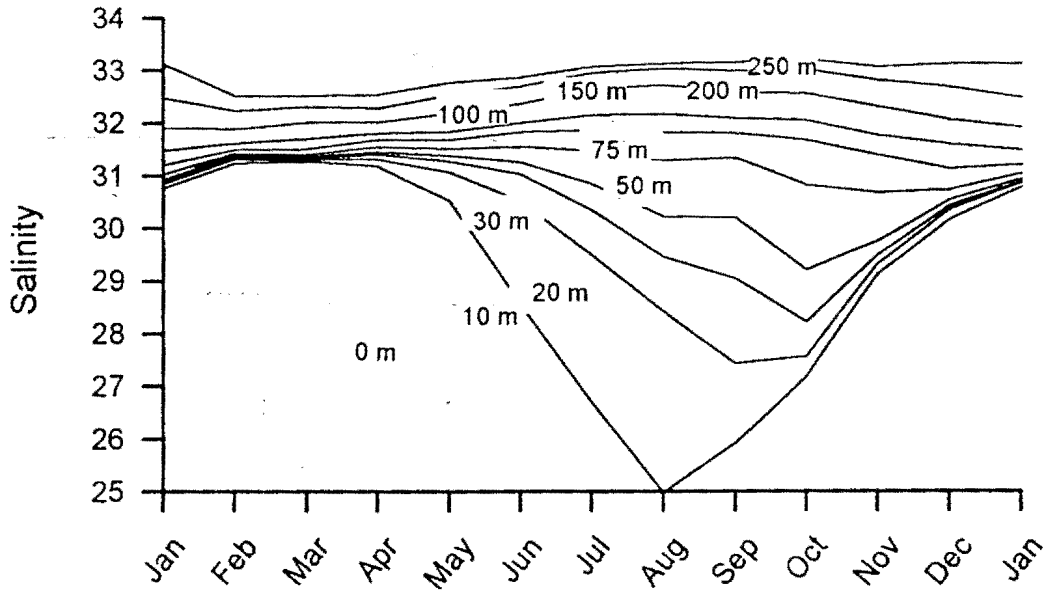

Figure 5. Mean monthly salinity at GAK1 as a function of depth. The means are computed from data collected between 1970 and 1996.

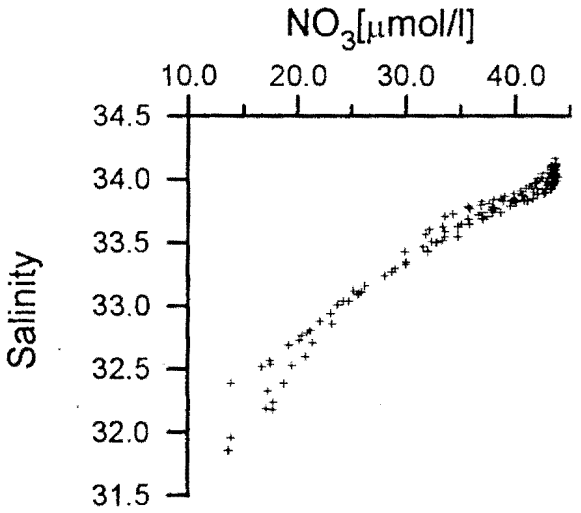

Figure 6. NO_3–salinity scatter plot from the shelf and slope of the northwest Gulf of Alaska in May–June 1993.

Revision 1/9/98
Approved TC 8-13-98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999	LONG RANGE FUNDING REQUIREMENTS					
				Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
Personnel	$22.8	$0.0						
Travel	$3.1	$0.0						
Contractual	$6.1	$85.4						
Commodities	$1.9	$0.0						
Equipment	$23.8	$0.0						
Subtotal	$57.7	$85.4						
General Administration	$14.4	$6.0						
Project Total	$72.1	$91.4		$62.7	$66.6	$0.0		
Full-time Equivalents (FTE)		0.5						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY 99

Project Number: 99340
Project Title: Toward Long-Term Oceanographic Monitoring of the Gulf of Alaska Ecosystem
Name: University of Alaska Fairbanks
Agency ADF&G

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel	$22.8	$33.1
Travel	$3.1	$3.0
Contractual	$6.1	$6.2
Commodities	$1.9	$1.9
Equipment	$23.8	$30.2
Subtotal	$57.7	$74.4
Indirect	$14.4	$11.0
Project Total	$72.1	$85.4
Full-time Equivalents (FTE)	0.3	0.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
$62.7	$66.6	

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: 99340
Project Title: Toward Long-Term Oceanographic Monitoring of the Gulf of Alaska Ecosystem
Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Personnel Costs: Name	Position Description	Months Budgeted	Monthly Costs	Overtime	Proposed FY 1999
Weingartner, T.	Principal Investigator/Asst. Professor	1.0	7.0		7.0
Vallarino, M.	Programmer	2.5	5.1		12.8
Shoemaker, P.	Marine Techician	0.5	4.7		2.4
Allen, D.	Technician	1.8	4.6	2.6	10.9
	Subtotal	5.8	21.4	2.6	
				Personnel Total	$33.1

Travel Costs: Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1999
Fairbanks to Seward - research	0.4	2	10	0.1	1.8
Fairbanks to Anchorage - EVOS annual meeting	0.3	1	5	0.1	0.8
Adjustment to recognize rounding					0.4
				Travel Total	$3.0

FY 99

Project Number: 99340
Project Title: Toward Long-Term Oceanographic Monitoring of the Gulf of Alaska Ecosystem
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 – September 30, 1999

Contractual Costs:	Proposed
Description	FY 1999
CTD calibration	0.6
Shipping of instrumentation	0.3
MicroCat calibrations (6 @ $500/ea)	3.0
Vessel use (R/V *Little Dipper*) (3 half-days @ $260/day, 3 days @ $500/day)	2.3
Contractual Total	$6.2

Commodities Costs:	Proposed
Description	FY 1999
Batteries, O-rings, tools	1.0
Safety shackles and sling links for moorings	0.3
Mooring thimbles	0.1
Mooring anchor and lashing chain	0.3
Standard salinity seawater (6 @ $30/vial)	0.2
Commodities Total	$1.9

FY 99

Project Number: 99340
Project Title: Toward Long-Term Oceanographic Monitoring of the Gulf of Alaska Ecosystem
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities DETAIL

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1998 – September 30, 1999

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 1999
Seabird Electronic SBE 37 SM with pressure sensor	1	4.4	4.4
Seabird Electronic SBE 37 SM (5 @ $3,155/ea)	5	3.2	16.0
Edgetech BACS 8202 acoustic release	1	10.0	10.0
Adjustment to recognize rounding			-0.2
Those purchases associated with replacement equipment should be indicated by placement with an R.		**New Equipment Total**	$30.2

Existing Equipment Usage: Description	Number of Units

FY 99

Project Number: 99340
Project Title: Toward Long-Term Oceanographic Monitoring of the Gulf of Alaska Ecosystem
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

Prepared: 7/9/98

Revision 7-3-98
Approved TC 8-13-98

Harbor Seal Recovery: Controlled Studies of Health and Diet

Project Number:	99341
Restoration Category:	Research
Proposer:	M. Castellini/UAF
Lead Trustee Agency:	ADFG
Cooperating Agencies:	None
Alaska SeaLife Center:	Yes
New or Continued:	Cont'd
Duration:	2nd yr. 4 yr. project
Cost FY 99:	$194.2
Cost FY 2000:	$124.1
Cost FY 01:	$85.4
Cost FY 02:	$0.0
Geographic Area:	Kenai Peninsula, Seward
Injured Resource/Service:	Harbor seal

ABSTRACT

This project will continue a long-term study to quantify the impact of specific fish diets on the health and body condition of harbor seals. The ability to conduct such investigations under controlled conditions is now available at the Alaska SeaLife Center. This project will establish whether specific diets are nutritionally adequate to maintain seal health. Even though health status biomarkers for marine mammals in Prince William Sound were established during field trials (Project /001), the critical test of how each marker varies in an individual as a result of a specific prey item has not been established. While this project will focus on the issue of harbor seal health, the approach is potentially applicable to any of the injured top predators.

INTRODUCTION

An underlying component of the ecosystem-based research approach supported by the Trustee Council has been the hypothesis that food limitation could be inhibiting the recovery of injured species in the Prince William Sound (PWS). Inherent in this concept is the assumption that food stressed animals can be distinguished by population-wide surveys of critical health parameters. Following this approach, an extensive sampling effort by multiple projects established a series of biomarkers used to profile the health and body condition of wild populations of marine mammals inside PWS. Population health status and body condition indices were, and continue to be, developed and tested for a range of birds, sea otters and seals. On the basis of this wide-ranging effort, reference range values for these health parameters have been established and are being used to compare whole groups of animals across time and space (1–8). This approach is critical to understanding how these markers work on a population health level.

Establishing such a series of population-wide health indicators is necessary, but not sufficient, to link their biological activity to known health problems or food limitation. This is because the variance of each indicator over time or under different feeding conditions in any one individual cannot be tested in the field. In the sea otter and seal studies conducted under Trustee Council funding, each individual animal can only be captured once. Recaptures of individuals are extremely rare and certainly not planned. Thus, we can establish the range of reference values for any particular indicator across a whole group of animals, but we do not know how this indicator varies within any given animal under changing conditions of health or feeding status. In human health studies for example, this would be equivalent to establishing the reference ranges for body mass index (BMI) in a study group, but not testing how varying BMI is correlated with changing health status, such as hypertension, coronary heart disease, diabetes or anorexia. It has only been through the careful study of how these health states relate to BMI, that this index can now be used as one of a series of important biomarkers for human health. Thus, medical advice suggests we keep our BMI within given ranges to reduce our chances of health related problems. This type of combination of population monitoring and laboratory study is routine in human health and should be extended to include other species.

The Trustee Council has supported the population-monitoring component of health biomarkers for marine mammals in Prince William Sound. Now, with the creation of the Alaska SeaLife Center (ASLC) in Seward, we are in the position to test those biomarkers under controlled conditions, in the same animals over time (particularly seasonally) and under changing experimental conditions. Of particular interest is the effect of specific diets on harbor seal physiology. This will address the question of food limitation more completely, including the suggestion that certain prey may not be nutritionally adequate. Work on birds using the basic elements of this concept has already been initiated (6).

Work has begun at the ASLC and the University of Alaska Fairbanks (Project 98431) to establish scientific protocols for assessing the assimilation efficiency of harbor seals fed different diets. Steve Trumble (Ph.D. student associated with this project) has been working with Dr. P. Barboza at UAF to learn tracer techniques that will allow measurement of assimilation efficiency. In addition, he has participated in three field expeditions (supported by ADF&G) in which he was responsible for measuring health biomarkers in harbor seal pups. Feeding protocols have been established in conjunction with the ASLC veterinarian and pinniped husbandry staff. The Alaska

SeaLife Center took possession of eight harbor seals in April 1998 and the preliminary acclimation and monitoring phase of the study have already begun. The animals are being closely monitored (weight, morphometrics and biweekly blood samples) and, starting in September, will be placed on experimental diets of specific prey items.

NEED FOR THE PROJECT

A. Statement of Problem

The Restoration Program has established a strong field component that has tested a series of health and body condition biomarkers for many of the top-level predators in the Sound (2, 3, 5–7), including harbor seals (1,4,8). Many of these indices are related to metabolic alterations that might occur in animals that are food limited, or stressed. These include markers for fat, protein and carbohydrate metabolism (fatty acid patterns, blood urea nitrogen, ketone bodies, glucose), water balance (plasma and whole blood water), blubber quality in harbor seals (energetic density, lipid distribution, histology) and total body fat. Other markers have addressed more health or contaminant related issues such as indicators of oil contamination (P450, PAH), whole body inflammatory response (haptoglobin, interleukin), organic residue contamination (PCB) and clinical indicators of disease state (clinical chemistry panels, blood hemograms).

While this significant field-based effort is critical, these markers must now be tested in the laboratory where animals can be fed different food diets and put onto controlled caloric intakes. These markers must also be tested in the same animals over long time periods so that individual variance and seasonal differences can be monitored and experimental conditions altered. For example, we suspect that molting condition in harbor seals impacts haptoglobin levels, an indicator of inflammatory response, but until we follow the same animal through a whole season, we will not be able to test this theory. Finally, these markers must also be tested in animals known to be sick (rehabilitation, stranded) to quantify how they vary with disease or poor health.

B. Rationale/Link to Restoration

The rationale for this project is if we theorize that various health and body condition markers react in the field to ecosystem wide changes in food availability or animal health, then we should be able to quantify those mechanisms in the laboratory under controlled conditions. The SeaLife Center has research animals that are healthy and will be put onto differing diets of specific prey. In addition, it has sick animals that are brought in for rehabilitation. Both groups allow us to examine how these health markers respond to food and health status. Experiments following the same conceptual protocol have been carried out in Europe on harbor seals fed diets of fish that differed in contaminant loads (9). In those studies, it was found that seals fed contaminated fish showed measurable decreases in immune function. In this proposal, we do not suggest feeding contaminated fish, but rather fish of differing energy densities (pollock and herring) and monitoring sick animals that are at the Center for rehabilitation. These "rehab" animals represent seals whose ability to survive in the wild has been compromised and they present a unique view into the biology of sick animals that are under-represented in our field studies in the Sound (8).

An additional rationale concerns the "junk food" hypothesis. One of the most popular hypotheses

concerning the cause for the decline of marine mammals and birds in Alaskan waters was first voiced at a Sea Grant sponsored workshop in 1991 on whether or not food limitation could account for the observed population patterns (10). At that workshop, the "junk food" hypothesis was proposed. This thesis stated that Alaskan waters had a sufficient biomass of pollock to support the harbor seals and Steller sea lions populations, ***but*** pollock was nutritionally poor compared to other less common species, such as herring and capelin. Because the marine ecosystem of Alaska experienced a "regime shift" in the late 1970s that moved the system from a groundfish/herring based food web to a pollock dominated food web, the high-energy food that pinnipeds used to eat simply disappeared. Thus, the hypothesis proposes that seals and sea lions may be starving in a sea full of pollock. The presence of The Alaska SeaLife Center will allow us to critically test this hypothesis.

C. Location

The experiments for this work will be conducted at the Alaska SeaLife Center in Seward. Similar experiments are proposed for birds and sea otters. Thus, there should be considerable collaboration between the projects and the possibility of significant sharing of resources and personnel. Similar experiments are underway with Steller sea lions through funding provided by the National Fish and Wildlife Foundation.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

The field work on harbor seals has involved integral collaboration with Native communities throughout the Gulf region in conjunction with the BIOSAMPLING program (Project /244) and we anticipate Native collaboration to continue. Given that the Alaska SeaLife Center, the EVOS Trustee Council, the Alaska Native Science Commission and the Alaska Native Harbor Seal Commission are all currently working on joint scientific collaboration, we expect this project to include involvement with Native communities. Since harbor seals are important food items for these communities, it is likely that the results of this work will be of interest to the Alaska Native Harbor Seal Commission. The findings of this and previously funded studies have been, and will continue to be, shared with the Native communities at the Alaska Native Harbor Seal Commission meetings.

An important mission of the Alaska SeaLife Center is to educate the public about unique Alaskan habitats and the importance of stewardship. It will spotlight the role that research plays in understanding and contributing to the stewardship of that environment. Research done at the SeaLife Center will be highly visible both to local communities as well as thousands of visitors each year.

PROJECT DESIGN

A. Objectives

This project will quantify the nutritional value of several key Alaskan fish species for harbor seals and will follow health indices over time in both healthy and rehabilitation animals. There are four major objectives:

1. Feed controlled diets of pollock and herring to harbor seals.

2. Quantify body condition, health, and blood chemistry biomarker changes in the seals during the feeding trials.

3. Assess the assimilation efficiency (AE) of the different fish diets (how much energy can be utilized) for harbor seals.

4. Quantify seasonal, metabolic state and clinical health impacts on biomarkers and health indices.

B. Methods

Feeding schedules and timing patterns of controlled diets are currently being developed in conjunction with the ASLC veterinarian and pinniped staff. It is understood that there may be other research personnel interested in taking advantage of controlled diet protocols and it is our expectation to accommodate these additional needs. In particular, EVOS projects /371 and /441-BAA will utilize the same feeding schedules to conduct their work on lipid metabolism and stable isotope biochemistry.

Eight harbor seals are currently in residence at the ASLC and are undergoing the preliminary trials for handling, dietary monitoring and blood sampling necessary to conduct this project. At this time (July, 1998) each animal is examined every two weeks for all measurements and several are trained to voluntarily move onto scales to obtain mass values every day. Groups of seals will begin exposure to experimental diets in September, 1998. The eight animals are evenly split male/female, while four are mature animals and four are young.

Food maintenance trials

A detailed matrix of the feeding schedule is shown below. The procedure will utilize a cross-over repeated measures approach and will allow statistical comparisons within any one group of seals between diet and season. Statistical software (SYSTAT) will be used to analyze the cross-over method. However, there are several considerations that must be addressed using this matrix.

CROSS-OVER REPEATED MESAURES ANOVA

FEEDING TRIALS FOR HARBOR SEALS

PERIOD	HERRING	POLLOCK	CONDITION
Sept-Dec 1998	Seals A,B,C	Seals D,E,F	Molting
Jan—April 1999	D,E,F	A,B,C	Spring
May-August 1999	A,B,C	D,E,F	Breeding
Sept-Dec 1999	D,E,F	A,B,C	Molting
Jan-April 2000	A,B,C	D,E,F	Spring
May-August 2000	D,E,F	A,B,C	Breeding

Two seals (G, H) will be in a separate feeding trial. They will follow alternating four month periods of herring and pollock, but for these animals feeding frequency and total mass fed will be varied every two weeks. In this case, we will determine the impact of these variables on assimilation efficiency and digestive passage rates.

This feeding matrix allows each group of seals to experience a different diet at similar physiologically relevant times of the year. Group A,B,C for example, will work with a herring diet during molting season in one year and with a high pollock diet in year two. We will work during the summer of 1998 to establish the highest amount of pollock in a diet that will be accepted by the animals. We expect this to be at least 75-80 pollock.

A problem with cross-over ANOVA designs is that residual or carry-over effects from previous treatments can complicate the analyses. We correct for this with extremely long test periods and phased cross-overs. That is, since each feeding trial will last for four months, several weeks of diet switching will be allowed. This provides the additional advantage of allowing us to study the biochemical impact of the phased switch.

In any captive situation, the behavior of the pinniped may influence feeding patterns, especially if the diet changes in palatability (11). Fortunately for this study, both fish species are part of the natural diet of harbor seals. In addition, feeding trials will extend for four months and trainers will work with the animals continually on feeding behavior. To move the animals from one diet to another, the change will be gradual over several weeks as the percentage of herring or pollock is adjusted. In addition, the effect of air and water temperature on feeding rates (10, 11) will be monitored from automated sensor systems installed at the ASLC.

Under controlled feeding conditions, the feeding frequency during any given day impacts issues such as satiation, over-feeding, etc. Two of the eight animals will be in a separate detailed study where frequency and volume of food will be adjusted to test for this effect. Frequency of feeding versus assimilation and metabolizable intake will be assessed during these tests. We will work with the trainers and husbandry personnel to maintain a regular and adequate food intake and make sure that the animals are fed at the same time each day (13).

An additional consideration is the number of animals per feeding trial. As shown above, we will stagger animals through these long-term feeding schedules, however, three to six animals per trial are commonly used (13) and considered adequate for determinations of digestive efficiency.

Long-term alterations in the basic metabolic needs of the animals will occur as a result of annual cycles (e.g., molting). The metabolic demand of phocids varies throughout the year (14-15). We assume that the absolute number of maintenance calories per unit time will change seasonally. Therefore, we must be able to factor that change into any nutritional limitations of the food itself. We must measure these long-term changes to accurately interpret the biochemical profiles obtained in the field data. To offset these problems we will implement the staggered feeding regime shown above. We will separate the seals into two groups of three, one feeding on a different food item than the other. Each group will feed on a given food item for at least four months, then alternate with another group at the end of each four-month trial. These feeding trials will continue for two years, exposing each animal to various seasonal or yearly cycles with each prey species. This will provide standard deviations in assimilation efficiency, digestive efficiency and metabolizable energy while minimizing potential errors associated with temporal fluctuations (season or year) or metabolism (e.g., molting) and confounding errors associated with each prey item during a particular feeding trial. Although staggered feeding methods have been utilized in captive bird studies (16) few data exist on long-term assimilation studies for captive marine mammals.

The final issue is the application of laboratory data to the field environment. *We are not proposing to model the metabolic demands of harbor seals in the wild.* The stresses and food requirements of wild populations are very different from captive animals. Instead, we are investigating the metabolic response to differing diets and the effect of these diets on blood chemistry, blubber physiology and body condition of these animals. That is, we do not seek to model how may calories an animal may consume per month and apply that to field estimates of mass of fish consumed at sea. *We will quantify how blood chemistry biomarkers change when an animal is fed several different kinds of fish and compare those chemical changes to observed patterns already collected from wild populations.* For example, we know different populations of sea lions exhibit circulating red cell hemoglobin concentrations (MCHC) that vary significantly from one another. This study is designed to investigate whether fish diets and seasonal alterations

in food demand impact these chemical levels.

The food provided to the seals will come from frozen stocks of Alaska herring and pollock held by the ASLC husbandry collection. The fish are analyzed for body composition and inventoried by batch number so that any variation in food composition can be monitored.

Body condition, health and blood chemistry alterations

BODY CONDITION

Seals are weighed at every biweekly handling or more often for those trained to move onto load scales to obtain mass measurements. The trainers are working with additional seals to establish the same behaviors. At these handlings, measurements of length, girth and blubber depth (using portable ultrasound) are collected. Every month, whole body bio-impedance (BIA) will be used as a proxy for water content and every six months this technique will be calibrated with labeled water. In this technique, deuterated water (D_2O) is injected into the seal, allowed to equilibrate with the total body water and then blood samples are drawn to measure D_2O dilution. This is a routine procedure for body water determination and we have used it on both Steller sea lions and harbor seals. There are conflicting views of whether BIA accurately reflects total body water in pinnipeds (17), but our current research with Steller sea lions suggests it is reliable over the changes that would occur seasonally or with development. At the same time the D_2O experiments are conducted, total plasma volume will be determined using Evan's Blue dilution techniques. In order to facilitate the field/laboratory comparisons, these morphological indices are the same as those we developed for use on wild populations of pinnipeds. Models of the most sensitive indicators for the field animals exist for harbor seals (1, 8, 18).

BLOOD CHEMISTRY

To date, we have a database of blood indices from over 450 adult harbor seals and 100 harbor seal pups as well as 300 Weddell seals, 400 Steller sea lion pups, 20 Steller sea lion juveniles and over 80 Steller sea lion adults collected under field conditions. These indices include not only clinical veterinary panels of blood chemistry and hematology, but also additional indicators we have developed for specialized use on pinnipeds.

Blood samples will be collected every two weeks from each animal throughout the duration of the study. The blood sample is taken from the extradural sinus directly into the appropriate vacuum collection tube. We routinely take blood into both EDTA (for hematology) and heparin tubes (for chemistry). The blood will be analyzed on site for most of the metabolites and hematological parameters of interest. Because these animals are highly trained for research protocols, this frequency of handling should not induce any negative behaviors that could compromise the project. All eight seals have been handled by research teams for many years and have easily adapted to their new protocols.

One of the implications of the junk food hypothesis is that the impacted animals are nutritionally stressed. Therefore, we have developed a series of blood indicators for fieldwork that provides a profile of the fasting and starvation status of pinnipeds. These markers include *ketone bodies* (metabolites produced to support neural function in the face of decreasing food intake), *blood urea nitrogen* (marker for increased muscle tissue degradation during starvation), *differential fatty acid utilization* (selective utilization of fat from lipid stores in the blubber during fasting),

water balance in the plasma (particularly sensitive as pups gain nutritional independence) and red cell characteristics including *hemoglobin content/cell* and *mean cell volume*. We have found these markers to be useful in determining whether or not pinnipeds are feeding, fasting, or entering starvation in the wild (19, 20, 21). However, we need to verify with controlled studies that different feeding regimes can alter these metabolites. Recent work with wild harbor seals in Scotland suggests that switching from a herring to cod-based diet is correlated with several of these markers (22). The captive studies are critical to test whether differing diet alters blood chemistry for these markers.

Nutritional assimilation

Estimating prey or nutritional requirements of a predator using an energy model necessitates that assimilation efficiency be quantified (23). Assimilation efficiency (AE), which is defined as the proportion of dry matter assimilated from a prey source, is influenced by food quality, meal size, feeding frequency and digestive passage rate (24, 25). Recent studies have suggested that assimilation efficiency is low when food quality is low (16, 26). For example, harp seals (*Phoca groenlandica*) fed Atlantic herring or capelin had a higher AE, and consumed less food, than those fed invertebrates of lower energy density (26). However, conflicting results have been reported for harbor seals (14) and northern fur seals (11), while studies of California sea lions fed pollock did not show a significant decrease in AE with lower energy density food, such as pollock (27).

During the feeding experiments to quantify assimilation efficiency and metabolizable energy (ME), each group of three captive seals will be fed a diet of one primary prey item, keeping other variables such as meal size and feeding frequency constant. The design and interpretation of feeding experiments takes into account the potential effects of seasonal variation in AE and ME and this is discussed above in the feeding trial design using staggered schedules. Each group of animals will be moved from wet to dry holding areas at the ASLC so that fecal samples can be collected as necessary. Another, separate group of two animals will be utilized for studies on meal size and frequency. These two animals will be fed a staggered diet of pollock or herring, but the frequency of feeding and volume of fish at any given trial will be altered and changes in AE monitored.

For all animals, dietary prey and fecal samples will be freeze-dried and analyzed for energy (cal/g), nitrogen, total lipid, and ash. Routine bomb calorimetry will be used for energy density, nitrogen (protein) concentration will be determined using a carbon–nitrogen auto-analyzer, total lipid by Soxhlet extraction and ash by muffle furnace combustion. All these methods are routinely used at the UAF facilities and will be available at the SeaLife Center.

To determine digestibility of food absorbed in the digestive tract of seals, manganese (Mn^{2+}) concentrations will be measured using subsamples of prey items fed to individual animals and from their fecal samples. Mn^{2+} is used as a naturally occurring, inassimilable dietary marker. Its use has been applied to pinniped AE studies (27, 28). Differences in the Mn^{2+} concentrations between diet and feces will be used to calculate AE. Mn^{2+} concentrations will be determined using atomic absorption spectrophotometry (28). The tissue samples will be extracted in Seward and analyzed by our own laboratory staff in Fairbanks.

In order to determine the passage of digesta (mean retention time), feces will be collected during

the feeding experiments. Rate of passage of digesta is one of the important factors that determine the efficiency of utilization of food (29). It has been documented in birds that the retention time of food in the gut is a function of food quality (30). In pinnipeds, such as the harbor seal, data indicate both high caloric prey items with soft parts and low caloric prey species have the fastest transit times through the digestive tract (31). However, the assimilation efficiency of the prey items fed to these seals was not known. Miller (11) reported that the passage rate of digesta in sub-adult female northern fur seals was rapid, although the AE appeared to be consistently high for the different prey items. Mean retention time will be calculated in order to examine its relationship with AE. If prey size and feeding frequency are equal in all trials, prey items with higher energy value should have shorter retention times and pass through the digestive tract more quickly. Methods that will be used will include inert prey/feces markers such as carmine red or stable isotopes to estimate emptying time of the stomach.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The Marine Mammal Protection Act permit and internal UAF and ASLC Institutional Animal Care and Use Committee permits required for this project have been approved.

SCHEDULE

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

Each feeding trial will take four months and work with sick animals may occur at any time of the year. We have scheduled the feeding trials to begin in September, 1998.

September-December:	Trial 1 of staggered feeding protocol, monitoring condition and health of seals during period of molting for two groups of three animals. Assimilation efficiency experiments. Begin frequency studies on separate group of two.
January-April:	Trial 2 of staggered feeding protocol, monitoring condition and health of seals during spring. Assimilation efficiency experiments. Continue frequency trials
May-August	Trial 3 of staggered feeding protocol, monitoring condition and health of seals during breeding season. Assimilation efficiency experiments. Continue frequency trials.

B. Project Milestones and Endpoints

Major milestones will occur in each of the remaining years of this project, but the three objectives listed above will be carried through the life of the project.

FY 99: First full year of feeding trials; second year of stranded pups and/or rehabilitation animals.

FY 00: Full year of feeding trials; third year of pups and/or rehabilitation animals.

FY 01: Wrap-up of protocols, close out project, final reports.

C. Completion Date

This project will finish on September 30, 2001.

PUBLICATIONS AND REPORTS

During FY 99 we anticipate publishing short papers on how several of the health biomarkers change through seasons, in healthy vs sick animals, etc., with more comprehensive articles appearing in later years, once feeding trials have been completed.

PROFESSIONAL CONFERENCES

The PI requests funds to attend a major medical conference each year to work with colleagues who follow such biomarkers in human health studies. Dr. Castellini has a long history of participating in these meetings (Experimental Biology) and they occur each April. Work on this project will be presented at these meetings as well as at the 10th anniversary EVOS meeting in March 1999 and the Alaska Native Harbor Seal Commission meeting in March 1999.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

As noted above, we anticipate that there will be several projects looking at controlled diets in birds and mammals at the ASLC. These multiple experiments will require close coordination from the associated principal investigators, the ASLC animal staff, veterinarian and staff, science officer and executive director.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

This proposal is a continuation of Project 98341 with no changes proposed from the original plan. While FY 98 focused on preparation for arrival, acclimation and initial monitoring of research animals at the ASLC, the FY 99 DPD focuses on initiation of feeding trials with these animals. This follows the initially proposed time-line in the FY 98 DPD. Experimental protocols for measuring AE are currently being validated and no changes to the protocols are anticipated although additional information about methodology has been provided.

PROPOSED PRINCIPAL INVESTIGATOR

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Revision 7 - 98
Approved TC 8-13-98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel	$67.5	$0.0
Travel	$15.0	$0.0
Contractual	$11.1	$116.9
Commodities	$5.0	$0.0
Equipment		$0.0
Subtotal	$98.6	$116.9
General Administration	$24.8	$8.2
Project Total	$123.4	$125.1
Full-time Equivalents (FTE)	2.4	2.4

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2000	Estimated FY 2001	Estimated FY 2002
$124.1	$85.4	$0.0

Dollar amounts are shown in thousands of dollars.

Other Resources

Comments:

Project Total: $125.1
+ 69.1 ASLC Bench Fees
$194.2

FY 99

Prepared: Prepared: 7/9/98

Project Number: 99341
Project Title: Harbor Seal Recovery. Phase II: Controlled Studies of Health and Diet
Name: University of Alaska Fairbanks
Agency: ADF&G

FORM 3A
TRUSTEE
AGENCY
SUMMARY

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel	$67.5	$67.0
Travel	$15.0	$8.7
Contractual	$11.1	$11.8
Commodities	$5.0	$6.0
Equipment		
Subtotal	$98.6	$93.5
Indirect	$24.8	$23.4
Project Total	$123.4	$116.9
Full-time Equivalents (FTE)	2.4	2.4
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
	Estimated FY 2000	Estimated FY 2001	Estimated FY 2002		
	$124.1	$85.4			

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.

Student personnel costs include resident tuition of $2,916 per year each.

Travel to Anchorage for EVOS activities is by shuttle bus.

FY 99

Project Number: 99341
Project Title: Harbor Seal Recovery. Phase II: Controlled Studies of Health and Diet
Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

Prepared: 7/9/98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 – September 30, 1999

Personnel Costs: Name	Position Description	Months Budgeted	Monthly Costs	Overtime	Proposed FY 1999
Castellini, M.	Principal Investigator/Assoc. Professor	2.3	8.4		19.3
Castellini, J. M.	Research Associate	3.0	4.3		12.9
TBN	Ph.D. Student	12.0	1.6		19.2
TBN	M.S. Student	12.0	1.3		15.6
	Adjustment to recognize rounding				0.0
	Subtotal	29.3	15.6	0.0	
				Personnel Total	$67.0

Travel Costs: Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 1999
Seward to Anchorage for annual EVOS meeting	0.1	2	10	0.1	1.2
Seward to Anchorage for EVOS workshop	0.1	1	5	0.1	0.6
Seward to Fairbanks to oversee and carry out chemical analyses	0.3	6	24	0.1	4.2
Anchorage to Sitka for Alaska Native Harbor Seal Commission Meeting in March (to share findings with Native communities)	0.5	1	3	0.1	0.8
Seward to Washington DC to be a presenter at the annual Experimental Biology Meeting in April	0.9	1	5	0.2	1.9
				Travel Total	$8.7

FY 99

Project Number: 99341
Project Title: Harbor Seal Recovery. Phase II: Controlled Studies of Health and Diet
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 7/9/98

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

Contractual Costs:	Proposed FY 1999
Description	
Publication/dissemination costs	1.0
Communications	0.8
Postage, shipping, freight	1.0
Contractual services (blood - veterinary analysis)	6.0
Contractual services (additional animal services)	3.0
Contractual Total	$11.8

Commodities Costs:	Proposed FY 1999
Description	
Laboratory expendables for collection of blood samples	3.0
Laboratory expendables for analysis of blood samples	3.0
Commodities Total	$6.0

FY 99

Project Number: 99341
Project Title: Harbor Seal Recovery. Phase II: Controlled Studies of Health and Diet
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities DETAIL

Prepared: 7/9/98

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: 99341
Project Title: Harbor Seal Recovery. Phase II: Controlled Studies of Health and Diet
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

Prepared: 7/9/98

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		$64.6
Commodities		$0.0
Equipment		$0.0
Subtotal		$64.6
General Administration		$4.5
Project Total		$69.1
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.

FY 99

Project Number: 99341
Project Title: Bench Fees: Harbor Seal Controlled Studies of Health & Diet
Agency: ADFG

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Approved TC 8-13-98

Project Title: **Publication of a Indexed Bibliography of the Genus *Ammodytes* (Sand Lance)**

Project Number: 99346

Cooperating Agencies: U.S. Forest Service, U.S.G.S.

Cost FY 98: $5,400

Cost FY 99: $9,600 ($10,400 with G.A.)

This is a request for additional funding to cover the cost of publication because the bibliography is much larger than our original estimate (about 3 times larger). We have now completed the literature search and all references and available abstracts have been entered into a word processing document. Key wording and initial clean-up has been completed for about 25% of the manuscript. This manuscript includes about 2,000 references and will total about 440 pages, single space. The final publication will include two additional chapters, in addition to the bibliography -- a review of sand lance biology and sand lance as a cornerstone species. Both of these review chapters should enhance the value of the bibliography considerably. The chapter on sand lance as a cornerstone species is nearly complete and the chapter on sand lance biology is being written.

The manuscript will be published as a General Technical Report by the U.S. Forest Service, Pacific Northwest Research Station. We have attached an estimate of publication cost from the Communications Group of the Pacific Northwest Research Station. Our request includes an additional $1,000 to cover the cost of secretarial help.

Completion Date

Final report will be submitted to the Senior Scientist for review in October 98. Publication date will depend on reviews and printer schedule--we estimate in spring of 1999.

Publications and Reports

Overall publication as a U.S. Forest Service, Pacific Northwest Research Station, General Technical Report will include three chapters.

Chapter 1: Robards, M.D. et. al. A Review of Sand Lance Biology.

Chapter 2: Willson, M.F., Armstrong, R.H., Robards, M.D. and J.F. Piatt. Sand Lance as 'Cornerstone Species' for Predator Populations.

Chapter 3: Armstrong, R.H.; Robards, M.D.; and M.F. Willson. Indexed Bibliography of the Genus *Ammodytes* (Sand Lance).

PRINCIPAL INVESTIGATORS

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Revision 6/29/98
Approved TC 8-13-98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FY 1998	Proposed FY 1999
Personnel		$1.0
Travel		$0.0
Contractual	$5.0	$8.6
Commodities		$0.0
Equipment		$0.0
Subtotal		$9.6
General Administration	$0.4	$0.8
Project Total	$5.4	$10.4
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

		Estimated FY 2000	Estimated FY 2001	Estimated FY 2002	
		$0.0			

Dollar amounts are shown in thousands of dollars.

Comments:

1999

Prepared: 6/29/98

Project Number: 99346
Project Title: Publication of Indexed Bibliography of Genus Ammodytes
Agency: USFS

FORM 3A
TRUSTEE
AGENCY
SUMMARY

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

Personnel Costs:		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	Proposed FY 1998
Name	Position Description					
Unknown	Secretary					1.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		0.0	0.0	0.0	
					Personnel Total	$1.0

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
					0.0
				Travel Total	$0.0

1999

Prepared: 6/29/98

Project Number: 99346
Project Title: Publication of Indexed Bibliography of Genus Ammodytes
Agency: USFS

FORM 3B
Personnel
& Travel
DETAIL

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

Contractual Costs:	Proposed FY 1999
Description	
Publication charges for Pacific Northwest Research Station are estimated as shown in the letter attached to the DPD. No more accurate estimates are available at this time, until total length of publication and number of copies to be printed are determined.	8.6
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$8.6

Commodities Costs:	Proposed FY 1999
Description	
Commodities Total	$0.0

1999

Prepared: 6/29/98

Project Number: 99346
Project Title: Publication of Indexed Bibliography of Genus Ammodytes
Agency: USFS

FORM 3B
Contractual & Commodities
DETAIL

1999 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

1999

Prepared: 6/29/98

Project Number: 99346
Project Title: Publication of Indexed Bibliography of Genus Ammodytes
Agency: USFS

FORM 3B
Equipment
DETAIL

Approved TC 8-13-9

Fatty Acid Profile and Lipid Class Analysis for Estimating Diet Composition and Quality at Different Trophic Levels

Project Number:	99347
Restoration Category:	Research
Proposer:	R. Heintz/NOAA
Lead Trustee Agency:	NOAA
Cooperating Agencies:	None
Alaska SeaLife Center:	No
New or Continued:	Cont'd
Duration:	2nd yr. 3 yr. project
Cost FY 99:	
	$92.6
Cost FY 2000:	$35.8
Cost FY 01:	$0.0
Cost FY 02:	$0.0
Geographic Area:	Prince William Sound, Lower Cook Inlet
Injured Resource/Service:	Various

ABSTRACT

This project will begin the systematic development of fatty acid profiles and lipid class analysis to identify diet differences and quality in forage fish and their prey. The spatial and temporal variability of fatty acid profiles in herring, sand lance, and zooplankton will be examined and related to the nutritional condition of these forage fish. The spatial comparisons, which began in FY 98, will provide insight into the energetic differences in forage fish in disparate parts of Prince William Sound. These comparisons are based on samples collected by APEX (Project /163). In FY 99, temporal comparisons will be made, which will provide information on the energetic changes that inevitably occur with seasonal, ontogenetic, and reproductive changes.

INTRODUCTION

This project seeks to extend the utility of fatty acid (FA) analysis for estimating diet composition, by relating FA compositions in forage fish to their prey and examining the nutritional condition of these animals through lipid class analysis. Iverson et al (in press) have indicated that FA profiles in seals in Prince William Sound (PWS) reflect the profiles found in their prey. In view of its promise, the utility of FA analysis for estimating diet composition warrants investigation in other predators.

Before FA analysis for estimating diet composition can be extended, the basic assumption that a predator's FA composition resembles its prey requires demonstration and the sources of variation underlying the FA composition need to be described. The basic assumption has been investigated under laboratory conditions, but not tested in the field. This assumption indicates the sources of variation in the FA profiles of their prey must be quantified because a predator's FA profile will be influenced by the FA available in its foraging range. In fact, Iverson et al. (In press) reported spatial and ontogenetic variation in herring FA profiles, but the spatial and temporal scales of this variability have not been defined. Last year this project began analyzing the spatial scale of variation in herring and sandlance, this year we propose examining the temporal scale of variation in sandlance. An new unsolicited project has been proposed to demonstrate the basic assumption underlying this analysis.

FA can be viewed as the energetic currency that is exchanged when predators consume prey. After consumption, some fraction of the consumed FA are used to provide energy for the Krebs cycle, and surplus FA are distributed via the blood stream to fat depots located throughout the organism. Examination of the FA composition of the surplus FA affords an integrated view of the FA derived from a predator's prey. Iverson (in press) has concluded that changes in a predator's FA composition occur within a short time. Thus, while examination of the FA composition may provide insight into diet composition, it is important to know how sensitive this tool is to the temporal variations in diet.

Examination of the relative abundance of lipid classes in organisms provides a measure of their nutritional condition. Lipids can be classified by their structure into several classes. Each class represents lipids used for either membranes, energy reserves, structural elements or hormones. Comparing the relative abundance of the energy reserve class, triacylglycerides (TAG) in fishes and wax esters in zooplankton, to the total amount of lipid provides a measure of the relative amount of energy reserve, thus the nutritional condition of the specimen. Combining observations of dietary differences with evaluations of nutritional condition can lead to extremely powerful interpretations of efficiencies in predator prey relationships. This power is easily obtained since FA analysis for estimating prey composition is most sensitive when performed on the energy reserve portion of the total lipid composition, thus lipid class analysis is the first step to analyzing FA composition.

We propose two field surveys designed to demonstrate 1) the spatial and temporal scales of variation in the FA profiles of important forage fish in PWS and lower Cook Inlet, and 2) the analysis of FA profiles and lipid class analysis for examining the nutritional consequences for predators consuming different diets. These projects are the first steps in the systematic development of these techniques for examining broad scale trophic relationships. Specifically,

the studies provide detailed information on the spatial and temporal variability of FA profiles in sandlance as well as measuring the consequences of dietary differences by evaluating the availability of surplus energy. An objective of the first year of this study, FY98, proposed to examine the spatial variability of FA profiles of herring, sandlance, and zooplankton collected at different sites in PWS by APEX 163A investigators. These samples are currently being processed. In FY99, the temporal variability of FA will be examined by processing sandlance samples collected every 2 weeks from April through August, 1998, by APEX 163M investigators in Lower Cook Inlet. The investigation into the temporal variation will be supplemented with samples collected monthly from June through August by APEX 163E investigators working near Point Eleanor in Prince William Sound. The results of these studies will help define the spatial and temporal limits to discriminating fatty acid profiles in this important forage species.

NEED FOR THE PROJECT

A. Statement of the Problem

Trustee sponsored projects including APEX, SEA and NVP focus on understanding trophic relationships, but depend on diet information that do not adequately quantify energy transfer between predator and prey. Diet studies are typically underpowered, because parametric techniques for estimating sample sizes are not well understood (Ferry and Cailliet 1996). Even if analysis of stomach contents could provide precise estimates of diet over spatial and temporal scales, the data are biased by differences in prey digestibility and the assumption that stomach contents at collection represent diets averaged over time. Marine mammal diets are usually assessed by examining scats, which have many of the same biases as stomach contents. In addition, diet evaluation by stomach or fecal content analysis provides only an indirect method for estimating the amount of energy transferred between predator and prey, since measurements of energy density and digestibility estimate energy availability rather than energy acquisition.

FA analysis for estimating prey composition may have tremendous potential for avoiding the biases observed in stomach content or scat analysis, while lipid class analysis provides a more direct measure of energy acquisition in predators. The application of FA analysis in seals was reported in Restoration Project 95064 (Frost et al. 1996). In addition, the FA profiles in predators has been found to reflect the profiles in prey in a number of feeding studies involving herring (Gatten et al. 1983), cod (dos Santos et al. 1993), chinook salmon (Kennish et al. 1992) and pike (Schwalme 1992). However, these latter studies have been under laboratory conditions where developmental stages, diets and environments have been tightly controlled, and field application remains to be examined. Similarly, lipid class analysis coupled with FA analysis has been used to study trophic relationships in closed systems (Fraser 1987). Lipid class analysis measures nutritional condition by expressing the TAG content as a proportion of total lipid, with high proportions of TAG indicating increased amounts of storage lipid (Fraser 1987).

The success of FA analysis for estimating prey composition depends on understanding the nutritional requirements of the predator, its foraging behavior, and the FA composition of its prey. Iverson et al. (In press) demonstrated that herring in PWS have FA profiles that vary both

spatially and morphometrically. These differences are thought to arise from dietary differences in herring from different locations, and their consumption of different sized prey. Phocid seals and their prey may be a good model system for this technique since seal foraging ranges may be quite small with respect to the scale of spatial variability in their prey (Frost et al. 1996), while FA profiles of less selective predators, or predators that forage over broad spatial scales may be more difficult to match to prey. Also, establishing direct links between prey and predator is contingent on tracing the route of essential FA from prey to predator.

Systematic development of a trophic relation that can be examined by FA and lipid class analysis requires identification of essential FA in the predator, and examination of the sources of variability in the FA profiles of its prey. Essential FA are best identified in controlled feeding trials where the FA composition of the predator can be evaluated over time and related to known changes in the FA composition of its prey. Ideally, feeding trials will survey several developmental stages in the predator since, FA profiles will change in response to ontogenetic demands (Leger 1985). This examination is being proposed for sandlance under a separate title. After validating the assumption that a predators FA composition reflects its diet, the analysis of FA profiles to examine trophic relationships needs to be extended by understanding how variation in FA composition is structured spatially and temporally. It is important to know if the variation if FA composition within a local aggregate is greater or less than variation between distant aggregates because these sorts of differences provide a basis for statistically identifying aggregates. Similarly, it is important to know if the variation in FA composition of a fish aggregation sampled at a particular time is greater or less than the variation observed between two times. Also, how does the magnitude of this variation compare with variation in other species. The answers to these questions will demonstrate the utility of FA analysis for examining trophic relationships.

The structure of variation between groups identified *a priori* can be examined with existing multi variate techniques. Once the structure to variation in the FA composition has been described then the plausibility of specific models aimed at hindcasting predator diets from the FA composition of its depot fats will be known. Ideally, predator FA profiles would be compared to a library of prey profiles described for the predator's foraging range, and the relative abundance of each prey item in the predator diet would be predicted with some measure of statistical confidence. Currently Tree Structures (CHART) are used to specify prey compositions in predator diets, but no statistical confidence is associated with the compositions identified by this technique, nor are the relative contributions of the prey predicted. Development of a parametric model for hindcasting diet composition must wait until the sources of variation in prey FA profiles are better understood and essential FA identified.

B. Rationale/Link to Restoration

We propose to continue the investigation into the variability of FA profiles and nutritional condition of forage fish by expanding the scope of the project to examine temporal scales of variation. This supplements the investigation of the spatial variability of FA profiles proposed in the first year of this study. The allocation of consumed and stored energy of forage fish is dependent on the requirements of the organism as dictated by its particular life stage as

well as a number of physical environmental factors. Juvenile fish are primarily allocating their energy to growth while mature fish might be allocating energy to gonad production and fish preparing for winter dormancy are building fuel reserves. These allocations might also be influenced water temperature, physical activity, and prey availability. We propose to analyze sandlance over a time period that encompasses the period of lipid buildup, energetic allocations, and preparation for reproduction. We will investigate how these temporal changes influence the FA profile and the nutritional condition of sandlance.

APEX project 163M and 163E propose to characterize the relationships between seabird populations and forage fish densities. They will provide sandlance samples collected as part of their routine monitoring and collection cruises and will benefit from the specific energetic data proposed in this project. Also, analysis of these samples will provide APEX investigators with valuable information regarding the nutritional value of sandlance in Lower Cook Inlet and PWS. Field collections of sandlance will also address questions about the variability of FA profiles posed by Restoration Study 064 (Harbor Seals), and further complement plans made by Restoration Study 064 by providing those investigators with increased power to resolve harbor seal diets. Using the sampling design proposed by APEX we can provide investigators cost-effective analysis of energetic content and nutritional condition. Thus, the studies proposed here have direct links to a number of ongoing and proposed projects, and will also provide information that is of interest to other Trustee programs.

A stated objective of the Trustee funded APEX project is to examine the differences in forage fish diets and determine the consequences of the differences at the individual and population level. We propose to supplement the cruder evaluations of energetic content (calorimetry) in herring and sandlance proposed under the APEX studies with analysis of lipid class composition and FA profiles, since lipid class composition provides a direct measure of the energetic consequences of different diets (Fraser 1987). In this two year project examination of the FA profiles of herring, sandlance and their prey from PWS and Cook Inlet will quantify the temporal (FY99) and spatial (FY98) range of diet variability because dietary differences are thought to be reflected in FA profiles. Sampling designs by APEX investigators include fine scale sampling of sandlance, herring and their prey in PWS and Cook Inlet.

C. Location

This project depends on forage fish samples collected from lower Cook Inlet and central PWS. All the samples will be shipped to and processed in Auke Bay, Alaska.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Scientists involved in this study will regularly present progress reports and results in scientific and public forums, including the annual workshop. They will be available to talk with interested public and will provide information for Trustee Council newsletters and annual reports as appropriate. The project uses existing agency labor to process and analyze the samples.

PROJECT DESIGN

A. Objectives

The main objectives are to examine of the spatial and temporal ranges of variability in sandlance FA profiles and relate these differences to nutritional condition.

In FY98 we began the examination of spatial using samples collected in July, 1997 by APEX investigators. Young of the year herring and sandlance were collected at several locations near Naked Island in central Prince William Sound and at locations near Bainbridge Island in SW Prince William Sound. In addition, the lipid quality and composition of prey fields sampled in these two locations will also be characterized. The FA profiles and lipid class composition of the major zooplankton taxa will be evaluated. These values will be weighted by the relative abundance of these taxa (as estimated by APEX investigators) to model the FA availability in local prey fields. The hypotheses we plan to test with data acquired in FY98 are:

1. FA profiles of herring and sandlance are the same.
2. FA profiles of herring are the same regardless of the presence of sandlance.
3. FA profiles of herring are the same between the central and southern parts of PWS.
4. FA profiles of herring are the same between bays within southern PWS.

Similarly, the zooplankton tows will be analyzed and the following hypotheses tested:

5. Energy is the same between bays within a region
6. Energy is the same between the central and southern regions of PWS

In FY99 we propose to complete statistical analysis of data collected in FY98 and examine the temporal scales of variability in the FA profiles of sandlance using samples collected by APEX 163M investigators in lower Cook Inlet and APEX 163E investigators in PWS. We plan to relate these temporal changes to the developmental stage of the organism. A timed series of FA profiles from 2 separate locations provides investigators valuable information into how energy allocation is affected by ontogenetic and reproductive changes and if differences are dictated by location as well as ontogeny. Specific FY99 objectives are listed below.

1. Determine how FA profiles change in one location over time and relate those changes to the life stages of adult and juvenile sandlance.

2. Determine of temporal changes are unique to a specific area of if the changes are similar between lower Cook Inlet and PWS.

Herring have not been included in this plan because their broader foraging ranges suggest the probability of consistently sampling a herring aggregate through time is minimal. Sandlance present a low cost solution to this problem.

B. Methods

Temporal Scale of Variability in Sandlance FA Profiles

From May through September APEX 163M investigators make biweekly collections of sandlance in lower Cook Inlet near Kachemak Bay. We propose to determine the FA profiles of juvenile and adult sandlance during these 10 collection opportunities. Seven juvenile and adult sandlance will be processed as whole body samples. In total this results in 140 samples.

To supplement the time scale of FA profiles of sandlance in lower Cook Inlet we propose to collect supplemental sample within PWS in conjunction with APEX 163E. Sandlance will be collected monthly, June to August, at 2 locations in PWS. Adult and juvenile sandlance will be sampled as in Kachemak Bay, providing a total of 84 samples.

APEX 163M investigators will be responsible for the lower Cook Inlet sample collection, storage and shipment to Auke Bay. APEX 163E will augment sampling in PWS. Fish will be stored in airtight containers and labeled with unique sample numbers and codes reflecting the collection location and date. Sampling design and analytical priorities will be contingent on fish availability. All samples will be collected by APEX investigators during FY98 as part of their existing study plans.

Lipid Class/FA Analysis

Samples will be extracted by methods developed by Folch (1957) and modified by Iverson (1988). Lipid classification will employ high performance liquid chromatography (HPLC) and evaporative light scattering detection (ELSD) equipped with a stream splitter and an automated integration system. The lipid classes will be separated on a silica based HPLC column; as they elute from the column, each lipid class will be split with one portion being directed to the detector and the other portion being collected for FA analysis. The portion going to the detector will be integrated and the chromatographic data for each lipid class will be quantified by standard calibration curves established by analyzing standards with lipid compositions similar to the sample.

After separation the lipid class of interest will undergo acid catalyzed transesterification as outlined in Christie (1982). The resulting FA methyl esters (FAME) will be determined using a gas chromatograph coupled with a mass selective detector (MSD). The FAME will be identified by comparison of the chromatographic peaks with those of known laboratory standards. Peaks not identified by direct comparison to standards will be identified from the fragmentation pattern resolved by the MSD. FA will be reported as a percentage of the total amount of FA and named according to IUPAC nomenclature.

These methods will give results directly comparable to that of the conventional methods using TLC/Iatroscan for lipid class determination and gas chromatography-flame ionization detection (GC-FID) for FAME analysis. The ELSD will allow for simultaneous detection and separation of lipid classes without developing rods or TLC plates and without extracting lipids from the TLC media for FA analysis. Likewise, analysis of FAME mixtures by MSD will forego the need for silver nitrate augmentation to identify of peaks that are not components of standard

mixtures. Since each compound has a unique fragmentation pattern the identity of unknown peaks can be determined from the mass spectral data.

Statistical analysis

Statistical analysis of the proposed fish collections will use multi variate techniques to measure the similarity between groups classified *a priori*. Groups will classed by age, location and sampling period and their FA compositions will be summarized by discriminant analysis and the distance between group centroids will be measured and tested to determine if they are different from 0. Rejection of a null hypothesis that the distance is 0 indicates significant differences exist between the groups, therefore variation in FA composition within the group is less than variation between the groups. In addition, differences among FA profiles can be related to APEX-generated data on diet diversity, as well as species diversity and energy density of concurrently sampled prey fields.

Differences in nutritional condition between the logically associated groups identified by ordination will be examined by ANOVA. The existence of different logical groups based on differences in FA profiles of the TAG component suggests dietary differences, this analysis will examine the nutritional consequences of these dietary differences. Nutritional condition will be calculated as the proportion of total lipid comprised of TAG. A one way ANOVA will be used to examine differences in the mean nutritional condition between logical groups.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The experiments described in this proposal are designed to initiate development of techniques for examining broad scale trophic relationships and supplement other Trustee Projects. In this project we begin by examining the structure of variation in FA composition. In a separate unsolicited project we propose to demonstrate in the field the underlying assumption that a predator's FA composition is similar to their prey. The combination of these projects may provide empirical validation for the theory of FA composition analysis. Afterwards, application to higher level predators can proceed. We have chosen to examine a forage fish model because of their central value to the PWS ecosystem. Our proposed studies depend on the sampling protocol of APEX study 163M and 163E. APEX investigators will be responsible for collecting, labeling and storing samples until they return to Auke Bay. APEX 163M and APEX 163E will benefit from our analysis by relating our measures of dietary differences and their energetic consequences to their coarser indices of nutritional condition.

SCHEDULE

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

October 1: Complete sample processing for spatial variability of FA.

	Begin analysis of temporal variability samples.
December :	Complete statistical analysis of data from spatial variability samples.
March:	Attend 10th Anniversary Symposium
April:	Submit annual report
Sept. 30:	Complete sample processing for temporal variability of FA.

B. Project Milestones and Endpoints

FY99

Oct. 1998	Complete lab processing of herring, sandlance, and zooplankton collected for spatial comparisons. Begin lab processing herring and sandlance collected for temporal comparisons.
Dec. 1998	Complete statistical analysis of spatial variation data.
March 1999	Report on spatial scales of variability in forage fish FA profiles.
June 1999	Complete manuscript on spatial scales of variation of herring and sandlance in PWS.
Sept. 1999	Complete processing of herring, sandlance, and zooplankton collected for temporal comparisons.

FY00

Dec. 1999	Complete statistical analysis of temporal variation data.
Jan 2000	Report on temporal scales of variability in forage fish FA profiles.
Jul 2000	Final Report submitted

C. Completion Date

This project will began in FY98, and will continue through FY00. Synthesis of herring, sandlance, and zooplankton spatial data will be complete in the middle of FY99. Synthesis of the temporal data will be complete in the first quarter of FY00, and the final report will be submitted in the middle of FY00.

PUBLICATIONS AND REPORTS

April 1998: Annual Report containing update on sample processing for the forage fish experiment.

Jan 1999 Submit scientific manuscript to journal:

Heintz, R , M. Larsen, S. D. Rice, and APEX investigator. 1999. Spatial

Variation of FA Profiles and Lipid Class Compositions in Herring, Sandlance and Their Prey in Prince William Sound, Alaska. Journal uncertain.

April 1999: Annual Report containing data on the forage fish studies

Jan. 2000: Submit scientific manuscript to journal:
Heintz, R., M. Larsen, S. D. Rice, and APEX investigator. 1999. Temporal Variation of FA Profiles and Lipid Class Compositions in Sandlance in Lower Cook Inlet and Prince William Sound, Alaska. Journal uncertain.

April 2000: Final Report.

PROFESSIONAL CONFERENCES

Report on forage fish results at National Meeting of the American Fisheries Society in September 1999.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

NOAA/ NMFS has statutory stewardship for most living marine resources; however, if the oil spill had not occurred NOAA would not be conducting this project. NOAA/ NMFS proposes to make a significant contribution (as stated in the proposed budget) to the operation of this project, making it truly cooperative.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

The original proposal included temporal sampling by APEX 163A investigators in PWS in FY99 which is no longer possible because cruises have been eliminated. Sampling for temporal variations will therefore be conducted in lower Cook Inlet by investigators from APEX 163M and supplemented by sampling in PWS with the aide of APEX 163E.

PROPOSED PRINCIPAL INVESTIGATOR

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Revision - 8-98
Approved TC 8-13-98

1999 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1998 - September 30, 1999

Budget Category:	Authorized FFY 1998	Proposed FFY 1999
Personnel	$61.3	$57.2
Travel	$4.1	$6.6
Contractual	$0.0	$5.0
Commodities	$20.0	$14.9
Equipment	$16.0	$0.0
Subtotal	$101.4	$83.7
General Administration	$9.2	$8.9
Project Total	$110.6	$92.6
Full-time Equivalents (FTE)		0.8
Other Resources		$43.5

LONG RANGE FUNDING REQUIREMENTS

Estimated FFY 2000	Estimated FFY 2001	Estimated FFY 2003	Estimated FFY 2004	Estimated FFY 2005	
$35.8	$0.0	$0.0	$0.0	$0.0	

Dollar amounts are shown in thousands of dollars.

NOAA Contribution:

Habitat Investigation Program Manager, S. Rice,0.5 mo = $5.5K, Principle Investigator, R. Heintz 1.5 mo @9.7K, Senior Analytical Chemist, M. Larsen 2.5 mo @ 15 K, J. Lunasin Research Chemist 1 mo @ 5 k; Senior Research Chemist, J. Short 1 mo. @ 8.3K for a total NOAA contribution of 43.5 K.

1999

Project Number: 99347
Project Title: Fatty Acid Profile and Lipid Class Analysis for Estimating Diet Compostion and Quality at Different Trophic Levels
Agency: National Oceanic & Atmospheric Administration

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared:7/2/98

1999 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	FFY 1999
J. Lunasin	Research Chemist	9/6	4.0	5.0		20.0
R Heintz	Co-PI: Fishery Research Biologist	12/3	2.0	6.6		13.2
M. Larsen	Co -PI: Analytical Chemist	11/6	2.0	6.0		12.0
L. Holland	Research Chemist	11/6	2.0	6.0		12.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		10.0	23.6	0.0	
					Personnel Total	$57.2

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FFY 1999
Anchorage , 10th Anniversary Symposium, 2	0.5	2	8	0.2	2.6
Miscellaneous (Car rental, telephone chgs, POV mileage, etc.)					0.4
					0.0
National American Fisheries Society Meeting, 1	1.5	1	4	0.2	2.3
Miscellaneous (Car rental, telephone chgs, POV mileage, etc.)					0.2
					0.0
APEX Technical Review Session, 1	0.5	1	2	0.2	0.9
Miscellaneous (Car rental, telephone chgs, POV mileage, etc.)					0.2
R Heintz PI					0.0
					0.0
					0.0
					0.0
				Travel Total	$6.6

1999

Project Number: 99347
Project Title: Fatty Acid Profile and Lipid Class Analysis for Estimating Diet Compostion and Quality at Different Trophic Levels
Agency: National Oceanic & Atmospheric Administration

FORM 3B
Personnel
& Travel
DETAIL

Prepared:7/2/98

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

Contractual Costs:	Proposed
Description	FFY 1999
Labor for sample processing (sample sorting, extractions, etc.)	5.0
	0.0
	0.0
	0.0
	0.0
	0.0
	0.0
	0.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$5.0

Commodities Costs:	Proposed
Description	FFY 1999
Sample Analysis: reagents, standards, laboratory expendables	14.9
Commodities Total	$14.9

1999

Project Number: 99347
Project Title: Fatty Acid Profile and Lipid Class Analysis for Estimating Diet Composition and Quality at Different Trophic Levels
Agency: National Oceanic & Atmospheric Administration

FORM 3B
Contractual & Commodities DETAIL

Prepared:7/2/98

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 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
HPLC	1	NOAA
GC/MS	1	NOAA

1999

Project Number: 99347
Project Title: Fatty Acid Profile and Lipid Class Analysis for Estimating
Diet Compostion and Quality at Different Trophic Levels
Agency: National Oceanic & Atmospheric Administration

FORM 3B
Equipment
DETAIL

Prepared:7/2/98