19.11.02 (3 of 12)

The *Exxon Valdez* Oil Spill: Guidance for Future Research Activities "Submitted Under the BAA #52ABNF900033"

Project Number:	BAA ~~00~~02360
Restoration Category:	Ecosystem Synthesis
Proposer:	Chris Elfring, Polar Research Board, National Research Council
Lead Trustee Agency:	NOAA
Cooperating Agencies:	N/A
Alaska SeaLife Center:	No
Duration:	3rd year of three-year project
Cost FY 00:	$196,450
Cost FY 01:	$315,980
Cost FY 02	$84,236
Geographic Area:	
Injured Resource/Service:	potentially all

ABSTRACT

The Exxon Valdez Oil Spill Trustee Council is developing plans for a long-term environmental research and monitoring program in the northern Gulf of Alaska. The Trustee Council expects the research and monitoring to make it increasingly possible to detect and understand the origins and consequences of long-term biological change in the region, and to communicate this knowledge to all concerned. Funds from the trust are expected to be disbursed starting in late 2003. The National Research Council's Polar Research Board (PRB) and Board on Environmental Studies and Toxicology (BEST) propose to continue the committee appointed (list of members attached) to provide outside guidance to the development of the program and review the scope, content, and structure of the draft Research and Monitoring Plan. To date, the committee has provided guidance in two documents: a November 2001 letter report commenting on the schedule and process by which the draft science plan would be developed and a February Interim Report providing detailed comments on underlying foundation of the program, including mission, goals, administration, scale, data management, and community involvement elements.

The committee's next and final task will be to prepare a final report analyzing whether the Research and Monitoring Plan is complete, scientifically sound, and meets the expectations of the Trustee Council. This task will be conducted when the Draft Research and Monitoring Plan is available for review. As currently scheduled, we will receive the draft document in June and hold a meeting to begin our review June 14-15, 2001. The committee will spend the summer and early fall preparing its final report. The report is expected to go to outside review in November 2001 and be delivered to the Trustee Council in January 2002.

INTRODUCTION

The National Research Council (NRC) proposes to continue the committee appointed to provide outside guidance to the development of the program and review the scope, content, and structure of the Gulf of Alaska Ecosystem Monitoring Program. To date, the committee has provided guidance in two documents: a November 15, 2000, letter report commenting on the schedule and process by which the draft science plan would be developed and a February Interim Report providing detailed comments on underlying foundation of the program, including mission, goals, administration, scale, data management, and community involvement elements. The committee's next and final task will be to prepare a final report analyzing whether the Research and Monitoring Plan is complete, scientifically sound, and meets the expectations of the Trustee Council. This task will be conducted as soon as the draft science plan is available for review.

This study is being conducted by a committee of 12 volunteer experts, supported by NRC staff. The committee has met 3 times to date, for the purposes of gathering information and preparing the letter report and interim report. The committee is expected to meet 2-3 more times to understand, discuss, and review the draft science plan. This proposal seeks support for this activity in the amount of $84,236 for year three of its activities.

NEED FOR THE PROJECT

A. Statement of the Problem

The Exxon Valdez Oil Spill Trustee Council is progressing in its process of developing, reviewing, and adopting a Science Program and a Research and Monitoring Plan and the National Research Council's Committee to Review the Gulf of Alaska Ecosystem Monitoring Program stands ready to continue to provide outside scientific guidance to this process. The Trustee Council's vision for the future is to implement long-term monitoring and related research that permit improved understanding of the origins and consequences of biological changes in the northern Gulf of Alaska. The vision includes effectively communicating those understandings to all parties concerned with the management and use of birds, fish, shellfish, mammals, and other organisms.

As background, in 1989 the T/V Exxon Valdez spilled 11 million gallons of crude oil into Prince William Sound in Alaska. In 1991, the U.S. District Court approved a civil settlement that required Exxon Corporation to pay the United States and the State of Alaska $900 million over 10 years to restore the resources injured by the spill and compensate for the reduced or lost services (human uses) the resources provide. Under the court-approved terms of the settlement, a Trustee Council of three federal and three state members was formed to administer the funds. The mission of the Council has been to return the environment to a "healthy, productive, world-renowned ecosystem" by restoring, replacing, enhancing, or acquiring the equivalent of natural resources injured by the spill and the services provided by those resources.

Funds from the Exxon Valdez Oil Spill Trustee Council (EVOS) have been disbursed for

almost 10 years, at first for damage assessment activities (approximately 1989-1991) and then in relation to identified important "resource clusters," or communities/resources affected by the oil spill (1992 to present). During the course of its existence, the Trustee Council has pursued independent, non-government agency peer review of its projects, encouraged and funded publication in peer reviewed scientific journals, and fostered interdisciplinary collaboration essential to ecosystem oriented studies. Many other scientific studies conducted by entities not associated with the Trustee Council are relevant to the NRC committee's efforts.

As the Trustee Council plans a strategy for continued research and monitoring in perpetuity in the region, it must consider options for building on the now-large base of scientific knowledge made possible in part by Trustee Council studies. The final payment from the Exxon Corporation will arrive in 2002, after which activities will be funded solely out of the Restoration Reserve, which was created from portions of the Exxon Corporation payments saved over the previous 10 years. The trust will fund a scientific program and research and monitoring plan to guide future resource management activities, and independent peer review of scientific content is considered essential.

B. Rationale/Link to Restoration

An independent assessment of the proposed Science Program and Research and Monitoring Plan is important to help the Trustee Council plan for the wise and sustainable use of funds contained in the Restoration Reserve trust fund and to ensure that decision-makers plan the best possible strategy for continued, long-term research and monitoring.

C. Location

This project is a review of the draft Science Program and Research and Monitoring Plan the Exxon Valdez Oil Spill Trustee Council is preparing to guide long-term research and monitoring in the northern Gulf of Alaska, and thus deals with many locales.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

The committee has done outreach to communities as we have collected information, holding both our main meetings in Alaska and including many guest speakers and opportunities for anyone to speak. We have counted on the Trustee Council staff to be sure that the Public Advisory Group and the community liaisons have been kept informed of our activities and received copies of our reports. The study itself will have no direct impacts on the communities. When the final report is available, a summary will be made widely available, copies will be available through the National Academy Press, and the report will be posted in full on the National Academy of Sciences website. Current project information, including committee appointments and announcements of meetings, is also always available on the website.

PROJECT DESIGN

A. Objectives

This activity is designed to provide independent scientific guidance to the Trustee Council, research community, and public as the Trustee Council develops a comprehensive plan for a long-term, interdisciplinary research and monitoring program in the northern Gulf of Alaska. Specifically, the committee's overall charge is to:

- Gain, through briefings and literature review, familiarity with the relevant body of scientific knowledge, including but not limited to that developed by the research and monitoring activities sponsored by the Trustee Council in the past.

- Convene one or more information-gathering meetings in Alaska where researchers, the public, and other interested people can convey their perspectives on what the research and monitoring plan should accomplish.

- Review the general strategy proposed in the draft Science Program (which includes information on the social and political context, mission, approach, and scientific background) and make suggestions for improvement.

- Review -- once it is available -- the draft Research and Monitoring Plan, including the scope, structure, and quality of the approach proposed for a long-term research and monitoring program in the northern Gulf of Alaska. This will include whether the conceptual foundation provides an adequate basis for long-term research and monitoring, and whether the research and monitoring plan adequately addresses gaps in the knowledge base and existing uncertainties. The committee will also address broader issues related to overall effectiveness of the Trustee Council's program and plan for guiding continued efforts to understand biological change in the Gulf of Alaska.

The committee conveys its guidance in the form of reports. It has produced two reports so far, a letter report in November 2000 and a short interim report in February 2001. Once the draft Research and Monitoring Plan is available, the committee will provide a final report containing more comprehensive comments and recommendations to guide the Trustee Council and the public in decision-making about the design and implementation of a long-term research and monitoring strategy for Prince William Sound and the northern Gulf of Alaska.

B. Methods

This study is being conducted by a multidisciplinary committee of 12 members, who are experts in a variety of relevant fields such as ecology, biological oceanography, fisheries biology, intertidal communities, marine mammal biology, ornithology, population dynamics, environmental assessment, cold water oil spill chemistry and impacts, environmental restoration, and long-term research and monitoring. Committee members serve as volunteers, receiving only reimbursement for travel and direct expenses. The committee was selected by the Academy to bring disciplinary expertise and a diversity of experience and perspectives; no members will have ties to parties involved in related litigation. All members will be subject to standard NRC procedures regarding bias and conflict of interest. The committee conducts its work at meetings and via email and conference calls.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Not applicable.

SCHEDULE

A. Measurable Project Tasks

FY 2000 (October 1, 1999 – September 30, 2000)

November 1999:	Funds awarded. Informed that availability of GEM plan would be delayed until spring 2000.
January – March 2000:	Committee selection process (nominations, investigate suitability, interviews).
April 2000:	Committee slate announced and posted for public comment period. Draft Science Program conveyed to committee.
June 15-17 2000:	First meeting: orientation and introductory briefings. Public sessions. Plan study strategy. Anchorage, AK
October 5-7 2000:	Second meeting: continued information-gathering activities, deliberations. Anchorage, AK
November 2000:	Delivered letter report

FY 2001(October 1, 2000 – September 31, 2001)

December 7-8, 2000:	Third meeting: deliberations, conclusions & recommendations; finalized interim report. Washington DC
Dec - Feb 2000/01:	Interim report to outside review; response to review; Academy approval process.
February 2001:	Interim report delivered
April 2001:	Committee chair and one member to Trustee Council meeting to discuss Interim Report.
June 14-15, 2001:	Expect delivery of draft Science Plan: June 1 If on

	schedule, committee will hold its fourth meeting to begin deliberations.
Sept - Oct 2001:	Fifth Meeting: report-writing workshop; finalize conclusions and recommendations.

FY 2002 (October 1, 2001 – January 31, 2002)

Fall 2001	Sixth meeting: editorial subgroup to work on final report, either before or after outside review as needed.
Oct - Nov 2001:	Report prepared for Academy outside review process. Review occurs.
December 2001:	Response to review
January 2002:	Final revisions; Academy approval process
January 2002:	Report delivery (prepublication copies) with dissemination activities as needed.
March 2002:	Published volume available.

B. Project Milestones and Endpoints

See schedule, above.

C. Completion Date

The committee's final report will be delivered to the Trustee Council and released to the public in late 2001 (if possible) or January 2002 (more likely), based on the committee receiving the draft Science Plan on June 1, 2001. Delays may result if the draft is provided off-schedule. It was agreed that the delivery of the interim report in February 2001 was in lieu of the required April 15, 2001 annual report. The delivery of the final published report will be in lieu of the required April 15, 2002 annual report.

PUBLICATIONS AND REPORTS

According to standard Academy operating procedures, no drafts or portions of the report will be conveyed; the final report will be submitted after it has completed the full Academy review process. Reports resulting from this effort shall be prepared in sufficient quantity to ensure their distribution to the sponsor and to other relevant parties in accordance with Academy policy. Reports will be made available to the public without restrictions.

PROFESSIONAL CONFERENCES

This proposal contains a request for travel funds for the committee chair (or a delegated committee member) and study director to attend the annual Restoration Workshops.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project will help the Trustee Council in its efforts to synthesize the lessons learned from the extensive research efforts conducted to date, and apply those lessons to the draft science plan.

PROPOSED PRINCIPAL INVESTIGATOR

This study is being conducted by a volunteer committee composed of scientists with expertise in ecology, biological oceanography, fisheries biology, intertidal communities, marine mammal biology, ornithology, population dynamics, environmental assessment, cold water oil spill chemistry and impacts, environmental restoration, and long-term research and monitoring. The committee will be put together using standard NRC procedures to identify and select candidates. Final selection of members remains the responsibility of the Executive Office of the National Research Council.

The staff officer responsible for the activity will be:

Chris Elfring, Director
Polar Research Board (HA 454)
National Research Council
National Academy of Sciences, National Academy of Engineering
2101 Constitution Avenue NW
Washington, DC 20418
202-334-3426
202-334-1477
celfring@nas.edu

Additional staffing will be provided by:

David Policansky, Associate Director
Board on Environmental Science & Toxicology
National Research Council
National Academy of Sciences, National Academy of Engineering
2101 Constitution Avenue NW
Washington, DC 20418

OTHER KEY PERSONNEL

This activity will be conducted by a committee of experts appointed specifically for the described tasks, following normal Academy procedures. These committee members are responsible for the substantive content of their advice. Oversight for the study will be provided by the Polar Research Board and all other regular levels of Academy oversight.

OTHER RELEVANT INFORMATION

FEDERAL ADVISORY COMMITTEE ACT (FACA)

The Academy has developed interim policies and procedures to implement Section 15 of the Federal Advisory Committee Act, 5 U.S.C. App. § 15. Section 15 includes certain requirements regarding public access and conflicts of interest that are applicable to agreements under which the Academy, using a committee, provides advice or recommendations to a Federal agency. In accordance with Section 15 of FACA, the Academy shall submit to the government sponsor(s) following delivery of each applicable report a certification that the policies and procedures of the Academy that implement Section 15 of FACA have been substantially complied with in the performance of the contract/grant/cooperative agreement with respect to the applicable report.

Public Information About the Project:

In order to afford the public greater knowledge of Academy activities and an opportunity to provide comments on those activities, the Academy may post on its website (http://www.national-academies.org) the following information as appropriate under its procedures: (1) notices of meetings open to the public; (2) brief descriptions of projects; (3) committee appointments, if any (including biographies of committee members); (4) report information; and (5) any other pertinent information.

The NRC will maintain a public access file containing copies of materials and data made available to the committee, so these are available to the public. Limited, selected materials such as drafts of their report and personal financial disclosure forms are not made public.

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2000 EXXON VALDEZ TRU : COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002						
Personnel	$89,621.0	$30,543						
Travel	$102,586.0	$7,948						
Contractual	$16,744.0	$16,086						
Commodities	$1,200.0	$100						
Equipment	$0.0	$0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$210,151.0	$54,677				Estimated FY 2003		
Indirect	$105,829.0	$29,559						
Project Total	$315,980.0	$84,236				$0		
Full-time Equivalents (FTE)	0.9	0.6						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:
Under contractural please note that we have included copying, technology, postage, phone charges, and meeting expenses. These are NOT necessarily contracted out.
Office supplies have been included under commodities.
Dissemination costs are included for the interim report which includes an editor, copies and postage.

NOTE: Due to change in project timeline, there will be a carryover of from FY01 to FY02.

FY02

Prepared: 4/2/2001

Project Number: ~~00~~02360
Project Title: Exxon Valdez Oil Spill Study
Name: The National Academies/Polar Research Board

FORM 4A
Non-Trustee
SUMMARY

2000 EXXON VALDEZ TRU : COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2001
	Chris Elfring	Director, PRB	5.0	1983.4		9,917.0
	David Policansky	Sr. Staff Officer, BEST	5.0	906.6		4,533.0
	Robert Greenway	Project Assistant	5.0	1076.2		5,381.0
	Toni Greenleaf	Administrative Associate	5.0	174.6		873.0
		Salary Adjustments for above				911.0
		Fringe Benefits for above @ 26.50%				5,728.0
						0.0
	Editor/TBD	Editor (10 days)	0.0			3,200.0
						0.0
						0.0
						0.0
		Subtotal	20.0	4140.8	0.0	
					Personnel Total	$30,543.0

Travel Costs:			Ticket	Round	Total	Daily	Proposed
	Description		Price	Trips	Days	Per Diem	FY 2001
	Anchorage	Workshop in Winter 2001 (2 committee/2staff)	1000.0	4	20	140.0	6,800.0
			0.0	0	0	0.0	0.0
	TBD	Chair and Staff to discuss strategy for the committee					0.0
		report (Domestic rates negotiated	1148.0	1			1,148.0
		with ONR/combine air and per diem)					0.0
							0.0
							0.0
							0.0
							0.0
						Travel Total	$7,948.0

FY02

Project Number: 00360
Project Title: Exxon Valdez Oil Spill Study
Name: The National Academies/Polar Research Board

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 4/2/2001

2000 EXXON VALDEZ TRU : COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Contractual Costs:	Proposed FY 2001
Description	
Photocopies	709.0
Postage/Delivery	740.0
Technology/Communications	2,042.0
Report (Final)	12,595.0
Contractual Total	$16,086.0

Commodities Costs:	Proposed FY 2001
Description	
Office Supplies	100.0
Commodities Total	$100.0

FY02

Prepared: 4/2/2001

Project Number: 00360
Project Title: Exxon Valdez Oil Spill Study
Name: The National Academies/Polar Research Board

FORM 4B
Contractual & Commodities DETAIL

2000 EXXON VALDEZ TRU : COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2001
			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	

FY02

Project Number: 00360
Project Title: Exxon Valdez Oil Spill Study
Name: The National Academies/Polar Research Board

FORM 4B
Equipment
DETAIL

Prepared: 4/2/2001

Planning for Long-Term Monitoring in the Nearshore: Designing Studies to Detect Change and Assess Cause

Project Number:	02395
Restoration Category:	Research
Proposer:	Coastal Resources Associates, Inc. NOAA Auke Bay Laboratory U.S. Geological Survey - Alaska Biological Science Center Simon Fraser University Western EcoSystems Technologies
Lead Trustee Agency:	DOI--USGS
Cooperating Agencies:	NOAA
Alaska SeaLife Center:	No
Duration:	1st year, 2-year project
Cost FY 02:	$91.3K
Cost FY 03:	$0
Geographic Area:	Gulf of Alaska
Injured Resource/Service:	Intertidal communities, sea otters, harlequin ducks

ABSTRACT

The goal of this proposal is to produce a draft nearshore monitoring plan that provides a framework for future monitoring that is practical, sensitive, and cost-effective. The process we will use to create this plan will be to formulate hypotheses with respect to potential changes to the nearshore environment, identify questions that must be answered before a design can be developed to address these hypotheses, answer design questions by analyzing existing data or conducting directed field studies, and conduct cost-benefit analyses to identify the most powerful design within funding constraints. The final product will be a draft plan for nearshore monitoring that can be incorporated into the Gulf Ecosystem Monitoring (GEM) plan. Workshops will be held during the course of plan development to seek input from the Trustee Council and stakeholders.

INTRODUCTION

The Gulf Ecosystem Monitoring (GEM) program has five major programmatic goals:

DETECT: Serve as a sentinel (early warning) system by detecting annual and long-term changes in the marine ecosystem, from coastal watersheds to the central gulf;

UNDERSTAND: Identify causes of change in the marine ecosystem, including natural variation, human influences, and their interaction;

PREDICT: Develop the capacity to predict the status and trends of natural resources for use by resource managers and consumers;

INFORM: Provide integrated and synthesized information to the public, resource managers, industry and policy-makers in order for them to respond to changes in natural resources; and

SOLVE: Develop tools, technologies, and information that can help resource managers and regulators improve management of marine resources and address problems that may arise from human activities.

The goal of our proposed study is to develop and refine a design for monitoring the nearshore habitat as part of a future GEM program. It is NOT our intent to initiate such a monitoring program, but rather to identify and answer remaining questions about nearshore systems necessary to develop a cost-effective and sensitive nearshore monitoring program. Planning a 100 -year long-term monitoring effort is no trivial task, and advanced planning will help insure that the program gets started on a path that will persist (and no doubt evolve) over the next century and will provide meaningful insights into the Gulf of Alaska (GOA) ecosystem.

We will design a nearshore monitoring program appropriate for detecting changes that may occur within the nearshore system, with emphasis on intertidal communities. The nearshore is explicitly considered as a part of the Draft GEM program presented by the Trustee Council and is a necessary and useful component of any marine monitoring program within the GOA because:

- It is a unique "triple interface" between air, land, and sea (Peterson 2000) and provides an important link between these systems.
- It is particularly vulnerable to a variety of anthropogenic disturbances on a scale ranging from global climate change (e.g., Barry *et al.* 1995; Sagarin *et al.* 1999) to localized effects of shoreline development (Short and Wyllie-Echeverria 1996).
- Communities in the nearshore are appropriate for cost-effective study because they are accessible, many of the organisms are sessile or of limited mobility, and there is a well-developed understanding of ecological processes that occur there, allowing development of testable hypotheses.

While much of the focus of the draft plan will likely be on the animals and plants that live in the intertidal zone, we will also consider incorporating components of the nearshore subtidal zone for monitoring, as well as larger mobile predators such as sea otters (*Enhydra lutris*) and harlequin ducks (*Histrionicus histrionicus*). These species are nearshore predators that rely upon intertidal and subtidal resources, are widely distributed throughout the northern GOA, have

proven to be important sentinels of the health of nearshore systems, and have a history of ecological research in the GOA that facilitates definition of hypotheses and interpretation of data (Esler *et al.* 2000, Monson *et al.* 2000).

The final product of this study will be a draft plan that can be used as a framework for a cost-effective nearshore component of the more broadly-scoped GEM program. The process we will use to develop this plan will be to identify hypotheses with respect to natural and anthropogenic sources of variation in the nearshore, identify metrics that may be sensitive and powerful tools for addressing these hypotheses, identify specific design questions, address these questions by analyzing existing data or conducting limited field studies, and conduct cost-benefit analyses.

Analyses of data from past Coastal Habitat Studies (Highsmith *et al.* 1996, Hooten and Highsmith 1996, Stekoll *et al.* 1996, Sundberg *et al.* 1996, van Tamlen and Stekoll 1996) and studies conducted by NOAA hazmat (Driskell *et al.* 1996, Ebert and Lees 1996, Houghton *et al.* 1996) that address design issues relating to the specific question of assessing oil spill impacts are currently underway (T.A. Dean and L.L. McDonald, in preparation). While these studies will assist in directing a future monitoring program, questions remain with respect to the design of a more broadly focused GEM monitoring effort that should detect change on a variety of temporal and spatial scales.

The process of refining a draft nearshore monitoring plan will be an interactive one in which the Trustee Council, peer reviewers, and stake holders will have input. We will hold a series of informal workshops conducted at critical stages during the process. As part of the process, we will also identify potential cooperative or interactive agreements with other agencies with existing nearshore monitoring programs (e.g., NOAA National Status and Trends, Prince William Sound and Cook Inlet RCAC) to leverage any work that may eventually be sponsored by the Trustees.

The design of any monitoring program depends in part on the specific objectives of the plan and the funding available. Determining the scope of future nearshore monitoring effort is clearly the responsibility of the Trustee Council. However, in order to provide some bounds for development of a draft design, we have assumed that approximately 10 to 20% of GEM funding will be directed toward monitoring in the nearshore zone.

As a starting point for this process, we developed an initial concept presented as a preliminary nearshore monitoring plan (Appendix A). In brief, the objective of the draft plan is to detect changes within the nearshore system in the GOA and to assign cause to these changes. The focus of the draft plan is on intertidal communities, representative subtidal species, and selected nearshore vertebrate predators. Hypotheses regarding nearshore community response to change will be developed and sampling plans will be designed to test these hypotheses. Our initial concept includes sampling at a series of approximately 10 to 20 sites along the GOA coast between Sitka and Kodiak. Sampling would be conducted within a restricted number of habitat types that are representative of the region or perhaps unique to the region, sensitive to change, and tractable to sample. At each site representative nearshore intertidal and subtidal species would be enumerated. The focus would be on numerically dominant, keystone , sentinel,

indicator or strongly interacting species. At these same sites, the concentrations of potential toxicants (e.g. persistent organic pollutants) in sediments and in the tissue of mussels would be measured. Also, the abundance, and possibly other metrics (e.g., Cytochrome P450 1A levels, age/sex ratios, etc.) of representative nearshore vertebrate predator species (e.g. fishes, sea otters, or harlequin ducks) would be measured at each site. At a subset of these sites that span the geographic range, more intensive monitoring would be done to detect larger-scale changes that may result from climate change or other large-scale events and to elucidate relationships among measured metrics. Included in our initial concept of nearshore monitoring is more intensive sampling at a subset of sites which may include more detailed demographic measures for selected species. The latter will be used to provide an early warning system for detecting change in latitudinal distributions of species and helping to describe processes by which those changes may occur. We present this preliminary draft plan as a logical starting point, based on our experience working in nearshore environments, and recognize that the final plan resulting from this proposed work may or may not resemble this initial concept.

NEED FOR THE PROJECT

A. Statement of Problem

A draft Gulf Ecosystem Monitoring (GEM) program has been developed that will likely serve as a blueprint for future GOA monitoring sponsored by the Trustee Council. The draft GEM program recognizes the value of the nearshore and specifically identifies the need for monitoring this portion of the GOA system. However, few specifics are given as to which parts of the nearshore are to be monitored or how the monitoring will be conducted. As with the development of any program of this scope, the devil is often in the detail, and the success of a nearshore monitoring program will depend on careful planning. This project will provide a framework from which a successful plan can be developed and implemented. It is NOT our intent to initiate such a monitoring program during the life of this project.

B. Rationale/Link to Restoration

The future GEM program will provide a long-term legacy of the EVOS restoration effort. This will assist managers in making reasoned decisions that will lead to long-term efforts to restore and preserve injured resources. Foremost among those injured resources are those in the nearshore zone that this proposal addresses.

C. Location

The final report will be a draft plan for nearshore monitoring to be conducted throughout the Gulf of Alaska

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Community representatives and native villagers will be asked to review the nearshore monitoring program and to participate in workshops.

PROJECT DESIGN

A. Objectives

The objective of the proposed study is to produce a draft nearshore monitoring plan that provides a conceptual framework for cost-effective monitoring of nearshore habitats and the resources that they support.

B. Methods

Overview of the process

The draft plan for nearshore monitoring in GEM will be developed through a series of steps as follows:

1. Develop a preliminary draft plan that identifies hypotheses with respect to potential changes in the nearshore realm, identifies predictive models which are in need of nearshore data, identifies decisions that must be made in designing studies to test these hypotheses, and makes preliminary design decisions based on existing analyses.
2. Identify remaining design questions.
3. Conduct a workshop to present the preliminary draft and plans for addressing remaining questions to the Trustee Council for review. Revise the plan as appropriate.
4. Where possible, address design questions through additional analyses of existing data.
5. Propose directed, limited field studies to answer design questions that cannot be addressed through analysis of existing data.
6. Refine the draft nearshore monitoring plan and list alternatives that provide a viable means of detecting change and addressing hypotheses.
7. Conduct cost-benefit analyses to select among remaining viable alternatives.
8. Conduct a workshop and present the revised draft plan to the Trustee Council and stake holders for review.
9. Finalize the draft plan, including documentation of how design decisions were made and the final plan was derived.

We will seek input from the EVOS Trustee Council and others at critical stages of the design development (Table 1). First, we will develop a preliminary draft plan and make a tentative list of recommendations, a list of remaining questions, and recommendations for future analyses. These will be presented to the Trustee Council and peer reviewers at a workshop to be held in January 2001 in conjunction with the annual EVOS Trustee meetings. The plan and a list of tasks to be conducted to address remaining questions will be revised, additional analyses and fieldwork will be conducted, and a revised plan will be presented to the Trustee Council and to stakeholders for public review.

As indicated above, an initial step in the process of developing a draft plan will be to identify remaining design-related questions, and we anticipate that additional analyses and some directed field efforts will be needed to address these questions. For example, power analyses will likely be conducted to determine the sampling effort required to detect a given level of change and additional sampling will likely be required to provide estimates of spatial variation to be used in these analyses. However, specifics as to what kind of analyses and additional field sampling will be required cannot be determined until after the initial design phase is completed. For budgetary purposes, we have estimated the level of effort that will likely be required to do the necessary analysis and sampling. However, specific tasks will only be determined after these questions regarding remaining design issues are identified, and the allocation of effort between analytical and field sampling effort may change as a result.

There has been a substantial sampling effort in the nearshore in Prince William Sound over the past several years, and some sampling in the nearshore habitat was done in the Kenai Peninsula and Kodiak regions as part of the Trustee-sponsored CHIA sampling program. Data from these studies will be used to guide future efforts. However, we have relatively little understanding of the normal range in variation within the nearshore from elsewhere in the Gulf of Alaska. Thus, we anticipate that sampling may be required to provide estimates of spatial variation within these areas. Furthermore, because determination of power is specific to a given sampling design, existing data from Prince William Sound or elsewhere may not be adequate to address all remaining design-related questions. Therefore, in spite of the large stockpile of historical data from Prince William Sound, some additional directed sampling within this region may be required. However, we do not propose additional field work at this time.

Example of the process

The process of developing a monitoring plan will begin by identifying hypotheses regarding changes that may potentially occur in the nearshore zone (Table 2) and by making a list of design-related issues that need to be considered (Table 3). Based on these, a list of potential monitoring options will be made, criteria for evaluation of the options will be developed, and a preliminary evaluation made. For example, in our preliminary draft plan (Appendix A) we recognize that, in order to be cost-effective, a nearshore program will not be able to sample all existing habitats, but will need to focus on representative ones. We have listed the habitats (Table 4) and developed criteria for selection. The criteria include: the distribution of these habitats (whether they occur throughout the GOA and are relatively common), how important they are as resources, how vulnerable they may be to disturbance, and how tractable sampling would be within the habitat. Based on these criteria, high- energy beaches and exposed rocky shores were excluded from further consideration. A list of questions regarding unanswered issues with respect to habitats was then made and means of addressing these questions identified (Table 5).

This process will be repeated for each of the design issues identified and the draft plan will be revised accordingly. The plan will then be presented to the Trustee Council and peer reviewers, and revised again.

The next step in the process will be to examine existing data or to conduct field studies to address unresolved design issues. We anticipate that most questions can be answered by examining existing data sources. However, it is likely that there will be issues, especially in relation to between-site variability, that will require limited field sampling. With respect to the example for habitat selection outlined above, remaining questions can be addressed by reviewing existing habitat sensitivity index maps for each region and determining the extent to which a given habitat might occur within each GOA region. Based on these new analyses, a modified list of habitats will be made.

It is anticipated that the selection of a final design will depend, in large part, on a cost-benefit analysis. It is likely that there will be insufficient funds to evaluate all of the remaining options, and there will need to be decisions made with respect to the final plan based on costs. The first step in the cost-benefit analysis will be to estimate the cost to sample each metric at a particular site at a given time. We expect that our analyses of existing data will allow us to determine the sampling effort required to obtain a reasonable estimate for each metric within a particular habitat at a site, and that the final cost decisions will rest primarily on which metrics are measured, which habitats are sampled, how many sites are sampled per habitat, and the frequency of sampling. A cost matrix will be developed that will allow us to do 'what if" analyses so that we can evaluate the effect of manipulations in the design to the overall program cost, and evaluate the impact of various trade offs in the design on cost and program effectiveness (e.g., power and sensitivity). For example, we might determine that comparable reductions in cost could be obtained by eliminating surveys of sea otter abundance or by reducing the frequency of sampling of hydrocarbons in mussel tissue from once every other year to once every third year. An evaluation would then need to be made as to the overall value of sea otter abundance *vs.* more frequent tissue hydrocarbon analysis with respect to tests of overall hypotheses regarding change in the nearshore system. It is likely that many of these decisions will be difficult ones and will require reliance on professional judgment as well as hard data. However, the process will allow an objective evaluation of alternatives, will provide documentation of how decisions were made, and will allow easy modifications of decisions as necessary.

The initial cost-benefit analyses will be conducted by the project team and the results presented to the Trustee Council members and stakeholders for review. A plan will be revised based on these reviews and a final plan will be written and presented to the Trustee Council.

The project will be conducted by a team of scientists who have been directly involved in the studies of the nearshore system in Prince William Sound since 1989. The work will be administered jointly by the NOAA Auke Bay Laboratory and by the Biological Resources Division of the U.S. Geological Survey. Thomas Dean, President of Coastal Resources Associates, Inc. will serve as project coordinator. Thomas Dean and Charles O'Clair of the Auke Bay Laboratory will be responsible for invertebrate, algal, and eelgrass portions of the plan. Jeff Short of the Auke Bay Laboratory will be responsible for contaminant and physical/chemical aspects. Jim Bodkin of the USGS and Dan Esler of Simon Fraser University will be responsible for consideration of nearshore vertebrate predators (nearshore marine mammals and sea birds). Lyman McDonald will provide statistical advice.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

This proposal is being submitted by NOAA and USGS, who will fund contracts to Coastal Resources Associates, Inc.,Western EcoSystems Technologies, Inc., and Simon Fraser University.

SCHEDULE

A. Measurable Project Tasks for FY 02 (October 1, 2001 - September 30, 2002)

Measurable tasks for FY-02 include:

- Presentation of the preliminary plan to the Trustee Council and reviewers in a January 2002 workshop
- Completion of additional data analysis

B. Project Milestones and Endpoints

Milestones for the project are as follows:

October 1, 2001	Obtain Funding
January 1, 2002	Complete preliminary plan
January 20, 2002	Present preliminary plan to Trustee Council for review
March 31, 2002	Complete revision of plan and define additional analysis and fieldwork required
August 31, 2002	Complete additional data analysis
October 31, 2002	Complete cost-benefit analysis
November 30, 2002	Conduct workshop to present revised plan to the Trustee Council and stakeholders
February 28, 2003	Present final plan to the Trustee Council
March 31, 2003	Submit a manuscript on plan development for review

C. Completion Date

It is anticipated that the project will be completed by April 2003.

PUBLICATIONS AND REPORTS

A final report will be presented to the Trustee Council that outlines the plan for monitoring of nearshore resources as part of GEM.

A manuscript will be prepared entitled "Developing a 100-year monitoring plan for nearshore habitats in coastal Alaska: Processes and decisions." T. A. Dean, J. Bodkin, D. Esler, M.

Lindeberg, L. McDonald, J. Short, and S. Rice are anticipated authors. It is intended that this manuscript will be submitted for publication to the Journal of Environmental Management or to Ecological Applications.

PROFESSIONAL CONFERENCES

No funding is being requested for attendance at professional conferences in FY02.

NORMAL AGENCY MANAGEMENT

The work proposed here is not part of normal agency management and is related specifically to addressing EVOSTC restoration concerns. No similar work has been conducted, is currently being conducted, or is planned using agency funds.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Under the coordination and integration of restoration effort section, the proposed work relies on analysis of data collected across a number of EVOSTC-funded studies and will require integration and coordination as other potential aspects of the GEM plan are conceived. As described in the introduction, this research relies on incorporation of data from other Trustee sponsored research, including the CHIA, NOAA-HAZMAT and NVP studies. Proposed efforts include use of the results of those studies to aid decisions in designing a cost-effective, sustainable, nearshore monitoring plan. We do not anticipate purchasing equipment under this project and will likely use equipment purchased previously under those EVOSTC projects identified above. Proposed research and data collection and analysis, where necessary, will follow previously established protocols and standards.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

None

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BIOGRAPHICAL SKETCHES FOR PRINCIPAL INVESTIGATORS

Dr. Thomas A. Dean, Ph. D. University of Delaware, is President of the ecological consulting firm Coastal Resources Associates, Inc. (CRA) in Vista, CA. Dr. Dean has over 20 years of experience in the study of nearshore ecosystems, and has authored over 30 publications, including several dealing with impacts of the *Exxon Valdez* oil spill on nearshore plants and animals. He has extensive experience in long-term monitoring studies, and has played a major role in both intertidal and subtidal EVOS investigations since 1989.

Dr. Lyman McDonald, B.S., M.S. Oklahoma State University, Ph.D. Colorado State University, is a Biometrician with 30 years of comprehensive experience in the application of statistical methods to design, conduct, and analyze environmental and laboratory studies. He has designed and managed both large and small environmental impact assessment and monitoring programs.

James L. Bodkin, Research Wildlife Biologist, and team leader for coastal ecosystem research in Alaska for the Alaska Biological Science Center of USGS, Biological Resources Division. He has over 30 peer-reviewed scientific publications and directs an active coastal marine research program. He has studied and published on sea otter foraging ecology and community structuring since 1988 and has been principal investigator for sea otter survey methods development. He is currently a co-principal investigator for the Nearshore Predator Project (NVP), and is examining the recovery of sea otters.

Dan Esler is a University Research Associate with Simon Fraser University in British Columbia. He has conducted waterfowl research in arctic and subarctic regions of Alaska and Russia for the past 12 years. Since 1995 he has served as project leader for harlequin duck studies as part of the EVOSTC-sponsored Nearshore Vertebrate Predator project. He earned a M.S. from Texas A&M University in 1988 and a Ph.D. from Oregon State University in 2000. He has authored over 20 peer-reviewed journal publications and numerous reports and presentations addressing research and issues in waterbird conservation.

Jeffrey W. Short, B.S. in Biochemistry & Philosophy, M.S. Physical Chemistry from the University of California, Santa Cruz. He has established and managed the hydrocarbon facility at Auke Bay Laboratory since 1989 and has been a principal investigator of EVOS research including the analysis of PAH in seawater, the EVTHD database, and the role of pristane in PWS.

Mandy R. Lindeberg, has been involved in *Exxon Valdez* oil spill research for the last 10 years. Her research includes intensive studies on intertidal invertebrates and seaweeds, mussel populations, and currently she is a co-principal investigator of spot shrimp populations in Prince William Sound. Her responsibilities include quality control of field and laboratory sample processing, data analysis, graphics, and proposal and report preparation.

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Table 1. Flow diagram indicating the process of determining design elements through an interactive and iterative approach.

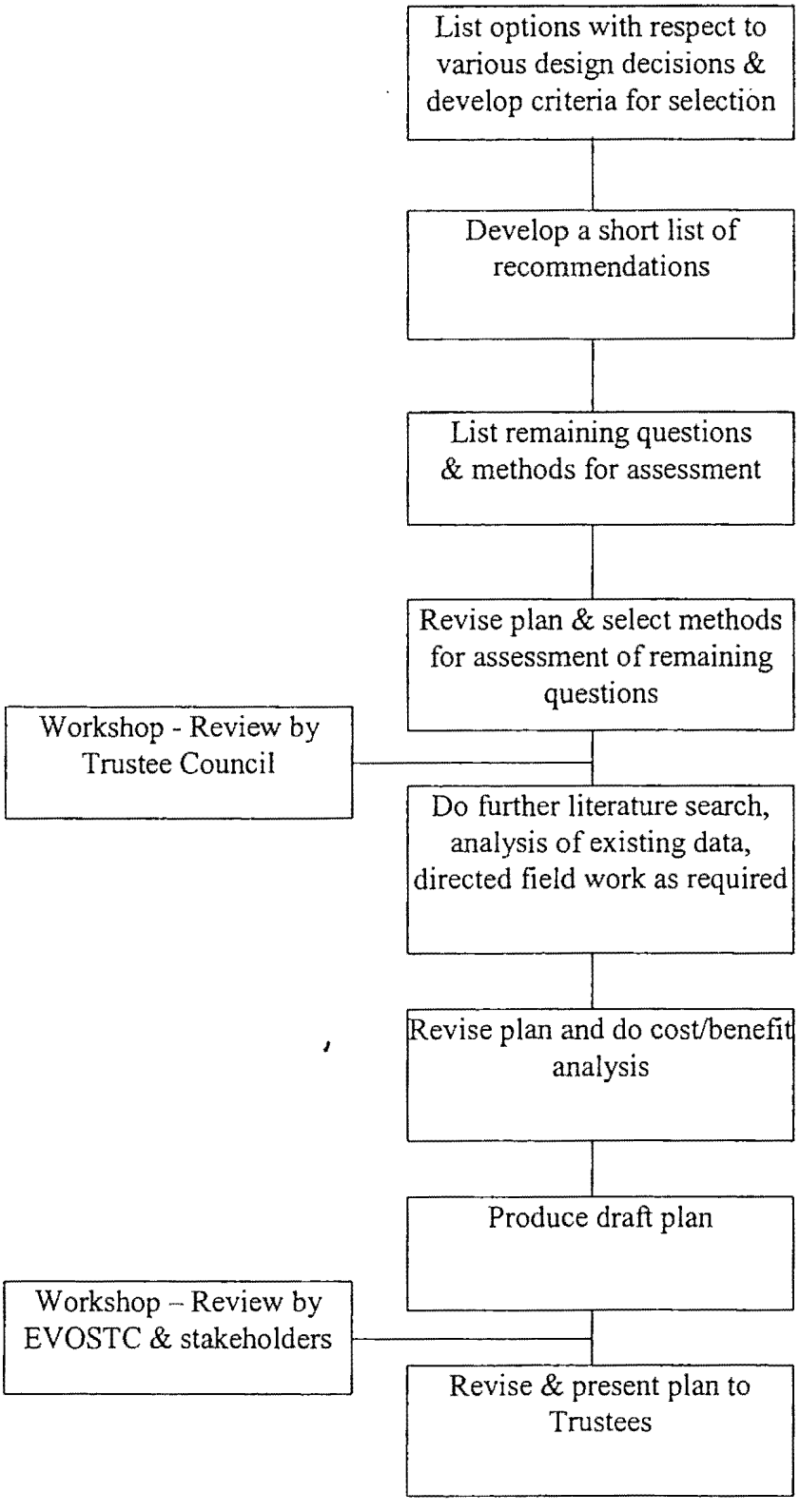

Table 2. Examples of hypotheses for change in nearshore ecosystems in the Gulf of Alaska.

Potential Perturbation	Hypothesized Effects
Anthropogenic	
Climate change (warming)	• Poleward shift in species distribution • Increase in abundance of more southerly distributed species • Increase in frequency of recruitment for more southerly species • Increase in eelgrass production • Decrease in macroalgal production due to UV increase
Introduction of persistent organic pollutants	• Increased toxicant loads in target species • Decreased growth, survival, reproduction in some (especially higher order vertebrate) species
Logging activities	• Reduction in abundance of species, especially those sensitive to increased sedimentation, bark deposition, and organic-enrichment • Distributional or demographic response by birds and mammals
Harbor construction	• Reduction in eelgrass and other species sensitive to increased sedimentation • Increased toxicant (TPAH) in sediments & animals • Reduced abundance of birds & mammals
Increased tourism and recreational use	• Reduction in abundance of intertidal species from increased foot traffic • Distributional response by birds & mammals; potential demographic response
Natural	
PDO cycle (18.6 year sol-lunar cycles)	• Temporary (decade long) poleward or equatorial shift in species distribution associated with maximum/minimums in the temperature cycle • Temporary (decade long) increase in frequency of recruitment during warming for more southerly species

	associated with peaks in the temperature cycle • Associated variation in vertebrate abundance/demography
El Nino /La Nina	• Temporary (one to two year) poleward shift in species distribution in warm years, especially among mobile forms like fishes. • Temporary (one to two year) increase in frequency of recruitment for more southerly species in warm years. • Short-term changes in vertebrate demography
Earthquakes	• Local reduction in intertidal species in uplift areas • Reductions in invertebrate-eating birds and mammals

Table 3. Primary categories of design related questions for nearshore monitoring.

Category	Examples of Design Related Questions
Habitat	Which habitat (e.g., sheltered shorelines with mixed cobble-gravel substratum, exposed rocky shores, tidal mud flats, eelgrass beds) are to be sampled?
Site	How many sites are to be sampled, how are they to be distributed, how are sites selected?
Frequency of Sampling	How frequently are different sites or metrics at each site to be sampled?
Metrics	What physical attributes (e.g., temperature, salinity), target species, biological attributes (e.g., diversity, number of species, population density of dominant taxa, P450 expression in individual species) are to be measured at each site?
Specific Collection Methods	What specific methods are to be used to sample a given metric at each site (e.g., for mussel density, how many quadrats and how large a quadrat are to be sampled at each site. How are they to be distributed and selected?)

Table 4. Example of preliminary selection of habitats to be sampled.

Habitat	Distribution	Importance	Vulnerability	Sensitivity	Tractability
Sheltered rocky shores	Widely distributed except from Cape Spencer to PWS & along outer Kenai	Important as habitat	Very - generally in areas of likely disturbance from development	Moderately - changes expected due to climate change	Very – many are easily accessed and relatively inexpensive to sample
Exposed rocky shores	Somewhat restricted to outer coasts of PWS, Kodiak, & SE Alaska	Important as habitat	Moderately - vulnerable to development activities	Moderately – change expected due to climate change	Not very – sites are inaccessible & difficult to sample
Sheltered mixed or soft substrate	Widely distributed in Kodiak, PWS, Cook Inlet, & parts of SE. Rare from PWS to Cape Spencer	Important	Very vulnerable – in areas of likely developments & in areas where toxicants are likely to persist	Very sensitive. Easily disturbed habitats	Very – many accessible by road. Sampling somewhat more costly than sheltered rocky
Exposed sand beaches	Restricted to outer coasts from SE Alaska to PWS	Of less importance	Relatively invulnerable	Not sensitive	Not very – Sites are largely inaccessible
Subtidal rocky (kelp beds)	Widely distributed, especially in SE Alaska, PWS, Lower Cook Inlet, & Kodiak	Important	Moderately vulnerable	Moderately sensitive	Accessible – but may require diving
Subtidal soft (eelgrass beds)	Widely distributed in sheltered locations	Very important as habitat	Very vulnerable – in areas of likely development	Sensitive to change	Accessible – but may require diving

Table 5. Questions regarding selection of habitats for sampling and methods for answering these.

Question	How to Address
• What habitats are prevalent in the GOA?	Review environmental sensitivity index maps for each region. Discuss with local experts.
• Are there cost-effective means of assessment, especially in subtidal habitats?	Review methods for remote sensing or other cost-effective means of obtaining data.
• Are there historical data of changes within the habitat in question?	Literature review of existing data.
• What is the extent of variation between sites in different portions of GOA?	Literature review and preliminary sampling of selected metrics within the habitat in question, especially at the geographic extremes (Kodiak and Sitka?).

Appendix A.

Long-Term Monitoring in Nearshore Communities:

Detecting Change and Assessing Cause
(Preliminary Draft)

14 April 2000

Long-Term Monitoring in Nearshore Communities: Detecting Change and Assessing Cause

Summary

The objectives of the nearshore portion of the GEM program are to detect changes that occur within the nearshore in the Gulf of Alaska (GOA), over various scales of time and space, and to estimate relationships between measured variables which help explain those changes. The nearshore-monitoring program will focus on sampling of selected intertidal invertebrates, nearshore subtidal species, and nearshore vertebrate predators at fixed sites within the coastal region between Kodiak and Sitka, Alaska. An explicit objective will be to examine potential interactive effects of the intertidal and nearshore subtidal resources with the larger mobile predators that utilize these resources, to test identified hypotheses concerning these relationships, and to provide data for use in predictive models. Sampling of selected metrics (e.g., the abundance of numerically dominant or keystone species in the intertidal zone, the concentrations of toxicants in the tissue of mussels, and the abundance of selected marine mammals and birds (e.g., sea otters and harlequin ducks) will be conducted at a series of 10 to 20 sites (or 20 to 100 sites if annual visits are not required) within selected habitats in the GOA region. Some of the sites will be located near areas of likely disturbance while others will serve as reference sites in undisturbed areas. This scale of sampling will be conducted primarily to assess moderate scale impacts that may result from human induced perturbations such as harbor development, local contamination, timber harvest, etc. More intensive sampling of the intertidal community will be conducted at a subset of the reference sites (3 to 15 in number depending on the frequency of required visits) in order to assess changes due to large scale perturbations such as global climate change and to elucidate relationships among measured metrics. Directed studies also will be conducted to assess impacts of future accidental disturbances such as an oil spill and to determine the mechanisms of change. Specific hypotheses regarding changes in the environment will be tested. The program will be integrated with existing or future nearshore sampling efforts conducted by other agencies in order to reduce costs, leverage the results, and expand the area covered by the Trustee sponsored work.

Introduction

The goals of the Gulf Ecosystem Monitoring (GEM) program are:

DETECT: Serve as a sentinel (early warning) system by detecting annual and long-term changes in the marine ecosystem, from coastal watersheds to the central gulf;

UNDERSTAND: Identify causes of change in the marine ecosystem, including natural variation, human influences, and their interaction;

PREDICT: Develop the capacity to predict the status and trends of natural resources for use by resource managers and consumers;

INFORM: Provide integrated and synthesized information to the public, resource managers, industry and policy makers in order for them to respond to changes in natural resources;

and

SOLVE: Develop tools, technologies, and information that can help resource managers and regulators improve management of marine resources and address problems that may arise from human activities.

This portion of the GEM plan will focus on the nearshore system. The nearshore community is explicitly identified and emphasized in GEM because:

1. It is a unique "triple interface" between air, land, and the sea (Peterson 2000) and provides an important link between these systems.
2. It is particularly vulnerable to a variety of anthropogenic disturbances on a scale ranging from global climate change (e.g., Barry *et al.* 1995, Sagarin *et al.* 1999) to localized effects of shoreline development (e.g., Short and Wyllie-Echeverria 1996).
3. Communities in the nearshore are relatively inexpensive to study because they are accessible and many of the organisms are sessile or of limited mobility (e.g., Lewis 1996).
4. There is a well-developed understanding of the processes that occur there allowing the development of testable hypotheses (e.g., Connell 1972, Paine 1977, 1994, Estes *et al.* 1998).
5. Unlike most pelagic systems, the components of the nearshore system have a restricted spatial scale. Therefore, nearshore systems are more useful in determining impacts from disturbances that may occur on a small to moderate spatial scale (e.g., Dayton 1971, Sousa 1979, Lewis 1996).
6. The nearshore provides habitat for a variety of economically, recreationally and culturally valuable resources, important to both Alaska coastal residents as well as residents throughout the country.

While much of the focus will be on the animals and plants that live in the intertidal zone, the plan will also examine selected aspects of the nearshore subtidal zone, and will examine potential interactive effects of the intertidal and nearshore subtidal resources with larger mobile predators that utilize these resources. The latter will include representative nearshore vertebrate predators, which have strong ties to intertidal resources. We will select vertebrate predator species such as sea otters and harlequin ducks that are widespread throughout the GOA (Bodkin *et al.* 1994, Robertson and Goudie 1999) and have proven to be important sentinels of the health of nearshore systems (Ballachey *et al.* 1999, Bodkin *et al.* 1999, Esler *et al.* 1999, Monson *et al.* 2000, Esler *et al.* 2000).

The following section lists hypotheses regarding potential change in the nearshore system that are likely to occur within the GOA over the next several decades, gives an overview of how these hypotheses are to be tested, provides a rationale for the selected design and sampling plan, gives a preliminary plan with respect to specifics of sampling, and provides an overview of how results from this plan may be analyzed and interpreted.

Hypotheses regarding changes in the nearshore

Changes in the nearshore community are likely to occur over the next several decades, and these will likely vary with respect to temporal and spatial scales. Both natural and anthropogenic perturbations are probable. For example, long-term (multi-decadal) and widespread changes in intertidal communities are likely to occur as a result of temperature fluctuations caused by

naturally occurring cycles as well as anthropogenically induced climate change. More localized and shorter term perturbations may result from events like earthquakes, shoreline development, point source pollution, or oil spills. The following reviews potential changes that may occur. These hypotheses help to focus the sampling program on strata and species, which will help predict effects of large-scale environmental changes, verify model assumptions, and provide data for predictive models.

Anthropogenically induced climate change There is now little doubt that there have been alterations in climate that result from anthropogenic activities. Those factors important to nearshore ecosystems are as follows:

1. Increase in Atmospheric CO_2 There has been an increase of about 25% in the levels of carbon dioxide in the atmosphere since the onset of the Industrial Revolution and CO_2 levels are expected to triple by the end of this century (Beardall *et al.* 1998). The increase in inorganic carbon will result in a relative increase in photosynthesis among seagrasses compared to benthic algae (Beardall *et al.* 1998, Short and Neckles 1999). Seagrass photosynthesis is limited by available inorganic carbon while macroalgal photosynthesis generally is not (Beardall *et al.* 1998).

2. Increase in Temperature The increase in CO_2 levels is expected to result in an increase in global average temperature by about 3°C by the end of this century (Beardall et. al. 1998). Effects on seawater temperature are expected from this warming. The extent of warming will likely vary depending on location and season. There has been little documented increase in sea surface temperature (Morel *et al.* 1990), but indirect evidence suggests this has occurred. There has been a reduction in ice cover at both poles (Johannessen *et al.* 1995, Overpeck 1996) and studies in nearshore benthic communities in both the Atlantic and Pacific Oceans have observed an influx of more southerly species and a reduction in northerly species associated with temperature increases (Barry *et al.* 1995, Holbrook *et al.* 1997, Southward 1967, Sagarin *et al.* 1999). There is also an expected increase in the frequency of recruitment for more southerly distributed species and a resulting shift in size-distributions toward smaller individuals (Lewis 1996). Distribution shifts in species abundance may be confounded by naturally occurring shifts in temperature (El Nino events and 18.5 year sol-lunar oscillation cycle) (Denny and Paine 1998) or by interactions among species (Davis *et al.* 1998) but are suggestive of changes that may occur due to longer-term increases in temperature.

3. Increase in UV Radiation There is strong evidence indicating a recent increase in the flux of UV-B radiation to the earth's surface due to decreasing ozone concentrations (Crutzen 1992). The effects are most notable in the Antarctic, but also occur in the Arctic. The increase in UV-B can have inhibitory effects on photosynthesis. These effects will probably be most noticeable among subtidal kelps, especially in their early life-stages that are especially susceptible to adverse effects of UV exposure (Beardall *et al.* 1998).

4. Decrease in Salinity The increase in temperature and increase in sea level will also result in a reduction in salinity in nearshore zones, and especially estuarine systems in arctic or subarctic regions that are closely linked with glaciers and larger watersheds. These reductions in salinity have not been widely discussed in the literature. However, these might be expected to have strong effects in coastal Gulf of Alaska. Generally depauperate benthic communities are noted in lower salinity portions of estuaries and communities are especially depauperate in locales where salinities fluctuate widely. Thus, salinity reduction and fluctuations may cause changes in species distributions and abundance in

coastal Alaska that rival or exceeds those changes more directly related to increases in temperature.

Based on the expected changes in the physical environment and the changes observed elsewhere, we hypothesize that the following changes will occur within the nearshore community in response to climate change.

1. A poleward shift in species ranges with an increase in the occurrence of more southerly species, and a reduction in more northerly species near their southern limit of distribution.
2. An increase in the abundance of species near the northern limit of their range and a reduction in abundance of more northerly ones.
3. An increase in the frequency of occurrence of recruitment for more southerly species, and a resulting shift in size distributions toward ones with proportionally more small individuals. This will be especially true for longer-lived species.
4. An increase in the photosynthesis rates for seagrasses (especially *Zostera marina*) and an increase in the relative contribution of seagrasses to nearshore primary production.
5. A reduction in nearshore kelps as a result of increased UV radiation levels.
6. A reduction in the number of species, especially within regions susceptible to increases in fresh water input. More stenohaline species are the most likely to be lost.

The intertidal species most likely to extend their ranges into the northern Gulf of Alaska are those with their northern limit in Sitka or Yakutat (Table 1). Other species with a northern distribution limit in Prince William Sound, Cook Inlet, or Kodiak would be expected to increase in abundance (Table 1) and perhaps experience a reduction in interannual variation in recruitment.

There is some evidence to suggest that these predicted changes may already be taking place. For example, Lindstrom *et al.* (1999) noted northerly range extensions for at least ten species of intertidal macroalgae in Prince William Sound based on collections made between 1990 and 1996. Furthermore, the largest number of species were observed in the warmest year (1993) when several more southerly distributed species flourished. Also, there is evidence for more frequent recruitment in populations of the intertidal limpet, *Tectura persona*. Limpet populations had proportionally more small individuals in 1991 through 1993 (Hooten and Highsmith, unpublished data) than in 1964 (Haven 1971) suggesting more frequent recruitment. It is possible that changes in algal species composition may be due to recently increased sampling effort, and that changes in limpet size distributions may be due to physical differences between sites sampled in 1964 and 1991 through 1993 or to interannual variation in recruitment. Furthermore, comparison of historical data (Haven 1971, Nybakken 1969) to more recent surveys (Highsmith *et al.* 1996, Houghton *et al.* 1996) do not indicate any large-scale changes in species distributions. However, these data are at least suggestive of changes that may, with further study, prove to be a biological consequence of climate change.

Effects of climate change on nearshore vertebrate predators are difficult to predict. Effects could manifest as indirect consequences resulting from changes in community structure (e.g., prey composition or abundance) or as direct effects on physiology, behavior, or habitat suitability. In turn, these may have population-level implications if they result in changes in vital demographic rates (survival and productivity). Population responses to climate change likely will vary by species based on life history and natural history characteristics (Moss 1998) and the degree of flexibility of each species for responding to change (Sutherland 1998). For example, Robertson

and Goudie (1999) speculated that global warming would affect spring run-off, which in turn might have implications for harlequin duck productivity and subsequent population dynamics. We hypothesize that climate change may affect nearshore vertebrate populations in the following ways:

1. Shifts in prey availability will result in corresponding changes in diets of bird and mammal nearshore predators, with potential effects on survival or reproduction.
2. Breeding phenology may change in response to warming trends; productivity may be either enhanced or constrained, depending on timing of reproduction in relation to optimal conditions.
3. For migratory birds, migration routes and phenology may change.
4. Breeding and wintering distributions of migratory birds may change in response to climate change; productivity and survival may be affected and changes in bird community structure may have indirect effects on some species.

El Nino, La Nina and multi-decadal oscillations in temperature Fluctuations in temperature due to El Nino or La Nina events or multi-decadal temperature shifts may also cause changes in the nearshore community. El Nino and La Nina events are short-term (generally one to two year) deviations in temperature (positive and negative respectively) that can result in short-term changes in such biological processes as algal growth and survival (Dayton *et al.* 1998, Dean and Jacobsen 1986) and fish recruitment (Cowen 1985). Multi-decadal changes in temperature (Francis *et al.* 1998, McGowan *et al.* 1998) may also cause changes to nearshore systems including increases in some nearshore fishes and reductions in shrimps (Anderson and Piatt 1999, Robards *et al.* 1999).

The predicted changes that may result from shorter term, naturally occurring increases in temperature are much the same as those predicted to result from temperature increases associated with anthropogenically induced climate change. These would include an increase in the abundance of more southerly species and an increase in the frequency of recruitment for more southerly species. The major differences in nearshore community response is that shifts in distributions or increases in recruitment caused by El Nino or multi-decadal oscillations would be more temporary (perhaps persisting for a decade or so). Furthermore, changes associated with increases in CO_2 concentrations or UV radiation that occur as the result of climate change would not be evident during El Nino events or upswings in multi-decadal temperature oscillations.

Increases in the concentration of toxic chemicals Large-scale changes in the nearshore may also result from increases in concentrations of certain toxic chemicals (Loganathan and Kannan 1991, Stromberg 1997). The GOA may be particularly susceptible to contamination originating in Asia and transported to the eastern Pacific. Changes that are likely to result because of an increase in toxic chemicals include an increase in the concentrations of toxicants in intertidal invertebrates, subsequent uptake by vertebrate predators that rely on these resources for food, and possible reductions in survival or recruitment of the predators.

Moderate scale changes due to development Anthropogenic induced changes that occur over spatial scales ranging from a bay to a region (e.g., Prince William Sound) are also likely. These include impacts associated with 1) increased human use, especially as related to development of infrastructure allowing access to remote locations, 2) harbor construction activities, 3) logging activities, and 4) increased introduction of toxic chemicals associated with shore-side development. These kinds of perturbations have historically led to a reduction in sensitive

species and a general alteration in the species abundance and distribution patterns. For example, trampling of intertidal communities from increased foot traffic is known to have a severe impact on the abundance of some intertidal algae and invertebrates (Keough and Quinn 1998, Brown and Taylor 1999, Schiel and Taylor 1999); harbor development, dredging activities, and an associated reduction in water clarity are thought to be the primary cause for a 90,000 hectare reduction in eelgrass beds worldwide between 1985 and 1995 (Short and Wyllie-Echevarria 1996); harbor construction is known to cause local increases in heavy metals and polycyclic aromatic hydrocarbons (AEC 1986, McMahon 1989); logging activities are known to affect water quality and cause a shift in benthic fauna with the elimination of many sensitive species and an increase in stress tolerant ones (Conlan and Ellis 1979, Pease 1974). Changes to community structure can result in shifts in the diet and distributions of nearshore vertebrates (e.g., Custer and Custer 1996, Wormington and Leach 1992).

Based on these changes that have been observed elsewhere we predict that development activities in the GOA will cause:

1. A reduction in sensitive species (especially some algae) in the intertidal zone as a result of physical disturbance associated with increased foot traffic or physical disturbance due to logging.
2. A reduction in eelgrass, other nearshore plants and sensitive animals, as a result of dredging activities and a general increase in sedimentation associated with shoreline development.
3. An increase in the level of toxicants in nearshore invertebrate species and an increase in exposure to toxicants among nearshore vertebrate predators.
4. An increase in plants and animals that are stress tolerant and respond positively to increased sedimentation and organic enrichment.
5. Changes in nearshore vertebrate distribution, behavior, and physiology, with subsequent effects on survival and productivity.

Introductions of exotic species Changes in the nearshore community are likely to result from the introduction of exotic species. For example, the green crab, *Carcinus maenus*, was introduced into the Pacific Northwest and has moved northward into British Columbia in recent years. Impacts of the crab on the nearshore system are likely (primarily through predation on juvenile Dungeness crabs, oysters and clams) but have not been documented to date (Cohen *et al.* 1995, Grosholz and Ruis 1995, Jamieson *et al.* 1998). The spread of this crab or other introduced species may be exacerbated by increases in temperature associated with climate change or natural cycles in temperature. Except in a few instances (e.g., the one given for the green crab above) the spread of exotic species and their potential impact on nearshore communities are difficult to predict.

Earthquakes Over the next several decades it is extremely likely that there will be changes to the nearshore in the GOA that result from uplift or subsidence due to earthquakes. This is an extremely active geologic area, and there is evidence that multiple seismic events have probably caused changes to the nearshore fauna and flora over the past several decades (Tarr 1912). The 1964 Alaska earthquake caused uplift of up to 7 m in portions of Prince William Sound, causing severe impacts on intertidal communities where uplifting occurred (Baxter 1971, Haven 1971). The earthquake caused mass mortality of almost the entire intertidal assemblage in areas of uplift that were on the order of 1 m or more (Haven 1971) and resulted in a mortality of roughly one third (11 to 41% depending on species) of the hard shell clams at 12 sites within the uplifted

portions of the sound (Baxter 1971). Future earthquakes of comparable tectonic movement, either uplift or subsidence, will likely cause comparable mortality in most intertidal organisms.

Oil spills and other accidental disturbances Accidental disturbances such as oil or other contaminant spills are likely to occur. These events are unpredictable in terms of where and when they will occur and the magnitude and duration of the perturbation.

Unpredictable and relatively undetectable events It is naive to think that we can predict all potential perturbations or even recognize them when they occur. For example, the introduction of pesticides into the nearshore system could result from future efforts to control pests such as the spruce bark beetle and this may have subsequent impacts on nearshore wildlife. Yet an increase in the concentration of pesticides cannot be detected easily without chemical sampling. We can not plan a study to detect impacts of all possible environmental perturbations, but the broad scale coverage that we propose is likely to detect most perturbations that are of regional significance.

Overview - Tests of hypotheses

This preliminary plan calls for testing the above hypotheses regarding large- and moderate-scale changes in the nearshore system by sampling a series of approximately 10 to 20 sites along the GOA coast between Sitka and Kodiak. Sampling will be conducted within a restricted number of habitat types that are representative of the region, sensitive to change, and tractable to sample. At each site, representative nearshore intertidal and subtidal species will be enumerated. The focus will be on species that are numerically dominant, keystone predators, economically important, or of subsistence value. At these same sites, the concentrations of potential toxicants in sediments and in the tissue of mussels will be measured. Also, the abundance or other metrics (e.g., cytochrome P450 1A levels, survival rates, or age and sex ratios) in representative nearshore vertebrate predator species (e.g., sea otters and harlequin ducks) may be measured. At a subset of these sites that span the geographic range, more intensive sampling will be done to detect GOA-wide changes that may occur as a result of climate change or other large-scale events. This intensive sampling will include a more thorough evaluation of species composition (perhaps within selected taxonomic groups) so that changes in latitudinal distributions of species can be detected. More directed studies will be conducted to assess change due to accidental disturbances such as oil spills. Sampling will focus on determining criteria used to select pairs of impact and reference sites in the event of a future spill or other accidental disturbance, and to help satisfy the assumption that these sites would be similar in species composition and relative abundance of species in the absence of the disturbance. Finally, process studies will be conducted as needed to determine mechanisms of change. For example, studies of metals concentrations in the tissue of predators may be required to establish a link between contamination and a reduction in the abundance of the predator.

Monitoring approaches and rationale

Use of a multi-pronged sampling approach The scales of a potential impact, both in terms of space and time, are extremely important in designing a monitoring plan. Disturbances have been classified as "pulse" or "press" (Bender *et al.* 1984) depending on whether they are a one-time event, or a continuing impact. In reality, disturbances generally occur over a broader range represented by a continuum from an event that might occur over the course of hours or days (e.g., an earthquake) to one that occurs over multiple decades (global warming). Spatial scales also vary from small (e.g., a single bay in Prince William Sound) to large (Gulf of Alaska wide). The scales of space and time of a perturbation then determine what temporal and spatial sampling

scales should be used to detect an effect.

Because it is not practical to address all potential impacts with a single design, we propose an approach that is multi-pronged and focuses on detection of changes due to (1) predictable large-scale events (e.g., climate change), (2) predictable moderate-scale events (e.g., impacts of toxins from land- based development), and (3) unpredictable events (e.g., oil spills). The plan also makes provisions for the study of mechanisms that will help to elucidate causes for observed changes. The elements of the plan are as follows:

1. Monitoring of moderate-scale (local) disturbance events Yearly (or less frequent) monitoring of 10 to 100 sites spread throughout the GOA. It is anticipated that monitoring will be initiated at fewer (on the order of 10 to 20) sites. However, if less than annual visits to sites are judged to be adequate, perhaps after the first few years, then broader spatial coverage may be possible allowing monitoring with better statistical inference to the entire GOA. Less frequent visits will also require less dependence on professional judgment for selection of study sites. These studies will focus on moderate- scale perturbations (e.g., input of toxic substances from land-based development, logging activities, harbor development). Sampling will take place at particular sites selected within an area where potential perturbations may be expected (e.g., in areas of harbor expansion) and at sites that are expected to serve as reference sites in the near future. The exact procedure for selection of study sites is yet to be developed, but when feasible, the sites will be selected by an unbiased procedure, probably systematic, from a list of potentially affected sites and a corresponding unbiased selection from a list of reference sites. Some judgment selection of potentially affected sites and references may be conducted to meet the objectives in this section. While it is often the responsibility of other agencies (e.g., US Fish and Wildlife Service or the US Army Corps of Engineers) to investigate impacts of site-specific events such as the construction of harbors, such programs generally lack a larger scale perspective in which these impacts can be evaluated. Also, there is no monitoring program that evaluates impacts from less site-specific events or from heretofore-undiscovered sources of disturbance. Therefore, long-term monitoring at a number of sites will provide a region-wide framework upon which other monitoring or impact assessment programs can build, and which can be used to identify potential problem "hot spots" or regional trends.

2. Monitoring of large scale (GOA wide) disturbance Yearly (or less frequent) monitoring of select resources within a subset of the reference sites (probably 3 to 10 in number) that represent a broad geographic range representative of gulf-wide conditions. These more intensively sampled sites are designed to detect GOA-wide changes that may result from climate change or other large-scale perturbations.

3. Monitoring of impacts from accidental disturbance Special studies will provide guidelines for selection of pairs of impacted and reference sites to be used in the event of future accidental disturbance such as an oil spill. Although "fixed" sites monitored on a regular basis (as described in No. 1 above) will be of use in this regard; it is anticipated that evaluations of impacts of unpredictable events such as an oil spill will need to be supplemented by sampling conducted after the event. The proposed work will focus on developing methods to help satisfy the assumption that reference and impact sites would be similar in the absence of an impact.

4. Monitoring of processes Directed process studies will investigate mechanisms of change observed. These will be designed to relate changes in biological systems to changes in the physical or chemical environment and will be the cornerstone of predictions as to future impacts.

Noise reduction through stratification and process studies As stated above, the objectives of the nearshore monitoring plan includes detection of change and study of relationships between variables measured in temporal or spatial studies. However, there are some sources of variation that are of little concern to GEM. For example, there is strong vertical zonation within rocky-intertidal communities, and abutting sand beaches and rocky shore can have almost totally different communities with little or no overlap of species. A strictly random sampling of the intertidal would almost surely result in such a high level of variability among sites (noise) that one would be unable to detect even very large changes that are of concern (the signal). Designing a study to account for noise is critical to detecting a signal.

While the nearshore habitat can still be temporally and spatially variable (e.g., Menconi *et al.* 1999, Underwood and Chapman 1998) much of the spatial variation within the nearshore can be accounted for by using a stratified sampling design. Noise in the system can be greatly reduced by stratifying vertical zone geomorphologic characteristics, or other factors (e.g., Schoch and Dethier 1996, Zacharias *et al.* 1999, Chapman and Underwood 1999). However, while increasing the number of strata adds to the ability to detect change, it also makes it more difficult to make inferences based on observations within a particular strata to the system as a whole. Furthermore, even with a relatively few strata identified, it is often impractical to sample all of them. As a result, choices need to be made regarding the level of noise that is acceptable and the breadth of inference that is desired. In the sampling designs proposed, noise is reduced by stratifying intertidal habitats and then selecting only a few strata for monitoring. Strata that are sensitive indicators of change and representative of broader scale changes within the nearshore community will be selected for study.

Even with stratification some noise will undoubtedly persist. Process studies may identify sources of noise and that information can be incorporated into future stratified designs. In the meantime, the plan will rely on preliminary sampling to identify the current level of noise within the system, and the design will include sufficient replication that an effect of a reasonable size can be detected given the amount of noise expected.

Selection of metrics In addition to selecting the kinds of communities one might study on selected sites (e.g., intertidal communities on protected rocky shores), it is also important to determine what metrics to examine (Underwood and Peterson 1988, Underwood 1994, Jones and Kaly 1996). These include decisions with regard to the species chosen for study as well as the kinds of measurements one will make on those species. The metrics can range from whole community biomass to immune response functions within a particular organ of a particular species. It is clearly not practical to measure everything, and as with the stratified sampling programs described above, there is often a trade-off between sensitivity and the ability to make broader inferences. In our preliminary monitoring plan, metrics are selected that are sensitive to change at a more community-wide level.

Process studies A well-founded monitoring program will be able to detect changes that may

occur, but making reliable predictions of future changes will rely on process studies that describe the mechanisms for change (Peterson 1993). For example, extensive studies of mechanisms of likely impact on the nearshore community adjacent to the proposed San Onofre Nuclear Generating led to the accurate prediction of many (but not all) eventual impacts that occurred after the plant was constructed (Ambrose et. al. 1996). Studies of mechanisms are also important in helping to make judgments about causes of observed effects. For example, detailed mechanistic studies of oil impacts on nearshore vertebrate predator species (Holland-Bartels *et al.* 1999) led to the strongly supported conclusion that the lack of recovery of several nearshore vertebrate species following the *Exxon Valdez* oil spill was inhibited by continued exposure to residual oil. In the case of the GOA monitoring program, it is difficult to predict what types of mechanisms will need to be investigated. These should be more evident as the monitoring program progresses and changes are identified. While no specific recommendations of process studies are included in the plan, it is important that provisos be made to fund process studies to reveal mechanisms responsible for changes that may occur.

Preliminary evaluation of details of sampling

Site selection A site is defined as an area on the order of 10 square kilometers (about the size of Herring Bay). Sampling is to be conducted at sites throughout the GOA to detect moderate to large-scale changes. The number and location of these sites will be determined, but it is anticipated that approximately 10 to 20 sites will be sampled in the initial years and possible expanded over time. The sites will be spread along the GOA coastline from Sitka to Kodiak, and will be concentrated within the Prince William Sound and Cook Inlet regions. We anticipate selection of relatively accessible sites close to Sitka, Yakutat, Cordova, Valdez, Whittier, Seward, Homer, Kasitsna Bay, and Kodiak and sites historically sampled following the EVOS in Prince William Sound. Some sites will be subjectively placed in areas of anticipated development while others will be selected according to some combination of random or systematic procedure, if possible. Many of these represent centers for future development. More intensive sampling will be conducted at a subset of three or four sites in order to detect changes that are anticipated as a result of climate change or other large- scale events. Sites in Sitka, Prince William Sound, and Kodiak will likely be selected for this purpose. The Sitka and Kodiak sites represent geographic range limitations for many species within the intertidal community (Table 1). Changes in species distributions that may result from climate change or other large-scale effects should be most easily detected by examining changes that may occur near these natural boundaries.

A strategy that will be considered to extend the spatial range of inference of the monitoring program is to select a larger number of sites and visit the sites every two years to five years. We will investigate the trade-offs between the expanded spatial coverage and decreased temporal coverage. For example, for detection of most long-term effects and to give broader spatial coverage, it may be advisable to select 60 to 100 sites and schedule visits every three to five years.

Habitats Sampling within sites will be stratified by habitat type, and only one to three habitats are likely to be sampled. Stratification by habitat will reduce inter- site variation and increase the power to detect changes. The number of habitats sampled will be restricted to reduce costs. Criteria for selection of habitats will include how representative they are of the GOA region, how

important they are to the system, how sensitive they are to disturbance, and how tractable they are to sample. Based on a preliminary analysis, we anticipate that habitats characterized by mixed cobble and gravel substrate in the intertidal region, and bordered by eelgrass beds in the nearshore subtidal region will be among the habitats considered.

Frequency of sampling The frequency of sampling will be determined based on preliminary analyses of existing data to determine the range of temporal variation that may be expected within the nearshore community. However, it is anticipated that sampling will be no more frequent than once per year. Also, it is anticipated that different sampling frequencies may be applied to different metrics (see a discussion of metrics below). For example, examination of abundance of several indicator species may be required on an annual basis, but determination of concentrations of toxicants in mussel tissues may be required only once every four years. It is also likely that the frequency of sampling for a given metric may not be constant over time. For example, yearly sampling may be required initially on a subset of the sites, but a better estimate of temporal variation obtained after several years may allow for a reduction in sampling frequency and broader spatial coverage.

Metrics to be sampled The metrics to be sampled at each site will be determined after a preliminary analysis of existing data and an estimation of cost. However, it is anticipated that metrics may include a suite of physical variables (e.g., geomorphologic characteristics, temperature, and salinity), the concentration of toxicants in mussel tissues, abundance of dominant intertidal plants and invertebrates (e.g., *Fucus*, mussels, clams, limpets, and littorines), abundance of invertebrate keystone predators (e.g., sea stars), the size or age distribution of several representative species (e.g., clams), abundance of representative subtidal species (e.g., eelgrass, greenlings, and cod), and the abundance of nearshore vertebrate predators (e.g., sea otters and harlequin ducks). Photographs may also be taken to provide documentation of the distribution of dominant intertidal species at a site. It is also anticipated that a more comprehensive determination of species composition and abundance will be made at a subset of sites. These will be used to examine potential shifts in the distribution of species caused by climate change. More detailed measures of physical oceanography and vertebrate demography may also be conducted at the subset of sites.

Specific sampling methods Sampling of the intertidal community at each site will be within replicated shoreline segments of given habitat types. The number and distribution of segments to be sampled, as well as the specific methods of sampling and the area to be sampled within each segment are to be determined based on analysis of existing data, or on preliminary sampling.

Sampling in anticipation of accidental disturbances Monitoring will also be conducted that focuses on development of methods for selection of paired sites to be chosen in the event of future oil spills and other unpredictable disturbances such as local natural disturbances (e.g., small earthquakes, rapid expansion of a glacier, etc.). We will develop a list of characteristics that would likely describe a biological community, measure these at a number of systematically selected sites, determine the geomorphologic or physical characteristics that best correlate with the biological community, and determine how similar the community is between site pairs selected on this basis. The focus will be on those habitats and metrics that are most vulnerable to oil spills and have proven to be reliable indicators of impact during the *Exxon Valdez* oil spill. Sampling at fixed sites within a given habitat, as described above, will be used in our initial determination of how to select site pairs. These data will also be used to determine the level of

similarity that can be expected in biological communities at geomorphologically similar sites over various spatial scales. Additional sampling will be conducted in other habitats over time. The timing for this sampling, the frequency of sampling, and methods to be employed will depend on sampling designs as determined in the initial fixed-site monitoring program.

Process studies No specific process studies are included in this preliminary plan. However, it is anticipated that process oriented investigations of the mechanisms of change will be a vital part of the long-term monitoring effort. As changes are identified, specific projects are to be funded to address questions regarding the cause. For example, if a regional decline in eelgrass abundance is observed and is associated with harbor construction, then a mechanistic study of harbor construction on reduction in water clarity and associated relationships between water clarity and eelgrass growth may be warranted.

Analyses, interpretation, and the use of results

The results of the monitoring program described above will be used to detect changes from various causes. How this is done, what level of change can be detected, and how quickly change can be detected will depend in large part on the patterns of natural temporal and spatial variation observed. We have some idea of the extent of spatial variability within a site and among sites of close proximity based on data obtained in post oil spill sampling programs funded by the Trustees. However, there are no data that span the entire GOA as we are proposing to collect, and there are no long- term data sets (spanning more than a decade) from which we can determine the extent of this variability.

To illustrate the generalities of the data analysis and interpretation process, we provide a simple hypothetical data set that shows changes the abundance of a representative species (the sea star, *Pisaster ochraceus*) over a 20- year period (Figure 1). The mean of all sites sampled within the GOA as well as the yearly abundance values for a given site impacted by harbor development are shown. Two patterns of change can be observed in this figure. First, there has been a long-term increase in the average abundance of *Pisaster* within the GOA region. This is first detectable in 2018, when the mean abundance increased above the 95% confidence intervals for mean of the previous years estimates. The pattern of long-term change is more clearly evident when data through 2022 are analyzed and indicate a significant increase in *Pisaster* abundance over time (a regression line with slope significantly greater than zero). The northern limit of the distribution of *Pisaster* is the northern Gulf of Alaska and the center of its distribution is in central California. Furthermore, we know from past experimental studies that the feeding efficiency of *Pisaster* increases with increasing temperature (Sanford 1999) and presumably the abundance and production of *Pisaster* are positively correlated with temperature. Thus, we speculate that the long-term increase in *Pisaster* abundance is due to increasing temperature. The causes for increasing temperatures (i.e., anthropogenically induced climate change or naturally occurring regime shifts) are to be determined from other studies outside the scope of the nearshore program.

The second pattern is that the abundance of *Pisaster* at site x is significantly less than the mean for all GOA sites beginning in 2016. The deviation of site x from the longer-term trend of increasing abundance of *Pisaster* became evident shortly after the construction of a harbor at site x. Based on this, and perhaps on follow-up studies to more directly determine the causes for the relative decline in *Pisaster*, we conclude that the harbor construction had a significant adverse

effect on local populations of *Pisaster*. Note that there was no significant reduction of *Pisaster* at site x over time, and the impact of harbor development was evident based only on the relative decrease in abundance observed by comparing the data from site x to that from other GOA sites.

It is likely that changes in the abundance of invertebrates that result from range contraction or expansion as a function of changes in climate, will have cascading effects throughout the nearshore communtity. Some of those cascading changes may be predictable, many will not, but our ability to detect and understand those changes will improve with a sampling design that includes a diversity of taxa, including those that are directly important to humans.

To illustrate how effects of changes in the abundance of *Pisaster* might cascade through the community we can look at both the direct effects on their prey and further, how other predators may be indirectly affected. In the example of increasing *Pisaster* densities and foraging efficiency, we could see a decline in their principal intertidal prey, the blue mussel, *Mytilus trossulus*. *M. trossulus* also serves as an important prey for harlequin and goldeneye ducks (Vermeer 1982, Goudie and Ankney 1986) and may be an important sea otter food item, particularly for juveniles (Doroff and Bodkin 1994). If increasing *Pisaster* densities reduce mussel densities, we might anticipate cascading adverse effects on other consumers of mussels, such as sea ducks and sea otters. For nearshore resources important to humans, including invertebrates, fishes, birds and mammals, it will be valuable for managers and consumers to understand how large-scale climate change affects nearshore marine communities.

The data sets that will be generated from the long-term monitoring in the nearshore will obviously be much more complex than the examples given. However, the examples illustrate several main points. First, the detection of larger scale trends due to global climate change or to other factors will be detected by comparing changes in means from the entire GOA over long time scales. While we may be able to obtain an indication that changes are occurring over a several year period, the trend can only be confirmed with longer-term sampling. Second, moderate scale changes will be detected by comparing trends at given sites with the means from other sites within the GOA. This is essentially a BACI design with multiple reference sites. Finally, in the examples given, the interpretation of the causes for change is strengthened because they represent confirmation of predicted patterns. The GOA-wide increase in the density of *Pisaster* was predicted as a change that would result from impacts of global warming on species with more southerly distributions, and the decrease in abundance at site x was a predicted impact of harbor development.

Data from the nearshore program are likely to lead directly to management decisions. For example, a severe GOA- wide reduction in sea otters or harlequin ducks may lead to more stringent restrictions on hunting or increased habitat preservation for this species. Other management decisions may stem from as of yet undetermined process studies. For example, if studies indicate a decline in eelgrass in the vicinity of newly constructed harbors, and process studies suggest that this is the result of a reduction in water clarity, then mitigation may be required and future harbor construction either prohibited or the designs modified to lessen impacts on water clarity.

Leveraging of studies and cooperation with other agencies

The goals of the program we have described overlap those of several agencies that are currently

carrying out monitoring programs in the Gulf of Alaska region. For example, Prince William Sound and Cook Inlet RCACs and NOAA Status and Trends Programs are also examining longer- term trends in environmental quality within the region. A cornerstone of the RCAC and Status and Trend programs is 'mussel watch' sampling efforts that estimate levels of contamination in mussel tissue. Our program will coordinate with these existing efforts in order to insure that data are gathered under similar protocols and that the overlap is complementary rather than redundant. For example, we may be able to utilize existing 'mussel watch' sites for our program, thereby extending the historical record of mussel contamination and eliminating much of the future costs of sampling mussel tissue at these sites.

We also anticipate that the data gathered under this program will serve as a framework for more specific impact assessments carried out by other agencies. For example, the US Fish and Wildlife Service (USFWS) is currently concerned about impacts of harbor development in the Whittier and Tatitlek portion of Prince William Sound, and may require that impacts of harbor development on the nearshore environment be investigated. Funding for Trustee studies may be offset by funding from other sources that are required to study harbor development impacts at these sites.

We also anticipate that there will be opportunities to leverage the Trustee funded studies by cooperating with other agencies conducting investigations. For example, USFWS is also concerned about impacts of harbor development at several sites along the western portion of the Alaska Peninsula. Cooperative agreements with the USFWS may lead to the sampling at these sites using a similar protocol to what we will use within the Kodiak to Sitka portion of the GOA arc. Thus, there may be opportunities to extend the monitoring effort over larger geographic areas, at least for some short periods of time. The combining of efforts and the standardization of protocols wherever practical should lead to development of an efficient yet comprehensive nearshore monitoring effort that, in turn, will lead to the preservation of GOA resources.

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Table 1. Estimated distributional ranges for common intertidal invertebrates that are at or near the northern limit in the Gulf of Alaska. (Compiled from O'Clair *et al.* 1996 and O'Clair and O'Clair 1998)

Species with a northern limit in Northern GOA	Current Range
Tectura persona	Alaska to Isla Socorro, Mexico
Ceratostoma foliatum	PWS to San Diego
Calliostoma ligatum	PWS to San Diego
Crassadona gigantea	Kachemak Bay to San Diego
Tresus nuttallii	Kodiak to Baja California
Tresus capax	Shumagin Island to California
Macoma nasuta	Kodiak Island to Baja California
Macoma yoldiformis	Afognak Island to Baja California
Cancer gracilis	PWS to Baja California
Cancer productus	Kodiak Island to Baja California
Lophopanopeus bellus bellus	Resurrection Bay to Point Sur, Ca.
Lophopanopeus bellus diegensis	PWS to San Diego
Hemigrapsus oregonensis	Resurrection Bay to Baja California
Pisaster ochraceus	PWS to Baja California
Orthasterias koehleri	PWS to southern California
Dermasterias imbricata	PWS to Baja California
Amphiodia occidentalis	Kodiak to San Diego
Strongylocentrotus franciscanus	Kodiak to Baja California
Strongylocentrotus purpuratus	Cook Inlet to Baja California
Chelyosoma productum	PWS to southern California

Species with a northern limit in Southern GOA	Current Range
Calliostoma canaliculatum	Sitka to Baja California
Haliotis kamtschatkana	Yakutat to Point Conception
Bittium eshrichtii	Sitka to Baja California
Tegula pulligo	Sitka to Baja California
Corambe pacifica	Sitka to Baja California
Cadlina luteomarginata	Lynn Canal to Baja California
Cadlina modesta	Juneau to La Jolla
Acanthodoris nanaimoensis	Baranof Island to Santa Barbara
Aldisa cooperi	Hogan Island to California
Flabellina verrucosa	Hogan Island to San Juan Islands
Crytolithodes sitchensis	Sitka Alaska to San Diego
Pugettia producta	Chichagof Island to Asuncion Point, Mexico
Hemigrapsus nudus	Yakobi Island, Alaska to Baja California
Pinnixa faba	Prince of Wales Island to Baja California
Pinnixa littoralis	Sitka to Baja California
Asterina miniata	Sitka to Baja California
Pisaster brevispinus	Sitka to San Diego

Distaplia occidentalis	Chichagof Island to San Diego
Aplidium californicum	Chichagof Island to San Diego
Ritterella pulchra	Yakutat to southern California
Ritterella rubra	Chichagof Island to Monterey, CA
Eudistoma ritteri	Chichagof Island to San Diego
Perophora annectens	Chichagof Island to San Diego
Styela yakutatensis	Yakutat to Vancouver Island
Halocynthia igabota	Chichagof Island to Santa Catalina Island

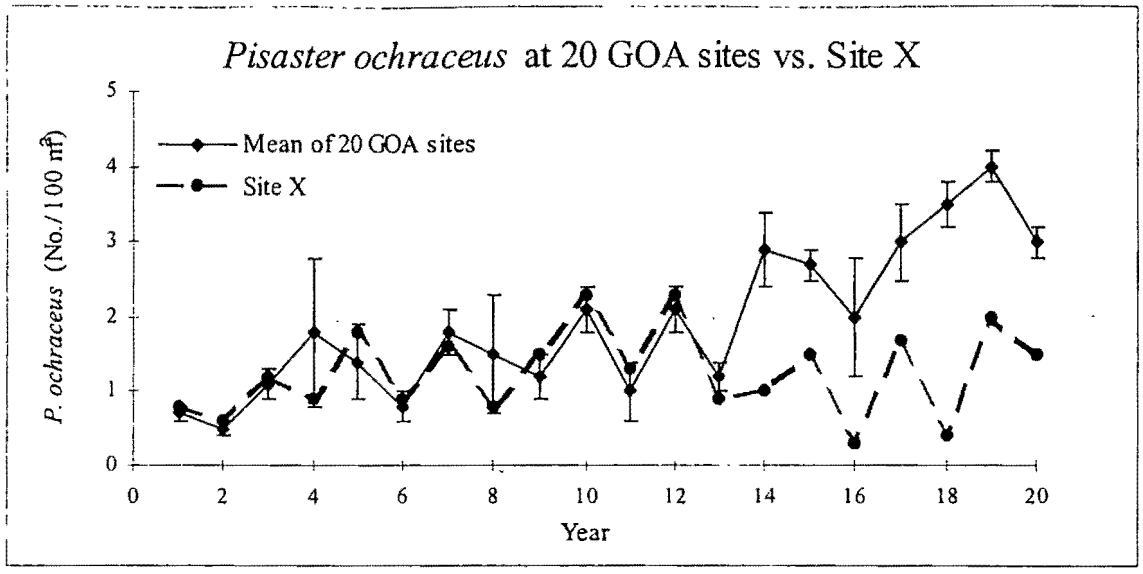

Figure 1. Hypothetical example of possible changes in the abundance of the sea star, *Pisaster ochraceus*, in the Gulf of Alaska over the next twenty years. Means (± 95% confidence intervals) for 20 GOA sites and the average from a single site (site x) are given.

2001 EXXON VALDEZ TRU[illegible]E COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2001	Proposed FY 2002	PROPOSED FY 2002 TRUSTEE AGENCIES TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
							$68.7	$23.3
Personnel	$0.0	$19.9						
Travel	$0.0	$4.6						
Contractual	$0.0	$60.3						
Commodities	$0.0	$0.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$84.8				Estimated FY 2003		
General Administration	$0.0	$7.2						
Project Total	$0.0	$92.0				$0.0		
Full-time Equivalents (FTE)	0.0	0.2						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$0.0	$0.0			$0.0	$0.0		

Comments:

FY02

Prepared: 4/13/01

Project Number: 02~~###~~395
Project Title: Planning for Long-Term Monitoring in the Nearshore
Lead Agency: DOI--USGS

FORM 2A
MULTI-TRUSTEE
AGENCY SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2001	Proposed FY 2002	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$3.6						
Travel		$0.0						
Contractual		$60.3						
Commodities		$0.0						
Equipment		$0.0						
Subtotal	$0.0	$63.9				Estimated FY 2003		
General Administration		$4.8						
Project Total	$0.0	$68.7						
Full-time Equivalents (FTE)		0.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY02

Prepared: 4/13/01

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore
Agency: USGS

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	Proposed FY 2002
Name	Position Description					
						0.0
J. Bodkin	Principal Investigator		0.5	7.2	0.0	3.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		0.5	7.2	0.0	
					Personnel Total	$3.6

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 2001
Description					
					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

FY02

Prepared: 4/13/01

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore
Agency: USGS

FORM 3B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed FY 2002
Description	
Coastal Resources, Inc. See Linkage to 4AB	24.5
Western Ecosystems Technologies, Inc. See Linkage to 4AB	30.6
Simon Fraser University. See Linkage to 4AB	5.2
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$60.3

Commodities Costs:	Proposed FY 2002
Description	
	0.0
	0.0
Commodities Total	$0.0

FY02

Prepared: 4/13/01

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore
Agency: USGS

FORM 3B
Contractual & Commodities DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2002
			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

FY02

Prepared: 4/13/01

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore
Agency: USGS

FORM 3B
Equipment
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2001	Proposed FY 2002	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$16.3						
Travel		$4.6						
Contractual		$0.0						
Commodities		$0.0						
Equipment		$0.0						
Subtotal	$0.0	$20.9				Estimated FY 2003		
General Administration		$2.4						
Project Total	$0.0	$23.3						
Full-time Equivalents (FTE)		0.2						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

NOAA's Contribution:
Personnel: 1 month salary for Jeff Short, 1 month salary for Mandy Lindeberg

FY02

Prepared: 4/13/01

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore
Agency: NOAA Auke Bay Lab

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2002
						0.0
Jeff Short	Senior Research Chemist	GS- 13	1.0	10.1		10.1
Mandy Lindeberg	Fisheries Research Biologist	GS- 11	1.0	6.2		6.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		2.0	16.3	0.0	
					Personnel Total	$16.3

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2000
RT Juneau/ Anchorage Trustee Workshop	0.6	2	2	0.2	1.6
Short,Lindeberg					0.0
					0.0
RT Juneau/Anchorage planning meeting					0.0
Short, Lindeberg	0.6	2	9	0.2	3.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$4.6

FY02

Prepared: 4/13/01

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore
Agency: NOAA--Auke Bay Lab

FORM 3B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TR[redacted]EE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed FY 2002
Description	
	0.0
	0.0
	0.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 2002
Description	
	0.0
	0.0
Commodities Total	$0.0

FY02

Prepared: 4/13/01

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore
Agency: NOAA-Auke Bay Lab

FORM 3B
Contractual & Commodities DETAIL

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2002
			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
computers/printers	3	NOAA
		NOAA
		NOAA

FY02

Prepared:4/13/01

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore
Agency: NOAA--Auke Bay Lab

FORM 3B
Equipment
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY2001	Proposed FY2002
Personnel	$0.0	$12.0
Travel	$0.0	$2.3
Contractual	$0.0	$0.0
Commodities	$0.0	$0.0
Equipment	$0.0	$0.0
Subtotal	$0.0	$14.3
Indirect		$10.2
Project Total	$0.0	$24.5
Full-time Equivalents (FTE)	0.0	0.1
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
			Estimated FY2003		

Dollar amounts are shown in thousands of dollars.

Comments:

Indirect costs calculated as follows:
Indirect costs = Overhead + General and Administrative costs + Fee
Overhead = 59.5% of personnel costs
G&A = 12.85% of personnel + overhead + other direct (excluding contractual)
Fee = 4% of Total Direct + Indirect (excluding contractual)

FY02

Prepared:3/16/01

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore Name: Coastal Resources Associates, Inc., contract to USGS

FORM 4A
Non-Trustee
SUMMARY

2001 EXXON VALDEZ TRU[illegible]E COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2002
T.A. Dean	Senior Scientist, P.I.		1.5	8.0	0.0	12.0
					0.0	0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	1.5	8.0	0.0	
					Personnel Total	$12.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 2002
RT San Diego-Anchorage		0.6	2	7	0.15	2.3
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$2.3

FY02

Prepared 4/11/01

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore
Name: Coastal Resources Associates, Inc. contract to USGS

FORM 4B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TR[illegible]EE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed FY 2002
Description	
Contractual Total	$0.0

Commodities Costs:	Proposed FY 2002
Description	
	0.0
	0.0
Commodities Total	$0.0

FY02

Prepared 4/13/01

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore
Name: Coastal Resources Associates, Inc. contract to USGS

FORM 4B
Contractual & Commodities DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 2002
Description			
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:	Number of Units	
Description		
None		

FY02

Prepared: 4/13/01

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore
Name: Coastal Resources Associates, Inc. contract to USGS

FORM 4B
Equipment
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2001	Proposed FY 2002
Personnel	$0.0	$12.6
Travel	$0.0	$2.7
Contractual	$0.0	$0.0
Commodities	$0.0	$0.0
Equipment	$0.0	$0.0
Subtotal	$0.0	$15.3
Indirect		$15.3
Project Total	$0.0	$30.6
Full-time Equivalents (FTE)	0.0	0.2

LONG RANGE FUNDING REQUIREMENTS					
			Estimated FY 2003		

Dollar amounts are shown in thousands of dollars.

Comments:

FY02

Prepared 4/13/01

Project Number: 02xxx
Project Title: Planning for Longterm Monitoring in the Nearshore
Name: Western Ecosystems Technologies, Inc. contract to USGS

FORM 4A
Non-Trustee
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2002
L. McDonald	Senior Scientist, P.I.		1.0	8.1	0.0	8.1
M. Bourassa	Biometrician I		1.0	4.5	0.0	4.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		2.0	12.6	0.0	
					Personnel Total	$12.6

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 2002
RT Laramie to Anchorage		0.8	2	7	0.15	2.7
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$2.7

FY02

Prepared 4/13/01

Project Number: 02xxx
Projet Title: Planning for Monitoring in the Nearshore
Name: Western Ecosystems Technologies, Inc. contract to USGS

FORM 4B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TR[illegible]E COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed FY 2002
Description	
None	
Contractual Total	$0.0

Commodities Costs:	Proposed FY 2002
Description	
None	
Commodities Total	$0.0

FY02

Prepared 4/11/01

Project Number: 02xxx
Project Title: Planing for Long-Term Monitoring in the Nearshore
Name: Western Ecosystems Technologies, Inc. contract to USGS

FORM 4B
Contractual & Commodities DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 2002
Description			
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:	Number of Units
Description	
None	

FY02

Prepared 4/11/01

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore
Name: Western Ecosystems Technologies, Inc. contract to USGS

FORM 4B
Equipment
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2001	Proposed FY 2002	LONG RANGE FUNDING REQUIREMENTS					
					Estimated FY 2003			
Personnel		$3.4						
Travel		$1.8						
Contractual		$0.0						
Commodities		$0.0						
Equipment		$0.0						
Subtotal	$0.0	$5.2						
Indirect		$0.0						
Project Total	$0.0	$5.2						
Full-time Equivalents (FTE)		0.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: SIMON FRASER UNIVERSITY

No overhead or fees are charged by the university on this contract.

FY02

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore
Agency: DOI-USGS --Simon Fraser University Contract

FORM 4A
Non-Trustee
SUMMARY

Prepared: 4/11/01

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2002
D. Esler	University Research Associate		0.5	6.8		3.4
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		0.5	6.8	0.0	
					Personnel Total	$3.4

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 2002
Vancouver to Anchorage		0.9	2	6	0.0	1.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$1.8

FY02

Prepared: 4/11/01

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore
Agency: DOI-USGS--Simon Fraser University Contract

FORM 4B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TR[illegible]E COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed
Description	FY 2002
	0.0
	0.0
	0.0
	0.0
	0.0
Contractual Total	$0.0

Commodities Costs:	Proposed
Description	FY 2002
	0.0
	0.0
	0.0
	0.0
	0.0
	0.0
Commodities Total	$0.0

FY02

Prepared: 4/11/01

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore
Agency: DOI-USGS--Simon Fraser University Contract

FORM 4B
Contractual &
Commodities
DETAIL

2001 EXXON VALDEZ TRU[illegible]E COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number of Units	Unit Price	Proposed Fy 2002
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		

FY02

Project Number: 02xxx
Project Title: Planning for Long-Term Monitoring in the Nearshore
Agency: USGS--Simon Fraser University Contract

FORM 4B
Equipment
DETAIL

Prepared: 4/11/01

Alaska Salmon Shark Assessment Project

Project Number:	02396
Restoration Category:	Research
Proposer:	Dr. Stan Rice and Lee Hulbert NMFS, Auke Bay Laboratory ABL Program Manager, Dr. Stan Rice
Lead Trustee Agency:	NOAA
Cooperating Agencies:	Alaska Department of Fish and Game
Alaska Sea Life Center:	no
Duration:	Closeout of 2 year project
Cost FY 02:	$29.4K
Cost FY 03:	$0.0
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pacific salmon, Pacific herring, rockfish

ABSTRACT

This project will fund a closeout year of data analysis and manuscript preparation for this two-year study of salmon sharks in Prince William Sound. There will not be a field work component to the project in FY 02. Funding will cover analysis and final write-up of (a) Data transmitted from satellite tags deployed on salmon sharks that will be scheduled to transmit during winter and spring of 2002, and (b) Data transmitted from satellite tags deployed on salmon sharks that will transmit when the sharks frequent surface waters during summer, (c) Stomach samples collected during 2001 field sampling and pre-arranged stomach sample collections from the Copper River gillnet fleet and the Prince William Sound salmon seine fleet during the 2001 commercial fishing season. The funding will also cover FY 02 Argos time, NOAA Joint Tariff Agreement costs for satellite tag data recovery, and contracted data analysis. The final report will describe salmon shark movements, habitat utilization, regional fidelity, and diet composition from data collected during the project.

INTRODUCTION

The salmon shark, *Lamna ditropis,* is one of the predominant shark species in coastal Gulf of Alaska (GOA), yet very little is known of their movements, regional fidelity, or diet composition. The ecological role of salmon sharks in PWS will depend upon seasonal patterns of these parameters. Since FY 00 we have been investigating salmon shark diet through stomach collections and analyses, and salmon shark movements and fidelity to Prince William Sound (PWS) through use of two types of satellite transmitters. This research is yielding previously unknown information on salmon shark prey preference, prey switching, and seasonal habitat utilization in PWS and the GOA. Important stomach contents and satellite tag data describing these behaviors will be recovered in FY 02. Funding is needed to collect and synthesize this data for final manuscript preparation.

Data transmitted from satellite tags deployed in FY00 prove that the tagging works, and are yielding previously inaccessible information that are necessary to study salmon shark movements and ecology. In contrast, conventional tag-and-recapture efforts are not yielding much information because there are no shark fisheries for tag recoveries, and as indicators of movement and behavior have limited resolution. To date, of the 223 salmon sharks tagged with spaghetti tags in 1999 and 2000, only one has been recaptured. Utilization of satellite telemetry technologies provide state-of-the-art methods to acquire otherwise unattainable data on the movements, seasonal residency, regional fidelity, and ecology of these apex fish predators in PWS and GOA ecosystems.

Seasonally diverse salmon shark diet data are needed to assess the ecological role of salmon sharks in PWS and GOA ecosystems. Cooperation has been established with commercial and sport fishermen and various agencies to acquire seasonally and regionally diverse salmon shark stomach samples in the GOA. These efforts are ongoing and will continue through FY 01 and into FY 02.

Synthesis of historical salmon shark distribution and abundance data in the north Pacific from literature and bycatch databases was completed in FY 01. This work documents increasing salmon shark abundance in the GOA because of their importance as predators not only to Pacific salmon, but also to other economically and ecologically important species in the region. We reviewed potential influences leading to a sudden increase in salmon shark abundance in the Northeast Pacific beginning in the mid 1990s, including; the 1992 moratoria on all large-scale pelagic driftnet fishing on the high seas; salmon shark bycatch demographics and distribution records in the North Pacific, and; trophic regime shifts and increasing Pacific salmon production occurring in the GOA beginning in the 1980s. We suggest that a convergence of factors are resulting in the increasing importance of salmon sharks as predators in the changing ecology of the GOA.

Understanding the ecology and impact of sharks on the predator/prey dynamics of PWS requires research on TWO shark species; salmon sharks (*Lamna ditropis*) and Pacific sleeper sharks (*Somniosus pacificus*). The evidence of increasing numbers occurs for both species. These species have different biologies, although little is known about the diet and migration of either species. Salmon sharks are caught in salmon fisheries; sleeper sharks are not. Sleeper sharks are caught often in long line gear; salmon sharks are not. Parallel but independent will be sleeper shark

studies conducted by the NMFS using Stellar Sea Lion funds beginning in March 2001. Although the present evidence is meager, there is growing evidence of predation by sleeper sharks on marine mammals. This EVOS study will focus on salmon sharks, and at this time, is projected to be the last and only directed study on salmon sharks.

Progress to date

In FY 00 satellite tags, data archival tags, and spaghetti tags were deployed on salmon sharks. During the FY 00 field season we also collected side-looking and down-looking hydroacoustic data along stratified random line transects and aerial survey counts in Port Gravina.

In FY 01 we completed a draft manuscript of historical salmon shark distribution and abundance data synthesized from literature and analysis of bycatch databases from North Pacific fisheries. This work was performed to investigate evidence of changing salmon shark population trends. During FY 01 field work, nine PAT (pop-up archival transmitting) satellite tags and three SPOT2 (smart position-only transmitting) tags will be deployed on salmon sharks. Three PAT tags will be programmed to pop-up on each of three dates: October 1, 2001; February 1, 2002; and July 1, 2002. The tags provide large-scale geographic movement data, time spent at depth, time spent at temperature, and seasonal PWS and GOA residency information. SPOT2 tags are bolted to the sharks dorsal fin and transmit high resolution movement data to ARGOS satellites when the tag breaks the waters surface. The SPOT tags are providing information on salmon shark regional fidelity, seasonal PWS residency, and large and small scale spatial and temporal movements. Salmon shark stomachs will also be collected during the July 2001 field season, and from contributions from pre-arranged sources in FY 01 and FY 02.

In FY 02 we will retrieve and analyze satellite tag data, finish salmon shark stomach contents analyses, and synthesize a final report from satellite tag and salmon shark diet data collected in FY 00, FY 01, and FY 02. The will be no field season component in FY 02.

NEED FOR THE PROJECT

A. Statement of the Problem

The ecological role of sharks in PWS and their affects on the recovery of spill-injured resources in the region will vary with temporal and spatial patterns of movement. Salmon shark seasonal residency patterns, movements, and diet in PWS and the GOA have not been described.

Large numbers of sharks coupled with high food consumption to support above ambient body temperatures indicates that shark predation may be dominant and directly limit other key species (salmon, herring, rockfish, sablefish). Salmon shark body temperature averages 26.5^{0}C (80^{0}F) (Goldman 1999 unpublished data) and may be the highest of any shark. Because of this and the cold waters they inhabit in the GOA, salmon sharks likely possess a high metabolism and high daily ration. Eighteen salmon shark stomachs collected in late July and early August, during peak pink salmon returns, contained as many sablefish as salmon and also contained herring and rockfish (Hulbert 1999 unpublished data). In regions of high abundance, salmon sharks have the potential to

affect the recovery of oil spill injured species, including Pacific herring, Pacific salmon, and rockfish.

Salmon sharks inhabiting Alaskan waters have low fecundity, long life, and slow maturation. Once sharks reach a dominance level in the community they are likely to continue that dominance for a long time. Observations suggest salmon sharks may be a dominant predator in PWS now and for some time into the future, but we do not understand the significance of this role to other species and the ecosystem.

B. Rationale

This research will provide a valuable contribution to the understanding of shark ecology in the GOA and PWS and will document predator/prey interactions in the region. This information is needed to further the understanding of the ecological role of sharks in PWS and their effects on the recovery of spill injured resources in the region.

Pop-up archival transmitting (PAT) tags, and smart position-only transmitting (SPOT2) tags were successfully demonstrated by the project in FY00 and FY01 for monitoring the movements and diving behavior of salmon sharks. Data from satellite tags and opportunistic aerial observations will continue to be collected and analyzed in FY01 and FY02 to describe salmon shark movements, migrations, regional fidelity, and critical feeding areas.

Shark stomachs will be collected during directed sampling efforts, pre-arranged cooperation from commercial and sport fishermen, and from NMFS and ADF&G biologists. Efforts to collect and analyze seasonally diverse diet samples will be emphasized in an effort to describe prey switching when spawning aggregations of Pacific salmon are not present.

The project will also synthesize historical salmon shark distribution and abundance in the north Pacific from published literature and analysis of bycatch databases. This work is needed to investigate whether evidence of salmon shark population trends are revealed.

C. Location

Prince William Sound and Gulf of Alaska

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

A traditional and local knowledge component has been incorporated in this study. People from Cordova, Chenega, and Tatitlik have been and will continue to be asked to contribute their knowledge of shark temporal abundance and distribution. Community members may also be hired to recover PAT tags if they "pop-up" in PWS.

PROJECT DESIGN

A. Objectives

FY 01: Deploy satellite tags, collect seasonally diverse salmon shark stomach samples for diet analyses, and analyze historical salmon shark bycatch dat in the North Pacific Ocean.

FY 02: Retrieve and analyze satellite tag data, finish stomach analyses, and synthesize a final report. The final report will include salmon shark movements, movements, regional and seasonal fidelity to PWS and the GOA, and historical bycatch and population trends.

B. Methods

Data will be analyzed and manuscripts prepared by the investigators who were primarily responsible for the research.

C. Cooperating Agencies and Volunteers

Alaska Department of Fish and Game port samplers will collect salmon shark stomachs and tissue samples.

University of Alaska Fairbanks (Evelyn Brown) will provide opportunistic PWS aerial salmon shark observations.

Cordova Air will provide opportunistic PWS aerial salmon shark observations.

SCHEDULE

A. Measurable Project Tasks (Milestones) for FY 02 (October 1, 2001-September 30, 2002)

August- November 2001	Organize and analyze stomach data, and SPOT2 satellite tag data (position only tags) when available
December 2001- July 2002	Retrieve, analyze, and synthesize satellite tag data as available; analyze salmon shark stomach contents from contributions to the project from pre-arranged sources
August- September 2002	Analyze stomachs and satellite tag data, complete reports/manuscripts

C. Completion Date

September, 2002	Final Report (Date of final report allows for analysis of satellite tag data transmissions from SPOT tags which are likely to transmit during summer months when the sharks are active in surface waters and PAT tags which will be programmed to transmit during winter and spring, 2002.)

D. Budget Summary

Budget Category:	**FY02**
Personnel	$15.0
Travel	$ 1.4
Contractual	$10.0
Commodities	$ 0.0
Equipment	$ 0.0
Subtotal	$26.4
General Administration	$ 3.0
Project Total	$29.4

PUBLICATIONS AND REPORTS

A final report detailing results and accomplishments of the research will be accompanied by: A draft salmon shark seasonal diet manuscript; a draft salmon shark spatial and temporal movement manuscript; and report detailing the results of salmon shark historical distribution and abundance synthesis.

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

The information gathered in this study may be useful to understanding the lack of recovery of some non-recovering species (harbor seals, Pacific herring).

PRINCIPAL INVESTIGATOR

Jeep Rice
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11305 Glacier Highway
Juneau, Alaska 99801-8626
(907)789-6020
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OTHER KEY PERSONNEL

Lee Hulbert, NMFS, Auke Bay Laboratory

FY 02 *EXXON VALDEZ* TRU . COUNCIL PROJECT BUDGET

October 1, 200 . eptember 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002
Personnel	$28.2	$15.0
Travel	$2.2	$1.2
Contractual	$22.2	$10.0
Commodities	$26.6	$0.0
Equipment	$0.0	$0.0
Subtotal	$79.2	$26.2
General Administration	$5.8	$3.0
Project Total	$85.0	$29.2
Full-time Equivalents (FTE)	0.5	0.25
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
Estimated FY 2003					
$0.0					

Dollar amounts are shown in thousands of dollars.

Comments: Comments: This close-ourt year of the will analyze data produce a final report on investigations of salmon shark seasonal residency, movements, and trophic interactions in the eastern Gulf of Alaska (GOA) and Prince William Sound (PWS). State-of-the-art satellite tag data will be used to describe salmon shark movements and migrations, diet, and critical feeding areas and depths.

NOAA Contribution: Lee Hulbert 1 mo @ 5K, Dr. Stan Rice 1 mo @13K for a total NOAA contribution of 18K.

FY02

Prepared:4/12/01

Project Number: 01396-CLO
Project Title: Alaska Salmon Shark Assessment Project
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 02 *EXXON VALDEZ* TRU: COUNCIL PROJECT BUDGET
October 1, 200 . eptember 30, 2002

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2002
L. Hulbert		GS9	3	5		15.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		3.0	5.0	0.0	
					Personnel Total	$15.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2002
	0				0.0
					0.0
RT Juneau to Anchorage (Lee Hulbert, EVOS workshop)	0.4	1	4	0.2	1.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.2

FY02

Prepared:4/12/01

Project Number: 01396
Project Title: Alaska Salmon Shark Assessment Project
Agency: NOAA

FORM 3B
Personnel
& Travel
DETAIL

FY 02 *EXXON VALDEZ* TRU COUNCIL PROJECT BUDGET

October 1, 200. eptember 30, 2002

Contractual Costs:	Proposed FY 2002
Description	
Contract to analyze data	5.0
Argos time and Joint Tariff Agreement	5.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$10.0

Commodities Costs:	Proposed FY 2002
Description	
Commodities Total	$0.0

FY02

Prepared:4/12/01

Project Number: 01396
Project Title: Alaska Salmon Shark Assessment Project
Agency: NOAA

FORM 3B
Contractual & Commodities DETAIL

FY 02 *EXXON VALDEZ* TRU[illegible] **COUNCIL PROJECT BUDGET**
October 1, 200[illegible] September 30, 2002

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2002
			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

FY02

Prepared:4/12/01

Project Number: 01396
Project Title: Alaska Salmon Shark Assessment Project
Agency: NOAA

FORM 3B
Equipment
DETAIL

ASSESSMENT OF SPOT SHRIMP ABUNDANCE IN PRINCE WILLIAM SOUND A DECADE AFTER THE EXXON VALDEZ OIL SPILL

Project Number:	02401
Restoration Category:	General Restoration
Proposer:	Mandy Lindeberg and Charles O'Clair NMFS, Auke Bay Laboratory ABL Program Manager: Dr. Stan Rice
Lead Trustee Agency:	NOAA
Cooperating Agencies:	Valdez Native Tribe/Charlie Hughey Prince William Sound Economic Development Council
Alaska Sea Life Center:	no
Duration:	4th year, 4 year project
Cost FY 02:	$ 27.2
Geographic Area:	Prince William Sound
Injured Resource/Service:	Spot Shrimp/Subsistence

ABSTRACT

This proposal is for year four of a four year project. The project will estimate the abundance of spot shrimp and determine the structure of the spot shrimp population in Prince William Sound (PWS). The project will augment current Alaska Department of Fish and Game (ADF&G) surveys to determine whether the spot shrimp population is recovering from depletion. Our results and those of ADF&G in 1999 and 2000 indicate a cessation in the apparent decline of spot shrimp abundance in western PWS that had taken place between 1992 to 1998. Our data and that of ADF&G indicated a slight increase in the number and weight of spot shrimp per pot in 1999 compared to 1998. The increase was markedly greater in 2000. In year four we will close out, produce manuscripts, and provide input into the development of a shrimp management plan with ADF&G.

A. INTRODUCTION

The commercial spot shrimp fishery in Prince William Sound (PWS) was closed in 1992 after a rapid decline in the commercial catch following the peak harvest of over 110 tonnes in 1986 (Trowbridge 1994, Orensanz et al. 1998). The commercial fishery remains closed and further restrictions are being implemented for the sport and subsistence fishery. Annual surveys of the abundance of spot shrimp in PWS begun in 1989 by the Alaska Department of Fish and Game (ADF&G) continue to the present. The surveys sample spot shrimp at six to eight sites in the seven major statistical reporting areas that divide the Traditional Harvest Area in western PWS (Trowbridge 1992, 1994). From 1989 to 1998 the survey catch per unit effort (CPUE) declined from 0.6 kg/pot to 0.1 kg/pot (Trowbridge 1994; ADF&G, unpublished data). Catches of the present study and those of ADF&G in 1999 averaged CPUE's of 0.3 kg/pot and 0.2 kg/pot, respectively. In 2000 the mean CPUE of our catches was 0.44 kg/pot; that of ADF&G was 0.21 kg/pot. The mean number of shrimp/pot caught by the present study increased 1.9 x between 1999 and 2000. The mean number of shrimp/pot caught by ADF&G increased 1.5 x during the same period These results indicate that the decline in spot shrimp CPUE between 1989 and 1998 did not continue into 1999 and 2000, and that there is some evidence of the beginning of recovery in the spot shrimp population in western PWS.

This proposal covers the final year of a four year study designed to augment the ADF&G annual survey data for 1999 and 2000 by adding population information from other areas in PWS. We seek to enhance our understanding of spot shrimp population dynamics by providing information on juvenile distribution, abundance, and size structure, and will ultimately aid ADF&G in developing a management plan for spot shrimp when the population recovers. In FY'99 NMFS personnel took input from the Valdez Native Tribe and former PWS commercial shrimpers to identify potential sampling sites. A preliminary, exploratory cruise was conducted in August 1999 to evaluate potential sites. The first sampling cruise of the study took place in October 1999 a week or two after the annual ADF&G cruise. The second full sampling cruise of the study took place in October 2000 and overlapped the ADF&G cruise for 2000.

NEED FOR PROJECT

A. Statement of Problem

Evidence for depletion of the spot shrimp resource in PWS after 1989 is convincing (Trowbridge 1994). The role that the *Exxon Valdez* oil spill (EVOS) may have played in the reduction of spot shrimp abundance in western Prince William Sound is unclear. Trowbridge (1992) found reduced CPUE in weight and number of spot shrimp in oiled vs unoiled areas in 1989 and 1990 in PWS. The differences in CPUE (number and weight of shrimp) did not persist into 1991. Mean size of shrimp was reduced in the oiled area in all three years. However, Trowbridge (1992) could not find conclusive evidence "that spot shrimp within PWS were themselves

affected by the EVOS" owing, in large part, to limitations in time and funding for spot shrimp damage assessment. Spot shrimp were not considered a high priority species by the EVOS damage assessment process. Lack of pre-spill abundance information coupled with confounding reductions in spot shrimp abundance prior to the spill rendered the species less favorable for a definitive damage assessment study. Trowbridge (1992) ultimately concluded that the observed abundance and structure of the spot shrimp stock in PWS in the first few years after the *Exxon Valdez* oil spill could mostly be explained by fishing pressure. Nevertheless, he hypothesized that highly sensitive shrimp larvae which were probably in the water column and near the surface during the oil spill were adversely affected by oil toxicity. No damage assessment study focused on larvae was initiated after the spill. The impact on the shrimp population after 1989 of exposure to oil of the 1989 year class in the larval stage is unknown.

Of additional concern is the increased pressure on the spot shrimp resource by sport and subsistence shrimpers as a result of greater access to western PWS following the completed access road connecting Portage and Whittier. Increased cruise ship traffic in and independent tourist visitations to western PWS in recent years may be having adverse impacts on spot shrimp habitat within PWS.

B. Rational/Link to Restoration

This project falls under the category of monitoring. We seek to assess the extent to which spot shrimp abundance has recovered since the population decline which began just prior to 1989. Although the major cause of the decline was probably overfishing rather than the EVOS, there is great interest by subsistence users of shrimp as well as sport shrimpers and individuals who fished for spot shrimp commercially in PWS prior to 1992 in the present status of the spot shrimp population in PWS. The ADF&G currently surveys spot shrimp abundance at selected locations in PWS annually. The goal of this study is first to broaden the geographical coverage and increase the amount of replication within existing major statistical reporting areas of the assessment of spot shrimp abundance in PWS. Second by focusing on the reproductive potential of females and recruitment potential as indicated by the abundance of young males and juveniles in the population we seek to determine whether the population is recovering. The results of this work should greatly enhance the information base underpinning ADF&G management decisions.

C. Location

This study focuses on 12 sites in the Traditional Harvest Area for spot shrimp in western Prince William Sound. The project includes six sites currently surveyed by ADF&G as well as six additional sites in statistical reporting areas currently surveyed. Elements of the communities of Whittier, Valdez and Cordova that are now or have in the past been associated with the sport, subsistence or commercial harvest of spot shrimp may be affected by the results of the project.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Charles Hughey of Valdez Native Tribe acts as community facilitator for the project. Shrimpers in the Valdez Native Tribe provided information on potential sampling sites. Fishers in Valdez with shrimping experience participate in the project, providing vessels and crew.

PROJECT DESIGN

Two important considerations entered into the project design. First, the project overlaps existing survey sites of ADF&G as well as samples new sites, and, to the extent possible, the project duplicates the methods that ADF&G uses in their surveys. This accomplishes two ends: 1) It allows us to compare with greater confidence our data with that previously collected by ADF&G on spot shrimp abundance in western PWS in order to determine, more convincingly, whether spot shrimp population recovery is taking place in PWS, and 2) It will be more likely to provide data of the greatest value to ADF&G for future management of the spot shrimp resource in PWS.

The second consideration is that to maximize community involvement and to make the best use of traditional ecological knowledge, shrimpers associated with the Valdez Native Tribe are encouraged participate in the project and have timely access to project results. The shrimpers had input into the selection of the additional sampling sites. Because the shrimp pots and other fishing equipment used by the present study differ in configuration from that used by ADF&G, the extent to which the project can overlap the ADF&G sites and sampling dates may permit the calculation of correction factors for comparison of the project's data with that of ADF&G.

A. Objectives

1. Estimate abundance (CPUE) of spot shrimp by weight and number of individuals (years two and three).

2. Determine the sex and size composition of spot shrimp at the study sites (years two and three).

3. Estimate spot shrimp fecundity and relative number of egg-bearing females at the study sites (years two and three).

4. Estimate juvenile abundance and compare between sites (year three).

5. Compare abundance, sex and size composition, fecundity and proportion of ovigerous females between sites and years (year three).

6. Compare abundance data and data on population structure obtained under the present project with historical data collected by ADF&G to determine if the population is recovering and to assess the potential for full recovery of the spot shrimp population in PWS (year four).

7. Work with ADF&G, using data collected from this study, to develop a spot shrimp management plan for PWS.

B. **Methods**

The methods used in the present study are modified after Trowbridge (1992, 1994). Shrimp pots were fished at six sites in northern and western PWS previously surveyed by ADF&G (Figure 1). The sampling sites were located in Unakwik Inlet, at Golden in Port Wells, in lower Culross Passage, in Herring Bay, at northeast Chenega Island and at northern Green Island. Six additional sites located in Wells Bay, Eaglek Bay, McClure Bay, near East Finger Inlet in Port Nellie Juan, northwest Perry Island and near Jackpot Island. In 2000 a site at North Squire Island was substituted for the one in Eaglek Bay.

At least two strings of shrimp pots were set at each site. Each string consisted of 11 pots spaced 18.9 m (62 ft) apart along a groundline and buoyed at both ends. Standard, round, nesting pots were used. The diameter of the base and of the top of each pot was 107 cm (42 in) and 91 cm (36 in), respectively. The frame of the pot was mild steel with a black plastic coating and covered with a tar-coated mesh having stretched openings of 2.9 cm (1 1/8 in). There were two opposing tunnels in the side of each pot which had a 7.6 cm (3 in) opening. These pots differed in configuration from those of ADF&G which are rectangular pots measuring 41 cm x 41 cm x 91 cm (16 in x 16 in x 36 in). In 1999 we interspersed pots similar in configuration to, but somewhat smaller than (33 cm x 33 cm x 81 cm) those of ADF&G to test the relative efficiency of the two pot designs. The pots were fished in the depth range 27-183 m (15-100 fm) for a minimum of 18 h at each site. In year three additional pot sets were made in the depth range 0-27 m (0-15 fm) to assess the abundance of juvenile spot shrimp. The pots were similar in design to the larger nesting pots described above but were 71 cm (28 in) in diameter and covered with mesh with 8 mm openings. Each tunnel entrance had an opening of 5 cm (2 in).

Upon retrieval of the pot strings all pandalid shrimp in each pot were speciated. Spot shrimp were counted and the catch weighed to the nearest two grams on an electronic balance. Other species of pandalid shrimp (eg. *P. eous* and *P. hypsinotus*) were counted. All non-shrimp bycatch were speciated and counted. The carapace length of all spot shrimp was measured to the nearest mm. Carapace length was measured with calipers except when catches were large in which case the shrimp were photographed with a digital camera and carapace length determined with image analysis. A subsample of each catch was collected for staging and sexing in 1999. In 2000 all spot shrimp were collected for staging and sexing. Additional observations of ovigerous spot shrimp included egg condition (eyed vs uneyed) and egg color. The egg clutches of a total of about 10 ovigerous females were sampled at each site for estimates of fecundity and the number of dead eggs in the clutch. For nonovigerous females, the presence or absence of breeding dress [characterized by "...the presence of long, simple, and plumose setae on the protopodites of pleopods" (Butler 1980)] was recorded. Breeding dress indicates a mature female.

The sampling cruises were conducted in October (the time of year when ADF&G normally conducts the annual survey) for the purposes of comparing the catch data collected by this project with that collected by ADF&G.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

This project is a partnership between the National Marine Fisheries Service, the Valdez Native Tribe with Charlie Hughey as facilitator and Prince William Sound Economic Development Council.

SCHEDULE

A. Measurable Project Tasks for FY02 (October 1, 2001 - September 30, 2002)

October 1 - March 31	Complete processing of egg samples and analysis of data on spot shrimp adult and juvenile abundance, sex and size composition, and relative number of egg-bearing females and fecundity of spot shrimp at the study sites in year three.
April 1 - September 30	Produce a final report. Analyse spot shrimp fecundity and juvenile abundance at the study sites in year three.

B. Project Milestones and Endpoints

June 15, 2001	Complete estimates of spot shrimp fecundity and juvenile abundance at the study sites in year two.
October 31, 2001	Complete comparison of spot shrimp abundance, sex and size composition, fecundity and proportion of ovigerous females between sites and years.
January 15, 2002	Complete comparison of the abundance data and the data on population structure obtained under the project with historical data collected by ADF&G.
April 15, 2002	Submit final report and recommendations to ADF&G for development of a PWS shrimp management plan.

C. Completion Date

September 30, 2002

PUBLICATIONS AND REPORTS

A final report will be submitted on 15 April in FY02. It is anticipated that at least two publications will derive from this project.

PROFESSIONAL CONFERENCES

Travel funds are requested for attendance of one individual at the annual Exxon Valdez Restoration Workshop in January 2002.

NORMAL AGENCY MANAGEMENT

The National Marine Fisheries Service (NMFS) does not manage shrimp resources in Alaska and has never been required by statute or regulation to survey spot shrimp populations in PWS. No project similar to the one proposed here has been conducted by NMFS in the past without funds from the Trustee Council. Spot shrimp are managed by ADF&G which conducts annual surveys in PWS to assess the status of the resource.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The Valdez Native Tribe Facilitator Charles Hughey and Prince William Sound Economic Development Council will work with NMFS scientists to successfully complete this spot shrimp project. The ADF&G will be asked to review the final report to improve the quality of it and to increase the relevance of the report to management goals.

The Prince William Sound Economic Development Council has coordinated other projects for EVOS in the past. The projects include the Chenega Bay Beach Clean-up and the five Oil Waste Management buildings in Valdez, Whittier, Cordova, Chenega Bay and Tatitlek.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

In fall 1999 and 2000 circular pots were substituted for the rectangular pots that ADF&G uses. The pots are identical to the pots that ADF&G uses in their surveys in southeastern Alaska. In 1999 the circular pots were cross-calibrated with rectangular pots similar to those used by ADF&G in Prince William Sound.

PROPOSED PRINCIPAL INVESTIGATORS

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PRINCIPAL INVESTIGATORS

Charles G. Hughey is a commercial fisherman, EVOS community facilitator for Valdez, and serves on the Alaska Fish and Game Advisory Committee.

Sue Cogswell is executive director of Prince William Sound Economic Development Council and has experience in project management.

Charles E. O'Clair will be responsible for sampling, data analysis and interpretation and report writing.

Mandy Lindeberg. will be responsible for arranging logistics (vessels, equipment, contracts, etc.), will participate in sampling, data processing, and will assist in report writing.

LITERATURE CITED

Orensanz, J. M., J. Armstrong, D. Armstrong and R. Hilborn. 1998. Crustacean resources are vulnerable to serial depletion - the multifaceted decline of crab and shrimp fisheries in the Greater Gulf of Alaska. Reviews in Fish Biology and Fisheries 8: 117-176.

Trowbridge, C. 1992. Injury to Prince William Sound spot shrimp. Final report for Exxon Valdez Oil Spill State/Federal Natural Resource Damage Assessment Subtidal Study Number 5. 141 p.

Trowbridge, C. 1994. Spot shrimp *Pandalus platyceros* surveys in the Prince William Sound management area, 1989 -1993. Regional Information Report No. 2A94-31. Alaska Department of Fish and Game. Anchorage, Alaska. 30 p.

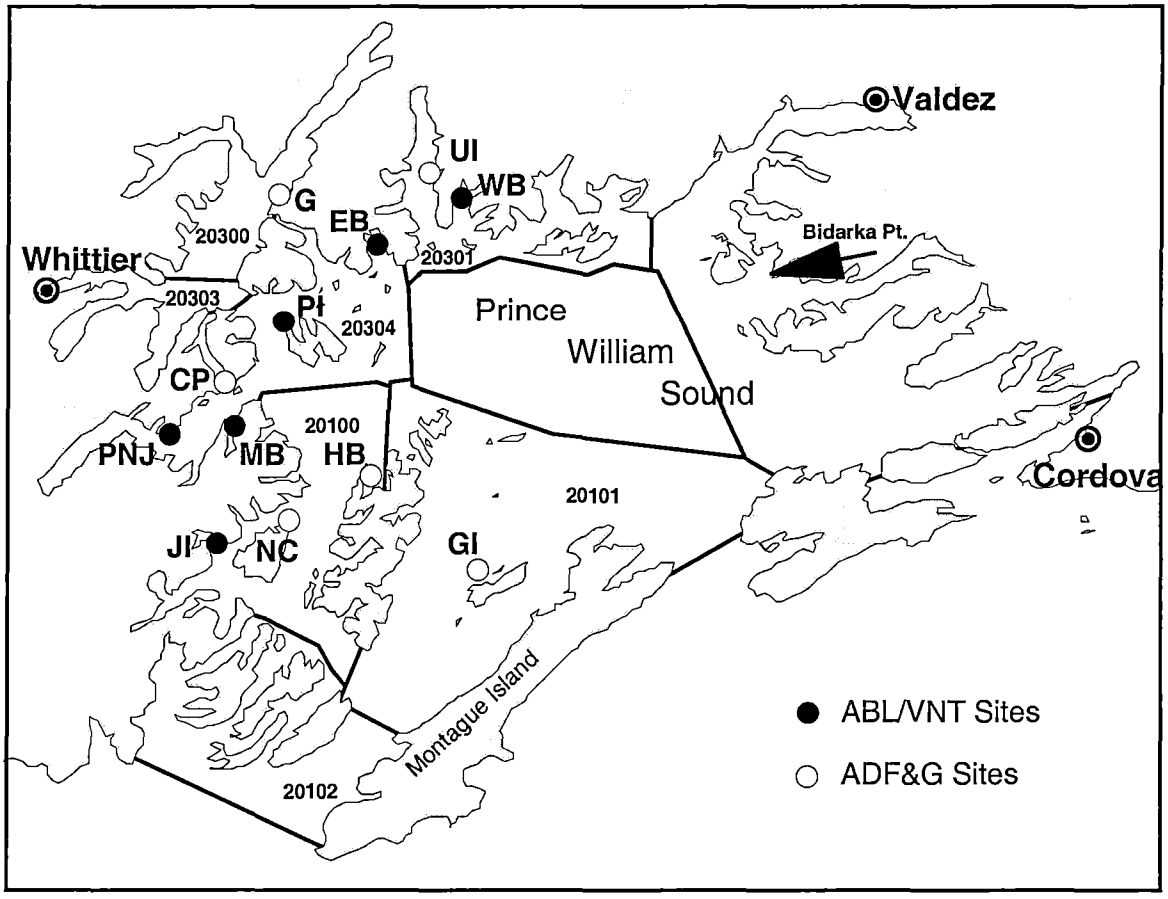

Figure 1. Location of spot shrimp study sites in Prince William Sound. The Alaska Department of Fish and Game (ADF&G) sites are those traditionally sampled during the ADF&G annual survey. The Auke Bay Lab/Valdez Native Tribe (ABL/VNT) sites were added in October 1999. The ADF&G major statistical areas for reporting commercial shellfish catch are outlined within the shaded area. (Major statistical areas are numbered.) The Traditional Harvest Area is that area west of a line drawn between Bidarka Pt. and Montague Pt. (Modified after Trowbridge 1992). Site abbreviations are: CP, Culross Passage; EB, Eaglek Bay; G, Golden; GI, Green Island; HB, Herring Bay; JI, Jackpot Island; MB, McClure Bay; NCI, North Chenega Island; PI, Perry Island; PNJ, Port Nellie Juan; UI, Unakwik Inlet; WB, Wells Bay.

FY 02 *EXXON VALDEZ* TRUS COUNCIL PROJECT BUDGET

October 1, 200'. ..ptember 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002
Personnel	$35.6	$15.0
Travel	$3.5	$0.8
Contractual	$39.1	$6.0
Commodities	$1.7	$2.7
Equipment	$0.0	$0.0
Subtotal	$79.9	$24.5
General Administration	$8.1	$2.7
Project Total	$88.0	$27.2
Full-time Equivalents (FTE)	0.5	0.2
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2003					
$0.0					

Dollar amounts are shown in thousands of dollars.

Comments:This is a closeout project.
NOAA contribution: Dr. Stan Rice, Habitat Program Manager .25 mo @3.2K

FY02

Prepared:4/12/01

Project Number: 02401
Project Title: **Assessement of Spot Shrimp Abundance in PWS**
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 02 *EXXON VALDEZ* TRU COUNCIL PROJECT BUDGET

October 1, 200 _ptember 30, 2002

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2002
Mandy Lindeberg	Fisheries Research Biologist	GS / 11/1	2.5	6.0		15.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		2.5	6.0	0.0	
					Personnel Total	$15.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2002
RT Juneau - Anchorage	0.4	1	2	0.2	0.8
EVOS Trustee workshop					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.8

FY02

Prepared:4/12/01

Project Number: 02401
Project Title: **Assessement of Spot Shrimp Abundance in PWS**
Agency: NOAA

FORM 3B
Personnel
& Travel
DETAIL

Contractual Costs:	Proposed FY 2002
Description	
Temporary Labor	
Report Preparation	6.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$6.0

Commodities Costs:	Proposed FY 2002
Description	
Publication/Presentation costs	2.7
Commodities Total	$2.7

FY02

Prepared:4/12/01

Project Number: 02401
Project Title: **Assessement of Spot Shrimp Abundance in PWS**
Agency: NOAA

FORM 3B
Contractual & Commodities DETAIL

FY 02 *EXXON VALDEZ* TRU . COUNCIL PROJECT BUDGET

October 1, 200 - September 30, 2002

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 2002
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number	Inventory
Description	of Units	Agency
computer (2)		5

FY02

Project Number: 02401
Project Title: **Assessement of Spot Shrimp Abundance in PWS**
Agency: NOAA

FORM 3B
Equipment
DETAIL

Prepared:4/12/01

Project Title: Testing Archival Tag Technology in Alaska Salmon

RECEIVED
APR 13 2000
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

Project Number: 02404
Restoration Category: Research
Principal Investigator: Dr. Jennifer L. Nielsen
Alaska Biological Science Center
USGS-Biological Resources Division
1011 E. Tudor Rd.
Anchorage, Alaska 99503

Lead Trustee Agency: DOI--USGS
Cooperating Agencies: ADFG
Alaska Sea Life Center: No
Project Duration: 2nd of 3 yrs
Cost FY 02: $104.6
Geographic Area: Cook Inlet
Injured Resource/Service: Coho salmon

ABSTRACT

Archive tags with temperature, pressure, and light-geolocation sensors will be monitored for hatchery released coho salmon (*Oncorhynchus kisutch*) in Cook Inlet. Light/location relationships specific to the Gulf of Alaska developed under EVOS study #00478 (FY00) will be applied in this study of movement and migration paths for coho salmon during maturation in salt-water environments in Cook Inlet. Contemporary physical oceanographic, climatic, and bathometric data available for Cook Inlet will be incorporated into our interpretation of geolocation results and analyses of critical marine habitat and migratory pathways derived from pressure, temperature, and light sensors deployed and recovered in coho salmon. Salmon for this study will be reared in captivity (ADFG hatchery at Fort Richardson) to 1+ year of age (200-250 mm), acclimated and released in Cook Inlet as part of ADFG's Ship Creek sport-fishing hatchery release. Return and recovery of the tagged coho will be monitored as jacks at the Ship Creek weir, and in the sports fishery including a reward system for tag recoveries in the Ship Creek silver salmon derby.

Archival tags can provide estimates of geolocation, vertical movements, and ambient and internal temperatures for individual fish for long periods of time (up to 18 months for these coho). Recent tag developments allow the application of internal archive tags in smaller fish (150 mm smolt; Keith Stoodley, LOTEK Marine Technologies, Inc, personal communications), making this technology appropriate for the study of salmonids in marine environments where tag recoveries can be obtained from sport fishery, commercial harvest, and/or captures of tagged fish in spawning migrations. The opportunity to test the development and application of this tag technology for the first time in coho salmon is available in collaboration with the Alaska Department of Fish and Game's Fort Richardson hatchery production of coho salmon for release into Ship Creek.

Tagging coho reared in the hatchery environment to the required size (200 - 250 mm) will allow us to test efficiency and accuracy of this technology in the study of ocean use and movement patterns for coho salmon throughout Cook Inlet. Live releases will follow preliminary tests of initial and delayed mortality, tag retention, physiological stress, growth, and fish behavior in the hatchery environment. The first year of work has included pilot studies of tag retention, behavior, and growth for coho in captivity (e.g. hatchery). We have 277 hatchery coho on an

accelerated growth regime (current mean size = 157 mm FL) at Fort Richardson hatchery. Coho over 150 mm have been tagged with visible implant tags (VIT) to identify them as individuals. We have contracted with LOTEK for the purchase of 125 "beta" archival tags for coho smolts and 60 dummy tags of the same size. Surgical implant protocols were developed in collaboration with the University of Waterloo (Dr. Scott McKinley) in Canada. Ship Creek coho will be tagged following tag delivery expected in mid-May. A spring release experiment in the first year will be contingent on the successful implementation and retention of these tags. All surviving tagged coho will be released with the rest of the Ship Creek hatchery coho the first week in June. We will survey for early jack recoveries at the Ship Creek weir and among sport fishers from mid-July through November 2001. Monitoring the recovery of tags in the coho commercial fishery in Cook Inlet and the derby sport fishery on Ship Creek facilitates a higher probability of adult recoveries in the first 18 months of this project.

Archive tagged fish will be used to document coho salmon use of marine habitats, migration routes, contribution to the sport fishery, and hatchery/wild interactions for salmon in Cook Inlet. Information on temperature, depth (pressure), and light from archive tags can be integrated with tidal stream data, climatic data, oceanographic bathometry, stream discharge, hydrographic records, and sea surface satellite imagery to help track salmon distribution and migration routes throughout Cook Inlet. We have researched electronic records for ocean bathymetry in Cook Inlet and are developing a base map in ARC-View to use in plotting coho movements throughout Cook Inlet based on tag recoveries and archival environmental data. Our understanding of marine habitat use, forage patterns, coastal and deepwater migrations, and maturation rates will greatly enhance EVOS recovery efforts and planning in future GEM conservation efforts.

INTRODUCTION

Our previous EVOS study (#00478) is testing light-based geoposition estimates for satellite pop-up and archive tags in the Gulf of Alaska. Light sensors attached to the smaller archive tags used in this study are being designed to collect identical data for geoposition estimates. Part of this study will continue these efforts to gain accuracy of geoposition estimates on the local scale within the Gulf of Alaska and Cook Inlet and to monitor local geography, climatic, and water quality conditions leading to errors in these estimates. To that end we will complete nine months collection of *in situ* data from two tags retained on halibut in captivity at the Alaska SeaLife Center (June 2001) and from tag arrays mounted on a stationary buoy at the entrance of Resurrection Bay (November 2001). Analytical analyses of light-based data for geoposition estimates made in this study will serve as a baseline for data collected from archival tags on coho in Cook Inlet. Archival tags recovered from salmonids with different ocean movement patterns will allow us to develop accurate correction factors to adjust for light attenuation at depth and special tidal and oceanographic conditions found in Cook Inlet.

The application of archive tag technology in ocean-going fish species has been underway for several years and is an effective tool for estimates of open-ocean migration pathways and to ascertain basin-scale movements along parts of the continental shelf (Welch and Eveson 1999; R. W. Brill, personal communications). Recent developments in the architecture and size of these tags have made them appropriate for use in maturing salmon such as steelhead, sea trout, Atlantic salmon, and Arctic charr (Welch and Eveson 1999; M.A. Svenning, and F. A. Voegeli pers. comm.) J. L. Nielsen (PI) recently received a Census of Marine Life grant from the Sloan Foundation's Pacific Ocean Salmon Tracking Project (CoML POST - 2002-2004) for a field test of archival and acoustic tagging of steelhead kelts on the Kenai Peninsula. Life history investigations of oceanic behavior by salmonids will be greatly enhanced by using archive tags to

trace migratory patterns of individual fish during their development at sea. Both offshore and coastal elements will provide critically needed insight on how salmon use the ocean during their extensive migrations. Implementation of this cutting edge tagging technology will provide improved understanding into how current and anticipated climate changes may affect salmonid population dynamics. Crepuscular diving behavior has been demonstrated in many pelagic marine species using archive tags, but the mechanisms driving this behavior remain unknown, i.e. reaction to light scatter at dawn and dusk and/or a search for uniquely available prey items at depth during these intervals (B. Block et al. 1998; Lutcavage et al. 1999). It is interesting that this behavior has been documented in both the Atlantic and Pacific Oceans for multiple species, including Atlantic salmon (J. Sturlaugsson, pers. comm.) It is unknown if Pacific salmon in open seawater exhibit this behavior, and if they do how they react to long crepuscular conditions in Alaska. Use of this technology has the potential to capture the imagination of the public through an education and outreach component.

Coho salmon (*Oncorhynchus kisutch*) from the Fort Richardson fish hatchery are thought to support significant commercial, sport and subsistance fisheries. The distribution of coho post-smolts and sub-adults throughout saltwater habitats in Cook Inlet is unknown. Recent documentation of Beluga whale distributions in Cook Inlet throughout the winter suggests that coho yearlings may provide an important part of the marine food web for this region. The effect of hatchery releases of coho on natural salmonid production in Cook Inlet is also unstudied. The implementation of new tagging technologies can be used to document the distribution and migration patterns of important salmonid populations in saltwater habitats. The development of effective application and protocols for these technologies under local conditions, however, require initial studies in non-critical populations. Alaska Department of Fish and Game (ADFG) production of coho at the Fort Richardson fish hatchery provides an excellent opportunity to grow fish to required size for tagging and subsequent release into natural marine habitats (L. Peltz, ADFG, pers. comm.) We have used the Ship Creek coho stock for our initial tagging studies using salmon archive tags.

We have been able to raise 277 hatchery salmon pre-smolts in captivity to the threshold size (150 mm) necessary for successful application of archive tag. Current coho sizes 95% CI range from 153-161mm fork length and 95% CI weights range from 48-55 grams. Larger coho have been tagged with visible implant tags (VIT) to identify them as individuals (N = 46). We have contracted with LOTEK for the purchase of 125 "beta" archival tags for coho smolts and 60 dummy tags of the same size ($61,843.20). Surgical implant protocols were developed in collaboration with the University of Waterloo (Dr. Scott McKinley). In these tests dummy tags were implanted in trout of various sizes and we monitored post surgical recovery (100%) and placed tagged fish in swimming stress tests post recovery. Two light-stalk positions (anterior center and from the lower side of the abdomen) were tested with our first experimental surgeries. We found no difference in swimming ability post recovery for tagged or untagged fish in these experiments. When the first beta-test salmon archive tags are available from LOTEK in mid-May we will test surgical implant protocols, fish recovery, and behavior in tagged coho salmon for one to two weeks prior to live releases in Ship Creek. All surviving tagged coho will be released with the Ship Creek hatchery coho the first week in June. We will survey for early jack recoveries at the Ship Creek weir and among sport fishers from mid-July through November 2001.

Finding where and when coho salmon go at sea and their temporal and spatial use of specific marine locations critical to oil spill management and recovery are important steps to identifying factors potentially contributing to survival and fitness under different environmental conditions. Data developed from archive tags on hatchery coho will provide inference on hatchery vs. wild fish interactions, "hot-spots" of coho production within Cook Inlet, migration paths and critical ocean habitat, and spawning fidelity of hatchery fish within the basin. All of these data will set baseline structure and sampling protocols for future implementation of archive tags on wild salmonid stocks throughout Alaska, including potential studies of endemic cutthroat trout (*O. clarki clarki*), Kenai feeder chinook salmon (*O. tshawytscha*), coastal steelhead (*O. mykiss*), Dolly Varden (*Salvelinus malma*), and Cooper River chinook and coho salmon. Our studies of hatchery stocks will provide valuable information to ADFG on the management and stability of hatchery production in this area and its contribution to the local fishery.

The definition of "critical habitat" in the marine environment for anadromous and pelagic fishes is essential to the development of reserves or protected areas (Anonymous, NOAA, 1999). In Alaska, the relationship of aquatic protected areas to subsistence, commercial, or sport fisheries is a critical factor in considerations of design and implementation of reserves. Resource protection and strategic use are not incompatible concepts when a sound foundation of scientific knowledge on the distribution and abundance of key species is incorporated into reserve planning and resource use, and if local community-based natural resource management is included in the analyses of such data (Getz et al. 1999). This proposal continues to test the application and deployment of a new technology, electronic archive tags, in investigations into the temporal and spatial distribution of key anadromous and marine fish species. Many aquatic species that fall under the jurisdiction of the Trustee Council in their efforts to restore the resources and services injured by the spill may benefit from the development and local adaptation of this technology. Monitoring of critical habitat use by near-shore and marine fish species will allow these organisms to speak directly to the managers of the resource during the development, implementation and applications of recovery or enhancement activities.

For many commercially important anadromous and marine fish species ocean-use and critical habitat remain uninvestigated with little or no scientific evidence to support distribution on temporal or spatial scales. The use of radio telemetry and satellite-linked tracking for studying fishes has experienced a recent exponential growth in the development of technologies and applications (Lucas et al. 1993; Eiler 1995; Sibert 2000). In addition to critical habitat designation, physiological telemetry can now be used to monitor energy expenditure, life history migrations, stage of life cycle, and environmental conditions critical to improving and validating habitat-use models for pelagic fishes (B. Block et al. 1998). Archival technologies offer the fisheries research community a new tool that is required to resolve movement patterns, spatial and temporal habitat use, and stock structure of many migratory marine species found throughout Alaska. The critical advantage to this new technology is that it allows documentation of habitat use that is independent of harvest or fishing effort. Conventional identification tags have been used on fish since the early 1900s to estimate catch effects. Hydroacoustic tags can provide multi-day records of location, depth, temperature and swimming speed in marine fishes, but their temporal and spatial scale is limited by the range of signal recovery and transmission duration in salt water. In the late 1980's the first generation of archive tags was developed and deployed on marine fish.

Recovery rates for archive tags in the open ocean are typically low (~30%). It is unclear, however, if these poor recoveries are due to differences in survivorship of the fish, differences in tagging technique, tags location, or tag failure. In studies with an active fishery and where fish carrying an external identification tag can be collected at terminal spawning locations, archive

tag recoveries can be quite successful (60-80%, D. Welch, pers. comm.) Testing tag recovery rates and efficiencies in a hatchery stock released into Cook Inlet provides the best possible conditions for initial archive tag studies using this technology in Alaska.

Data archived by these tags include records of ambient and internal body temperature, pressure, and light. It is possible to estimate latitude (geoposition) for tag location at any given time from light intensity, temperature, and accurate temporal measurements of dawn and dusk (Hill 1994). The longitude determination is equally accurate throughout the year and at all locations except those where no dawn and dusk events are recorded. Latitude determinations are most accurate at the solstices and useless at the equinoxes. This is clearly a problem in Alaska waters where long crepuscular periods (winter) are followed by intense solar periods (summer). The accuracy of light-level measurements, duration of crepuscular events, atmospheric or oceanic aberrations, and individual fish behavior can all impact the accuracy of geoposition estimates. A current error rate of 50-60 miles is not uncommon in the analyses of these data from temperate waters. We expect a much lower error rate in Alaskan waters based on current studies of light sensors and data analyses adapted to local light conditions (EVOS #00478).

Data from archive tags can be made available at the time of recovery to any user group after developed algorithms translate sequence data stored on tags into temperature, pressure, and light information. Successful integration of archive tag data into the EVOS Trustee Council's Gulf Ecosystem Monitoring (GEM) program will allow the development of a unique and continuous information base on natural use of critical marine habitat by coho salmon caught in the Ship Creek sport fishery and during spawning migrations. These data will allow estimates of the duration of ocean use, migrations, development rates, and movement of hatchery fish into natural salt and freshwater habitats in Cook Inlet. This proposal suggests that data collected from archive tags deployed in Cook Inlet be made available to local communities and interest groups through internet web links with a USGS/BRD web site dedicated to this study. This proposal is intended to test the accuracy and efficiency of archive tags for estimates of geoposition and ocean use by coho salmon in Cook Inlet. If successful these data can provide an effective database for sampling protocols and analyses of critical habitat use by post-smolt and maturing wild salmon populations throughout Alaska waters.

Additional research on cost-effective tagging regimes for this area need to follow our development of efficient light-based geoposition estimates using archive tags. To this end the PI (JLN) was invited to participate in a development consortium devoted to scientific advances in the application of electronic tagging tools in marine ecosystems. This informal consortium is made up of several research scientists, resource managers, and manufacturers devoted to tagging technology in ocean environments. The rationale of the consortium is to provide open communications on the existing technology (supply and demand, recent developments, application problems and successes) and to push for the appropriate level of investment and product specifications (e.g. size, transmission potential, data storage, validated data) for ongoing needs and the manufacturability (including quality, reliability, satellite platforms, price, and development times) for future research. This consortium provides an active dialogue among key researchers and institutions that are willing and able to invest resources to aid and abet the development and application of this technology in a transparent process that will share the risks and the rewards. Our satellite pop-up tag study (EVOS project 00478) designed to test geolocation technology under local application is considered one of the few "well structured technical assessments of this technology" currently in progress. J. L. Nielsen (PI), David Welch (Pacific Biological Station DFO, Nanaimo, B.C.), and George Boehlert (NMFS, Pacific Grove, CA) recently received a Census of Marine Life grant from the Sloan Foundation's Pacific Ocean Salmon Tracking Project (CoML POST - 2002-2004) for a field test of steelhead kelt migrations

on the Kenai Peninsula (Ninilchik River, Anchor, and Deep creeks), Smith River, California, and on the Keogh River, B.C., using archival and acoustic tags. Life history investigations of oceanic behavior by salmonids will be greatly enhanced by using archive tags to trace migratory patterns of individual fish during their development at sea. Both offshore and coastal elements will provide critically needed insight on how salmon use the ocean during their extensive migrations as pre-adult and adult fish.

Our current proposal (EVOS #01404) is investigating species-specific tagging protocols, size and location of tags as they affect survival rates (for both fish and tags), effects of coastal geology on tag recovery and data collection, and the effects of fish mortality and tag mortality on the interpretation of results in coho salmon in Ship Creek. These objectives will require integration of archive tag data with other significant geological, oceanographic, and climatic databases for this area. Alaska Department of Fish and Game will benefit from this study by an analysis of hatchery fish adaptation to and use of critical marine habitats in Cook Inlet. These data will allow interpretation of hatchery fish interactions with local fish stocks (both predators and prey) and other aquatic resources such as marine mammals at different locations or habitats. Significant data already exist for beluga whale distribution within Cook Inlet that can be compared to coho salmon migrations. These data will provide information important to the development of hatchery supplementation programs and conservation strategies for the marine food web in this area.

This proposal requests continued funding to undertake archive telemetry studies on Cook Inlet coho salmon incorporating five program elements. We address our progress made on all of these aspects of the study below:

1) Rear coho salmon from the Ship Creek stock maintained by ADFG for live releases into Cook Inlet at ADFG's hatchery facilities (Fort Richardson and Elmendorf) until they reach critical size for surgical implants of archive tags (~200 mm).

   a. This part of the project is underway and protocols for accelerated growth in coho salmon are in place at the hatchery. We initiated the study with 292 coho on 12/12/01 and currently are holding 277 live fish (5% mortality, primarily due to protocol implementation studies and initial tagging experiments).
   b. We initiated accelerated growth protocols for coho at Fort Richardson Hatchery. Water temperature was slowly increased to 14° C over two days. Diet rations were increased to 0.5g/fish/day. In three months the average coho fork length has increased from 109.63 mm to 157.02 mm and average weight from 15.85 to 51.46 grams. Average fish condition factor (K) has increased from 1.17 to 1.30 and instantaneous growth factor (IGR) ranged from 0.01 to 0.04 over the same period.

2) Implant beta-test archival tags in salmon pre-smolts. Monitor tag retention, behavior, and growth in captivity prior to any live releases.

   a. We have placed "visible implant tags" (VI tags) in 46 coho to date. These colorful individually numbered tags are placed in the ocular orbit above the eye and mark fish as individuals. VI tags should remain clearly visible in the coho through their adult stage and will allow identification of archive-tagged

coho in the study area if other external indicators fail. Beta production salmon archival tags (N = 125) and dummy tags (N = 60) of the same specifications have been ordered from LOTEK for $61,843.20.

b. We went to the University of Waterloo (UW), Toronto, Canada to experiment on implementation protocols for the first production of dummy archive tags. Dr. Scott McKinley, faculty at UW, is the only person in the world who has had experimental experience in the implementation of these tags in Atlantic salmon under contract with LOTEK. Dr. McKinley assisted Derek Wilson (USGS) in the development and experimental tests of protocols for coho salmon in our study. Fifteen hatchery rainbow trout were used as surrogates for coho pre-smolts and implanted with dummy archival tags in the laboratory at Waterloo. Fish size ranged from 180 - 335 mm in length. Tag size was 35 mm long by 1mm circumference with a 155 mm light stalk (average weight = 6.9 g). Two protocols for the extension of the external light stalk were tested, extension from the anterior side and extension from the central lower abdomen. All rainbow trout survived the surgical implants.

c. Swimming performance and stamina tests were made on tagged and untagged rainbow trout at UW. Control fish were of the same size as the tagged fish in this experiment. Fish were placed in velocity chambers and tested at water velocities ranging from 0.4 - 1.4 m/sec (0.1 m/sec intervals, RPM 240 – 840). Each fish was tested at each velocity interval for 10 minutes. U-crit speed was calculated by increasing the RPM/water velocity every ten minutes by 1/10 of a meter per second. There was no statistical difference between U-crit values for tagged trout (average = 1.047 m/sec) and control (untagged) fish (average = 1.054 m/sec).

d. The dummy tags received from LOTEK were slightly larger than the original specifications projected by LOTEK. After the UW experiments we feel that a critical size threshold will be 200 mm for these tags in coho or about 2.5% weight of the whole fish. We are currently modeling our experimental coho population at the hatchery to predict how many of the prototype tags we will be able to implement with these new criteria prior to the release of hatchery fish into Ship Creek. We are in communications with LOTEK on the standardization of these tags and how we might implement even smaller tags. Future design modification on the tags will be implemented in the 2002 release. An earlier start on accelerated growth at the hatchery in 2002 will also allow us to product more fish at the required size.

3) 2001 and 2002 live releases of archived tagged fish with VI and/or archival tags will be made in association with the standard hatchery releases made by ADGF into Ship Creek. Expected release dates are May 25-June 5 each year.

a. This release includes an imprinting period for coho in Ship Creek water at the Elmendorf Fish Hatchery outside of Anchorage. After an initial recovery period, tagged coho will be integrated into the general hatchery population for transport and eventual release into Ship Creek.

b. Observations will be made during integration and upon release for factors contributing to injury or incidental mortality of tagged fish under these protocols.
c. We will modify the 2002 releases based on data assembled from the first year's experiments.

4) Monitor tag recoveries in the fishery, at the hatchery release site, and in adjacent streams.

a. We have contracted with the Ship Creek silver salmon derby organizers to include information about our tagging program in their literature for 2001. We will be offering a tag recovery fee and a lottery for a reward drawn from all recovered tags in 2001.
b. We expect tag recovery to begin with the movement of coho jacks (immature males) into Ship Creek starting in mid-July 2001. We will work with ADFG in checking the Ship Creek weir everyday to monitor jack movements and look for tagged fish. USGS employees will walk the creek during peak angling hours, before, during, and after the derby. We will informally interview anglers to discuss the tagging study, our recovery efforts, and the lottery opportunity. We anticipate the first year's recover will consist primarily of jack recoveries in Ship Creek at the weir.
c. In 2002 and subsequent return years we will monitor the adult population for tagged fish migrating up Ship Creek both from the sport fishery and at the weir.
d. Information dissemination and outreach will be made to the Cook Inlet commercial coho fishery fleet in an effort to recover any tagged fish from their harvest. To this end all tagged fish will also have their adipose fin removed prior to release.

5) Plot estimates of geoposition, movement, critical habitat use, and maturation cycles from archive tags collected from coho salmon in Cook Inlet. Draw inference from these data for coho use of ocean conditions, migration paths, stray rates, and critical marine habitat needs. These data will be incorporated into the GEM database and provide information on:

a. Identification of the distribution and habitat utilization by key life stages of coho salmon in Cook Inlet.
b. Identify critical marine features:
    i. Do coho respond to sharp thermal boundaries?
    ii. Do coho depend on specific marine structural features?
    iii. Do coho use specific migration pathways?
c. Gain inference on the ecosystem dynamics of Cook Inlet;
    i. How do other species respond to coho movement with in Cook Inlet?
    ii. What is the interaction between hatchery and wild coho in Cook Inlet?
d. Predict how long-term trends in coho distribution, fish condition, growth, and survival may be impacted by changes in marine habitats due to natural or anthropomorphic shifts in ocean conditions.

NEED FOR THE PROJECT

A. Statement of Problem

Knowledge of the marine distribution of fish over time and space within Alaska's near-shore and oceanic ecosystems is needed to make sound management decisions for recovery, management of the resource, and for the development of reserves and/or protected areas in marine ecosystems. Without sound scientific support, recovery and conservation activities in marine systems will remain controversial among diverse user groups, especially in species governed by such diverse interests as coho salmon. Including local community based information in the deployment and recovery of these scientific data will be an effective tool in resource management. Documentation of individual fish behavior in economically and ecologically important species within Alaska will aid in the development of a common-ground database on fish distributions over time and space during the development and implementation of management units within the marine systems where frequent conflict-of-interest problems are expected to arise.

The marine environment imposes severe constraints on the type of tags that can be used to monitor the behavior of fish in their natural environment. Seawater is highly conductive and radio waves do not propagate well in this medium. Recently marine biologists have developed new technologies in an effort to address this problem. Archive tags are internally positioned in the fish's abdomen with light and temperature sensors extending outside the fish on a thin antenna. Sensors are programmed to collect data at set intervals for up to three years. To date this technology has been applied to many important marine species including cod and anadromous salmonids (primarily in Atlantic waters) and in Canadian steelhead populations (D. Welch, pers. comm.) The developmental approach used in the acquisition and analyses of light data generated by archive tags is the same as that used for pop-up tags (EVOS #00478) with the same need for adaptation to local climatic and solar conditions.

Additional research needs to be undertaken on cost-effective and efficient tagging regimes for this new technology, especially in salmon species. The implications of the successful application of archive tags in salmon for documentation of ocean use are enormous. Documentation of changes in salmonid ocean migrations, marine habitat use, and their reaction to critical production variables in the marine environment are necessary for our understanding of salmonid response to decadal shifts in ocean conditions and larger climatic cycles of ocean productivity. This study would facilitate investigations of species-specific tagging protocols, size and location of tags as they affect survival rates (for both fish and tags), effects of coastal geology and local climate on light data, recovery probability for different terminal captures and tag types (i.e. sport fishery and weirs with archive tags vs. satellite pop-up tags), and the effects of fish mortality and tag mortality on the interpretation of results. We will also develop a platform for data exchange, crossover studies, and data archive capacity for ecosystem scale marine habitat analyses in Cook Inlet. This latter objective will require integration of archive tag data with other significant geological, oceanographic, and climatic databases for this area.

Potential future applications directed at discovery and monitoring of ocean habitat use by coho salmon are broad. A clear understanding of marine life history and ocean forage migrations in salmonids will only become available with the development and appropriate application of this technology. Understanding temporal and spatial use of marine habitats by critical marine species will contribute significant information to fisheries resource management decisions in Alaska.

B. Rationale/Link to Restoration

Information collected during this study will contribute to our ability to use new technology to assess recovery and impediments to recovery (critical habitat) for an economically and ecologically important fish species found in marine waters throughout Alaska, coho salmon. The proposed work represents an initial scientific approach to increase our technological capacity to investigate the factors that affect population dynamics on multiple temporal and spatial scales. If successful, this technology will help in the definition of critical habitat for proposed marine reserves throughout Alaska. Without an understanding of the general underlying patterns of habitat use that dictate population change and species interaction within marine units or areas, we can not prescribe or limit specific activities within the reserve based on species distribution. Analysis of critical habitat use, hatchery/wild interactions, and interspecific competition for different life history stages of key species will allow integration of sustainable use or limited harvest in the conservation and management of these species within critical marine areas sensitive to anthropomorphic changes over time. The development of archive tag technology offers a promising window on this type of information.

Archival tag technologies offer the fisheries research community a new tool that is required to resolve movement patterns, spatial and temporal habitat use, and stock structure of many migratory marine species found throughout Alaska. The critical advantage to this new technology is that it allows documentation of habitat use based on actual fish movement and behavior in areas and at times where human observations are impossible. Conventional identification tags have been used since the early 1900s, but individuals must be recaptured before information is obtained. Hydroacoustic tags can provide multi-day records of location, depth, temperature and swimming speed in marine fishes, but their temporal and spatial scale is limited by the range of signal recovery and transmission duration. In 1996 the first generation of archive satellite "pop-up" tags were developed and deployed on pelagic fish, but these tags are currently limited to very large fish (~70 lbs). Implant archive tags allow recovery of data from much smaller individuals including salmon pre-smolts. The data archived by these tags can include records of ambient and internal body temperature, pressure, and light. It is possible to estimate latitude and longitude for tag location at any given time from changes in light intensity (see project #00478). Approaches developed from studies of satellite pop-up tags in the previous proposal are transferable to analyses of data collected from implant archive tags in salmon pre-smolts and young adults throughout Alaska.

C. Location

Data to be compiled will come from tags deployed in Cook Inlet. Initial physiological data concerning tagging effects and efficiencies of light intensity data will be assessed using a limited number of fish in captivity at ADFG hatchery facilities at Fort Richardson and Elmendorf Air Base. Tagging and recovery of coho with archive tags will take place in collaboration with ADFG and the local sport and commercial fishing communities. Tag array disposition on a stationary buoy in Resurrection Bay (project #00478) will provide general background information for the interpretation of light data in geoposition estimates for Alaska waters. Tag recoveries will employ local sport fishers through links with the Ship Creek silver salmon derby, survey for early returning males (jacks) in Ship Creek, collection of tagged adults at the release site (Ship Creek weir), and incidental recoveries in other sport, commercial and research fisheries in and around Cook Inlet.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

All efforts will be made throughout the project to incorporate participation in and provide local involvement in the implementation and development of this project in relation to target populations and tagging localities. Project staff will be available to present information to the local community. An active web site at <www. absc.usgs.gov> will include internet access to real-time data from tags as it becomes available to the PI. All articles, video, or photographs of the tagging study will be made available to the Trustee Council. The nature of the tagging study and the charismatic character of the fish subject make this a potentially high profile public relations project for the recovery and Trustee Council.

PROJECT DESIGN

A. Objectives

1) Rear coho salmon from the Ship Creek stock for live releases into Cook Inlet at ADFG's hatchery facilities (Fort Richardson and Elmendorf) until they reach critical size for surgical implants of archive tags (~200 mm).

2) Implant beta-test archival tags in salmon pre-smolts. Monitor tag retention, behavior, and growth in captivity prior to any live releases.

3) 2001 and 2002 live releases of all tagged fish with VI and/or archival tags will be made in association with the standard hatchery releases made by ADGF into Ship Creek. Expected release dates are May 25-June 5 each year.

4) Monitor tag recoveries in the fishery, at the hatchery release site, and adjacent streams.

5) Plot estimates of geoposition, movement, and marine habitat use from archive tags collected from coho salmon in Cook Inlet. Draw inference from these data for coho use of ocean conditions, migration paths, stray rates, and critical marine habitat needs. These data will be incorporated into the GEM database and provide information on:

   (a) Identification of the distribution and habitat utilization by key life stages of coho salmon in Cook Inlet.
   (b) Identify critical marine features:
      (i) Do coho respond to sharp thermal boundaries?
      (ii) Do coho depend on specific marine structural features?
      (iii)Do coho use specific migration pathways?
   (c) Gain inference on the ecosystem dynamics of Cook Inlet;
      (i) How do other species respond to coho movement with in Cook Inlet?
      (ii) What is the interaction between hatchery and wild coho in Cook Inlet?

B. Methods

Active archive tags and dummy tags will be deployed in each of two years and under various conditions to gather and analyze data tag recovery and marine habitat use by coho salmon in Cook Inlet. Prior to the initial release, we will monitor surgical tag implantation effects on a test population (University of Waterloo). Tests will include anesthetic effects, physiological stress during and after tagging, swimming ability post tagging, stability of implantation over time, fish mortality, fish growth and fish behavior post tagging. Live releases of 60 – 185 tagged coho will be made in years 2001 and 2002 from ADFG's coho hatchery facility at Fort Richardson into Ship Creek. Recovery of tags from the fishery and from natural returns to the Ship Creek weir and in geographically proximate spawning locations will be monitored for 18 months post release. Estimates of actual fish location will be obtained from data collected from tagged fish captured in the fishery or recovered at the weir. These data will then be compared and analyzed for rigor of geoposition estimates based of our findings from previous captivity light studies and the stationary tag array in the Gulf of Alaska.

Conversion of archive data to position and movement cycles for individual fish will be made using adaptations of existing conversion algorithms available from the vendor and our initial field trials of light sensor tags in the Gulf of Alaska. New approaches to estimating geoposition from light data using time series analyses will be used in this study (R. Hill, Wildlife Computers, pers. comm.) Data for location and position for individual tags collected in the wild will be plotted on digitized maps of the Cook Inlet (two dimensional) incorporating any bathymetric data (three dimensional) available for this area using standard telemetry and GIS mapping methods (Baltz 1990; Cressie 1991; Thompson et al. 1992).

This study will continue the development and implementation of the internet link of Alaska tagging studies in marine fishes and results will run parallel to the ongoing field studies and tagging data development. The web site will be posted on the USGS/BRD Alaska Biological Science Center's home page at <www.absc.usgs.gov>.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

This proposal relies on a number of significant research collaborators including ADFG's Bill Hauser, Larry Peltz, Jeff Milton, and Bob Clark. Many unnamed collaborations will develop during the implementation of this project (i.e. commercial or sport fishers, fishing volunteers, and community participants). Known collaborators include: Dan Mulcahy, DVM, USGS/BRD fish and wildlife veterinarian; Scott McKinley, University of Waterloo; Roger Hill, Wildlife Computers; Dr. Paul Howey, Microwave Telemetry, Inc., Jim Lotimer and Keith Stoodley, LOTEC Marine Technologies, Inc.; David Welch, DFO Nanaimo, Canada; George Boehlert, NMFS, Pacific Grove, CA. All technical and clerical staff will be employees of USDGS/BRD Alaska Biological Science Center or qualified individuals contracted directly for this project.

SCHEDULE

A. Measurable Project Tasks for 2001 - 2004

Funding 2001 (EVOS/USGS BRD)

January:	Initiate accelerated growth protocols for coho at Fort Richardson hatchery (292 fish). Implement population monitoring for growth and survival in coho salmon.
February:	Develop web page for project.
March:	Purchase of archival and dummy tags for coho study. Initiate VI tagging in fish at critical size.
April:	Control tests for surgical implants of tags for estimates of survival, handling stress, swimming ability and delayed mortality in tagged fish (University of Waterloo).
May – June:	Surgical implants of archive tags in size-structured study groups and implement monitoring protocols for tag retention, growth, behavior and survival. Release tagged coho with general hatchery release into Ship Creek.
July:	Update web page for study results and plots of initial data.
July – Nov.:	Monitor and evaluate tagged fish recovery, survival, behavior and tag retention from fish recovered in the sport fishery on Ship Creek, the Ship Creek weir, and the commercial fishery in Cook Inlet.

Funding 2002- 2003 (EVOS/USGS BRD)

Dec. 01-January 02:	Initiate accelerated growth protocols for 300 coho at Fort Richardson Hatchery. Implement population monitoring for growth and survival in coho salmon.
March 02:	Purchase of additional archive tags (second generation) for coho study. Initiate VI tagging in fish at critical size.
April 02:	Second year surgical implants of tags in captivity for estimates of survival, stress, swimming ability and delayed mortality in tagged fish at Fort Richardson Hatchery.
April 15, 02:	Annual report due EVOS on preliminary results.
May – June 02:	Surgical implants of archive tags in size-structured coho study groups. Release tagged coho with general hatchery release into Ship Creek.

July –Nov. 02:	Monitor and evaluate tagged fish recovery, survival, behavior and tag retention from fish recovered in the sport fishery on Ship Creek, the Ship Creek weir, and the commercial fishery in Cook Inlet.
Aug. 02:	Presentation will be given on preliminary results of study at AFS meeting, Baltimore, MD.
Nov. – Dec. 02:	Data integration for tag recoveries, plot coho distribution and movement patterns in Cook Inlet.
Jan. 2003:	Prepare data presentation and attend restoration meeting.
April 15, 03:	Annual report due EVOS.
July –Nov. 03:	Monitor and evaluate tagged fish recovery, survival, behavior and tag retention from fish recovered in the sport fishery on Ship Creek, the Ship Creek weir, and the commercial fishery in Cook Inlet.
Nov. – Dec. 03:	Data integration for tag recoveries, plot coho distribution and movement patterns in Cook Inlet.

Funding 2004 (USGS BRD)

April 15 2004:	Submit final report to EVOS on study results.
June – Sept. 04:	Preparation of manuscript for publication of results of coho tagging study.

B. Project Milestones and Endpoints

All EVOS costs for this project will be incurred in 2001 or 2002, with primary tagging costs in 2001 and secondary costs in 2002. Survey and monitoring costs increase in FY2002 due to increased probability of adult tag recoveries at the Ship Creek weir and a second tagging and release of coho from the hatchery. Similar costs of recovery in 2003 will be covered by USGS/BRD.

Due to timing of coho salmonid life cycle in Cook Inlet (one year at sea) data analyses will continue into FY2004.

Project will be completed upon submission of the final report prior to Sept. 15, 2004.

C. Completion Date

All project objectives billed to EVOS will be met before the end of Sept. 2003.

PUBLICATIONS AND REPORTS

Preliminary report submitted to EVOS April 15, 2002 in first year's recovery of tags. A final report of activities will be submitted to the Restoration Office on or before 15 Sept. 2004.

Manuscript containing final results and recommendations will be submitted to a peer-reviewed scientific journal for publication in FY04.

Website development and maintenance of our tagging database will be available FY01-04. At the end of the project we will transfer the internet site to a webmaster designated by the Trustee Council.

PROFESSIONAL CONFERENCES

International workshop was held on tracking salmon at sea FY01 (British Columbia, CA). Preliminary report of findings will be given at AFS meeting in Baltimore MD, August 2002. Final results will be presented at professional scientific meeting yet to be identified.

NORMAL AGENCY MANAGEMENT

The work proposed here is not part of normal agency management and is related specifically to research addressing oil spill restoration concerns. No similar work has been conducted, is currently being conducted, or is planned using agency funds.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This research provides fundamental information needed for the implementation and development a new technology dedicated to the identification of critical marine habitat for coho in Cook Inlet. The definition of critical marine habitat for economically and ecologically important fish species will serve as a cornerstone for future Trustee sponsored conservation and use management proposals under the GEM program. The major objectives of this work require interaction with several other investigators and integration of all available data that are relevant to the question of critical marine habitat in Alaska.

PROPOSED PRINCIPAL INVESTIGATOR

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PERSONNEL QUALIFICATIONS

Jennifer Nielsen is Fisheries Supervisor and Research Biologist (GS14) with the Alaska Biological Science Center, USGS Biological Resources Division. She has conducted salmonid and fisheries research throughout the western Pacific for the past 22 years. Dr. Nielsen is an Associate Professor at the University of Alaska, Fairbanks in the School of Fisheries and Ocean Sciences. From 1995 - 1999 she was a visiting scientist at Hopkins Marine Station, Stanford University, where the first experiments on satellite pop-up tags were conducted on blue fin tuna. From 1995 - 1999, she was an Adjunct Professor in Ichthyology and Fisheries at the University of California, Berkeley and Moss Landing Marine Laboratory, and served on the Scientific Review Board for the Monterey Bay Aquarium. Dr. Nielsen has published over 30 peer-reviewed journal publications and book chapters, numerous technical reports, and gives frequent national and international presentations at scientific meetings addressing research issues in fish conservation, behavior, evolution, and genetics. Her work on salmonid fishes is recognized internationally for its contribution and focus in fisheries conservation and management.

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2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Budget Category:	Actual FY 2001	Proposed FY 2002	LONG RANGE FUNDING REQUIREMENTS					
						Estimated FY 2003		
Personnel	$15.40	$44.1						
Travel	$0.60	$0.8						
Contractual	$1.30	$2.0						
Commodities	$0.90	$0.9						
Equipment	$54.40	$50.0						
Subtotal	$72.60	$97.8						
General Administration	$2.40	$6.8						
Project Total	$75	$104.6						
Full-time Equivalents (FTE)	0.4	1.4						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

USGS/BRD will provide salary for PI, staff veterinarian, and systems scientist throughout the study and support all activities including logistical travel and training costs.
Data analysis and reporting writing will be done with USGS/BRD funds.

Revision December 2000: The budget originally proposed for this project ($100K) is being revised downward to $75K as requested by the Trustee Council. The $25K reduction being taken from salary will now be funded by the USGS instead.

FY02

Prepared 4/9/01

Project Number: 02404
Project Title: Testing Archival Tag Technology in Alaska Salmon
Agency: DOI-USGS--BRD

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Personnel Costs*:		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	Proposed FY 2002
Name	Position Description					
J. Nielsen*	Fisheries Supervisor	GS14/01	3.5	7.2		0.0
D. Wilson**	Fisheries Biologist	GS7/01	9.0	4.2		37.8
D. Mulcahy*	Fish/Wild. Veterinarian	GS13/05	0.5	6.8		0.0
D.Douglas*	Fish/Wild Scientists	GS12/05	0.5	6.0		0.0
Biological technician TBA	Fisheries Technician	GS05/01	3.0	2.1		6.3
						0.0
						0.0
						0.0
*all personnel costs will be covered by USGS/BRD						0.0
**3 months salary will be funded by USGS/BRD						0.0
						0.0
	Subtotal		16.5	26.3	0.0	
					Personnel Total	$44.1

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 2002
Description					
PI travel to professional conference					0.80
Web site preparation at USGS/BRD costs					0.00
PI & veterinarian travel to tagging site at USGS/BRD costs					0.00
Technical staff travel to hatchery site and weir at USGD/BRD costs					0.00
Data analyses, ARC-View mapping at USGS/BRD costs					0.00
				Travel Total	0.80

FY02

Prepared 4/9/01

Project Number: 02404
Project Title: Testing Archival Tag Technology in Alaska Salmon
Agency: DOI-USGS-BRD

FORM 3B
Personnel
& Travel
DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Contractual Costs:	Proposed FY 2002
Description	
Tag recovery reward reimbursements - Ship Creek Fish Derby	2.0
Additional tag recovery costs for 2003 & 2004 covered by USGS/BRD	0.0
ARC-View technical mapping training covered by USGS/BRD	0.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$2.0

Commodities Costs:	Proposed FY 2002
Description	
Materials and supplies - misc.	0.9
Hatchery costs for accelerated growth in coho covered by ADFG	0.0
2002 - 2004 Publication costs will be covered by USGS/BRD	0.0
Commodities Total	$0.9

FY02

Prepared 4/9/01

Project Number: 02404
Project Title: Testing Archival Tag Technology in Alaska Salmon
Agency: DOI-USGS--BRD

FORM 3B
Contractual & Commodities DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2002
Archive tags (light/temp/pressure) (100 @ 480 ea.)	100	0.5	50.0
			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**	$50.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
Any tags remaining from FY01 will be implanted in coho in 2002.		

FY02

Prepared 4/9/01

Project Number: 02404
Project Title: Testing archival tag technology in Alaska salmon
Agency: USGS

FORM 4B
Equipment
DETAIL

EXXON VALDEZ OIL SPILL DETAILED PROJECT DESCRIPTION

Project Title: Harlequin duck population dynamics

Project Number:	02407
Restoration Category:	Monitoring
Proposer:	Alaska Department of Fish and Game
Lead Trustee Agency:	Alaska Department of Fish and Game
Cooperating Agencies:	USFWS, USGS-BRD
Alaska SeaLife Center:	No
Duration:	3rd year of 3 year project (not incl. close-out)
Cost FY02:	$68,700
Cost FY03:	$43,000 (Report Writing, Close-Out)
Geographic Area:	Prince William Sound
Injured Resource:	Harlequin ducks

ABSTRACT

Harlequin duck (*Histrionicus histrionicus*) populations in Prince William Sound (PWS) have not recovered from the effects of the *Exxon Valdez* Oil Spill. Populations are declining in oiled areas while increasing in unoiled areas. Proposed late-winter boat surveys have been designed to assess the recovery of ducks inhabiting oiled areas. Population structure, abundance, and recruitment will be compared between oiled and unoiled areas in PWS to assess trends, population dynamics, and the progress of recovery. This survey will also help identify changes to the Gulf of Alaska ecosystem and improve our ability to differentiate between natural and man-caused population changes. This will be the final year of field-work for Project \407.

INTRODUCTION

Harlequin duck (*Histrionicus histrionicus*) populations in Prince William Sound (PWS) have not recovered from the effects of the *Exxon Valdez* Oil Spill (*Exxon Valdez* Oil Spill Trustee Council 1999). Populations are declining in oiled areas while increasing in unoiled areas (Rosenberg and Petrula 1998). Ducks in oiled areas exhibited elevated levels of cytochrome P450 induction, indicating continued oil exposure, and adult female winter survival was lower in oiled than unoiled areas (Trust et al. 2000, Esler et al. 2000). Collectively, these studies suggest that oil exposure, female survival, and population dynamics are linked and provide strong evidence that harlequin ducks have not recovered from the effects of the *Exxon Valdez* oil spill.

Harlequin ducks occur year-round in intertidal zones of PWS (Isleib and Kessel 1973). At least 1,298 harlequin ducks were estimated to have died as a direct result of oil exposure following the Exxon Valdez oil spill (J. Piatt pers. comm.). Oil spill studies of harlequin ducks in western Prince William Sound (PWS) from 1990-93 found consistently low numbers of birds during the breeding season, little breeding, low productivity, and an apparent decline in post-breeding molting birds (Patten et al. 1998a, Patten et al. 1998b). In 1995, six years after the Exxon Valdez oil spill there was no sign of recovery (Exxon Valdez Oil Spill Trustee Council 1996).

As a result of the 1990-1993 findings and the lack of recovery, ADF&G initiated population monitoring in 1994 (Rosenberg and Petrula 1998). These studies, conducted from 1994 through 1997, found no difference in population structure between oiled and unoiled areas; no brood production in the spill area; and a decline in molting populations. Similar population structures, a positive finding, indicated that the population was in a position to recover. However, the declining trend in numbers during autumn surveys for the oiled areas of western PWS remained a concern, especially since populations in unoiled eastern PWS increased. This indicated that recovery has not occurred.

Other studies support our findings. Winter survival of adult female harlequin ducks was lower on oiled areas than unoiled areas in PWS (Esler et al. 2000). Modeling efforts based on this data predicted a declining population in the oiled area and a stable population in the unoiled area. Lower survival rates may be related to continued oil exposure (Esler et al. 2000, Peterson 2001). Results of USFWS marine bird surveys are ambiguous. These surveys show no evidence of population recovery based on summer surveys. However their March surveys show an increase in densities in both oiled and unoiled areas, suggesting that the recovery process may be underway (Lance et al. 2001).

Sea duck populations, in general, are composed of relatively long-lived birds with delayed sexual maturity. Productivity may be limited to a few favorable years and population levels may change slowly. Long-term population stability depends on high adult survival coupled with a few years of successful reproduction. Initial high losses of adults, especially females, may result in a long and slow recovery period, especially if initial causes of mortality are still influential.

Harlequin ducks occur year-round in the nearshore environment, feed on benthic invertebrates, exhibit site-fidelity, are relatively long-lived, and are widely dispersed in the Gulf of Alaska.

These characteristics make them unique among nearshore avian predators and ideal candidates for monitoring ecosystem change.

We propose one more year of winter surveys in order to compare population trends and structure with survey data collected in 2000 and 2001. We will survey oiled and unoiled areas identified in project \427 (Rosenberg and Petrula 1998) plus the additional oiled and unoiled areas added by this project (\407). With 3 years of expanded geographic coverage we can compare regional differences in population trends within oiled and unoiled areas, increase statistical power to detect recovery, and improve our ability to asses changes in the marine ecosystem. We will also be able to incorporate a 1997 winter survey of narrower geographic scope.

Surveys will be conducted in March. March is a period of relative stability in both numbers and movements of harlequin ducks. With modifications, this is a continuation of Project /427 Harlequin Duck Recovery Monitoring conducted from 1995-1997. No fieldwork was conducted on project /427 in FY98 or FY99.

NEED FOR THE PROJECT

A. Statement of Problem

Harlequin ducks have not recovered from the effects of the *Exxon Valdez* oil spill. Populations in oiled areas are continuing to decline (Rosenberg and Petrula 1998). Declining molting populations, coupled with low female survival, and exposure to hydrocarbons in oiled areas are all indicative of a lack of recovery and continued oil spill effects. Residual oil is still present in the nearshore environment (Carls et al. 2001) and has the potential to interfere with physiological processes (Holland -Bartels et al. 1999). Two main hypotheses have been presented to explain population declines: (1) ingested oil is continuing to cause either mortality and/or sublethal impairment of reproduction; and/or (2) initial mortality caused significant losses to the western PWS population which may result in a protracted recovery period.

The greatest biological problem in identifying the effects of the EVOS was our lack of basic knowledge on harlequin duck life history, ecology, distribution, and abundance. Poor knowledge of harlequin duck life history at the time of the spill made it difficult to design effective damage assessment and monitoring programs. Scant baseline data on population size made assigning injury and recovery based on pre-and post-spill comparisons tenuous because of a low sample size, high variability, and data that was collected many years before the spill. Poor understanding of regional differences within PWS confounded interpretations of differences between oiled and unoiled areas. This clearly pointed out the need to have good baseline information and time-series data on numbers, distribution, population structure, and a variety of life history events.

Identifying and establishing the cause of population declines depends on knowledge of the status of the resource immediately prior to environmental perturbations and an understanding of the inter-annual variability or the normal variation between years in periods of little perturbations in the larger physical system. Thus, our ability to detect departures from natural variation is necessary if we are to accurately evaluate the effects of major environmental perturbations

whether natural or man-caused. This requires numerous samples, distributed through time, preferably focusing on long-lived species that tend to show less natural variability. Without time-series data on harlequin duck abundance and abiotic and biotic ecosystem changes we lack the ability to interpret the affects of natural or man-induced processes.

B. Rationale/Link to Restoration

This proposed work represents a relatively simple, workable approach to the long-term monitoring of harlequin duck populations that will allow us to assess recovery from the spill, detect long-term ecosystem changes, gather basic life history information, and improve management.

We propose a survey that will have the power to detect trends in populations in oiled and unoiled areas, provide information on population demographics, and give insight into geographic differences within PWS. This study is directly linked to the recovery objectives for harlequin ducks in the EVOS Restoration Plan (Exxon Valdez Oil Spill Trustee Council 1999). This project will provide winter population trends; compare population structure, and provide an index of recruitment between oiled and unoiled areas.

Harlequin ducks are highly philopatric to breeding, molting, and wintering sites (Robertson and Goudie 1999, Robertson et al. 2000). This is an adaptive strategy in natural situations and predictable environments. It is not favorable in the face of dramatic environmental perturbations or rapidly changing land-use practices. It does not favor rapid recovery and colonization of new undisturbed sites. This strong philopatry may result in continued exposure to residual oil or delays in pioneering new nest sites once populations stabilize. Monitoring provides a direct approach to assess recovery.

Information from this project will aid in the development of a population model. A population model is central to monitoring harlequin duck recovery. The model must include demographic parameters and identification of critical periods of the annual cycle that may limit recovery from the *Exxon Valdez* oil spill. This will allow researchers to predict population trends and rate of recovery. While some of this information has been collected for PWS populations (Rosenberg and Petrula 1998, Holland-Bartels et al.1999) and harlequin ducks in North America (Goudie et al. 1994, Robertson and Goudie 1999), many specifics are still lacking, including data on productivity, recruitment, dispersal, and subadult survival.

Detecting trends in abundance and productivity from natural year-to-year variation will be met sooner with increased sampling. Results of this work will have a direct bearing on assessing the status and outlook for this resource and help guide agency programs and policies related to public uses, especially subsistence and recreational hunting, land-use practices, and wildlife viewing.

C. Location

The proposed project will be conducted in the oil spill area of western Prince William Sound and unoiled eastern PWS between Valdez and Cordova and northern Montague Island. March surveys will repeat areas surveyed in /427 Harlequin Duck Recovery Monitoring (Rosenberg and Petrula 1998). Additional survey sites in PWS will be located on Montague Island, following the sampling scheme of project \025 Nearshore Vertebrate Predator Project (Holland-Bartels et al. 1999), and southwestern PWS.

Surveys in the spill area will focus on Knight Island, Applegate Island, Foul Bay, Main Bay, Eshamy Bay, Crafton Island, Chenega Island, Green Island, Naked Island, and Bainbridge, Evans, and LaTouche islands in southwestern PWS. Surveys in non-oiled areas will include portions of Hinchinbrook Island, Simpson Bay, Sheep Bay, Port Gravina, Landlocked Bay, Bligh and Busby islands, Galena Bay and Valdez Arm, and Montague Island.

Communities affected by the project include Chenega Bay, Tatitlek, Whittier, Valdez, and Cordova.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

The project will continue to inform and coordinate our community involvement activities. This effort began with project /427 (Harlequin duck recovery monitoring) and a TEK report is included in Rosenberg and Petrula (1998). This effort was continued with project /273 (Scoter life history and ecology: linking satellite telemetry with traditional ecological knowledge).

Efforts have and will continue to be made throughout the restoration process to participate in and provide public involvement in the design and implementation of this project. Information gathered from this project will be shared with local communities. Study plans and results of project /427 and project /273 have been presented in the oil spill communities of Tatitlek, Chenega Bay, Cordova, Port Graham, Nanwalek, and Seldovia and at meetings of community facilitators. We will continue to present information to local communities and prepare articles or photographs for Trustee Council publications.

Boat and air charter contracts, and other services will continue to be contracted from local sources when possible.

PROJECT DESIGN

1. Surveys

A. Objectives

1. Compare population structure (number of breeding pairs, subadult males, adult males, and females) between oiled and unoiled areas during March.

2. Estimate density for oiled and unoiled survey sites in March.

3. Compare annual changes in density and population structure for oiled and unoiled survey sites.

4. Compare annual changes in density and population structure *within* oiled and unoiled survey sites during March.

5. Compare results with EVOS project /427 Harlequin Duck Recovery Monitoring (spring, summer and fall surveys).

6. Add to our knowledge of harlequin duck life history

7. Integrate data with other long-term monitoring surveys to detect long-term changes in marine ecosystems

B. Methods

This study will test the following hypotheses:

1. Objective 1.
   H_o: The ratio of males to females; total ducks to subadult males; and breeding pairs to total ducks is the same for oiled and unoiled populations during March.

   H_1: The ratio of males to females; total ducks to subadult males; and breeding pairs to total ducks is different for oiled and unoiled populations during March.

A generalized logit model (Agresti, 1990) will be used to test differences in population structure for oiled versus unoiled survey sites. Male:female ratios for individual survey periods will be compared by estimating proportions using cluster sampling (flocks) (Cochran, 1977).

2. Objective 2. No hypothesis is being tested.

3. Objective 3.
   Ho: The rate and direction of population change between years is the same for oiled and unoiled survey sites.

H_1: The rate and direction of population change between years is different for oiled and unoiled survey sites.

Density changes will be tested by regression and population structure will be tested with logistic regression (Agresti, 1990).

4. Objective 4.
H_o: The rate and direction of population change between years is the same within oiled and unoiled survey sites.

H_1: The rate and direction of population change between years is different within oiled and unoiled survey sites.

Density changes will be tested by regression and population structure will be tested with logistic regression (Agresti, 1990).

5. Objective 5. No hypothesis is being tested.

6. Objective 6. No hypothesis is being tested.

7. Objective 7. No hypothesis is being tested.

March surveys. Surveys will be conducted in representative portions of oiled areas in western PWS and unoiled areas in eastern PWS. FY 95-97 transects will be repeated (Rosenberg and Petrula 1998) and new transects have been added in areas of northern Montague Island and southwestern PWS. Surveys will be conducted from approximately March 20 through 30. Repeat surveys will not be conducted and surveys in oiled and unoiled areas will not be conducted simultaneously because population flux is expected to be minimal at this time of year.

All harlequin ducks will be recorded along each survey route. Observations will be recorded as pairs or by sex, and males will be divided into two age groups using predetermined criteria (Rosenberg and Petrula 1998). Surveys will be conducted from open skiffs up to 20 feet long. Each skiff will have two observers. Surveys will be conducted from within 30 meters of shore along predetermined routes. A pace and course will be chosen that will assure complete coverage of the survey area and maximize the opportunity to see ducks. All transects will be mapped and all observations will be recorded by date and location and mapped by flock.

Population composition and annual changes in density will be compared to test whether harlequin duck populations are exhibiting similar growth trends or the oiled (injured) population is exhibiting a different direction or rate of change. We will continue to test whether low reproductive success in oiled areas has resulted in changes in population age and sex structure. The proportion of first-year males to total males will be used as a measure of past reproductive success. Proportions of paired birds and male:female ratios will be compared for oiled and unoiled sites to indicate breeding propensity. Surveys will be used to detect changes in abundance

and compare the direction and rate of change between years for the two survey areas. Surveys within oiled and unoiled areas will be compared to determine if geographic differences are detectable. Data from FY95-FY97 surveys will be incorporated into the analysis when applicable.

Power Analysis. We compared our March 1997 survey with the corresponding subset of our March 2000 survey. Data from 2001 was recently collected and can not be added at this time. In EPWS (unoiled), 24 transects from 5 geographically similar regions were surveyed covering 244 km of shoreline. In WPWS (oiled), 18 transects from 7 geographically similar regions were surveyed covering 310 km of shoreline. For each transect we fit a simple linear regression model (y = density, x = year) to obtain an estimate of the rate of change in duck densities (birds/km). A hierarchical ANOVA was used to test for differences in the rate of change between locations. The model used was:

Rate of Change = overall mean + location + region (location) + transect (region location)

The power of the test was then calculated for several differences in slope between EPWS and WPWS and is presented below.

Difference in slope	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3
power (α= 0.10)	0.52	0.67	0.81	0.90	0.95	0.98	0.99	1.00	1.00
power (α= 0.05)	0.30	0.46	0.62	0.76	0.87	0.94	0.97	0.99	1.00

We observed a significant difference in the rate of change in density between EPWS and WPWS (difference in mean slopes = 0.76, p-value = 0.016). We would correctly reject the null hypothesis that there is no difference in the rate of change between EPWS and WPWS 81% of the time when the slopes differed by at least 0.7 (α=0.10). Because the slope is based upon density (birds/km), we can convert this change in slope to the change in the number of ducks we observe on our surveys.

By adding transects in oiled portions of southwest PWS (SWPWS) and unoiled Montague Island (Montague) we should be able to increase the power of our test, thus improving our ability to assess recovery. However, at present we cannot calculate a variance or slope for SWPWS or Montague because we only have one year of survey data. Thus, we cannot determine the power to detect a change in slopes between SWPWS and WPWS (i.e. within oiled areas) or between Montague and EPWS (within unoiled areas) until we have at least one more year of surveys. Regardless, the difference in slopes and how they compare to WPWS and EPWS will give us an estimate of geographic differences and of the contribution of these additional areas to any changes we observe.

Winter transects will give us greater power to detect change than our fall surveys (Rosenberg and Petrula 1998). With 3 years of survey data for the entire geographic coverage we will be able to calculate the true slope and variance. Beyond that, frequency of sampling will depend upon

biological and economic factors, and recovery objectives. Comparing the annual variation and rate and direction of slopes relative to each other will help determine sampling frequency.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

ADF&G personnel will conduct all data collection and analysis. Winter surveys and contracts for vessel support for winter surveys will be coordinated with related EVOS projects. Private sector contracts for winter vessel support will be solicited.

SCHEDULE

A. Measurable Project Tasks for FY 2002

October 2001	Project start-up. Interagency coordination. Plan logistics and personnel for winter surveys. Contract for vessel support.
Jan. –Feb. 2002	Hire seasonal technicians for March survey. Prepare field equipment. Finalize field logistics.
March 2002	Conduct winter surveys in PWS.
April – May 2002	Create databases, GIS. Analyze field data and begin report preparation. Maintain equipment.
June - July 2002	Analyze data
July-Aug-Sept 2002	Analyze data and begin report preparation
April 2002	Annual Report submitted

B. Project Milestones and Endpoints

FY02

October-February:	Coordinate and plan surveys, prepare equipment, contract for vessel support, hire personnel.
March:	Conduct population surveys.
April-September:	Data analysis and report preparation, maintain equipment.
April 15:	Submit annual report.

FY03

October-April:	Close-Out. Additional data analysis and manuscript preparation
April 15:	Submit Manuscripts.

This is a minimum three-year monitoring program designed to assess the recovery of an injured species. Each project objective will be assessed annually for oiled and unoiled areas then compared with each other and with data collected in subsequent years. Year to year trends will

first be compared in 2000 and then each year after. At the end of three years results will be compared with the restoration goals to assess whether recovery has occurred.

C. Completion Date

Under present guidelines, harlequin ducks will have recovered when breeding- and nonbreeding-season densities return to prespill levels. An increasing population and decreasing exposure to hydrocarbons in oiled parts of PWS will indicate that recovery is underway (Exxon Valdez Oil Spill Trustee Council, 1999).

This project will compare harlequin duck population structure and abundance between oiled and unoiled areas and within geographic areas. Until further information is gathered it will not be possible to predict when densities will return to prespill levels and oiled populations exhibit a positive trend, indicative of a population increase comparable to unoiled areas. This project may also discover new information that will suggest changes to the Recovery Objectives and it meets the objectives of the Gulf Ecosystem Monitoring program. If continued for the long-term, this survey will help identify changes to the Gulf of Alaska ecosystem and improve our ability to differentiate between natural population changes and those induced by human intervention.

PUBLICATIONS AND REPORTS

Annual reports will be presented to the Chief Scientist by April 15. Reports will include survey areas, population structure and abundance and movements and timing of marked birds. A final report will be prepared at the end of the proposed monitoring schedule unless continued monitoring is warranted or when recovery objectives are met. Special reports (publications) will be prepared during the course of the monitoring effort if warranted. Publications will be prepared for peer-review journals when sufficient data has been collected to warrant manuscript preparation.

PROFESSIONAL CONFERENCES

Harlequin Duck Working Group – date and time to be determined.

NORMAL AGENCY MANAGEMENT

There are no other agency or non-agency contributions to this project. ADF&G is not required to conduct these surveys by statute or regulation. Limited staffing and funding precludes ADF&G from undertaking these surveys as part of normal operations and in the past ADF&G has not conducted marine bird surveys in PWS as part of its normal waterfowl management functions.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This research relies on incorporation of methods and information from other EVOS Trustee

sponsored research, including projects /427, and /025. Equipment purchased by /427 and /273 will be used to conduct this research. Location of research sites, and data collection and analysis will follow previously established protocols. All efforts will be made to coordinate surveys and share vessel support and equipment with other EVOS projects. Personnel with ADF&G and USGS-BRD will assist each other when possible.

This project will be integrated with ongoing studies or findings of past studies including project \052B Traditional Ecological Knowledge; project \025 Nearshore Vertebrate Predator Project; project \427 Harlequin Duck Recovery Monitoring; and project \159 Prince William Sound Marine Bird and Mammal Surveys.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

No major changes from FY2001. This is the third-year of this proposed 3-year project (not including close-out).

PROPOSED PRINCIPAL INVESTIGATORS

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PERSONNEL QUALIFICATIONS

Dan Rosenberg has been a waterfowl biologist for The Alaska Department of Fish and Game (ADF&G) since 1985. From 1980-1983 Mr. Rosenberg conducted field research in Alaska as a waterfowl biologist for the U.S. Fish and Wildlife Service and from 1983-1984 as a Habitat Biologist for ADF&G. Mr. Rosenberg received a Bachelor of Science degree in Wildlife Management from Humboldt State University, Arcata, CA in 1979.

Mr. Rosenberg has conducted harlequin duck population (age and sex structure) and production surveys in Prince William Sound since 1994 as the Principle Investigator of a Trustee sponsored restoration project. Mr. Rosenberg is currently the principal investigator on EVOS Trustee sponsored project \273 Surf Scoter Life History and Ecology: Linking Satellite Telemetry with TEK to Conserve the Resource. He has conducted extensive waterfowl population monitoring and habitat assessment surveys on the Copper River delta, Stikine River delta, Kenai wetlands, upper Cook Inlet, Aleutian Islands, and Kodiak Island. As project leader, Mr. Rosenberg has assessed impacts to waterfowl and wildlife populations from hydroelectric development, urban expansion, habitat alterations, chemical pollutants, timber harvest, and surface mining.

OTHER KEY PERSONNEL

Mike Petrula, Wildlife Biologist, ADFG. Field logistics, surveys, data analysis, and report preparation. Mr. Petrula has an MS degree in wildlife Biology from the Univ. of Alaska, Fairbanks. He has been working on EVOS projects \427 Harlequin Duck Recovery Monitoring and \273 Surf Scoter Life History and Ecology: Linking Satellite Telemetry with TEK to Conserve the Resource.

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2002 EXXON VALDEZ TR EE COUNCIL PROJECT BUDGET

October 1, 20 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002						
Personnel	$38.5	$38.7						
Travel	$0.2	$1.4						
Contractual	$19.8	$19.6						
Commodities	$1.9	$1.8						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$60.4	$61.5		Estimated FY 2003				
General Administration	$7.2	$7.2						
Project Total	$67.6	$68.7		$43.0				
Full-time Equivalents (FTE)	0.6	0.6						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY02

Prepared:4/10/01

Project Number: 02407
Project Title: Harlequin Duck Population Dynamics
Agency: Alaska Department of Fish and Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2002 EXXON VALDEZ TR E COUNCIL PROJECT BUDGET

October 1, 200 - September 30, 2002

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2001
D. Rosenberg	WBIII, Principal Investigator	18J	3.0	6.5		19.5
Mike Petrula	WBII, survey and data analysis	16C	2.5	4.6		11.5
2 F&G Tech.	F&G Tech. III, Field Technician	11F	1.8	3.7	1.0	7.7
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		7.3	14.8	1.0	
					Personnel Total	$38.7

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
Whittier parking, 2 vehicles- 12 days					0.2
Whittier Toll - 2 vehicles and trailers					0.1
Harlequin Duck Working Group	0.6	1	5	0.1	1.1
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.4

FY02

Prepared:4/10/01

Project Number: 02407
Project Title: Harlequin Duck Population Dynamics
Agency: Alaska Department of Fish and Game

FORM 3B
Personnel
& Travel
DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Contractual Costs:	Proposed FY 2001
Description	
Boat and outboard motor repair and maintenance	2.0
Photo processing, presentation productions	0.4
Air charter for field support 4 hrs @ $270/hr	1.0
Trailer and boat moorage Whittier	0.1
Vessel support for March surveys 12 days @1300/day	15.6
Truck Leasing Costs	0.5
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$19.6

Commodities Costs:	Proposed FY 2001
Description	
Boat fuel 350 gallons @ $2.00/gal	0.7
Boat supplies- replacement parts, props, fuel lines, fuel filters, water filters, battery, absorbent rags, oil, emergency provisions	0.8
Field survey supplies- rite-in-rain notebooks/paper, nautical charts, batteries,	0.3
Commodities Total	$1.8

FY02

Prepared:4/10/01

Project Number: 02407
Project Title: Harlequin Duck Population Dynamics
Agency: Alaska Department of Fish and Game

FORM 3B
Contractual & Commodities DETAIL

New Equipment Purchases:		Number	Unit	Proposed
	Description	of Units	Price	FY 2001
	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:	Number	Inventory
Description	of Units	Agency
20 ft. Caribe rigid hull inflatable	1	ADFG
17 ft. Boston Whaler	1	ADFG
10x40 binoculars	4	ADFG
Spotting Scopes	2	ADFG
Survival Suits	2	ADFG
Outboard Motors/various hp	6	ADFG
Magellan GPS	3	ADFG
Marine VHF radios	4	ADFG

FY02

Prepared:4/10/01

Project Number: 02407
Project Title: Harlequin Duck Population Dynamics
Agency: Alaska Department of Fish and Game

FORM 3B
Equipment
DETAIL

CHENEGA BAY
STREAM ENHANCEMENT PROJECT
PROPOSAL

To: The Chenega Bay IRA Council
By: Andy McLaughlin -BS; Wildlife Management (Purdue University)

Summary

Currently several stream habitat constraints exist within the local airport stream watershed (O'Brian Creek). Improvements to these limiting factors would benefit the numerous fish species that utilize the habitat as well as the entire local ecosystem. The main goal of Phase 1 is to increase the depth of the water by creation of a series of dam and fish ladder structures. These enhancements would provide a renewable subsistence use fishery available for the native village of Chenega Bay, Alaska. Many species of salmon and trout populations occur in the stream. These species include, but are not limited to, Pink salmon (*Onchorynchus gorbuscha*), Chum salmon (*O. keta*), Coho salmon (*O. mykis*), Sockeye salmon (*O. nerka*), Dolly Varden trout (*Salvelinus fontinalis*), and cutthroat trout (*Salmo clarki*). Not only would all of the fish populations benefit from enhancement to the stream habitat but the remainder of the ecosystem would also benefit. The Native village of Chenega Bay would also gain an enormous potential for the expansion of socioeconomic factors. A self-sustaining limited subsistence use fishery would be priceless for the community, as well as adding potential for promoting tourism and recreation. By application of prescribed habitat enhancements the potential for improved salmonid reproductive success would be promoted. All of the salmonid species would benefit from such improvements, and numerous other wildlife species would also gain from the benefits of such restoration. This proposal is designed to improve numerous habitat conditions by enhancement of the present stream regime.

I.) SPAWNING HABITAT IMPROVEMENTS

Presently the salmonid species of O'Brian creek spawn in what can be considered marginal habitat. Some easily identifiable factors that can be improved upon are (in order of importance); water depth , structural diversity, spawning substrate supplementation, and hatchery supplementation of existing salmonid populations. All of these constraints can be easily improved upon both economically and physically. Such modifications will actively contribute to future natural salmon runs and increased productions will result.

Water Depth

The current stream water depth is for the most part too shallow for successful spawning and rearing of the larger salmonid species. In the main branch of the stream channel, in the lower stretches of the watershed, a series of dams and short height fish ladders could easily supplement the natural habitat and provide adequate spawning and travel depth for the returning adult salmon. The resulting increases in water depth would also provide more efficient rearing and outmigration environments for the newly hatched salmon fry in the early stages of their life cycle. A substantial increase in spawning area will also result. This series of dams would produce a stair step profile in the stream channel which will allow migrating salmon more efficient access to the forested upper stretches of the watershed. Spawning habitat that has previously had limited use (due to inadequate depth and lack of water) could be utilized by more fish. The series of pools

Water Depth (continued)

that will be created would also provide sediment deposition zones, where aquatic insects can harbor and improve the fish habitat. This series of dams and short height fish ladders is a vital constituent of the stream enhancement proposal in order to expand the range of habitat currently utilized by the spawning fish and should be considered as Phase 1 of the project.

In the small branch of stream that originates from the air strip watershed, and constitutes the fork that has confluence with the main stream channel just downstream from the bridge, a small dam can be positioned within a narrow portion of the pre-existing ravine that borders a narrow section of the flood plain. This area supports the greatest potential for providing a substantial deep water brood pond. The pond could be ~ 20 feet deep, and approximately 4 acres in area. If such a reservoir were constructed, and fitted with a tall height fish ladder, a drastic improvement in potential rearing environment would result. A series of fish ladders and dams would be needed below the reservoir dam in order to allow the returning adult salmonids access to the fish ladder. Certain salmonid species (Kings, Reds, and Silvers) that "require" a one year holdover in a freshwater rearing environment could have the potential to complete that part of their life cycle there. This reservoir could also house resident populations of both Cutthroat and Dolly Varden trout. Further investigations by a qualified stream hydrologist would be necessary to evaluate the feasibility of this potential brood pond location and to address any potential water quality issues. This particular drainage appears to contain high concentrations of iron. The close proximity of this location to the airstrip may also constitute the need for additional inquiry to the State of Alaska and the FAA. Upon completion of additional research, this reservoir part of the project could be considered as Phase 2. Even though such a brood pond environment would prove to be invaluable, the time constraint of additional research has lowered its apparent priority.

This proposed reservoir could also provide opportunities for the community to have recreational opportunities that have never previously existed. Not only would such a body of water provide a newly acquired niche for fish habitat, but it also could provide a location for ice skating, swimming, pick-nicking, fishing, and hunting. The specifically proposed area of this branch of watershed has previously had very limited use by both salmon and village residents. With the strategic placement of this dam creating a small reservoir in this drainage, it could provide undiscovered resource opportunities for both fish and community members that were not previously available.

Spawning Substrate

Presently the stream floor consists of bedrock, large rocks, gravel, and limited silt. By minimizing the areas of poor substrate (bedrock and large cobble rock) and increasing the amount of available spawning gravel on the stream floor the survivability of the naturally hatched salmon fry will improve. Enhancement of the stream floor substrate can be provided by the addition of imported small diameter pea gravel. Suspected areas in the streambed can be evaluated for egg hatch success and zones of marginal habitat can be identified and improved upon. Areas of high sedimentation do not provide ample percolation rates so that enough oxygen can be supplied to the developing salmonid embryos. Though the upper reaches of this watershed were heavily logged this watershed

seems very healthy. Excessive sedimentation does not appear to be a detrimental factor in the ecosystem. Though areas of bedrock or with predominantly too large of rock substrate do not provide adequate spawning material for salmonids to create their spawning "nests" or redds. Removal of inadequate substrate and replacement with a more successful substrate (small diameter gravel) will dramatically effect the hatching success and fish survivability. These areas can simply be manually dug out and supplemented with imported pea gravel. Such an improvement to egg environment will increase hatching success and provide higher outmigration numbers, which in turn will increase the marine survival. Increases in annual marine survival will cause larger numbers of adult salmon to return for spawning and the cycle can repeat itself perpetually. Introduction of a more suitable spawning substrate for a more sustainable fishery is another feasible alternative for improving the quality of the present zones of marginal spawning habitat, though it can also be considered phase 2, and of lower priority.

Stream Structure, Topographic Diversity, Habitat Restoration.

It will be imperative to maintain as much diversity within the stream structure as possible. Introduction of rip rap and levees on stream banks should be avoided, as this has been scientifically proven to have detrimental effects on stream diversity, though strategically placed vegetation, brush, logs, boulders, and root clumps for maintaining changes in stream channel direction and flow dynamics, are crucial ingredients for proper enhancement of the stream. Maintaining a diversity of these factors is necessary for a healthy stream. In allowing a natural meander of the stream channel within the flood plain in combination with stream flow obstacles, a diversity of depths and substrates can be maintained. Addition of randomly placed logs, root clumps, and woody debris have been proven to introduce the necessary nutrients needed for the smallest organisms of the food chain, thus benefiting the juvenile salmon. Such diversity is needed to meet the requirements for the life cycles of both vertebrate and invertebrate species. These aquatic insects and other organisms are food for fish, birds, and other wildlife. With addition of brush piles randomly positioned along the stream bank, juvenile salmon while obtain protected areas for predator avoidance. It is vital to keep a "dynamic equilibrium" in place within the entire watershed system and to not harm the function of natural stream habitat forming processes.

The introduction of short height fish ladders not only will provide an avenue for the adult salmon to return upstream, but it will also allow for the dual purpose of providing sufficient oxygenation of the water. There is a potential for times of low dissolved oxygen saturation to be reached when water temperatures reach high levels. Without increased oxygenation this could be a critical factor for the fish.

No areas of extreme erosion have been noted. The headwaters are the "lifeblood" of O'Brian Creek. Presently the forested zone of watershed (between the bridge and the clearcut) is acting as a buffer from severe sedimentation, but further upstream investigation is necessary within the deforested region to minimize organic material deposits that are caused by runoff. Controls of erosion can be provided in the future as the need arises.

II. Permitting

A.) **Environmental Impact Statements (EIS) and Environmental Assessments (EA)**

These necessary requirements can be met by a contracted environmental consulting firm. Though I have been informed that these requirements would only be necessary if federal funds are used for the project. This information was provided by the U.S. Forest Service.

B.) **Construction and Maintenance**

These processes can be provided by a local village resident work force. It is possible that extreme long term accumulation of sediment in the distant future could eventually require physical removal of silt from the stream bed.

C.) **Legal Issues**

Certain land use permission must be obtained from Chenega Corporation. It might be necessary to obtain a "conservation easement" in order to obtain the rights to provide this local stream enhancement project.

The State of Alaska (due to proximity of the airstrip to the watershed) might have to be involved and the Department of Transportation & FAA might have to be consulted for the reservoir construction during Phase 2 of the project.

Inquiry into the Alaska State Fish & Game Department will also be prudent in order to comply with any pending state regulations. I have been informed that an Alaska Fish & Game title 16 permit and a LOE 404 permit would be necessary for the project.

Other permits might be necessary in order to obtain the required fill and materials that can be provided from local sources.

All permitting issues could be provided by a contracted environmental consulting firm, if needed.

III.) WORK FORCE

A.) Labor

The general laborers can be provided "in house", and local residents can provide the majority of the jobs (other than what will be required by outside contractors).

B.) Equipment/ Materials

Several pieces of large heavy machinery already exist in the village and could be utilized for all of the needed support. Written permission should be obtained from the sources of the local machinery before they can be legally utilized.

Several tons of pea gravel /spawning substrate can readily be imported by landing craft from outside sources. The substrate materials needed for building the desired dams can be supplied locally.

Aluminum fish ladder deneils can be manufactured by an outside contractor to meet our specific requirements, or perhaps they can be donated or purchased from Prince William Sound Aquaculture Corporation.

B.) Equipment / Materials (continued)

Galvanized steel grating walkways supported by creosote treated piling should provide ample pedestrian access for observation of spawning salmon.

C.) Surveying

Limited surveying will be required to evaluate the adequate placement of the desired reservoir dam structures (Phase 2). Each small wire gabion dam (Phase 1) can be filled with pre-existing larger rocks from the same proximity of the local streambed. The location of the first dam should be placed at the high tide level in elevation where adult salmon travel depths first become inadequate. The proper placement of these water retainment structures will optimize spawning habitats by adopting prescribed water depths that are adequate for the needs of the fish. Each subsequent dam position should be determined by the next increase in increment of 2 feet while traveling up the stream channel.

IV. SPECIFIC PROJECTS

The entire stream enhancement and rehabilitation project consists of numerous smaller scale modifications to the existing stream habitat. Details on the areas in need of improvement will eventually be more specifically defined and mapped.

Fish populations can eventually be supplemented to the newly reformed habitat. If desired, hatcheries could eventually be utilized to supplement the naturally spawning salmon runs, or to stock a local trout population. Gametes from locally caught adult salmon and trout could be used in a hatchery program to provide the same genetic make-up as the wild stocks that presently occur. Or locally placed in stream incubation devices along with a locally performed egg take could be used to improve the existing hatch success, if desired. Alaska Fish and Game permits would be necessary in order to do so.

A series of 4 or 5 rock gabion dams constructed of nylon coated aluminum wire mesh basket material and welded aluminum fish ladders would be prudent for the lower stretches of the watershed that meets the tidal zone. This zone is also the area most easily accessible by heavy machinery and it contains the largest areas of unused gravel substrate within the flood plain. Dams strategically positioned there would increase the water depth resulting in a vast increase in spawning area that previously could not be utilized by the salmon. It would be more feasible to build a series of smaller dams within the upper stretches of the watershed (in the forested region) with natural materials that already exist in the proximity of where the dams are needed. These "less permanent" dams could easily be constructed by a local work crew.

V. FUNDING

Aide for grant writing proposals can be provided by the local Environmental Specialist and Assistant if needed. An adequate source for funding of this specific project can easily be sought out.

Shared funding for the building of the brood pond dam could possibly be provided by Ducks Unlimited as the resulting wetlands habitat will stand to benefit multiple waterfowl species.

Trout Unlimited might also prove to be a funding source for the stream restoration and enhancement as benefit to the fish habitat is bound to result.

The Exxon Valdez Oil Spill Trustee Council will be very beneficial as a potential funding source. They have an interest in benefiting village subsistence, intertidal communities, subtidal communities, sockeye salmon, pink salmon, Cutthroat trout, Dolly Varden trout, and numerous other parts of the ecosystem that would stand to benefit from such a project.

Other funding sources interested in benefiting human services such as recreation, tourism, and subsistence could also be sought out.

VI. SUBSISTENCE USE and FISHING RESTRICTIONS

A sustainable subsistence harvest of returning adult salmon will be the largest benefit for community residents. If a multi-species salmonid escapement is allowed to increase on a naturally regeneratable basis, the benefits it would provide to the community would be immeasurable. These proposed stream habitat improvements can also provide potential for resident populations of trout which can also supply a sustainable subsistence food resource. The resulting increase in spawning area and brood pond will provide a newly available wetlands habitat niche that can be utilized by a diversity of waterfowl and wildlife species.

A specific protected spawning area in the rehabilitated stream should be provided in order to allow a constantly renewable resource. If adult fish are not allowed to spawn, then they will have no offspring that can hatch in order to perpetuate their life cycle. No spawning adult fish should be allowed to be molested or removed from a specifically designated spawning ground sanctuary. Locally designed restrictions and bag limits can be determined in the future to meet the specific needs and desires of the village.

VII. TOURISM

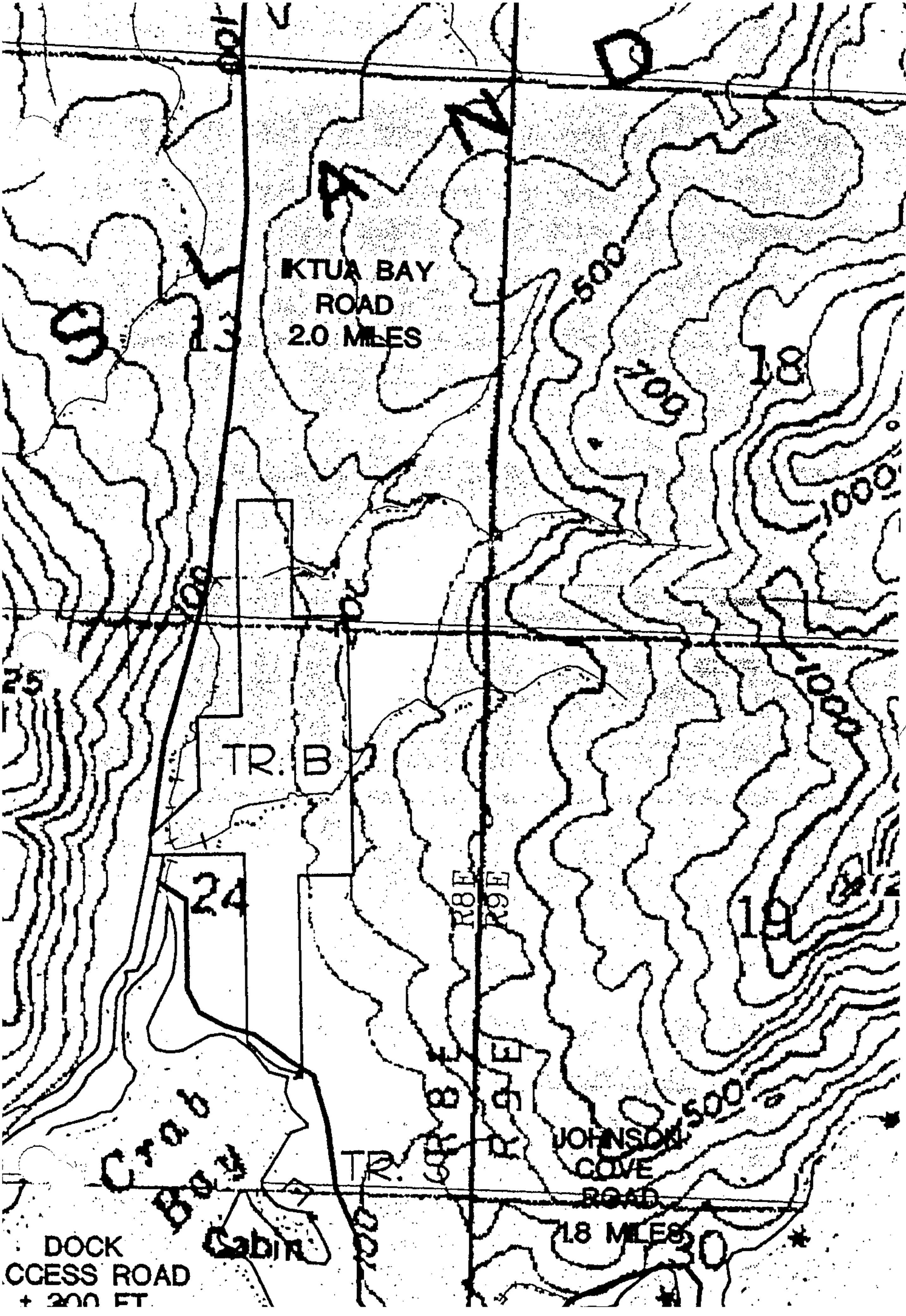
A parking area can be strategically constructed on the north side of the road, just East of the bridge. Inadequate fill is present, so this proposed parking area will need to be constructed in Phase 2 of the project (to coincide with the future roadway improvement project). Both residents and tourists will be able to access the walkway leading to the observation deck from the roadway in direct vicinity of the bridge. This public access walkway will allow easy access for spawning area observation. An observation deck and educational sign can be posted regarding the natural life cycle of the local fish, and the various stream enhancements that have been provided can also be listed and described in detail. These postings can provide credit to the funding sources that enabled them to happen. The walkway can begin at the proposed parking area and end at a stairway that leads up the airport road. This walkway loop will provide a valuable asset to both community recreation and potential tourism. The walkway should be constructed of either galvanized steel grating or fiberglass grating, as these materials will require the least amount of continual maintenance. They provide snow to fall through them and would withstand the least amount of damage from a winter snowload. The walkway grating will also allow for sunlight to access the surrounding vegetation and it will limit the erosion factor from heavy utilization of the area from human use. The walkway should be supported by posts and should have hand rails affixed. These both should be

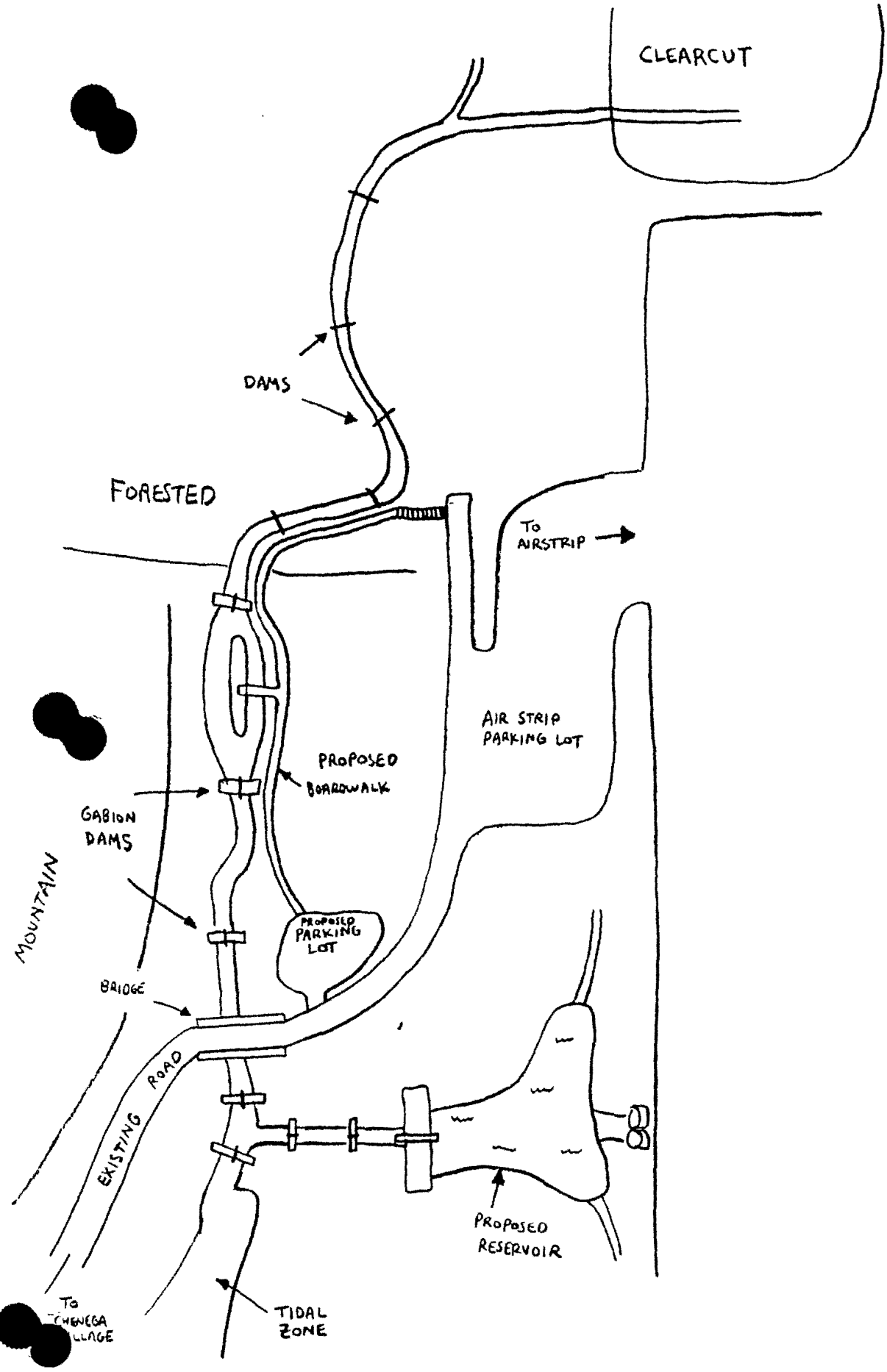
made of permanent materials that will last. Treated lumber should be avoided at all cost, due to the eventual cost of replacement from degradation in such a wet climate.

This habitat restoration project has little visible economic benefit to the community, but it does have the priceless potential to enhance both subsistence and recreational opportunities that exist beyond the limits within the present watershed habitat. Such ability to directly improve the local stream ecosystem by enhancement of the existing conditions could be considered cost effective when weighing the potential results.

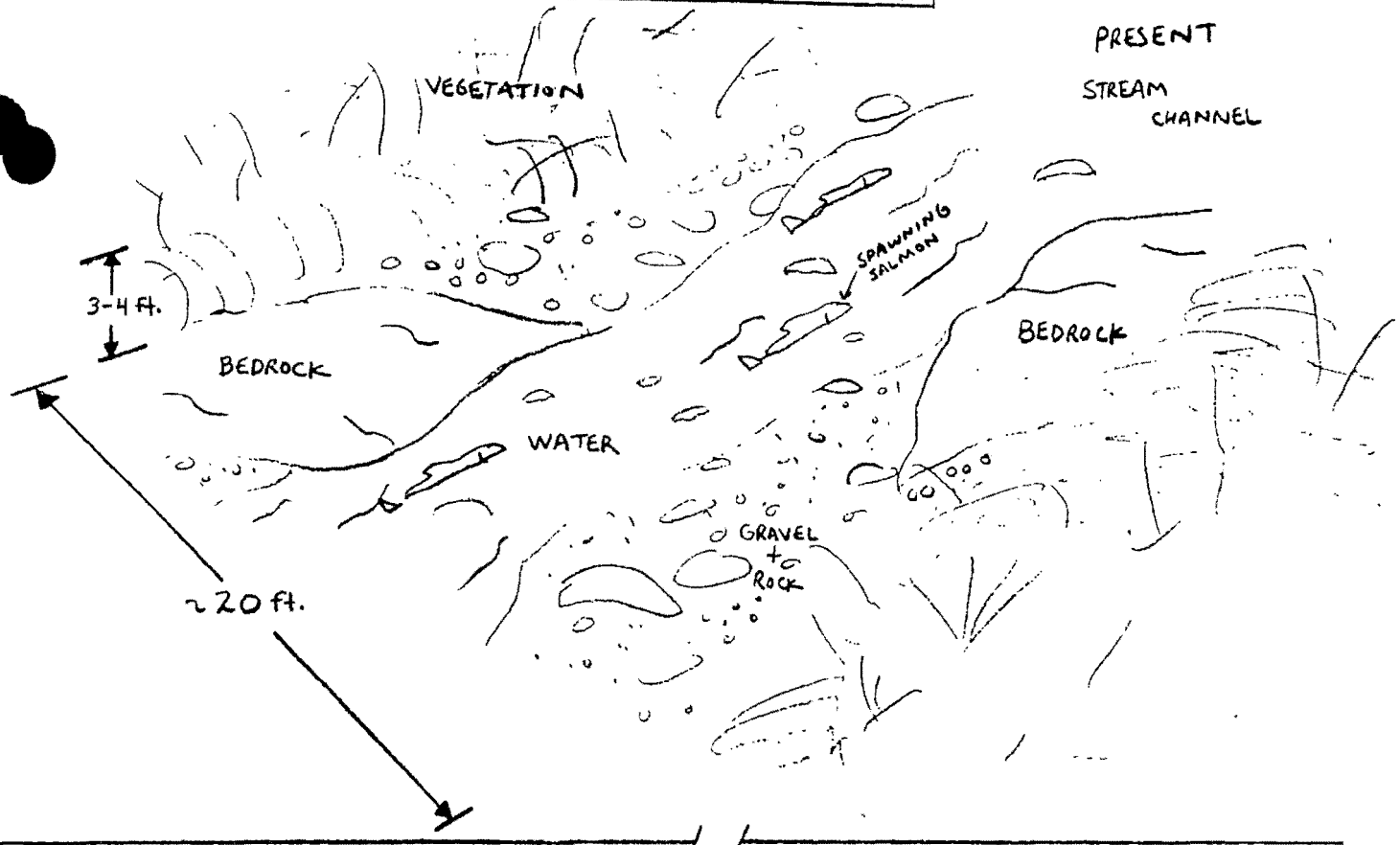
The potential for state of the art salmon stream habitat enhancement to take place in Chenega Bay, Alaska is at hand. If we are the first ones to do it in Prince William Sound others will surely follow suit, and our project can be used as an example. Hundreds of similar projects have already taken place elsewhere and could easily be consulted for direction if the need would arise.

Having a more self-sustaining fishery in addition to new recreational opportunities would be priceless. Eventually unforeseen tourism opportunities could also arise and additional expansions to this project would eventually have the potential to benefit the local community within its limited natural resources.

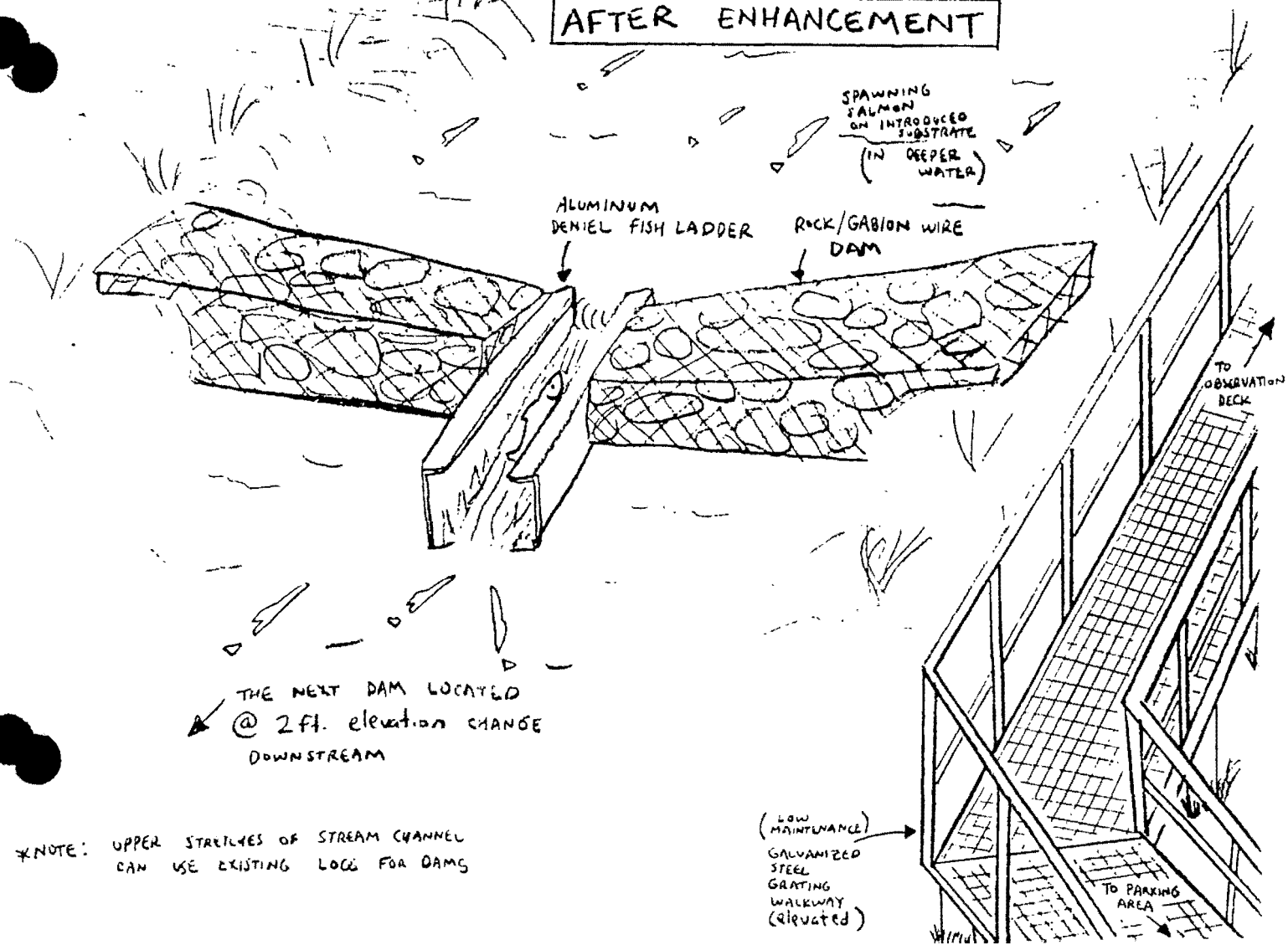

ISLAND
IKTUA BAY
ROAD
2.0 MILES
13
18
500
700
1000
TR. B
24
19
R8E
R9E
Crab Bay
JOHNSON
COVE
ROAD
1.8 MILES
30
DOCK
CCESS ROAD
Cabin


CLEARCUT
DAMS
FORESTED
TO AIRSTRIP
AIR STRIP PARKING LOT
PROPOSED BOARDWALK
GABION DAMS
MOUNTAIN
PROPOSED PARKING LOT
BRIDGE
EXISTING ROAD
PROPOSED RESERVOIR
TO CHENEGA VILLAGE
TIDAL ZONE

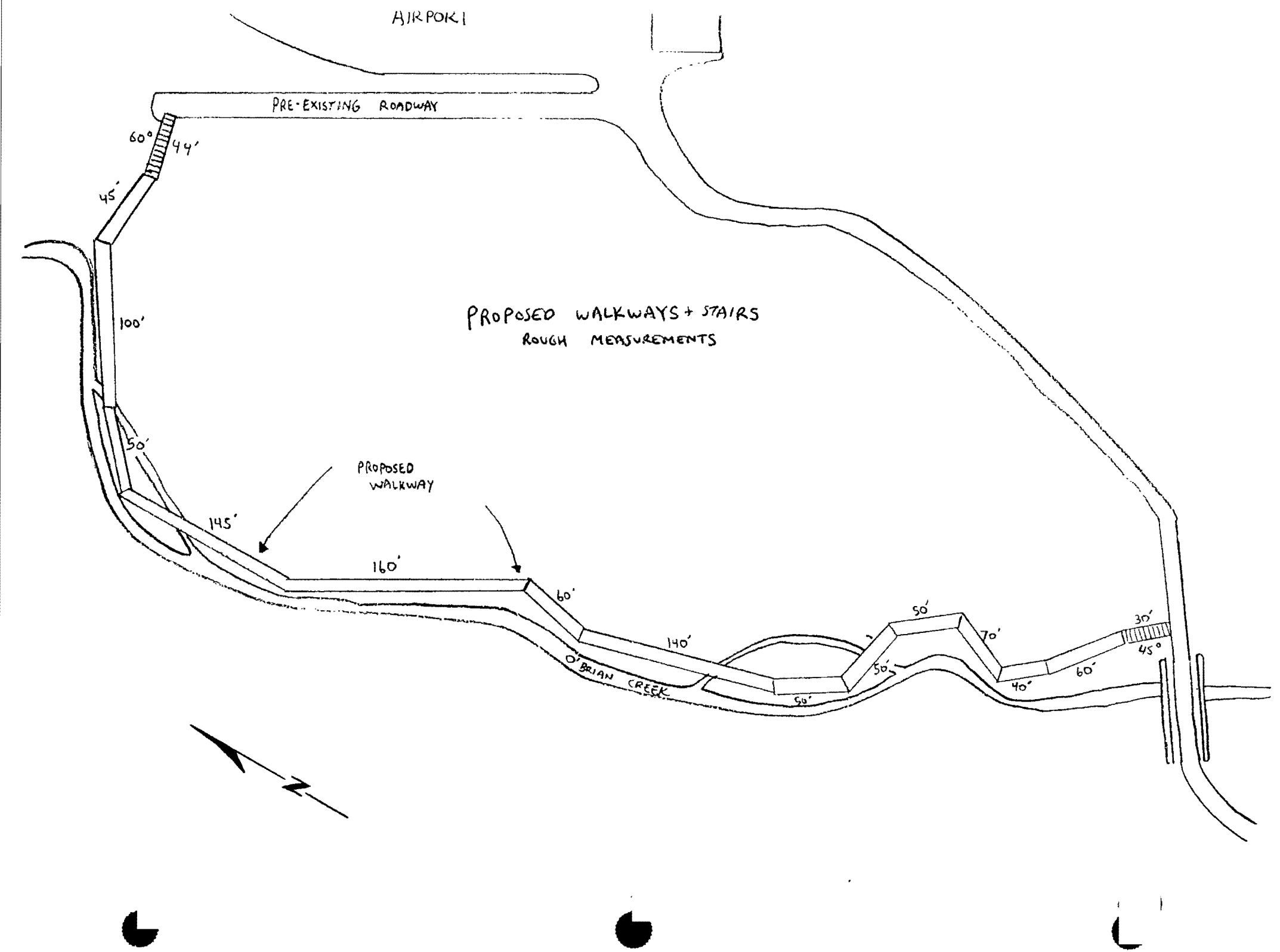
BEFORE ENHANCEMENT



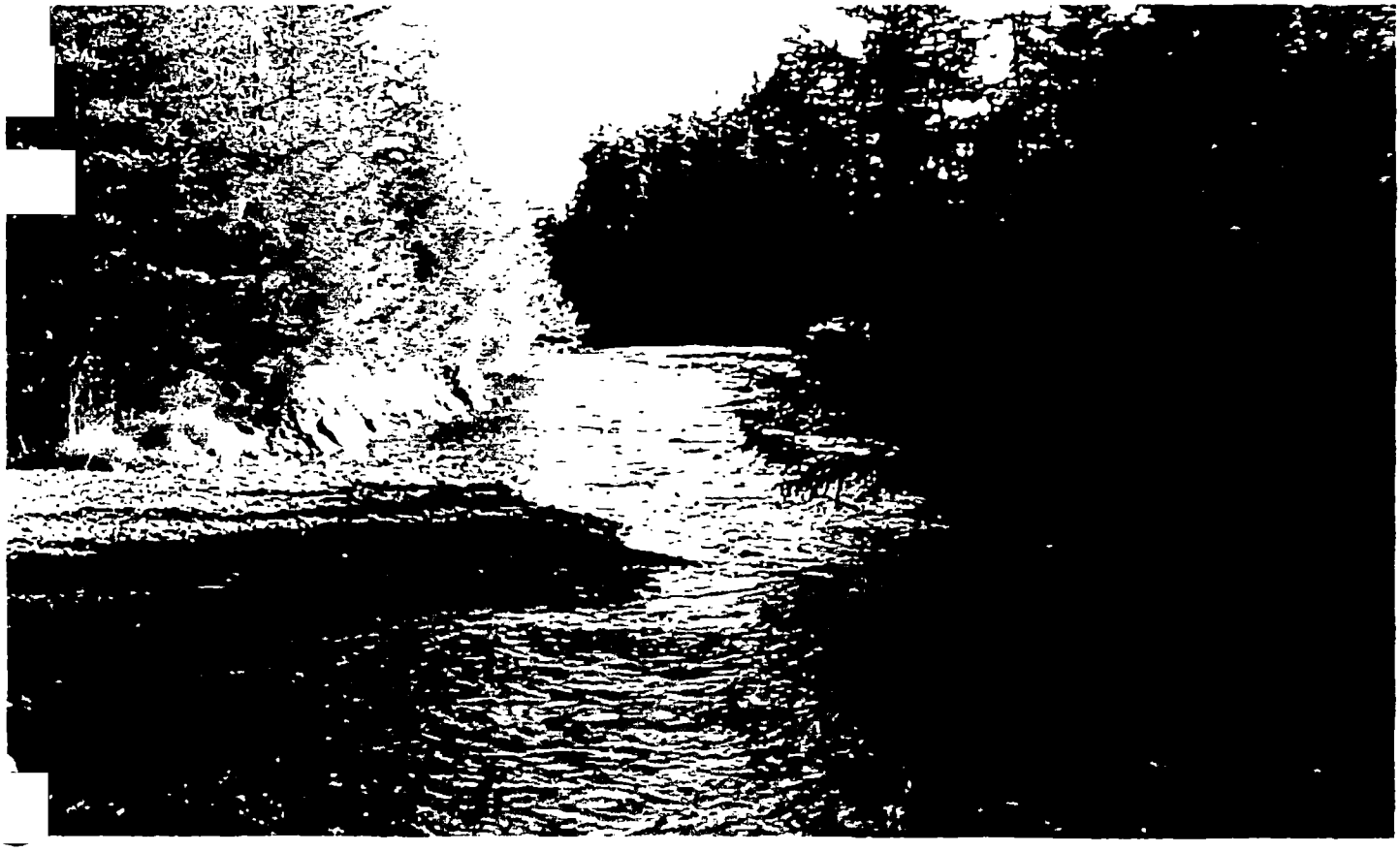
AFTER ENHANCEMENT

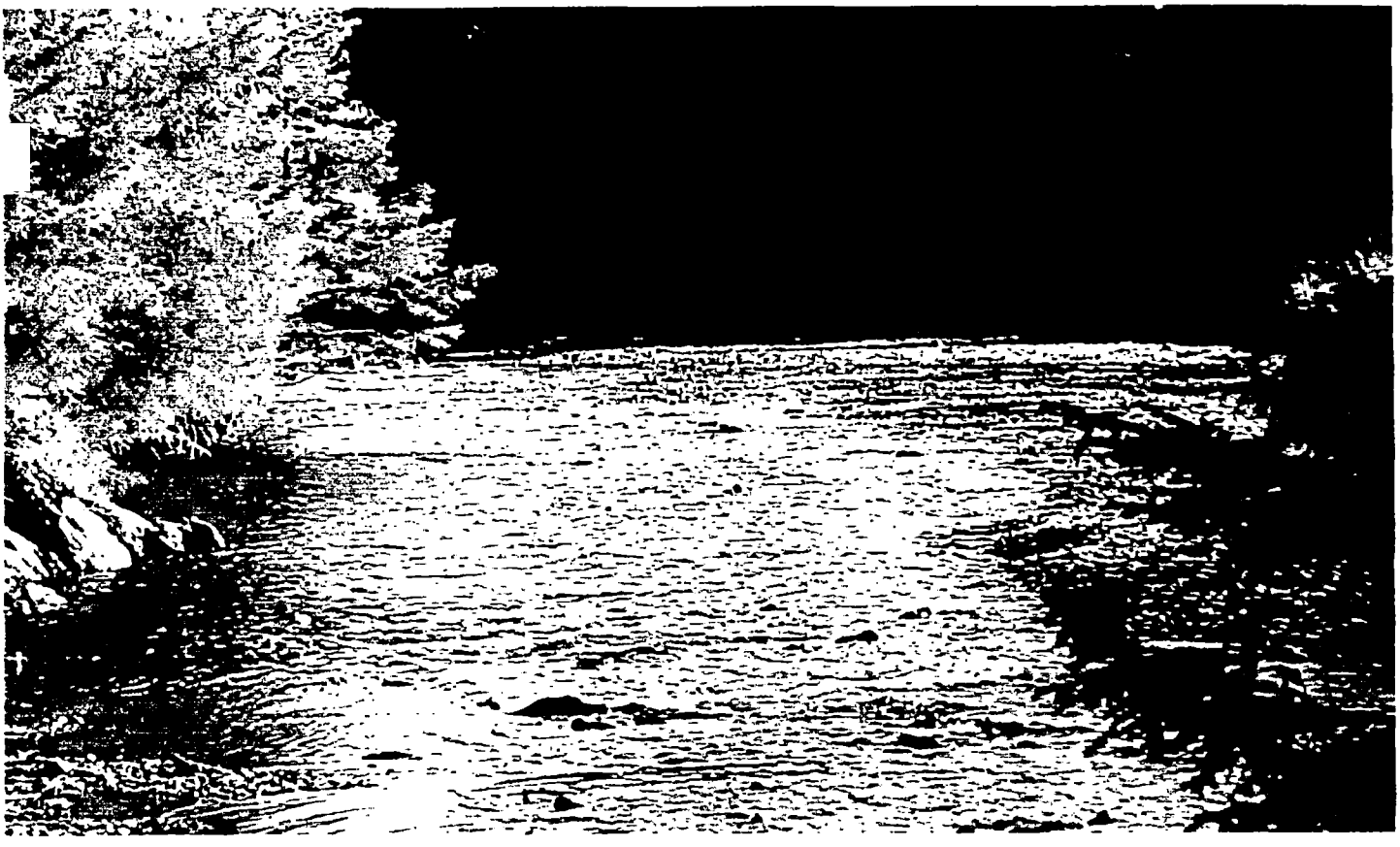


*NOTE: UPPER STRETCHES OF STREAM CHANNEL CAN USE EXISTING LOGS FOR DAMS

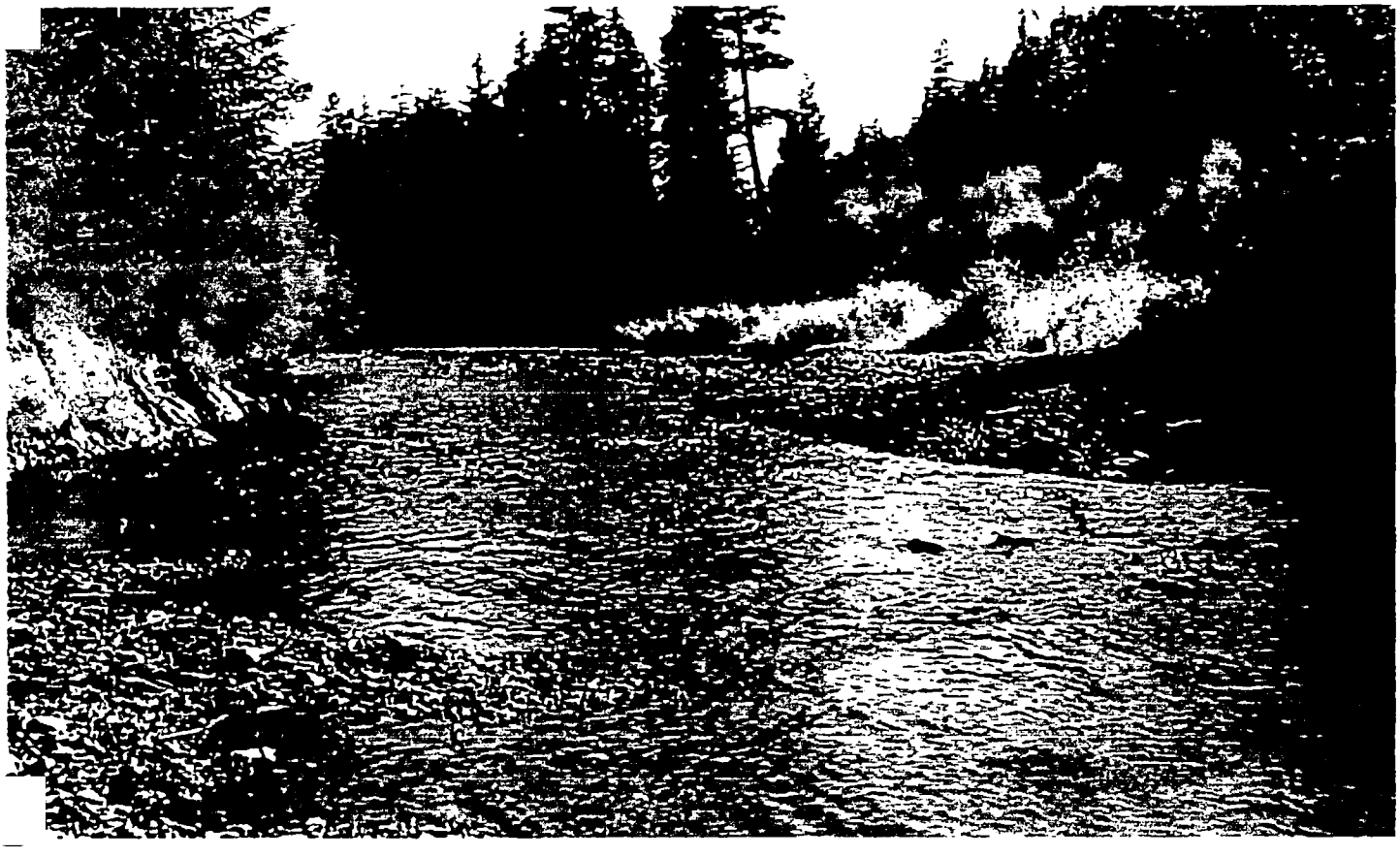

AIRPORT
PRE-EXISTING ROADWAY
60'
44'
45'
100'
50'
145'
160'
60'
140'
50'
70'
30'
45°
60'
40'
50'
50'
O'BRIAN CREEK
PROPOSED WALKWAYS + STAIRS
ROUGH MEASUREMENTS
PROPOSED WALKWAY

O'BRIAN CREEK CHANNEL DURING PINK SALMON MIGRATION
(PROPOSED GABION DAM / FISH LADDER SITE)





O'BRIAN CREEK CHANNEL DURING PINK SALMON MIGRATION



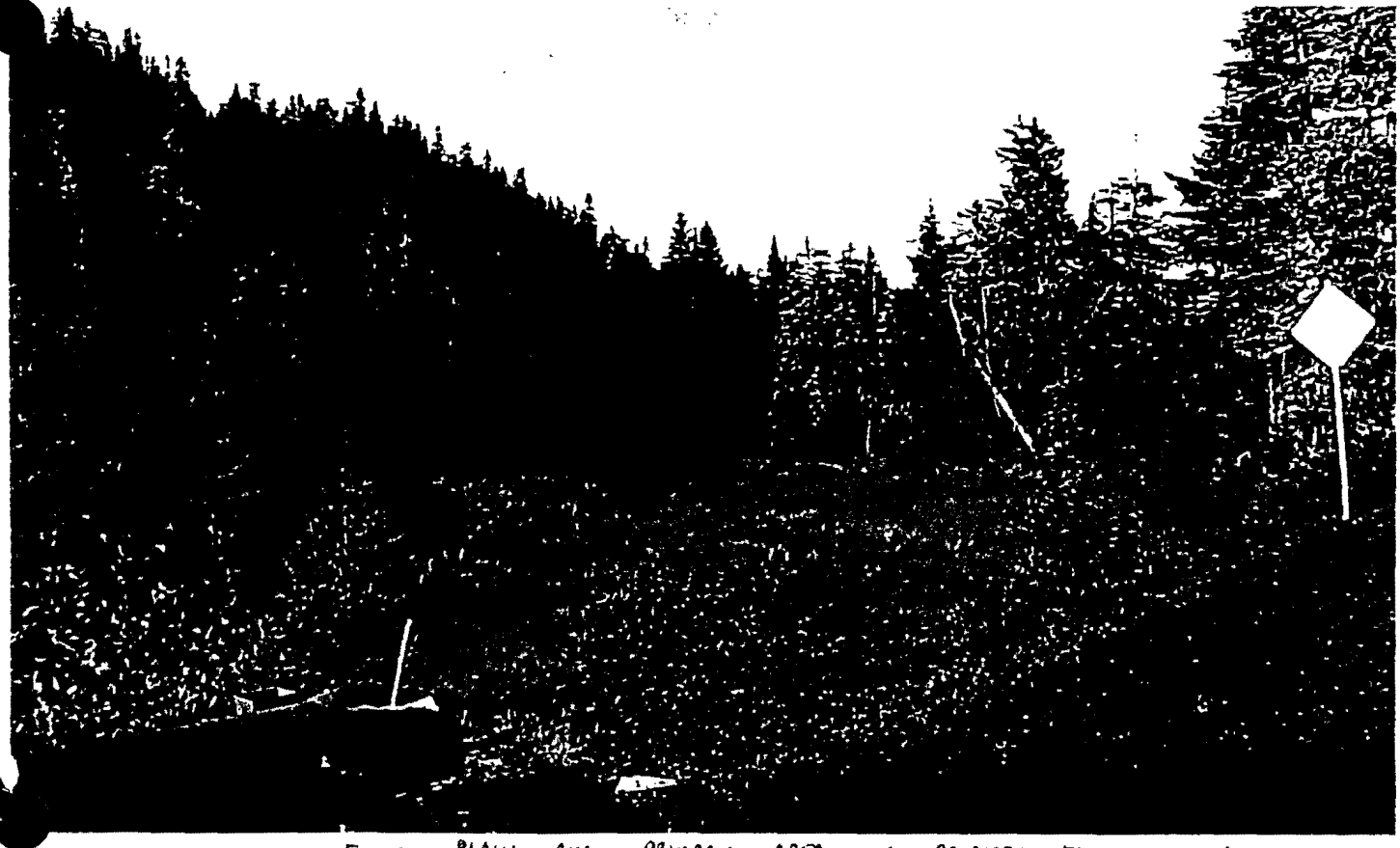
O'BRIAN CREEK CHANNEL

O'BRIAN CREEK CHANNEL
(PROPOSED FISH LADDER/DAM LOCATION)

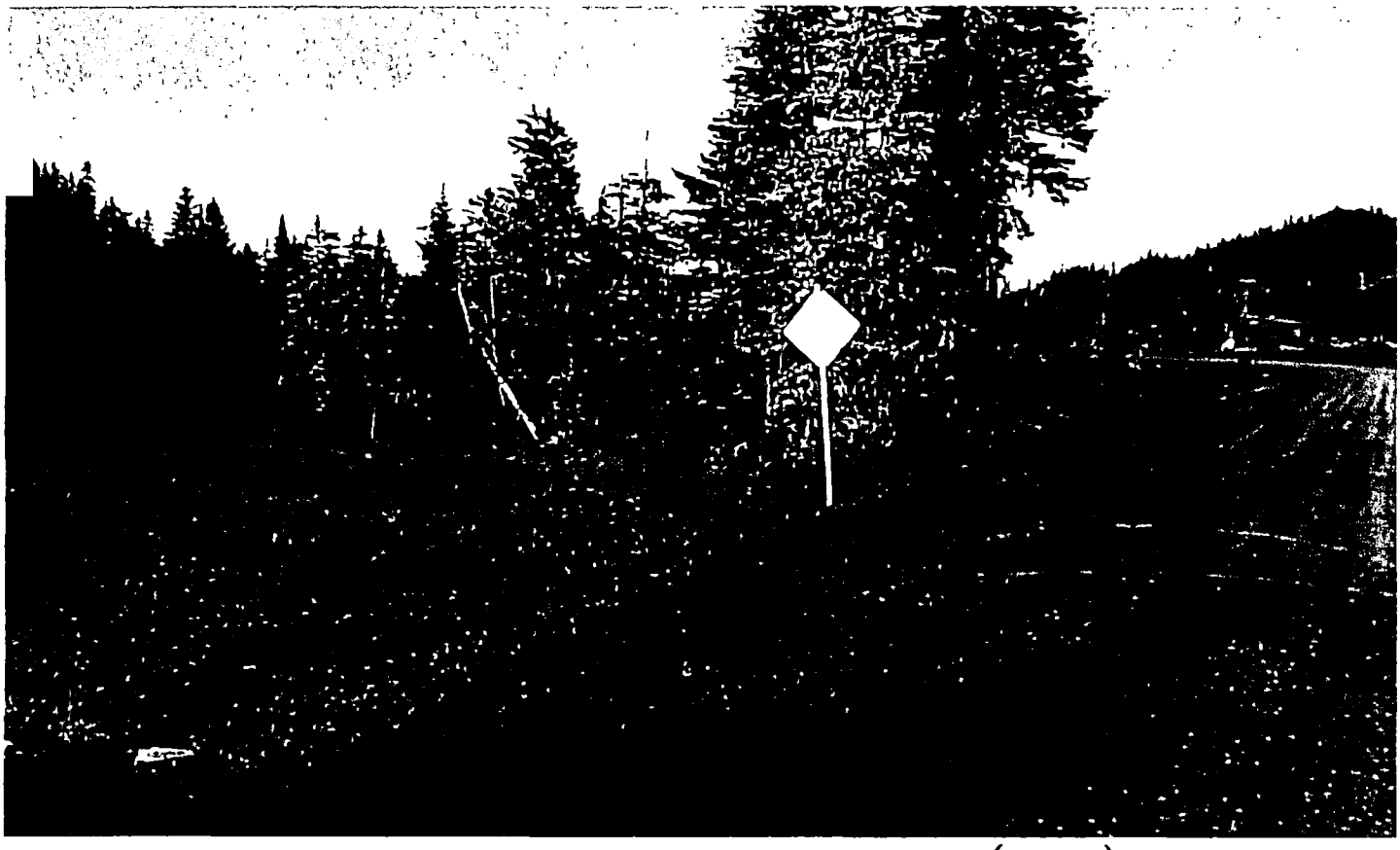
O'BRIAN CREEK BELOW THE BRIDGE
(PROPOSED TIDAL ZONE GABION DAM SITE)
WITH FISH LADDER

PINK SALMON IN O'BRIAN CREEK

PINK SALMON IN O'BRIAN CREEK



FLOOD PLAIN AND PRIMARY AREA OF PROPOSED ELEVATED WALKWAY



AREA OF PROPOSED PARKING LOT (PHASE 2)

MODEL OF STREAM ENHANCEMENT PROJECT LOCATED IN SITKA, AK.
("similar log structures could be used in the upper stretches of O'Brian Creek watershed")

Projected Budget Narrative

Total amount of project: $60,000.00
Amount requested from: Exxon Valdez Oil Spill Trustee Council

A. Personnel (Salaries, wages)
Estimated 90_ man-days for construction of in stream dams, habitat structures, and observation decks and walkways.
Pay rate set at $15/hr for 6 hours/day
$90/day x 15 perhr = $1,350.00 x 3 workers = $4,050.00
Total Personnel = $4,050.00

B. Fringe benefits @ 25% FICA, Workmans Comp, Esc and others
Total Benifits = $ 1,012.50

C. Supplies & Equipment
Galvanized Grating Walkways with handrails
$ 30,000.00 FOB Whittier

Pressure Treated Creosote Pilings (for walkway support)
20 count x 8 foot long each
$10,000.00 will be in kind contribution by the Chenega IRA Council

Pressure Treated Creosote 2 x 6
$1,486.00

Nylon coated aluminum wire Gabion baskets (dam material for 5 dams)
$1,500.00

Aluminum Fish Ladder Deneils (5 at 5 foot each)
$2,500.00

Post Hose diggers, Pick axes, and shovels 2 each
$850.00

Total Supplies & Equipment = $34,333.00

D. Shipping
Barge Charter for Whittier
2 trips x $2,300.00/trip = $4,600.00

Total Shipping Cost = $ 7,600.00

E. Services
Administrative services, office space, electricity, mechanical equipment, fuel, phone and other equipment needed to carry out the objectives of the project will

be donated in kind contribution by the Chenega IRA Council. The Council estimates this to be worth $30,500.00

F. Contractors

Environmental consulting firm charges for m=permitting issues = $4,000.00

Total Cost for Project Estimated at $60,000.00

Project Title: Patterns and Processes of Population Change in Selected Nearshore Vertebrate Predators

Project Number:	02423
Restoration Category:	Research and Monitoring
Proposers:	Jim Bodkin, Dan Esler, Tom Dean, Brenda Ballachey
Lead Trustee Agency:	DOI--USGS
Cooperating Agencies:	
Alaska SeaLife Center:	Yes
Project Duration:	4th year, 5-year project
Cost FY 02:	$361,600
Cost FY 03:	$250,000
Geographic Area:	Prince William Sound
Injured Resource/Service:	Sea Otter, Harlequin Duck

ABSTRACT

Sea otters and harlequin ducks have not fully recovered from the EVOS, based on population-level demographic differences between oiled and unoiled areas. Further, in oiled areas, both species show elevated cytochrome P4501A (CYP1A) through 1998, almost certainly reflecting continued exposure to oil. We propose to continue to explore links between oil exposure and the lack of population recovery, with the intent of understanding constraints to full recovery of these species and the nearshore environment generally. We also will monitor the progress of recovery of the species and the system. Proposed work consists of field components for both species, and a captive component for harlequin ducks. For sea otters, we will conduct aerial surveys of distribution and abundance, estimate age-specific survival rates, and examine spatial and temporal patterns of change in sea otter abundance in relation to prey production. For harlequin ducks, field studies will examine the relationship between survival and CYP1A and, further, will serve to monitor these key parameters. Captive experiments on harlequin ducks will examine the relationships between oil exposure and CYP1A induction, and the metabolic and behavioral consequences of exposure to oil.

INTRODUCTION

The nearshore environment of Prince William Sound (PWS) received about 40% of the oil spilled after the *Exxon Valdez* ran aground (Galt et al. 1991). Concerns about nearshore recovery and restoration resulted in a suite of studies sponsored by the *Exxon Valdez* Oil Spill Trustee Council, including the Nearshore Vertebrate Predator project (NVP). Principal findings of NVP include an apparent lack of population recovery for sea otters (*Enhydra lutris*) and harlequin ducks (*Histrionicus histrionicus*), both invertebrate feeders in the nearshore ecosystem (Bodkin et al. 1999; Esler et al. 1999, Dean et al. 2000, Bodkin et al. in press). Over a three year period, harlequin ducks residing in oiled areas had poorer survival than those in unoiled areas (Esler et al. 2000a). Sea otters also experienced poor post-spill survival through 1998, based on modeling of ages-at-death (Monson et al. 2000). Further indication of increased mortality (or higher rates of emigration) of sea otters in oiled areas compared to their counterparts in unoiled areas is provided by inferences based on capture data (Bodkin et al. 1999, Bodkin et al. in press). Additionally, both species show evidence of continuing exposure to hydrocarbons, based on higher levels of the biomarker cytochrome P4501A (CYP1A), in oiled areas than unoiled (Ballachey et al. 1999). Elevations in CYP1A are not explained by background or natural hydrocarbon sources, as these were found to be negligible in intertidal areas of PWS (Short and Babcock 1996), nor by area differences in PCB contamination (Trust et al. 2000; USFWS unpub. data), leaving continued exposure to residual *Exxon Valdez* oil as the most plausible explanation. Residual oil is still stranded in intertidal areas of PWS (Babcock et al. 1996; Hayes and Michel 1999).

Conceptual links have been drawn describing mechanisms by which oil exposure could have population-level demographic impacts on sea otters and harlequin ducks. However, these links, and thus the processes that may limit full recovery, remain speculative. Therefore, we propose to build on the base of knowledge gained through previous research to (1) explore the relationships between oil exposure, individual health, and demographic attributes that could have population level effects, and (2) monitor the parameters identified in previous work that are effective and statistically powerful in describing population status and lend insight into the process of recovery of sea otters and harlequin ducks, and the nearshore environment generally.

In addition to the work proposed and approved as part of project 01423, we are proposing to examine historical data on growth of the littleneck clam, *Protothaca staminea* in relation to patterns of sea otter recovery. Clams are the primary component of the diet of sea otters, and inter-annual variation in clam growth may help to explain changes in the abundance of sea otters. In addition, preliminary data suggest that clam growth may be correlated with changes in climate, thereby providing evidence of a possible link between climate driven changes in offshore primary production and responses in nearshore communities.

Sea Otters

The NVP study provided several lines of evidence indicating that sea otters in the most heavily oiled portions of western Prince William Sound (WPWS), at northern Knight and Naked islands, have not recovered from oil-related injury (Bodkin et al. 1999, in press; Dean et al. 2000; Monson et al. 2000). The sea otter population at northern Knight has not increased between 1993-99 (the

period for which we have aerial survey data), with numbers remaining at about half the estimated pre-spill abundance. Sea otters in oiled areas show reduced survival, relative to prespill rates (Bodkin et al. 1999; Monson et al. 2000). Levels of CYP1A were higher in sea otters from Knight Island than from unoiled reference areas, suggesting continued exposure to residual oil may be affecting recovery of the species. Additionally, increased proportions of larger-sized individuals of several sea otter prey species were identified at northern Knight, consistent with reduced predation and lack of recovery of the sea otter population in that area (Dean et al. 2000).

The sea otter component of this proposal builds on previous EVOS research (93045, 95025-99025) to develop a statistically sensitive and cost-effective program that will continue to track the WPWS sea otter population and nearshore ecosystem recovery, and investigate the effects of chronic oil exposure on sea otters. We will address the following questions: (1) are sea otters increasing in abundance in the most heavily oiled areas, and in western PWS overall ? (2) has survival of sea otters returned to pre-spill rates? (3) can the temporal and spatial patterns of change in the abundance of sea otters (including the lack of recovery of sea otters in northern Knight Island) be explained by differences in prey production?

Question 1 will be answered by continued aerial surveys of sea otter abundance at appropriate intervals to monitor the population and test predictions of a previously developed sea otter population model (Restoration study 99043; Udevitz et al. 1996). Surveys were done in 1999 and 2000, and will be conducted again in 2002. Sea otter aerial surveys were suspended in 2001, based on fiscal considerations and the need to re-sample sea otter survival and the bioindicator cytochrome P450 1A in that year. *This element is a continuation of work proposed and approved in Project 99423, and initiated in FY 1999.*

Question 2, regarding survival rates of sea otters, involves a modeling effort that utilizes ages-at-death of sea otters recovered as carcasses on beaches (Monson et al. 2000). This element was not initially included as part of Project 99423, but due to the compelling evidence of long-term injury provided by the modeling results in late 1999, the carcass surveys were added for FY2000-01 (supplementary funding provided in February 2000). We propose that carcass surveys be conducted again in 2002.

Question 3 will be addressed by examining temporal and spatial patterns in the growth of littleneck clams in relation to changes in sea otter abundance.

Harlequin Ducks

The most concerning result from NVP harlequin duck studies was the detection of significantly lower survival probabilities of adult females in oiled areas of PWS than in unoiled areas (Esler et al. 2000a). Analyses revealed that history of oil contamination was a more likely explanation for the survival difference than intrinsic differences between oiled and unoiled study areas. Further, projections of population trends using models incorporating these survival probabilities predicted declining populations on oiled areas and increasing populations on unoiled areas. This pattern was observed during Alaska Department of Fish and Game surveys (EVOSTC Project /427), suggesting that differences in survival were a likely mechanism for observed differences in

population trends. Also, harlequin duck densities were lower on oiled Knight Island than on unoiled Montague Island, after accounting for intrinsic habitat differences; this is the pattern that would be predicted given high site fidelity and poorer survival on oiled areas. Finally, higher levels of CYP1A induction were detected on oiled areas.

Results from these recent studies lead to speculation that continued exposure to oil could result in poorer survival of harlequin ducks, which in turn would result in differences in population trends and densities. There are reasonable explanations for how oil may be related to survival (see Statement of Problem below). Unfortunately, however, these links are drawn from a wide array of sources, with limited inference to wild harlequin ducks in PWS. Thus, we propose studies that will explore the relationship between oil exposure and survival using both field and captive bird approaches. These will serve to examine mechanisms or processes that may continue to limit harlequin duck population recovery. These studies also will monitor the most critical elements revealed in previous studies to gauge the progress of recovery.

The specific questions that will be asked by the harlequin duck components of this study are: (1) what is the relationship between levels of oil exposure and CYP1A induction, and what levels of oil exposure result in CYP1A values similar to those measured in PWS? (2) are there metabolic or behavioral consequences of oil exposure that could be a mechanism by which harlequin duck survival is compromised? (3) is oil exposure (as indicated by CYP1A induction) related to survival of harlequin ducks in the wild? and (4) is contaminant exposure declining over time and, similarly, are survival rates on the oiled area improving through time? Questions 1 and 2 will be addressed using captive birds at the Alaska SeaLife Center during winters 2000-01 and 2001-02. Questions 3 and 4 will be addressed by biosampling and radio telemetry work during winters 2000-01, 2001-02, and 2002-03. *These studies are a continuation of work proposed and approved in Project 00423.* This work will examine both the process of recovery (through understanding of the mechanisms constraining population demography) and will monitor the progress of recovery by sampling survival and CYP1A induction of wild birds starting 3 years subsequent to the last work done as part of NVP (winter 1997-98).

NEED FOR THE PROJECT

A. Statement of Problem

Sea otters and harlequin ducks occupy an invertebrate-consuming trophic level in the nearshore and are conspicuous components of the nearshore ecosystem. In 1995, the NVP Project was initiated to examine the status of recovery of nearshore vertebrates (including sea otters, harlequin ducks, river otters and pigeon guillemots), and to evaluate possible causes for the apparent lack of recovery. Results of the NVP project clearly suggest that complete recovery has not occurred for sea otters and harlequin ducks, and the lack of recovery may be related to continued exposure to oil. This proposed work follows up on the critical elements revealed by the NVP studies, in particular the status of the population, and the relationship between temporal and spatial patterns of change in the number of sea otters and patterns of prey production.

Sea Otters

The sea otter population in WPWS was injured as a result of the spill. Estimates of sea otter mortality due to the spill range from 750 to 2,650 individuals (Garshelis 1997, Garrott et al. 1993). A population model (Udevitz et al. 1996) predicted recovery of the WPWS sea otter population in 10 to 23 years, projecting maximum annual growth rates from 0.10-0.14. Surveys to date (1993-1998) have shown a significant increasing trend in the WPWS sea otter population, averaging about 4% per year since 1993 (power > 0.80 to detect a 1% annual change in 5 annual WPWS surveys). In contrast to the western Sound overall, at northern Knight Island sea otter numbers remain below pre-spill estimates and do not show a significant increasing trend (Figure 1; Bodkin et al. 1999, Bodkin 2000; Dean et al. 2000).

Sea otter carcasses have been recovered from beaches in WPWS since 1976, thus providing one of the few long-term baseline data sets for evaluating post-spill injury. Carcass surveys initially were not proposed as part of Project 99423. However, in 1999 we applied recently developed modeling techniques (Doak and Morris 1999) to estimation of sea otter survival rates, utilizing the distribution of otter ages-at-death as the basis for the model. The results provide compelling evidence of long-term injury from the EVOS (Monson et al. 2000). Briefly, the model involves a comparison of observed vs. predicted ages-at-death of sea otters prespill and postspill, using data from carcasses collected during 1976-98. Postspill survival of sea otters in the western Sound was poor relative to prespill rates, and by 1998, survival rates had not yet returned to prespill values. However, survival rates of younger age otters were increasing, suggesting that conditions were normalizing. These results are consistent with other observations of sea otters in western PWS, which suggest that the population in the most heavily oiled areas has not yet recovered (Figure 1). Carcass collections and modeling efforts based on age-at-death data may provide one of the most efficient tools for monitoring recovery of sea otters. Thus, we propose that carcass surveys (and subsequent modeling to estimate survival rates) be continued in 2002, as an additional tool for monitoring sea otter recovery in PWS.

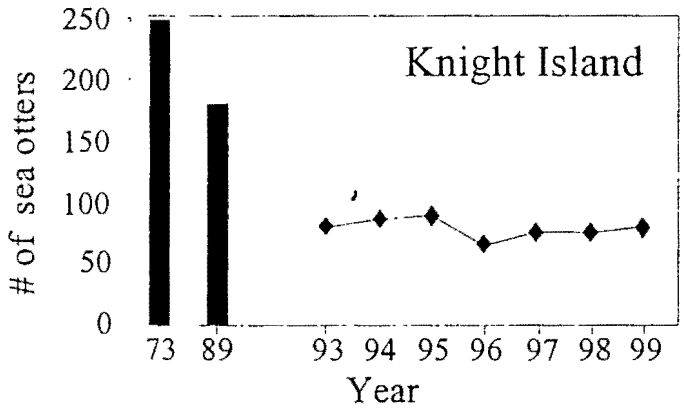


Figure 1. Estimated sea otter abundance at northern Knight Island.

The NVP study identified elevated expression of CYP1A in 6 species that inhabit the nearshore areas of WPWS, indicating continued exposure to residual EVOS oil (Ballachey et al. 1999). Sea otters were sampled in 1996-98, and in all years, animals from Knight and Naked islands (oiled area) had elevated CYP1A, compared to those from Montague Island (unoiled area; Figure 2). Further, levels at Montague were similar to those measured in otters from a relatively clean area in southeast Alaska with no known exposure to oil or other contaminants (USGS unpub. data). In 1998, the mean value of CYP1A in the oiled study area was lower than means for 1996 or 1997, suggesting exposure to

residual oil is diminishing over time. We will resample the wild sea otter population for CYP1A in summer 2001 to determine if hydrocarbon exposure continues, and if so, if it has declined relative to levels measured in 1996-98. Sea otters in the most heavily oiled areas of WPWS will be targeted for sampling, with particular effort to capture those residing in the vicinities of known persistent oiled shoreline and bivalve populations (Hayes and Michel 1999, Fukuyama et al. in press) and oiled mussel beds (Harris et al. 2000), potentially enabling us to make a link between biomarker levels in sea otters and petroleum contaminants in mussels and sediments of their nearby habitat. Sea otters from Montague Island also will be captured to provide a non-exposed reference sample. We are not proposing further collection of sea otters until blood samples collected in 2001 are analyzed.

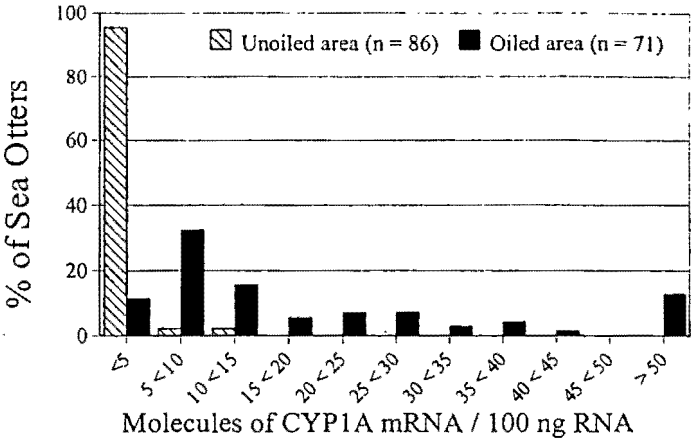


Figure 2. Measurement of cytochrome P4501A induction (RT-PCR technique) in sea otters in western Prince William Sound, 1996-98.

Previous work also examined the possible role of food limitation in constraining sea otter recovery (Dean et al. 2001). Based on the better condition of sea otters, a higher rate of consumption of prey, and at least equal availability of prey at northern Knight Island compared to Montague Island, we concluded that food limitation was not the primary cause for a lack of recovery. However, there were several remaining questions regarding the possible role of food limitation in regulating numbers of sea otters. First, sea otters at Montague Island were considered food limited, yet substantial increases in the numbers of sea otters occurred between 1993 and 1998 (Figure 3). This suggests that inter-annual variation in the production of prey may regulate numbers of sea otters. Second, differences in the changes in relative abundance of sea otters at Knight and Montague Islands may have been related to possible differences in the prey production between the two areas.

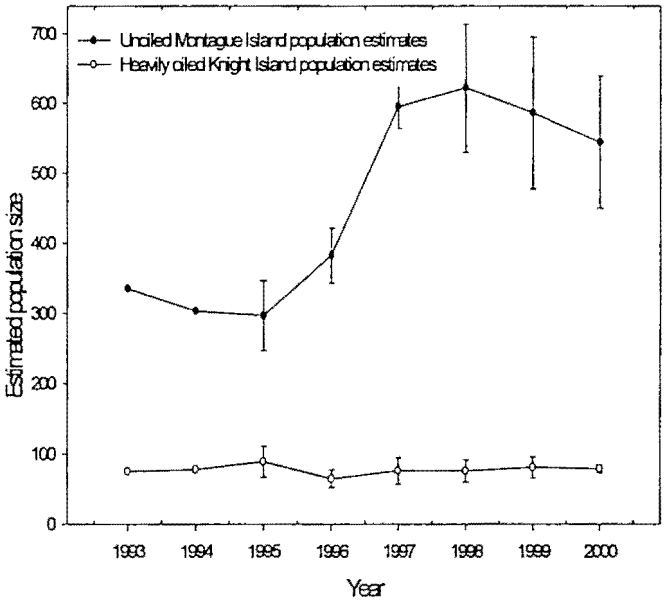


Figure 3. Trends in sea otter population size at Knight and Montague Islands

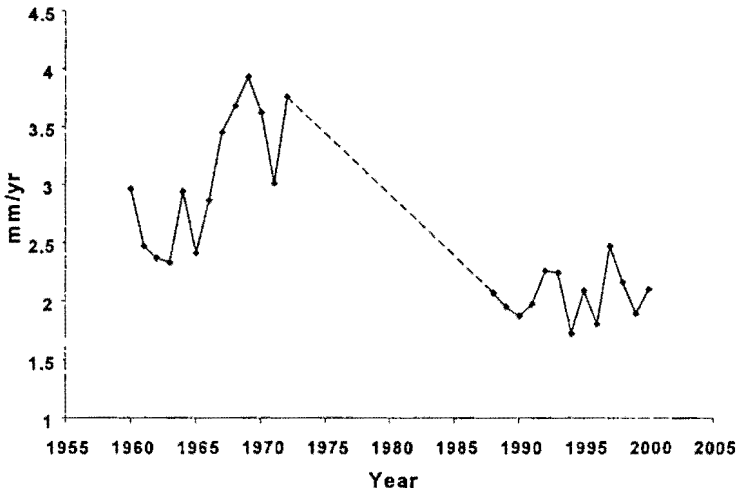
In summer 2000, we collected over 1,500 littleneck clams from a total of 12 sites in PWS: four in northern Knight Island, four from Montague Island, two from Olsen Bay and two from Galena Bay. The Bay of Isles and Montague sites are representative oiled and unoiled reference sites,

respectively. Olsen Bay and Galena Bay are sites where there are historical estimates of clam growth (Paul and Feder 1973; Paul et al. 1976). These clams have annulli, and the distances between annulli provide a record of growth over the past decade. To date, only a few of the clams collected (approximately 60 from Olsen Bay) have been examined to determine growth rates. However, these preliminary data provide some intriguing patterns that warrant further examination.

First, the estimates of growth from clams collected in Olsen Bay in 2000 are substantially lower than clams collected from the same sites in 1974, although there is substantial inter-annual variation in growth from both collection periods (Figure 4). The growth rates ranged from about 2 mm per year in 1995 to about 4 mm per year in 1969. Second, there is a strong negative correlation between annual growth rate and the atmospheric climate index (Klyoshtorin 1995), an index of climate variability (Figure 5). This suggests that clams grow more in cold years when, presumably, primary production is greater. More importantly, it suggests that nearshore secondary production (as indicated by clam growth) may be positively linked with offshore primary production and to climate change. Third, there is a weak positive correlation between clam growth rate and the change in numbers of sea otters (Figure 6) over the period from 1993 through 2000. Increases in sea otters at Montague Island were greatest in 1995, coincident with a peak in clam growth. The latter suggests that inter-annual variation in prey production may help to explain inter-annual variation in food-limited populations of sea otters.

All of the trends in clam growth and associated changes in climate and sea otters are based on very preliminary data, but suggest

Figure 4. Growth rate of Protothaca staminea in PWS over time



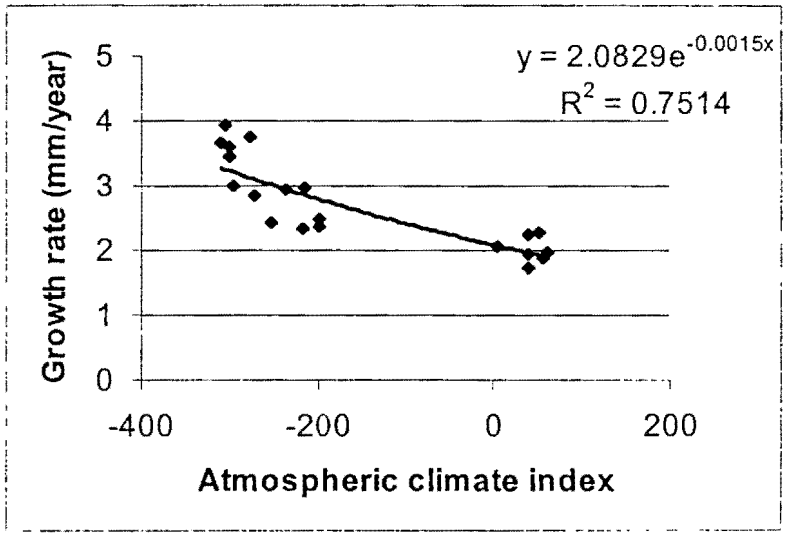
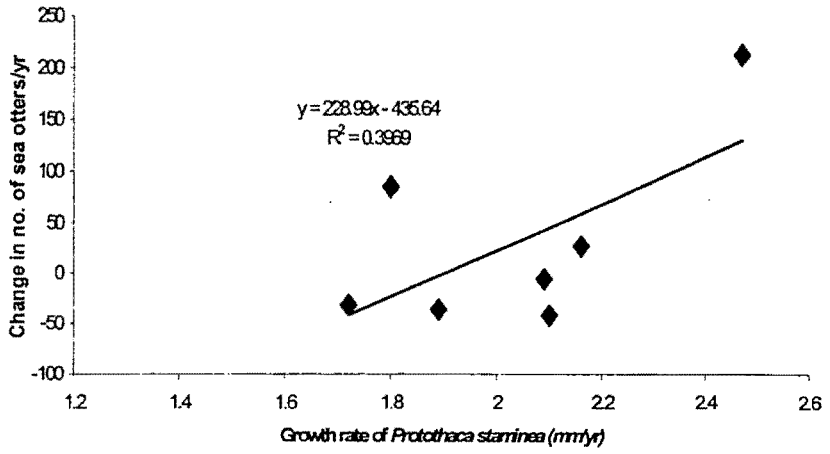


Figure 5 Relation between clam growth and the ACI

possible relationships between offshore production, clam growth, and numbers of sea otters. We propose to further investigate these possible relationships by measuring the growth rates of clams collected in 2000, comparing these to growth rates of clams collected from the same sites in prior decades (Paul and Feder 1973, Paul et al. 1976, Trowbridge unpublished data), examining the relationship between growth and various climate or primary production indices, and examining possible relationships between clam growth and changes in numbers of sea otters.

Figure 6. Annual change in sea otter population size relative to clam growth rates



In summary, we propose continued monitoring of sea otter distribution and abundance, survival rates, and prey production in WPWS. These studies will be valuable in documenting actual recovery time for the nearshore system including sea otters, and providing long-term population trend data which may be used in assessing initial damage and subsequent recovery of sea otter populations in the event of future oil spills.

Harlequin Ducks

Harlequin ducks were, and remain, particularly vulnerable to deleterious effects of the oil spill. Much of the oil from the *Exxon Valdez* was deposited in the nearshore intertidal and shallow subtidal zones (Galt et al. 1991), the coastal habitats where harlequin ducks occur. Also, Goudie and Ankney (1986) suggested that harlequins were near the lower limit of body size for sea ducks occurring in environments similar to Prince William Sound in winter. Because harlequin ducks exist close to an energetic threshold, any perturbation (e.g., an oil spill) that either affects health or condition directly (via toxic effects or increased metabolic costs) or indirectly (via food abundance) could have significant consequences for the population.

Also, among ducks, sea duck life histories are particularly K-selected (Eadie et al. 1988). Harlequin ducks typically defer reproduction for 3 years, have relatively low annual investment in reproduction, and are long-lived (Goudie et al. 1994). Species with these characteristics have relatively low potential rates of population change and, thus, following a perturbation such as an oil spill, require many years in the absence of continued adverse effects to recover to previous population levels. Further, population dynamics of animals with this life history strategy are particularly sensitive to variation in adult survival (Goudie et al. 1994, Schmutz et al. 1997).

Sea ducks have a general pattern of high philopatry throughout their annual cycle (e.g., Limpert

1980, Savard and Eadie 1989) and harlequin ducks follow this pattern, having high fidelity to molting and wintering sites (Robertson 1997; Esler, unpubl. data). High site fidelity could result in vulnerability to population effects because: (1) if residual oil spill damages exist, birds from oiled areas are vulnerable to spill effects as they return to those areas annually (i.e., these birds are affected disproportionately and are subject to cumulative effects), and (2) if dispersal and movements among areas are limited, recovery of groups of birds in oiled areas can occur only through demographic processes specific to that group (i.e., numbers are not enhanced through immigration from other areas). High site fidelity is an adaptive behavioral strategy in natural situations and predictable environments (Robertson 1997), but does not accommodate movement to undisturbed sites in the face of human-caused perturbations.

Evidence from recent studies (NVP and /427) suggests that, as might be predicted from their vulnerability, harlequin duck populations have not fully recovered and, in fact, continue to suffer deleterious effects from the oil spill. Over the course of 3 winters, survival probabilities differed between oiled and unoiled areas (Figure 7). Survival probabilities were high, and similar between areas, in fall. However, survival diverged between areas during mid-winter, presumably the period during which conditions are most difficult for harlequin ducks. Also, differences in CYP1A induction were detected between populations from oiled and unoiled areas (Figure 8; Trust et al. 2000), although this was measured on different birds than those for which survival data were collected. Further, body mass during winter showed a slight, negative relationship with CYP1A level.

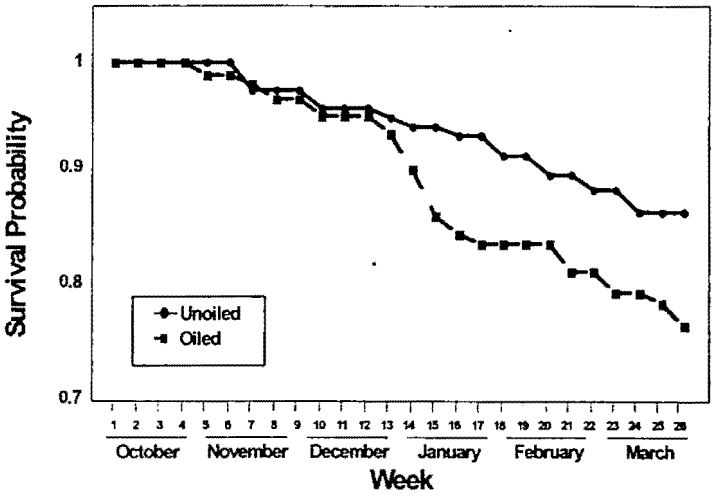


Figure 7. Survival probabilities of harlequin ducks.

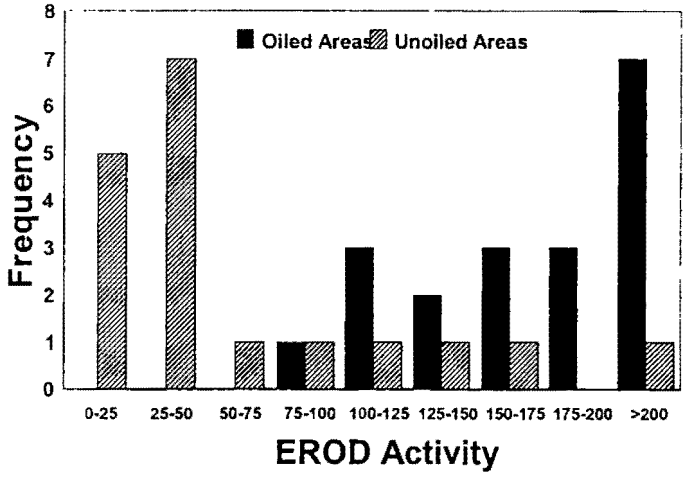


Figure 8. Comparison of CYP1A induction (hepatic EROD activity) in harlequin ducks from Prince William Sound.

One can speculate on mechanisms by which continued exposure to oil could be related to differences in survival probabilities. Most lab studies have shown that mallards are tolerant of internal ingestion of oil, with toxic effects not evident until very high doses. These studies have been used to suggest that harlequin ducks should, similarly, be unaffected by residual Exxon Valdez oil (Stubblefield et al. 1995, Boehm et al. 1996).

However, other studies have found that, with addition of other stressors such as cold temperatures, oiled ducks in the lab suffered considerably higher mortality than unoiled (Holmes et al. 1978, 1979). This seems to be a much more appropriate analog for wild harlequin ducks. Particularly given their vulnerability to spill effects and hypothesized existence near an energetic threshold, harlequin ducks may not be able to handle additive effects of the oil spill, even if relatively small.

To fully understand the process of harlequin duck population recovery from the oil spill, it is important to address these speculated links between oil exposure and survival probabilities, and subsequently population trends. The research proposed here is designed to explore these potential mechanisms constraining population recovery through field studies of winter survival and CYP1A induction and captive studies of metabolic, behavioral and CYP1A responses to controlled oil exposure. Further, because of their susceptibility to spill effects and high site fidelity, harlequin ducks are an ideal species for monitoring recovery of the nearshore environment.

B. Rationale/Link to Restoration

Sea otter and harlequin duck restoration requires assessments of population recovery status and definition of impediments to recovery. For harlequins and sea otters, the proposed work incorporates monitoring activities which, given the "baseline" data collected in NVP and other post-spill studies, will allow us to gauge recovery status. Additionally, the research components proposed herein represent a comprehensive approach to understanding the factors that affect population dynamics and definition of critical bottlenecks to recovery. Without an understanding of the underlying processes that dictate population change, we can not prescribe specific activities to enhance recovery. The project directly addresses the restoration objectives both by examining the processes affecting recovery and by monitoring the progress of recovery, including survival rates and contaminant exposure.

Sea Otters

Recovery of sea otters will be complete when population size returns to estimated pre-spill abundance, and there is no further evidence of continuing exposure to residual oil. Sea otter restoration requires an understanding of population status and the processes affecting changes in population status. Continued monitoring of sea otter distribution, abundance, survival rates and prey populations in WPWS,will provide insight into recovery and improve future recovery models, and potentially allow us to document the actual recovery time for the nearshore system, including sea otters. A further benefit of these project components is provision of long-term population trend data and monitoring tools which may be used in assessing initial damage and subsequent recovery of sea otter populations in the event of future oil spills.

Harlequin Ducks

Harlequin duck restoration will be complete when densities have recovered to prespill levels and birds no longer show evidence of oil contamination. Poor survival in oiled areas is the most plausible cause for lack of recovery to prespill densities; restoration requires an understanding of

the factors that affect survival rates, in particular the effects of oil exposure. The restoration objectives for harlequin ducks are addressed both by examining the processes affecting recovery and by monitoring the progress of recovery, in particular contaminant exposure.

C. Location

Studies will be conducted in PWS. Specific study sites for the sea otter components will be northern Knight Island and Port Chalmers/Stockdale at Montague Island, as used in the NVP project. Harlequin duck study sites also will be those used in previous NVP work: unoiled Montague Island and oiled Green Island, Crafton Island, Main Bay and Foul Bay. Captive studies will be done at the Alaska SeaLife Center in Seward. Communities affected by the project include Chenega, Whittier, Cordova and Seward.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

The project will continue to inform and coordinate our community involvement activities, including the collection of indigenous knowledge with Dr. Henry Huntington, TEK specialist Chugach Regional Resources Commission and Hugh Short, Community Coordinator, EVOS Restoration Office. We will continue to solicit advice from the above parties and gather information on TEK through local community facilitators and residents. Efforts have and will continue to be made throughout the restoration process to participate in and provide public involvement in the design and implementation of this project. Information gathered from this project will be shared with local communities. Project staff has and will continue to present information to local communities or prepare articles or photographs for Trustee Council publications. Boat and air charter contracts, and other services will be contracted from local sources when possible.

PROJECT DESIGN

A. Objectives

Sea Otters

Field Studies

1. Estimate of sea otter abundance and population trends over time in WPWS overall, and in oiled and unoiled study areas within WPWS.

2. Monitor progress of sea otter population recovery via tracking of survival rates in oiled areas.

Laboratory studies

1. Estimate the growth rate of littleneck clams collected from 12 locations in PWS in 2000, and obtain and analyze historical data on clams collected in 1989 and 1974.

Harlequin Ducks

Field Studies

1. Estimate winter survival rates of harlequin ducks in relation to area (history of oil contamination) and indices of oil exposure (CYP1A induction).

2. Monitor progress of harlequin duck population recovery via tracking of survival rates and CYP1A induction in oiled and unoiled areas.

Captive Studies

1. Measure the CYP1A response in oil-exposed, captive harlequin ducks.

2. Quantify the metabolic and behavioral consequences of oil exposure.

B. Methods

The proposed research employs field studies on sea otters, laboratory analysis of growth rates of sea otter prey, and both field studies and experimental work with harlequin ducks. This combination of approaches addresses the need for controlled work to look explicitly at the effects of oil exposure on hypothesized mechanisms of mortality and field work to document the relevance of those mechanisms under wild conditions. With captive studies on harlequin ducks, we propose to quantify metabolic and behavioral responses to known regimes of oil exposure as well as indicate the level of oil exposure that corresponds to CYP1A induction detected in the field. For both species, field studies are necessary to understand the relevance of these relationships to animals in the wild, and to monitor population and system recovery.

Sea Otters

Field Studies

The proposed sea otter work employs aerial surveys to track population abundance and growth. . This approach will provide information on recovery status of the population, assessed through trends in population size. Additional components proposed for 2002 are collection of carcasses for determination of ages at death, to be used in estimation of age-specific survival rates.

Sea otter population monitoring--We will continue to use previously developed aerial survey techniques which employ counts along systematic transects, and intensive search units (ISU's) to estimate a correction factor for each survey (Bodkin and Udevitz, 1999). We will conduct a

single survey of the entire WPWS in 2002, and in alternate years, conduct a survey of the entire PWS. From the combination, we will obtain an estimated population size for WPWS annually (except in 2001). We will continue annual replicate surveys (5 or more replications per survey) of the smaller NVP study sites, initiated in 1993 (except in 2001).

Carcass surveys--Age specific survival estimates will be generated based on age distributions of the dying portion of the population, evaluated through recovery of beach-cast sea otter carcasses in western PWS. Beaches will be surveyed once during late April or early May after snow melt but prior to summer revegetation, which may hide carcasses washed high on the beach by winter storms. Data recorded for each carcass include: (1) relative location of carcass on the beach, (2) relative condition and completeness of carcass, (3) position of remains relative to previous year's vegetation, (4) relative age (adult, subadult, pup), (5) sex, and (6) specimens collected (e.g., entire carcass, skull, baculum, none). Skulls (when present) will be taken from all carcasses and a tooth extracted for aging (Bodkin et al. 1997). Any fresh carcasses collected will be necropsied as soon as possible and tissue samples collected for potential toxicology and histopathology studies.

Laboratory Analyses of Clam Growth

Growth rates of approximately 1,500 clams collected from sites in PWS in 2000 (including Montague and northern Knight) will be determined by measuring the distance between annulli in shells. This method has been used to successfully to measure growth in littleneck clams, and tagging of clams in the field has been used to validate the method (Feder and Paul 1973). These data will be used to test for differences in the growth of clams from northern Knight and Montague Islands and to test for correlations between inter-annual variation in sea otter abundance and changes in clam growth.

In addition, we will examine historical data on clam growth from clams collected from Olsen and Galena Bays in 1974 (Paul and Feder 1973, Paul et al, 1976), and possibly from other sites in PWS in 1989 (Trowbridge unpublished data). (The status of the Trowbridge data has yet to be determined). Clams from the three collection periods will provide a nearly continuous 50 year record of clam growth. These data will be correlated with various indices of climate change and primary production to examine possible relationships between climate change and nearshore production.

Harlequin Ducks

Field Studies

The key data for field studies are paired CYP1A and survival data, which will allow for explicit tests of the hypothesis that mortality and oil exposure are related in wild harlequin ducks. We intend to collect survival and exposure data from 50 birds in each of 3 years by capturing them during early winter, conducting surgeries to both implant transmitters and biopsy livers, and monitoring subsequent winter survival. These types of data have been successfully collected during NVP studies.

This research requires capture of flighted harlequin ducks during early winter, after they have been on wintering sites long enough to be potentially exposed to residual oil, yet before the mid-winter period when survival probabilities diverged during NVP studies (Figure 7). The mid-winter period is presumably the time of greatest stress and thus the period when oil spill effects would be most likely to be expressed as differences in survival probabilities. The interval between capture and the critical mid-winter period must allow for at least a 2-week censor period to ensure that survival data are not biased by effects of capture, handling, or surgery (Esler et al. 2000b; Mulcahy and Esler 1999). Thus, we propose capturing birds during a 3-week period in November to generate both survival data and exposure data from the same individuals.

We will use floating mist nets (Kaiser et al. 1995) to catch flying birds in oiled (Knight Island, Green Island, Crafton Island, Main Bay, Foul Bay) and unoiled (Montague Island) study areas. Use of the same study areas as the NVP project allows for direct comparisons of results. The floating mist net capture technique was used successfully during NVP studies. However, this technique does not allow handling of as many birds as molt drives, so age cohorts used in survival estimation will not be as restricted as in NVP studies, which included only after-third-year females. We will radio females of all age classes; age parameters will be included in all analyses to account for any survival differences due to these effects. Captured birds will be banded with uniquely coded USFWS bands, aged by bursal probing (Mather and Esler 1999), and sexed by plumage characteristics.

To estimate survival probabilities of harlequin ducks, we will use implantable radio transmitters with external antennas (Korschgen et al. 1996). Implanted transmitters have been successfully used in waterfowl studies (e.g., Olsen et al. 1992, Haramis et al. 1993), and an increasing body of literature suggests that radio transmitters implanted into wild waterfowl are less disruptive than external methods of attachment, based on differences in survival or return rates (Ward and Flint 1995, Dzus and Clark 1996), behavior (Pietz et al. 1993), and reproductive rates (Pietz et al. 1993, Rotella et al. 1993, Ward and Flint 1995, Paquette et al. 1997), especially for diving ducks (Korschgen et al. 1984). NVP studies (Esler et al. 2000b) demonstrated that recapture probabilities of radio-marked harlequin ducks were not lower than unradioed individuals. Surgeries will be conducted by certified veterinarians experienced in avian implant surgeries, following procedures outlined in Alaska Biological Science Center, USGS Biological Resources Division standard protocol. Transmitters will weigh approximately 18g, which is $\leq 3\%$ of the body mass of the smallest wintering female harlequin ducks captured during NVP studies. Transmitters will be equipped with mortality sensors; the pulse rate will change from 45 to 90 beats per minute when a mortality is indicated. Mortality status will be confirmed by either carcass recovery or detection of signals from upland habitats, which are not used by harlequin ducks during nonbreeding periods.

We will conduct radio telemetry flights at approximately weekly intervals from the capture and marking period through the end of March. Survival data entry and general description will follow procedures outlined in Pollock et al. (1989a, 1989b), as modified by Bunck et al. (1995). We will examine effects of area, season, and CYP 1A on survival by comparing AIC_c values (Burnham and Anderson 1998) among models with different combinations of these effects. The AIC_c indicates the most parsimonious model by balancing the goodness-of-fit of each model (from the

maximum likelihood) with the number of parameters to be estimated. Under this approach, the model with the lowest AIC_c indicates the combination of parameters that are best supported by the data, which we will interpret as the factors related to variation in survival. Survival estimates and variances will be calculated by iterative solution of the likelihood using program MARK (White and Burnham 1999).

CYP1A induction will be measured by EROD activity. Small liver biopsies (approximately 0.1 g) will be surgically removed and immediately frozen in a liquid nitrogen shipper. EROD activity analyses will be conducted in a contracted lab following standard procedures (Trust et al. 2000). Plumage swabs (Duffy et al. 1999) and plucked feathers will be used to assess presence of external oil.

Captive Studies

Captive bird studies will examine metabolic, behavioral, and biomarker responses to known oil-exposure regimes. This work is designed to experimentally test effects of oil exposure on parameters that are hypothesized to influence dynamics of wild harlequin duck populations; these effects are impossible to assess under field conditions.

Harlequin ducks to be used in captive studies will be captured during wing molt from unoiled parts of PWS. During molt, harlequin ducks congregate and are susceptible to capture by herding flocks of flightless birds into pens (Clarkson and Goudie 1994). Birds will be banded with USFWS bands and with individually coded plastic tarsus bands. Tarsus bands will be oriented to be read from bottom to top as the bird is standing. Sex will be identified based on plumage characteristics and age class determined by bursal probing (Mather and Esler 1999). Body mass of all birds at capture will be measured.

Following capture, 25 females older than second-year will be flown to the Alaska SeaLife Center in Seward. We will use 21 birds for the winter 2001-02 experiments; we will release any birds that are not adapting well to captivity or are not needed for experiments back to capture sites. Captured individuals will undergo quarantine and adjustment periods prior to any experimental manipulation or oil exposure. Captive birds will be housed in outdoor pens to expose them to natural climatic and photoperiod conditions. Oil exposure will be designed to simulate long-term, intermittent exposure, which is likely similar to exposure experienced by wild birds. The experimental design for winter 2001-02 experiments will be determined following analyses of data collected during the first year of the experiment, which recently ended (March 2001). Oil exposure will continue through the critical mid-winter period and behavioral and metabolic measures will be taken throughout the winter. Because CYP1A sampling requires a liver biopsy, we will get only 1 measure of induction, taken in late winter. Following a 2-week post-surgery recovery period (without any exposure), captive birds will be released in the area of their original capture.

Behavior of captive birds will be quantified using time-activity observations throughout winter for all exposure levels. Behavioral categories will follow those used in studies of wild harlequin

ducks (Goudie and Ankney 1986, Fischer 1998), e.g., feeding, resting, swimming, courtship, etc. Time-activity budgets will be contrasted among treatments.

Metabolic consequences of oil exposure will be quantified using two approaches: doubly-labeled water to estimate daily energy expenditure (DEE) and oxygen consumption to estimate basal metabolic rate (BMR). This approach will allow different views into the metabolic effects of exposure. DEE is a measure of existence costs over longer (1-3 day) time periods. DEE incorporates all of the metabolic costs during this time; elevated DEE in exposed birds would be consistent with a hypothesis of oil exposure increasing existence costs with potential survival implications. Similar DEE among treatments but different activity levels (see above) also would have implications for survival under natural conditions. BMR estimates metabolism without costs of thermoregulation, digestion, and activity; these data will assess whether background metabolic costs are higher in exposed than unexposed birds. Body mass of all individuals also will be measured at all handling events; these data will be interpreted in light of metabolic and behavioral measurements.

DEE estimation using doubly-labeled water requires injection of water with both the oxygen and water isotopically-labeled. As the hydrogen is lost only through water and oxygen through both water loss and carbon dioxide production, the difference in turnover rates between marked hydrogen and oxygen can be used to estimate metabolism. BMR will be measured using a flow-through respirometer to measure oxygen consumption. An oxygen analyzer is on site at the Alaska SeaLife Center and was used in winter 2000-01 experiments. BMR of all birds will be measured throughout the winter, including prior to any exposure to establish background rates.

CYP1A induction of all captive birds will be measured at the end of the experiment by EROD activity, described above. EROD activity will be compared among all treatments.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

USGS-BRD personnel will be responsible for directing and conducting sea otter and harlequin duck studies.

Contract with Dr. Tom Dean for the sea otter prey (littleneck clam growth) component.

Contract with Dr. Dan Esler for the harlequin duck components.

SCHEDULE

A. Measurable Project Tasks for FY02

Sea Otters

December-March: Coordinate and plan aerial surveys, carcass collections, sea otter capture, community involvement, prepare equipment.

Obtain/update marine mammal permits.
Measure the growth rate of clams collected in 2000

April-May: Collection of beach-cast sea otter carcasses for survival estimates.

July: Aerial surveys of sea otters in PWS

August - April Data analysis and report prep

Harlequin Ducks

Oct-March: Conduct studies of captive flock at the Alaska SeaLife Center, with birds captured during late FY01.

November: Capture harlequin ducks for field studies of survival and CYP1A induction.

Nov-March: Monitor radioed birds for survival study.

March: Surgically biopsy livers of captive birds for EROD activity; after a recovery period, birds will be released at the original capture site.

April - August: Prepare for field studies (e.g., order radios, contact boat charter operators, maintain winter trap, contact biosample contractors, etc.).

B. Project Milestones and Endpoints

This is a projected five-year research and monitoring program (initiated FY99, with completion of all objectives by FY03; see below) designed to assess the recovery of two injured species. Project objectives will be assessed annually. At the end of each year results will be compared with the restoration goals to assess whether recovery has occurred. The reporting schedule is described below, and is consistent with EVOS Trustee Council guidelines.

Sea Otters

FY01-03: Field studies (aerial and carcass surveys) are scheduled to occur from April through July, 2002. Aerial surveys will be repeated in the summer of 2003. Sea otter carcass surveys will be repeated in April 2003.

Harlequin Ducks

FY01-03: Field studies are scheduled to occur from November through March, winters 2000-01, 2001-02, and 2002-03. Captive bird experimental work is scheduled for winters 2000-01 and 2001-02.

C. Completion Date

All project objectives will be met by FY03.

PUBLICATIONS AND REPORTS

Annual reports will be presented to the Chief Scientist by April 15. An annual report of FY02 activities will be submitted to the Restoration Office on or before 15 April 2003. A final report will be prepared at the end of the proposed work unless continued monitoring is warranted or when recovery objectives are met. Special reports (publications) will be prepared during the course of the study if warranted. Publications will be prepared for peer-review journals when sufficient data have been collected.

PROFESSIONAL CONFERENCES

D. Esler attendance at 2002 American Ornithologists Union meeting, date and location to be determined. J. Bodkin attendance at biennial Conference on Biology of Marine Mammals, November 2001, Vancouver, BC.

NORMAL AGENCY MANAGEMENT

The work proposed here is not part of normal agency management and is related specifically to research addressing oil spill restoration concerns. No similar work has been conducted, is currently being conducted, or is planned using agency funds.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

As described in the Introduction, this research relies on incorporation of data from other Trustee sponsored research, including projects /025 and /427. Equipment and commodities purchased under /025 will be used to conduct the proposed research and data collection and analysis will follow previously established protocols and standards.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

In 1998, the EVOS Trustee Council first approved funding for Restoration Project 99423, "Patterns and Processes of Population Change in Sea Otters", an extension of the NVP project. The objectives of the project included sea otter aerial surveys of PWS, replicate surveys of sea otters at Knight and Montague Islands and sampling of sea urchin populations. In 1999, the Trustee Council approved the addition of harlequin duck studies to 00423 with the revised project title "Patterns and Processes of Change in Selected Nearshore Vertebrates". Those studies included relating harlequin survival to oil exposure and captive studies to assess responses to controlled oil exposure. In February 2000, the Trustee Council approved an amendment to

00423, to fund carcass recovery surveys in WPWS, to collect data on sea otter ages at death for estimation of survival rates.

Differences in this 02423 proposal from projections in the 01423 proposal include addition of the clam growth work, which includes two months salary for Tom Dean, PI on sea otter prey studies, to support data analyses and interpretation, and preparation of the final report on the prey assessment component.

In July 2000, the project 01423 budget and DPD were revised to reflect suspension of the aerial surveys for sea otters in July 2001. Because salary costs were included in aerial surveys and also supported urchin work that is discontinued in 2001, salary costs of 28.8 K were redirected from aerial surveys to sea otter biomarker and survival sampling.

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PRINCIPAL INVESTIGATOR QUALIFICATIONS

Jim Bodkin, Research Wildlife Biologist, and team leader for coastal ecosystem in Alaska for the Alaska Biological Science Center of USGS, Biological Resources Division. He has over 40 peer-reviewed scientific publications and directs an active coastal marine research program. He has studied and published on sea otter foraging ecology and community structuring since 1988 and has been principal investigator for sea otter survey methods development. He earned a M.S. from California State Polytechnic University in 1986.

Dan Esler is a University Research Associate with Simon Fraser University in British Columbia. He has conducted waterfowl research in arctic and subarctic regions of Alaska and Russia for the past 12 years. Since 1995 he has served as project leader for harlequin duck studies as part of the EVOSTC-sponsored Nearshore Vertebrate Predator project. He earned a M.S. from Texas A&M University in 1988 and a Ph.D. from Oregon State University in 2000. He has authored over 20 peer-reviewed journal publications and numerous reports and presentations addressing research and issues in waterbird conservation.

Thomas A. Dean is President of the ecological consulting firm Coastal Resources Associates, Inc. (CRA) in Vista CA. Dr. Dean has over 20 years of experience in the study of nearshore ecosystems, and has authored over 30 publications, including several dealing with impacts of the *Exxon Valdez* oil spill on subtidal populations of plants and animals. He has extensive experience in long-term monitoring studies, and has played a major role in both intertidal and subtidal EVOS investigations since 1989. Dr. Dean is currently a co-principal investigator for the Nearshore Vertebrate Predator Project (NVP), and is examining the relationships between prey abundance and the recovery of sea otters, river otters, harlequin ducks, and pigeon guillemots.

Brenda Ballachey is a Research Physiologist at the Alaska Biological Science Center of USGS, Biological Resources Division. She was Project Leader for sea otter NRDA studies from 1990 through 1996, and has been involved in all aspects of post-spill research on sea otters, including the Nearshore Vertebrate Predator (NVP) project, with primary responsibilities for examining effects of residual oil on biomarkers and health of sea otters and other NVP study species. She received her M.S. in 1980 at Colorado State University, and Ph.D. in 1985 Oregon State University. She has authored or coauthored over 25 peer-reviewed publications.

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2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002	PROPOSED FY 2002 TRUSTEE AGENCIES TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
							$361.6	
Personnel	$169.0	$66.2						
Travel	$13.7	$3.9						
Contractual	$145.3	$253.5						
Commodities	$29.2	$10.5						
Equipment	$1.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$358.2	$334.1				Estimated FY 2003		
General Administration	$35.5	$27.5						
Project Total	$393.7	$361.6				$250.0		
Full-time Equivalents (FTE)	0.0	1.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$0.0	$0.0			$0.0	$0.0		

Comments:

FY02

Prepared: 4/9/01

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Lead Agency: DOI--USGS

FORM 2A
MULTI-TRUSTEE AGENCY SUMMARY

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002	LONG RANGE FUNDING REQUIREMENTS					
					Estimated FY 2003			
Personnel	$169.0	$55.7						
Travel	$13.7	$3.9						
Contractual	$145.3	$253.5						
Commodities	$29.2	$10.5						
Equipment	$1.0	$0.0						
Subtotal	$358.2	$323.6						
General Administration	$35.5	$25.9						
Project Total	$393.7	$349.5			$250.0			
Full-time Equivalents (FTE)		0.9						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY02

Prepared: April 9, 2001

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI--USGS

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2001
J. Bodkin (so)	Research Wildlife Biologist	GS 13-4	0.5	7.2		3.6
D. Monson (so, cl)	Research Wildlife Biologist	GS 9-02	6.0	4.2		25.2
B. Ballachey (so)	Research Physiologist	GS 12-4	3.0	7.0		21.0
						0.0
						0.0
						0.0
D. Mulcahy (hd)	Veterinarian	GS 13	0.8	7.4		5.9
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		10.3	25.8	0.0	
					Personnel Total	$55.7

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
Field crew/gear to Whittier (so)			10	0.1	1.0
Boat transportation to Whittier (so)	0.1	1			0.1
Travel Anch/Cord/Anch 14 d (so)	0.4	1	14	0.1	1.8
Meetings (1 so)					1.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$3.9

FY02

Prepared: April 9, 2001

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI-USGS

FORM 3B
Personnel
& Travel
DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Contractual Costs:		Proposed FY 2000
Description		
4A Linkage #1	Coastal Resources Associates (cl)	30.0
Charter vessel, sea otter beach walks - 10 days @ $1200 (so)		12.0
OAS aerial survey costs 80 hr @ 220/hr (so)		17.6
Matson's Laboratory - tooth ages, 75 @ $5 (so)		0.4
4A Linkage #2	Simon Fraser University (hd)	161.5
Oregon State Univerisity - graduate student support (hd)		32.0
When a non-trustee organization is used, the form 4A is required.	**Contractual Total**	$253.5

Commodities Costs:	Proposed FY 2001
Description	
Misc field/office supplies (so)	3.0
Equipment maintenance and repair (so)	1.0
Fuel (so)	2.0
Vet supplies (hd)	4.5
Commodities Total	$10.5

FY02

Prepared: April 9, 2001

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI--USGS

FORM 3B
Contractual & Commodities DETAIL

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2000
			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

FY02

Prepared: April 9, 2001

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI-USGS

FORM 3B
Equipment
DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002						
Personnel	$0.0	$10.5						
Travel	$0.0	$0.0						
Contractual	$0.0	$0.0						
Commodities	$0.0	$0.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$10.5			Estimated FY 2003			
General Administration	$0.0	$1.6						
Project Total	$0.0	$12.1			$0.0			
Full-time Equivalents (FTE)		0.1						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY02

Prepared: April 9, 2001

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI--FWS

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2001
						0.0
K. Trust (hd)	Biologist	GS 12	1.5	7.0		10.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.5	7.0	0.0	
					Personnel Total	$10.5

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
					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

FY02

Prepared: April 9, 2001

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI-FWS

FORM 3B
Personnel
& Travel
DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Contractual Costs:	Proposed FY 2002
Description	
	0.0
	0.0
	0.0
	0.0
	0.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 2001
Description	
	0.0
	0.0
	0.0
	0.0
	0.0
Commodities Total	$0.0

FY02

Prepared: April 9, 2001

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI--FWS

FORM 3B
Contractual & Commodities
DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

New Equipment Purchases:			
Description	Number of Units	Unit Price	Proposed FY 2000
			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

FY02

Prepared: April 9, 2001

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI-FWS

FORM 3B
Equipment
DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002	LONG RANGE FUNDING REQUIREMENTS					
					Estimated FY 2003			
Personnel		$16.0						
Travel		$0.0						
Contractual		$0.0						
Commodities		$0.0						
Equipment		$0.0						
Subtotal	$0.0	$16.0						
Indirect		$14.0						
Project Total	$0.0	$30.0						
Full-time Equivalents (FTE)		0.2						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: COASTAL RESOURCES INC.
Indirect costs calculated as follows:
Indirect costs = Overhead + General and Administrative costs + Fee
Overhead = 59.5% of personnel costs
G&A = 12.85% of personnel + overhead + other direct (excluding contractual)
Fee = 4% of Total Direct + Indirect (excluding contractual)

No overhead or fees are charged on contractual costs

FY02

Prepared:April 9, 2001

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI-USGS--contract to Coastal Resources, Assoc.

FORM 4A
Non-Trustee
SUMMARY

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2001
	T. Dean	Biologist	2.0	8.0		16.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	2.0	8.0	0.0	
					Personnel Total	$16.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2001
						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

FY02

Prepared: April 9, 2001

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI-USGS--CRA contract

FORM 4B
Personnel
& Travel
DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Contractual Costs:	Proposed FY 2001
Description	
Contractual Total	$0.0

Commodities Costs:	Proposed FY 2001
Description	
Commodities Total	$0.0

FY02

Prepared: April 9, 2001

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI-USGS--CRA contract

FORM 4B
Contractual & Commodities
DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

New Equipment Purchases:		Number of Units	Unit Price	Proposed FY 2001
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		

FY02

Prepared: April 9, 2001

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI-USGS--CRA contract

FORM 4B
Equipment
DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002	LONG RANGE FUNDING REQUIREMENTS					
					Estimated FY 2003			
Personnel		$69.0						
Travel		$6.4						
Contractual		$68.5						
Commodities		$17.6						
Equipment		$0.0						
Subtotal	$0.0	$161.5						
Indirect		$0.0						
Project Total	$0.0	$161.5						
Full-time Equivalents (FTE)		1.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: SIMON FRASER UNIVERSITY

No overhead or fees are charged by the university on this contract.

FY02

Prepared:April 9, 2001

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI-USGS --Simon Fraser University Contract

FORM 4A
Non-Trustee
SUMMARY

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2001
	D. Esler	University Research Associate	9.0	6.8		61.2
		Biological Technician	3.0	2.6		7.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	12.0	9.4	0.0	
					Personnel Total	$69.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2001
	Esler - Seward (hd)	0.8	3	25	0.1	4.9
	Field crew/gear to Whittier (winter) (hd)	0.5	1			0.5
	Meeting (hd)					1.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$6.4

FY02

Prepared: April 9, 2001

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI-USGS--Simon Fraser University Contract

FORM 4B
Personnel
& Travel
DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Contractual Costs:	Proposed
Description	FY 2001
Doubly-labelled water assays - 20 @ $350 (hd)	7.0
EROD activity - 70 @ $140 (hd)	9.8
Charter vessel (winter) - 21 days @ 1150 (hd)	24.2
Plumage swab analysis - 50 @ 100 (hd)	5.0
Air charter - survival monitoring - 90 hrs @ $250 (hd)	22.5
Contractual Total	$68.5

Commodities Costs:	Proposed
Description	FY 2001
Oxygen consumption materials (hd)	1.0
Biosampling materials (hd)	0.8
Winter trap maintenance (hd)	0.5
Radio transmitters - 50 @ $225(hd)	11.3
Metabolic chamber materials (hd)	1.0
Miscellaneous field/office supplies (hd)	3.0
Commodities Total	$17.6

FY02

Prepared: April 9, 2001

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI-USGS--Simon Fraser University Contract

FORM 4B
Contractual & Commodities DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 2001
Description			
			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		

FY02

Prepared: April 9, 2001

Project Number: 02423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: USGS--Simon Fraser University Contract

FORM 4B
Equipment
DETAIL

Design of a Video System for Remotely Monitoring Nesting Seabirds at East Amatuli Island

Project Number: 02434
Restoration Category:
Proposer: DOI-FWS
Lead Trustee Agency: DOI-FWS
Cooperating Agencies:
Alaska Sealife Center: No
Duration: 1st year, 1.5-year project (FY 02-FY 03)
Cost FY 02: $4.3K
Cost FY 03 $1.1K
Geographic Area: Barren Islands
Injured Resource/Service: Common murre

ABSTRACT

Documentation of the biological effects of decadal-scale changes in meteorological and oceanographic patterns requires that data collection methods be repeatable through long-term changes and short-term extremes in sea and weather conditions. During the 1990's rough seas at East Amatuli Island have occasionally blocked access to cliff plots where seabird breeding and population size data are collected; it is possible that in the future weather patterns could compromise datasets. Recently developed technology makes it possible to transmit video images of the cliff plots to the East Amatuli field camp. This could augment field observations and allow safe data collection to continue through periods of rough seas. We propose to specify design requirements for such a system, to research and price available components, and determine the price for contractual system design and assembly.

INTRODUCTION

The Barren Islands (about 58° 55' N, 152° 10' W), in the northwestern Gulf of Alaska (Figure 1), supported one of the largest breeding concentrations of common murres (*Uria aalge*) in the path of the *Exxon Valdez* oil spill (e.g. Sowls *et al.* 1978, Piatt *et al.* 1990, FWS 1994); murres comprised 74% of the 30,000 bird carcasses recovered after the spill (see Piatt *et al.* 1990). Since 1992 the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) has funded restoration monitoring of the breeding parameters and population size of murres and other seabirds at East Amatuli Island (Restoration Study Number 11 (1992), 93049, 94039, 95163J, 96144, 96163J, 97144, 97163J, 98163J, 99144, 99163J), in the Barren Islands group. At East Amatuli Island data collection on breeding parameters and some population counts of cliff-nesting seabirds (murres and kittiwakes) has relied on regular visits (approximately every 3 days) to observation posts on cliffs, where nest content and number of adults in plots are recorded. These visits require travel to the cliffs by skiff. The usefulness and comparability of the dataset depends on the regularity of the visits. For example, if murre chicks are not sighted within a few days after they hatch they cannot be aged precisely; when they later leave the cliffs it can't be determined whether they left cliffs prematurely or fledged.

Occasionally during the 1990's sea conditions too rough for skiff travel caused 7-day gaps between visits, which according to field protocol is the maximum allowable gap because of precision required for breeding success measurements. In a month, year, or decade of sea conditions that are worse than those we experienced in the 90's, comparability of the data could be compromised due to missing data and subsequent coarse-scale interpretation. Changes in personnel may cause a similar effect, as less experienced skiff pilots should be more conservative in day-to-day determination of whether sea conditions are safe for travel.

In 1999 The Alaska Maritime National Wildlife Refuge conducted EVOSTC Project 99434, East Amatuli Island Remote Video Link Project, jointly with the Pratt Museum, located in Homer (see O'Meara 2000). Using a signal repeater site at the tip of the Kenai Peninsula, the project successfully broadcast live video images 85 km from the breeding cliffs to an exhibit at the museum. The system was designed for two purposes: to test the system for seabird monitoring and to show to visitors the seabirds and the monitoring work. Visitors and monitors were able to control the camera's pan, tilt, and zoom from the museum.

If a similar system brought images from the cliffs to the East Amatuli field camp, it could improve the consistency of data collection. On days when sea conditions prevented travel to the plot observation stations, cameras could be used to collect the data from the plots.

The system has many other potential uses. For example, it could allow observation of murres at first light, when mates are absent and eggs, chicks, and postures of those murres at the nest sites are more easily observed. Images could be taped at camp with time-lapse recorders; an hour's record of postures could then be quickly scanned. Or, feeding frequency, nest attendance, and foraging trip duration could be analyzed from daylong time-lapse records, as we have done for several years with recorders at the cliffs; tapes could be changed at the field camp rather than at the cliffs. Black-legged kittiwakes (*Rissa tridactyla*) could be similarly monitored with this system; the kittiwake plots are adjacent to the murre plots.

The system might also be used to monitor tufted puffin (*Fratercula cirrhata*) populations, productivity, nest attendance, and feeding frequency. Tufted puffins are burrow nesters;

breeding effort and productivity are usually measured by hunting for eggs and chicks in burrows. Remote observation and time-lapse recording of roosting, arrivals, and departures of the adults may provide alternative methods for measuring these parameters. The video relay on Valley Rise (see Figure 2) and a camera and a transmitter would provide the needed link to make these observations or recordings at camp.

The system we propose to design would differ from that used in Project 99434 for 3 reasons:

1. It would transmit images to the field camp, rather than to Homer
2. It would be designed solely for seabird monitoring, not as an exhibit
3. It would be maintained by the field crew, rather than by a contractor

1) The image would follow the East Amatuli Island coast to the field camp (Figure 2). The transmission path would be only about 3 km, rather than the 85 km of Project 99434. This may change the optimal transmission frequency. We would require 2 relays to go around the island's mountains; Project 99434 used one relay. The relays would be easily accessible by the island's field crew for maintenance.

2) A system suited solely for monitoring will have:

A) Higher zoom capability for the camera lens. The magnification used in Project 99434 was strong enough to see the closest plots but not the farthest.

B) Finer motor controls and vibration protection, which will be required by higher magnification. Joystick control of pan, tilt, and zoom of the camera, rather than touch-screen control used in the previous system, would aid in this objective. For finer pan and tilt control we can forgo broad range of motion; the exhibit cameras had a much larger range of pan and tilt than we need to see the plots. To minimize vibration from wind we may house the camera in two containers, with the outside housing separate from the inside housing. The wind would act on the outside housing and vibration would not transfer to the inside housing.

C) Manual remote control of the focus also, rather than auto focus, so that the focus can be easily set for specific nests and so that the camera does not focus on rain. Manual focus should save power also.

3) The system will be maintained by the island's field crew. In Project 99434 the contractor that designed and supplied the system also maintained the components at the island, the repeater site, and in Homer. All of the components in the proposed monitoring system would be easily accessible by the field crew. The system should be designed so that the crew can either repair or replace components when they fail. Whether it would be preferable to purchase the equipment for the system or lease it from a contractor will be decided with prices for components and system design, and depreciation costs.

NEED FOR THE PROJECT

A. Statement of the problem

Visits to observation points for collection of common murre monitoring data are in some locations sometimes limited by weather or sea conditions, or other factors. This can cause data gaps and lower comparability of results.

B. Rationale/Link to Restoration

Improvements to the dependability of murre monitoring methods will help insure consistency of precision and accuracy of information about the recovery of murre populations.

C. Location

The project will be undertaken at the Alaska Maritime National Wildlife Refuge Headquarters, Homer, Alaska.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

We will include a local video systems designer in our list of designers to contact. We will notify of our results the local Pratt Museum, Alaska Department of Fish and Game, Kachemak Bay National Estuarine Research Reserve, and other members of the local community who may be interested in developing a similar system.

PROJECT DESIGN

A. Objectives

1. Determine camera, lens, control, and transmission specifications required for remotely monitoring cliff-nesting seabirds from the East Amatuli Island field camp.

2. Research availability and cost of equipment and system designers. Equipment to research includes the video camera; camera housing; camera pan, tilt, zoom, and focus motors, switches, and controls; camera lens; signal transmitters and receivers (including transmission frequencies); and viewing monitors. We will obtain the names of several companies that could design and assemble the system, and after discussions with them:

3. List costs for equipment, design, and assembly.

B. Methods

1. With rangefinder measurements of distances to the plots from the field observation posts, calculate the zoom capability required to observe postures, eggs, and chicks for the productivity plots. Test such a lens with dummy birds and eggs at plot distances.

2. List the horizontal and vertical angles required to see all of the plots from the observation points.

3. Choose locations for the transmitters, relays, and receiver and determine distances along the transmission path for each component.

4. With Internet and telephone searches and word-of-mouth, research component manufacturers and system retailers.

5. Contact system designers and ask them about components, and obtain price quotes for complete system design. Compare component prices, complete system prices, and time and expertise needed to build a system.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Private contracting will not be part of this project. We are only researching contractors and costs at this point.

SCHEDULE

A. Measurable Project Tasks for FY 02 (October 1, 2001 - September 30, 2002

October 2001 - September 2002:	List system specifications required. Research and list component availability, costs, and assembly time, and availability of system designers. List price quotes from system designers. List costs and benefits of various options.
April 15, 2003:	Submit EVOSTC Final Report

B. Project Milestones and Endpoints

See Measurable Project Tasks, above

C. Completion Date

April 15, 2003

PUBLICATIONS AND REPORTS

Final Report to the *Exxon Valdez* Oil Spill Trustee Council.

PROFESSIONAL CONFERENCES

The Principal Investigator will attend the annual Trustee Council Restoration Workshop in January 2003.

NORMAL AGENCY MANAGEMENT

This type of design work is not something the U.S. Fish and Wildlife Service (USFWS) is required to do by statute. The Alaska Maritime National Wildlife Refuge (part of the USFWS) normally monitors seabirds at some seabird colonies, but would not normally conduct the type of work proposed here.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Results of this project will be shared with other researchers who may be able to use a similar video system. These include researchers in the U.S. Fish and Wildlife Service, the U.S. Geological Survey, and the Alaska Department of Fish and Game.

PROPOSED PRINCIPAL INVESTIGATOR, IF KNOWN

Name: Arthur B. Kettle
Affiliation: Alaska Maritime National Wildlife Refuge
Mailing address: 2355 Kachemak Bay Dr. (Ste. 101), Homer, AK 99603-8021
Phone: (907) 226-1236
Fax: (907) 235-7783
E-mail: Arthur_Kettle@fws.gov

PRINCIPAL INVESTIGATOR

Arthur B. Kettle

Mr. Kettle received a bachelor's degree in Human Ecology from College of the Atlantic in 1984. During 1987-1991 he worked with a University of Washington (UW) study of Magellanic Penguins (*Spheniscus magellanicus*) in Argentina. In 1990 he began working in the Barren Islands. As a field team leader of a 1990-1992 Exxon-sponsored UW study he collected, compiled, and analyzed productivity and population size data at East Amatuli Island for common murres (*Uria aalge*), tufted puffins (*Fratercula cirrhata*), and fork-tailed storm petrels (*Oceanodroma furcata*).

Mr. Kettle joined the U.S. Fish and Wildlife Service in May 1993 and was field camp leader for the 1993-1994 EVOSTC-sponsored Barren Islands common murre restoration studies (Projects 93409 and 94039). He was field team leader for the Barren Islands Seabird Studies component of the EVOSTC-sponsored Alaska Predator Ecosystem Experiment (Projects 95163J, 96163J, 97163J, 98163J, and 99163J) and the East Amatuli Island Remote Video Link Project (Project 99434). As field team leader he was responsible for logistics at Amatuli Cove Camp and for ensuring that field data were obtained according to study design. He established observation stations, productivity plots, and field methods for collecting common murre and black-legged kittiwake (*Rissa tridactyla*) productivity data at the East Amatuli Island headlands, accessible only by boating and then climbing. He designed, assembled, operated, and maintained a dependable solar-powered system for video time-lapse recording and analysis of murre and kittiwake nest attendance and feeding frequency; this was used throughout the 1997-1999 APEX study years, and he successfully tested this system for use with tufted puffins. He helped to determine placement of, install, and test the Project 99434 remote video system at East Amatuli Island, and analyzed the resulting data. Each year since 1990 Mr. Kettle has compiled and analyzed data and written or helped to write reports and publications for Barren Islands studies.

Selected Seabird Publications

Roseneau, D.G., A.B. Kettle, and G.V. Byrd. 2000. Common murre population monitoring at the Barren Islands, Alaska, 1998, *Exxon Valdez* Oil Spill Restoration Project Annual Report (Restoration Project 99144), U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, Homer, Alaska.

_____, _____, and _____. 1999. Barren Islands seabird studies, 1998. Unpubl. annual rept. by the Alaska Maritime National Wildlife Refuge, Homer, Alaska for the *Exxon Valdez* Oil Spill Trustee Council, Anchorage, AK. (APEX Project 98163J).

_____, _____, and _____. 1998. Barren Islands seabird studies, 1997. Unpubl. annual rept. by the Alaska Maritime National Wildlife Refuge, Homer, Alaska for the *Exxon Valdez* Oil Spill Trustee Council, Anchorage, AK. (APEX Project 97163J).

_____, _____, and _____. 1997. Barren Islands seabird studies, 1996. Unpubl. annual rept. by the Alaska Maritime National Wildlife Refuge, Homer, Alaska for the *Exxon Valdez* Oil Spill Trustee Council, Anchorage, AK. (APEX Project 96163J).

_____, _____, and _____. 1996a. Barren Islands seabird studies, 1995. Unpubl. annual rept. by the Alaska Maritime National Wildlife Refuge, Homer, Alaska for the *Exxon Valdez* Oil Spill Trustee Council, Anchorage, AK. (APEX Project 96163J). 34 pp.

_____, _____, and _____. 1996b. Common murre restoration monitoring in the Barren Islands, Alaska, 1994. Unpubl. final rept. by the Alaska Maritime National Wildlife Refuge, Homer, Alaska for the *Exxon Valdez* Oil Spill Trustee Council, Anchorage, AK. (Restoration Project 94039). 76 pp.

Boersma, P.D., J.K. Parrish, and A.B. Kettle. 1995. Common murre abundance, phenology, and productivity on the Barren Islands, Alaska: The *Exxon Valdez* oil spill and long-term environmental change. Pp. 820-853 *in* *Exxon Valdez* Oil Spill: Fate and effects in Alaskan waters, ASTM STP 1219, P.G. Wells, J.N. Butler, and J.S. Hughes (eds.), Amer. Soc. for Testing and Materials, Philadelphia, PA.

Roseneau, D.G., A.B. Kettle, and G.V. Byrd. 1995. Common murre restoration monitoring in the Barren Islands, Alaska, 1993. Unpubl. final rept. by the Alaska Maritime National Wildlife Refuge, Homer, Alaska for the *Exxon Valdez* Oil Spill Trustee Council, Anchorage, AK. (Restoration Project 93049). 71 pp.

OTHER KEY PERSONNEL

G. Vernon Byrd (Project Manager)

Mr. Byrd will supply overall guidance to the project and will review the Final Report. Mr. Byrd received a B.S. degree in wildlife management from the University of Georgia in 1968, did post-graduate studies in wildlife biology at the University of Alaska-Fairbanks in 1975, and completed his M.S. degree in wildlife resources management at the University of Idaho in 1989. His thesis, entitled "Seabirds in the Pribilof Islands, Alaska: Trends and monitoring methods", explored statistical procedures for analyzing kittiwake *(Rissa* spp.*)* and murre *(Uria* spp.*)* population data.

Mr. Byrd has worked for the U.S. Fish and Wildlife Service for over 20 years, focusing on studies of marine birds in Alaska and Hawaii. His major interests center around monitoring long-term trends in seabird populations, including numbers of birds and reproductive performance at colonies. He has worked at murre colonies in the Aleutian Islands, the Bering and Chukchi seas, and western Gulf of Alaska. Mr. Byrd was a co-author of the final *Exxon Valdez* oil spill damage assessment report for murres. He was project manager of the 1993-1994 common murre restoration monitoring studies (Projects 93049 and 94039), projects to remove predators from islands containing seabird colonies (Projects 94041 and 95041), and the 1995-2000 APEX and murre monitoring studies (Projects 95163J, 95163K, 96163J, 96144, 97163J, 97163K, 97144, 98163J, 98163K, 98144, 99163J, 99163K, 99144, and 00163J).

He has authored over 55 scientific papers and 65 U.S. Fish and Wildlife Service reports on field studies, and has made about 35 presentations on seabirds at scientific meetings. Mr. Byrd is the supervisory wildlife biologist at the Alaska Maritime National Wildlife Refuge.

Selected Seabird Publications

Byrd, G.V., E.C. Murphy, G.W. Kaiser, A.J. Kondratyev, and Y.V. Shibaev. 1993. Status and ecology of offshore fish-feeding alcids (murres and puffins) in the North Pacific Ocean. Proceedings of "Symposium on the Status , Ecology, and Conservation of Marine Birds of the Temperate North Pacific". Canadian Wildlife Service, Ottawa.

Byrd, G.V., and J.C. Williams. Whiskered Auklet. 1993. A chapter describing the biology of the species in The birds of North America, No. 76 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia PA, and the American Ornithologists' Union, Washington, D.C. 12 pp.

Byrd, G.V., and J.C. Williams. Red-legged Kittiwake. 1993. A chapter describing the biology of the species in The birds of North America No. 60 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia PA, and the American Ornithologists' Union, Washington, D.C. 12 pp.

Springer, A.M. and G.V. Byrd. 1989. Seabird dependence on walleye pollock in the southeastern Bering Sea. Pages 667-677 in Proceedings of the International Symposium on the Biology and Management of Walleye Pollock. Alaska Sea Grant Rep. No. 89-1, Univ. of Alaska-Fairbanks.

LITERATURE CITED

FWS (Fish and Wildlife Service). 1994. Alaska seabird colony catalog computer data base and colony status record archives. U.S. Fish Wildl. Serv., Migratory Bird Manage., Anchorage, AK.

O'Meara, Michael S. 2000. East Amatuli Island Video Link Project. *Exxon Valdez* Oil Spill Restoration Final Report (Restoration Project 99434), Pratt Museum/Homer Society of Natural History, Homer, Alaska.

Piatt, J.F, C.J. Lensink, W. Butler, M. Kendziorek, and D.R. Nysewander. 1990. Immediate impact of the "Exxon Valdez" oil spill on marine birds. Auk 107:387-397.

Sowls, A.L., S.A. Hatch, and C.J. Lensink. 1978. Catalog of Alaskan seabird colonies. U.S. Fish Wildl. Serv., Biol. Serv. Prog. FWS/OBS 78/78, Anchorage, AK. 153 pp.

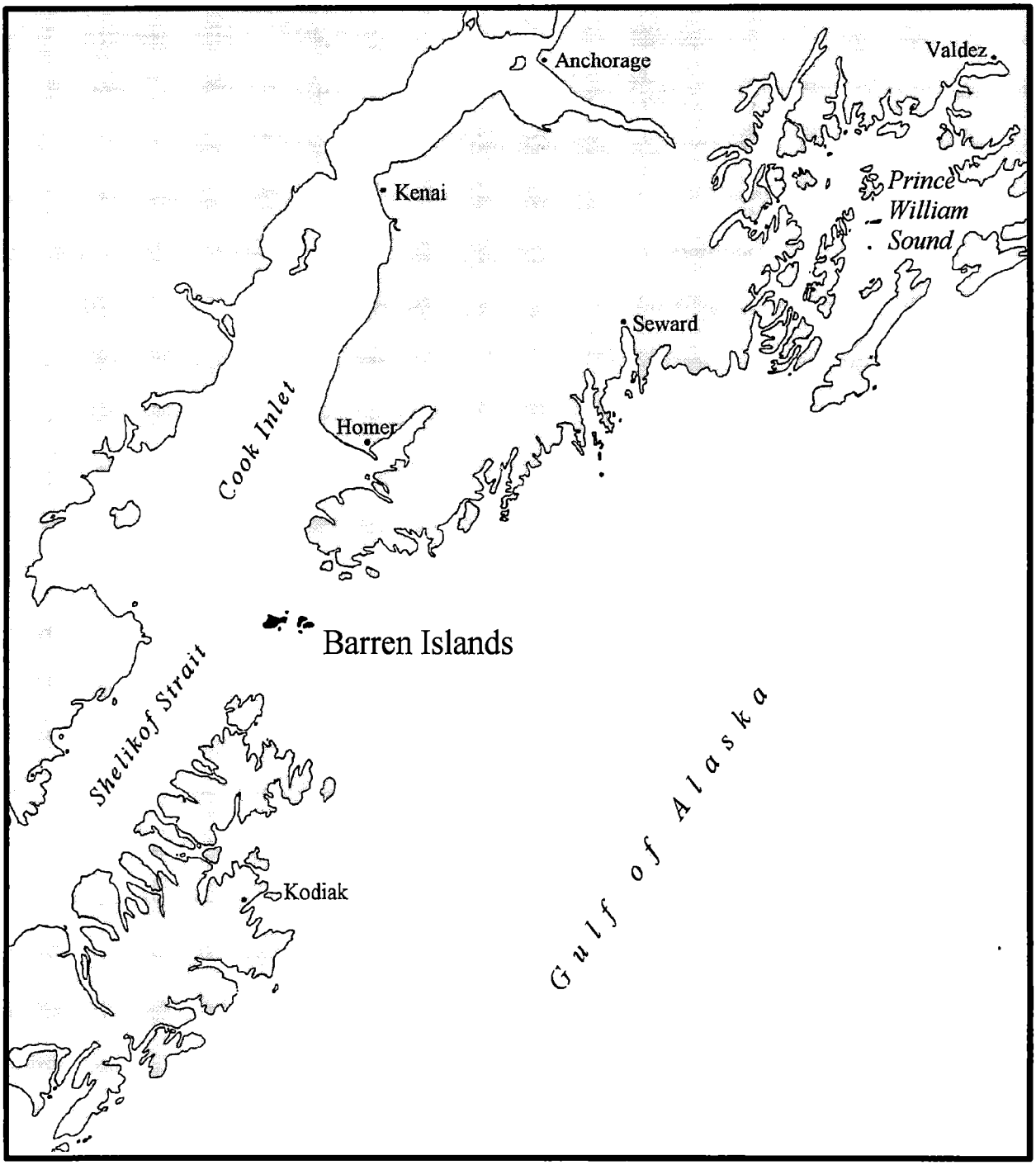

Figure 1. Location of the Barren Islands, Alaska

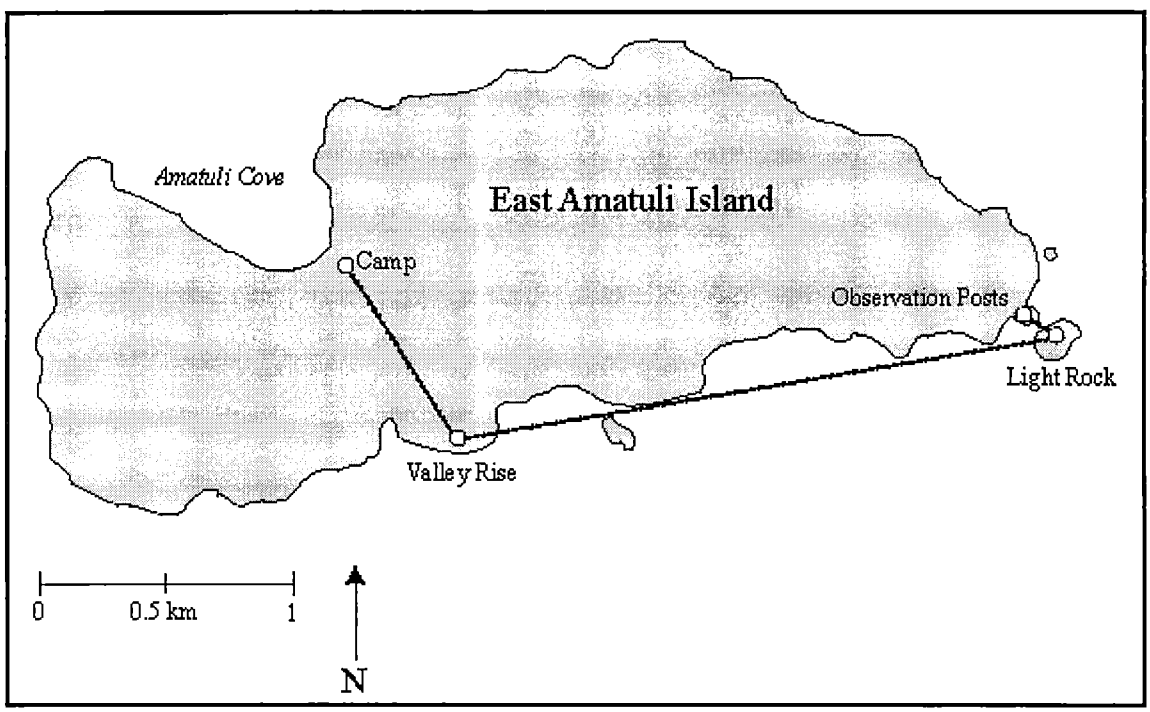

Figure 2. Signal path between the observation posts and field camp

2002 EXXON VALDEZ TF E COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FFY 2001	Proposed FFY 2002	LONG RANGE FUNDING REQUIREMENTS					
			Estimated FFY 2003	Estimated FFY 2004	Estimated FFY 2005	Estimated FFY 2006	Estimated FFY 2007	Estimated FFY 2008
Personnel		$3.2						
Travel		$0.6						
Contractual		$0.0						
Commodities		$0.0						
Equipment		$0.0						
Subtotal	$0.0	$3.8						
General Administration	$0.0	$0.5						
Project Total	$0.0	$4.3	$1.1	$0.0	$0.0	$0.0	$0.0	$0.0
Full-time Equivalents (FTE)		0.1						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

--$600 for travel to annual restoration workshop
--1 week in 2003 for report write-up
--The Alaska Maritime National Wildlife Refuge will donate one week of the project manager's time to the project. The refuge will also provide computers and office space for the study.

FY02

Prepared: 04/11/01

Project Number: 02434
Project Title: Design of a Video System for Remotely Monitoring Nesting Seabirds at East Amatuli Island
Agency: DOI-FWS

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2002 EXXON VALDEZ TR | **COUNCIL PROJECT BUDGET**

October 1, 2001 - September 30, 2002

Personnel Costs:		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	Proposed FFY 2002
Name	Position Description					
A. Kettle	Biological Science Technician	GS/07/04	0.8	4.0	0.0	3.2
	Subtotal		0.8	4.0	0.0	
					Personnel Total	$3.2

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FFY 2002
Description					
A. Kettle travel to EVOSTC workshop, January 2002	0.2	1	2	0.2	0.6
				Travel Total	$0.6

FY02

Prepared: 04/11/01

Project Number:
Project Title: Design of a Video System for Remotely Monitoring Nesting Seabirds at East Amatuli Island
Agency: DOI-FWS

FORM 3B
Personnel
& Travel
DETAIL

Contractual Costs:	Proposed FFY 2002
Description	
None	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FFY 2002
Description	
None [Note: FWS will furnish office materials and computers.]	
Commodities Total	$0.0

FY02

Prepared: 04/11/00

Project Number:
Project Title: Design of a Video System for Remotely Monitoring Nesting Seabirds at East Amatuli Island
Agency: DOI-FWS

FORM 3B
Contractual & Commodities
DETAIL

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 2002
No new equipment is needed for the project			$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
None		

FY02

Project Number:
Project Title: Design of a Video System for Remotely Monitoring Nesting Seabirds at East Amatuli Island
Agency: DOI-FWS

FORM 3B
Equipment
DETAIL

Prepared: 04/11/00

Project Title: Harbor Seal Recovery: Phase III. Effects of Diet on Lipid Metabolism and Health: Completion of Sample Analysis and Manuscript Preparation. Submitted under the BAA

Project Number:	02441 -BAA
Restoration Category:	Research
Proposer:	Randall Davis, Ph.D., Texas A&M University at Galveston
Lead Trustee Agency:	Alaska Department of Fish and Game
Cooperating Agencies:	
Alaska SeaLife Center:	No
Duration:	4th year, 4-year project
Cost FY 04:	$63.6
Geographic Area:	Prince William Sound and Alaska SeaLife Center
Injured Resource:	Harbor seals

ABSTRACT

In 1998, we began a three-year study on the effects of diet on lipid metabolism and health in harbor seals (*Phoca vitulina richardsi*). This study was prompted by a decline in the number of harbor seals in Prince William Sound during the past 10-15 years. An underlying hypothesis for the decline is that ecosystem-wide changes in food availability could be affecting harbor seal population recovery. To better understand the results from field studies of harbor seal health, body condition and feeding ecology, we need data for seals on diets that vary in nutritional composition. Working with the Alaska SeaLife Center, we collected blubber and muscle samples from captive harbor seals during controlled diets of herring and pollock that were alternated every four months for two years. These samples will be used to determine how the fatty acid composition changes with diet to better interpret field data for wild harbor seals. Preliminary analysis of available data indicates that the fatty acid signature in the blubber changes in response to an alternating diet of herring and pollock. However, analysis of the remaining samples is needed to resolve the temporal scale of the changes. In addition, we are assessing the aerobic capacity and lipid metabolism of skeletal muscle in harbor seals fed controlled diets and for wild harbor seals in Prince William Sound. Preliminary results show that the muscles of harbor seals exhibit significant morphological and enzymatic adaptations that maintain an aerobic, fat based metabolism during hypoxia associated with diving. Although a majority of the samples for this part of the study have been analyzed, some of the analyses have not been completed. In the proposed work, we will complete the analysis of samples that have already been taken, but could not be completed due to a shortage of funds available to the EVOS Trustee Council in FY2001. In addition, we will prepare a final report and five manuscripts. When our extensive data set is complete, the results will provide a better understanding of the nutritional role lipid and how it changes with diet in harbor seals. In addition, our results will complement those from other studies of harbor seal dietary preferences, health, body condition and ecology conducted by Frost (Project 001- Harbor seal condition and health status; Project 064- Monitoring habitat use and trophic interactions of harbor seals), Iverson (Project 117-BAA- Harbor seal blubber and lip), and Castellini (Harbor Seal Recovery. Phase II: Controlled Studies of Health and Diet).

INTRODUCTION

Understanding the feeding ecology and nutritional status of harbor seals is an essential component of ecosystem-based research on the recovery of species impacted by the Exxon Valdez oil spill in Prince William Sound. Until recently, determinations of prey preferences for pinnipeds have been based on stomach content and fecal analyses, both of which can only yield information on the most recent meals and may be biased due to differential rates of passage of food items. A new technique using fatty acid profiles of blubber can provide details on cumulative dietary history. It can also, in some cases, be used to determine foraging habitat. In pinnipeds, as with other carnivores and monogastric animals, dietary fatty acids generally remain intact through the digestion process and are deposited in adipose tissue with little or no modification (Iverson 1993). As a result, differences in the fatty acid composition of carnivore blubber can be used to infer dietary differences between individuals or populations and perhaps even species composition of the diet.

Previous research has shown that fatty acid signatures are significantly affected by spatial or temporal heterogeneity in habitat and food webs (Iverson 1993). In a study of harbor seal foraging ecology (Project 117-BAA; Harbor seal blubber and lipids) supported by the Restoration Program, Iverson et al (1997) were able to distinguish individual species of fish using fatty acid signatures. They also found fatty acid composition of these prey items to be correlated with body size as well as location within a study area. Hence, analysis of fatty acids in pinnipeds and their prey should provide details on the spatial scales of foraging and habitat use of both individuals and populations. Evaluating how harbor seal blubber fatty acids change with diet during controlled feeding studies where species composition of diet is known will improve the spatial and temporal interpretation of fatty acid profiles of wild seals whose diet composition is unknown.

Muscle condition and metabolic function can be used as indicators of the health status of marine mammals. Important indices of muscle function and health are aerobic capacity, the ability to store oxygen in the form of oxy-myoglobin and the size of lipid stores. In a preliminary study conducted by our laboratory (Kanatous et al 1999), we observed that the volume density of mitochondria, myoglobin concentration and citrate synthase activity in the swimming muscles of harbor seals were elevated relative to terrestrial mammals and appeared to be an adaptation for aerobic metabolism during diving. One objective of this study is to determine the effect of diet on the aerobic capacity, myoglobin concentration and lipid stores of skeletal muscles in harbor seals. In addition, we will measure the activities of citrate synthase and β-hydroxyacyl CoA dehydrogenase (an enzyme important for lipid metabolism) as indicators of aerobic capacity and the β-oxidation of fatty acids, respectively. Lactate dehydrogenase activity will also be analyzed to determine anaerobic capacity.

With controlled feeding studies of harbor seals at the Alaska SeaLife Center now completed, we are analyzing samples that will provide new information on the effects of diet on fatty acid signatures in blubber and the metabolic function of muscle, especially with regards to lipid. In addition, we collected an extensive set of muscle and blubber samples from wild harbor seals through the BIOSAMPLING Program run by ADFG in cooperation with the Native community in Prince William Sound. Because of the limited availability of funds, the EVOS Trustee Council deferred part of our support during the third year of this project. As a result, we were unable to complete the analysis of many samples being stored in our freezers. Funds requested

in this proposal will enable us to complete the analysis of all of our samples, which will greatly increase spatial and temporal resolution as well as the statistical significance of results. The results will improve our understanding of harbor seal feeding ecology and the effects of diet on health and metabolism.

Status of Sample Analysis

Table 1 shows the number of samples that were obtained for analysis, the number (n) of animals sampled, the number of samples for which analysis will be completed in 2001 (Year 3 of this project), and those samples for which we are seeking additional funds to complete our analyses in 2002. In terms of the number of blubber and muscle samples collected, 72% will have been analyzed by the end of 2001, leaving the remaining 28% for 2002.

Table 1

Tissue/Sample	Type of Analysis	n	No. of Samples	Samples Completed in 2001	To Be Completed in 2002
Blubber[1]	Fatty acid analysis	8	331	168	163
Dietary fish samples[1]	Fatty acid analysis		41	41	0
Muscle samples[1]	Mitochondrial vol. density	8	140	100	40
Muscle samples[1]	Lipid droplet density	8	140	100	40
Muscle samples[1]	Enzyme analysis	8	140	140	0
Muscle samples[2]	Enzyme analysis	10	500	500	0
Muscle samples[2]	Myoglobin analysis	10	500	500	0
Muscle samples[2]	Fiber typing	10	250	125	125
Muscle samples[2]	Mitochondrial vol. density	10	250	0	250
Organ samples[2]	Mitochondrial vol. density	10	40	40	0
Organ samples[2]	Enzyme analysis	10	40	0	40
Total			**2,372**	**1,714**	**658**

[1] Samples taken from captive harbor seals on a controlled diet at the Alaska SeaLife Center
[2] Samples taken from wild harbor seals in Prince William Sound

Preliminary Results

Analysis of blubber fatty acids in captive harbor seals on a controlled diet of herring and pollock. We have completed the analysis of about half of the blubber samples and all of the dietary samples (Table 1). These blubber samples were taken at the beginning and end (i.e., every four months) of each dietary regime (see Table 2 in the Methods for details). CART analysis of the data indicates that the fatty acid signature in the blubber changes in response to an alternating diet of herring and pollock. However, the temporal resolution will be greatly enhanced and the statistical significance improved by analyzing the samples taken at the mid-point of each dietary regime. These were some of the samples that had to be deferred due to a lack of funds in FY 2001. If this proposal is funded, these latter samples will be analyzed in October and November of 2001 (i.e., early FY 2002).

Mitochondrial volume density and lipid droplet density in the muscles of captive harbor seals on

a controlled diet. In a preliminary study with free-ranging harbor seals (Kanatous et al., 1999), we observed that the volume density of mitochondria, myoglobin concentration, volume density of lipid droplets and citrate synthase activity in the swimming muscles of harbor seals were elevated relative to terrestrial mammals of comparable size and appeared to be an adaptation to maintain aerobic metabolism during diving. However the results of the same study indicated diminished lipid stores in Prince William Sound harbor seals compared to other species of non-breeding Alaskan pinnipeds (0.2 ± 0.1% in harbor seals and 1.1 ± 0.3% in Northern fur seals). These diminished lipid stores may have been a result of nutritional stress faced by these animals. Preliminary results from this study show a slightly higher volume density of lipid droplets (0.3 ± 0.08% vs. 0.2 ± 0.1%), but a significantly lower volume density of mitochondria in the skeletal muscles of captive harbor seals as compared to our previous values found in free-ranging harbor seals (3.7 ± 0.3% and 9.3 ± 0.2%). The lower volume density of mitochondria may be due to the effects of captivity (e.g., less activity and shorter dive durations). There also appears to be no effect of changes in diet on the volume density of lipid droplets or mitochondria in the skeletal muscles (p=0.05). However, not all of the samples have been analyzed. We propose to finish the analysis in FY 2002.

Analysis of enzyme activity in the muscles of captive harbor seals on a controlled diet and wild harbor seals. Assays for the three enzymes (citrate synthase, B-hydroxyacyl CoA dehydrogenase and lactate dehydrogenase) have been completed for 140 muscle biopsies from captive harbor seals and 500 samples from wild seals taken by Native hunters (Table 1). A total of 5,760 enzyme assays were run (640 muscle samples assayed for three enzymes in triplicate). Contour maps of the enzyme activities for the wild seals are being prepared (Surfer, Golden Software, Inc., Colorado). Preliminary analysis of transverse sections of the swimming muscle (*Longissimus dorsi*) shows considerable heterogeneity for all three enzymes (i.e., a gradient in concentration is very apparent). Citrate synthase (Figure 1) and lactate dehydrogenase both have higher activities toward the exterior of the muscle and lower activities toward the interior of the muscle closest to the attachment to the spine. β-hydroxyacyl CoA dehydrogenase has a higher activity in the dorsal portion of the muscle, and the activity decreases ventrally. Analysis and interpretation of the entire data set will be completed in 2001.

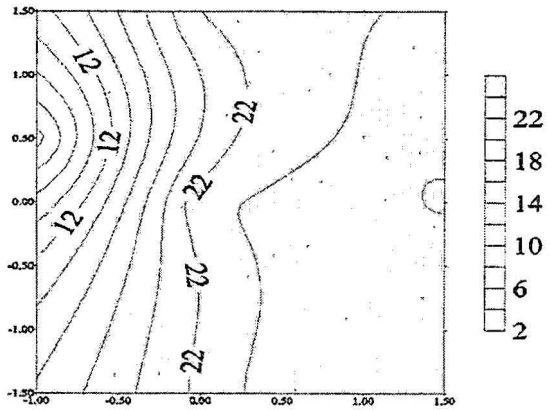

Figure 1. Contour plot of citrate synthase activity in a transverse section of the swimming muscle (L. dorsi) of a wild harbor seal. Spinal attachment is on the left and bottom sides of the figure. Activity is expressed in units/g wet weight.

Fiber typing in the muscles of wild harbor seals. Preliminary data from fiber typing of the swimming muscle (*Longissimus dorsi*) of wild harbor seals indicates that the muscle is comprised of Type I fibers (slow-twitch oxidative) and Type IIa fibers (fast-twitch oxidative), with Type IIb fibers (fast-twitch glycolytic) conspicuously absent. Fibers were counted

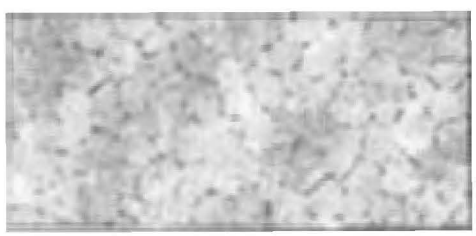

Figure 2. Type I (slow-twitch oxidative) fibers are stained pink in this section of harbor seal swimming muscle (L. dorsi). The remaining fibers are Type IIa (fast-

only if they showed good staining specificity for the appropriate myosin heavy chain isoform as depicted in Figure 2. The average percentages of Type I fibers for the anterior, medial, and posterior cross-sections of the muscle were 47.0%, 47.0%, and 48.4%, respectively. The average percentages of Type IIa fibers for the anterior, medial, and posterior cross-sections were 52.0%, 51.7%, and 52.1%, respectively. No Type IIb fibers were detected in any of the muscle sections. These results differ from previous results of fiber typing using traditional histochemical techniques. The published data on fiber typing of harbor seal *Longissimus dorsi* indicates a high percentage of Type I fibers (approximately 45-47%), few (<10%) Type IIa fibers, and a high percentage (approximately 45-47%) of Type IIb fibers (Reed et al., 1994; Hochachka and Foreman, 1993). The difference in our results and those of previous studies probably results from the extreme specificity inherent in the immunohistochemical procedure used in our study. Further analysis will elucidate whether the majority of harbor seal swimming muscle is comprised of either oxidative muscle fibers or a mixture of oxidative and glycolytic fibers. If most of the fibers turn out to be Type I and Type IIa, our results will confirm the oxidative poise of harbor seal skeletal muscle and its ability to maintain lipid metabolism during diving. The results from mitochondrial volume density and lipid droplet density for matching muscle sections, which we propose to analyze in FY 2002, will further confirm this oxidative, lipid-based metabolism.

Mitochondrial volume density and lipid droplet density in the heart, liver, kidneys and small intestine of wild harbor seals. Volume densities of total mitochondria in the liver of the dog, rat, and harbor seal were 15.8%, 14.4%, and 22.9%, respectively. Volume densities of lipid droplets for the dog, rat, and harbor seal were 0.21%, 0.02%, and 1.3%, respectively. A previous study in our lab showed that pinnipeds have an elevated mitochondrial volume density and lipid droplet density in their swimming muscles as an adaptation for fat-based energy metabolism during diving hypoxia (Kanatous et al. 1999). This is the first study to examine other organs for similar adaptations. These preliminary data suggest that liver tissue, in addition to skeletal muscle, may have an enhanced aerobic capacity for fatty acid metabolism. Assays will also be run for citrate synthase, B-hydroxyacyl CoA dehydrogenase and lactate dehydrogenase. These analyses will be finished in FY 2001.

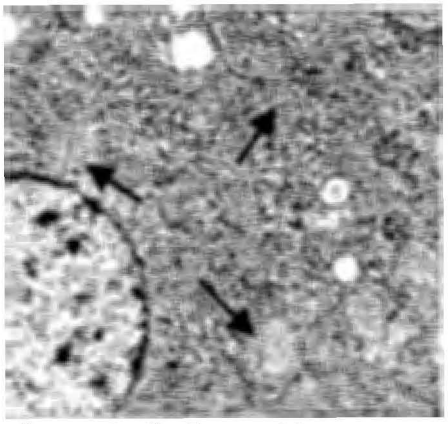

Figure 3. Harbor seal liver magnified 18,150-times. Arrows indicate mitochondria.

NEED FOR THE PROJECT

A. Statement of Problem

The Restoration Program has supported three harbor seal studies in Prince William Sound (Project 001- Harbor seal condition and health status; Project 064- Monitoring habitat use and trophic interactions of harbor seals; Project 117-BAA- Harbor seal blubber and lipids). One objective of these studies was to measure health and body condition indices related to metabolic

alterations that might occur in animals that were food deprived. Although these studies collected much useful information, some researchers realized that controlled dietary studies were needed to better interpret field data. In 1997, the Restoration Program funded a captive study (Harbor Seal Recovery. Phase II: Controlled Studies of Health and Diet) at the Alaska SeaLife Center designed to quantify the nutritional value of several key Alaskan fish species for harbor seals and to follow health indices over time in both healthy and rehabilitation animals. That project, which was successfully completed in October 2000 at the Alaska SeaLife Center, fed controlled diets of fish to harbor seals to examine changes in body condition, health, assimilation efficiency and blood chemistry biomarkers. We participated in these controlled feeding studies and took blubber biopsies every two months for fatty acid analysis and muscle biopsies every four months for mitochondrial volume density and lipid droplet density from eight harbor seals on the diets that alternated between herring and pollock. This resulted in 331 blubber samples, 41 dietary samples, and 140 muscle samples from eight harbor seals during the two year feeding trial (see (Table 1 above for details). In addition, we collected 500 muscle samples for enzyme and myoglobin analysis, 250 muscle samples for fiber typing and 40 organ samples for mitochondrial volume density and enzyme analysis from 10 wild harbor seals as part of the BIOSAMPLING Program in Prince William Sound. The analysis of this very large set of samples has occupied our lab for he past 18 months. However, additional funds will be necessary to complete this extensive analysis. We requested these funds during the third year of this project, but the EVOS Trustee Council deferred our request. This proposal will enable us to complete the analysis of our samples and incorporate the results into the final report and five manuscripts. This important work will augment previously funded investigations of diet and health to provide a more in depth understanding of the nutritional role of dietary fat for harbor seals.

B. Rationale

The harbor seal population in Prince William Sound has not recovered and may continue to decline. An underlying hypothesis is that ecosystem wide changes in food availability could be affecting harbor seal population recovery. To better understand the behavioral and physiological results obtained from field studies of harbor seal health, body condition and feeding ecology supported by the Restoration Program, we need comparable data for seals on diets that vary in nutritional composition. In 1998, a captive study was begun at the Alaska SeaLife Center to quantify the health effects of feeding several key Alaskan fish species to harbor seals. We collected extensive tissue samples to study changes in fatty acid profiles in seal blubber and muscle lipid content during controlled feeding studies where fish species composition was known. In addition, we collected muscle samples from harbor seals in the controlled feeding study and from wild animals in Prince William Sound to quantify the aerobic capacity and activities of enzymes that are crucial for muscle lipid metabolism and which may be affected by nutritional stress. Although most of these samples have been analyzed, additional funds (which were deferred in Year 3 of this project), are needed to complete the analyses. When completed, this will be the most extensive study of is kind on the effects of diet on lipid metabolism in harbor seals.

C. Location

The blubber and muscle samples, which have already been obtained and are currently stored at -70° C or fixed in glutaraldehyde, will be analyzed at Texas A&M University.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Monica Riedel at the Alaska Native Harbor Seal Commission in Cordova was instrumental in arranging for us to obtain blubber and muscle samples from wild harbor seals as part of the BIOSAMPLING program (Project 96244). The cooperation of the Native community was excellent in giving us access to animals within six hours of death, which was critical for this study. As a result, we have a large sample size that will enhance the statistical significance of our results if we can complete the analysis. Copies of the final report and published manuscripts will be provided to the Alaska Native Harbor Seal Commission.

PROJECT DESIGN

A. Objectives

1. Determine how fatty acids in the blubber of captive harbor seals change over time during controlled diets of herring and pollock.

2. Measure the content and composition of lipid in muscle of captive harbor seals fed controlled diets and for wild harbor seals in Prince William Sound.

3. Assess the aerobic capacity and lipid metabolism of skeletal muscle in harbor seals fed controlled diets and for wild harbor seals in Prince William Sound. We will also assess the aerobic capacity and lipid metabolism of certain organs (heart, liver, kidneys and small intestine) from wild harbor seals.

B. Methods

1. Hypotheses to be Tested.

1. Null hypothesis: Fatty acid profiles in the blubber of harbor seals are not affected by the fatty acid composition of the diet.

   Alternative hypothesis: Fatty acid profiles in the blubber of harbor seals will be directly affected by the fatty acid composition of the diet and will change as the diet is altered.

   Methodology: Feed controlled diets of different fish species to captive harbor seals. Assess temporal changes in the fatty acid composition of the blubber by taking serial biopsies. Compare with samples obtained from the BIOSAMPLING Program of wild harbor seals in Prince William Sound.

2. Null hypothesis: Mitochondrial volume density, myoglobin concentration, lipid content,

and the enzymatic activities of citrate synthase, *B*-hydroxyacyl CoA dehydrogenase and lactate dehydrogenase in skeletal muscle are not affected by diet.

Alternative hypothesis: These variables of muscle condition and function are affected by changes in diet.

Methodology: Feed controlled diets of different fish species to captive harbor seals. Assess temporal changes in these variables by taking serial muscle biopsies. Compare with samples obtained from the BIOSAMPLING program of wild harbor seals in Prince William Sound.

3. Null hypothesis: Fiber type, enzyme activities (citrate synthase, B-hydroxyacyl CoA dehydrogenase and lactate dehydrogenase), and myoglobin concentration are homogeneously distributed in the swimming muscles (*Longissimus dorsi*) of harbor seals.

   Alternate hypothesis: The distribution of these variables is heterogeneous in the swimming muscles and reflects differences in aerobic capacity.

   Methodology: Map the distribution of these variables (see Figure 1 and 2 above) in transverse sections of the swimming muscles of wild harbor seals in Prince William Sound. Muscle samples will be obtained from the BIOSAMPLING Program.

4. Null hypothesis: There is no elevation in: 1) mitochondrial volume density, 2) lipid droplet density or 3) the activities of citrate synthase, B-hydroxyacyl CoA dehydrogenase and lactate dehydrogenase in the organs of harbor seals when compared to terrestrial mammals.

   Alternate hypothesis: Mitochondria volume density, lipid droplet density and enzyme activities are elevated in the organs of harbor seals to maintain an aerobic, lipid-based metabolism during diving.

   Methodology: Measure these variables (see Figure 3 above) in samples of heart, liver, kidney and small intestine from wild harbor seals in Prince William Sound. Samples will be obtained from the BIOSAMPLING Program.

2. Harbor Seal Feeding Trials Conducted at the Alaska SeaLife Center (ASLC).

Animals. Eight harbor seals were acquired by the ASLC for the feeding trials that began in September 1998. During the staggered feeding trials, the diet was changed every four months. During these dietary manipulations, we obtained serial blubber samples every two months and muscle biopsies every four months from two sites on each animal. Blubber and muscle biopsies were taken from the same incisions located above the *L. dorsi* muscle in the dorsal lumbar region and above the pectoralis muscle on the animal's ventral thorax.

Design for Feeding Trials. The procedure used a crossover repeated measures approach that will allow statistical comparisons within any one group of seals between diet and season (Table 2).

Table 2. Crossover Repeated Measures ANOVA Feeding Trials for harbor seals

Period	Herring	Pollock	Condition
Sept-Dec 1998	Seals A,B,C,D	Seals E,F,G,H	Molting
Jan-April 1999	E,F,G,H	A,B,C,D	Spring
May-Aug 1999	A,B,C,D	E,F,G,H	Breeding
Sept-Dec 1999	E,F,G,H	A,B,C,D	Molting
Jan-April 2000	A,B,C,D	E,F,G,H	Spring
May-Aug 2000	E,F,G,H	A,B,C,D	Breeding

This feeding matrix allowed each group of seals to experience a different diet at similar physiologically relevant times of the year. Seals A,B,C,D for example, received a herring diet during the molting season in Year 1 and a high pollock diet in Year 2. A problem with crossover ANOVA designs is that residual or carry-over effects from previous treatments can complicate the analysis. We corrected for this with long test periods and phased crossovers. That is, since each feeding trial lasted for four months, several weeks of diet switching were allowed. This will provide the additional advantage of allowing us to study the impact of the phased switch on blubber and muscle lipid content and composition, and on muscle lipid metabolism.

Blubber Biopsies. Blubber samples were obtained through the full depth of blubber layer with a 6-mm punch biopsy inserted through a small incision in the skin. Each sample was then divided along its length to give an inner and outer sample. Samples were immediately transferred to liquid nitrogen and stored at -70°C until analysis. Total lipids will be extracted in chloroform according to Folch et al. (1957) as modified by Iverson (1988). Fatty acid methyl esters (FAME) will be prepared from the purified lipid extracts using the Hilditch reagent (0.5 N H_2SO_4 in methanol). FAME for fish in the controlled diets were obtained similarly from homogenates of individual food items. The methyl esters will be analyzed by temperature-programmed capillary gas-liquid chromatography. FAME will be identified and quantified using a combination of standard mixtures, including those identified using chromatography and an ion-trap mass detector. Individual fatty acids, expressed as weight percent of the total fatty acids, will be analyzed using classification and regression trees (CART) in S-plus (StatSci, Seattle), a non-parametric multivariate technique for classifying data. CART uses a series of algorithms to split data into groups as differently as possible, based on measures of deviance; the splitting continues in a tree-like form until a classification is made at a terminal node.

Muscle Biopsies. Two muscle samples of approximately 50 mg each were collected with a 6-mm biopsy cannula (Depuy, Warsaw, Indiana) from both the swimming (*M. longissimus dorsi*) and non-swimming (*M. pectoralis*) muscles. Control samples were collected from the *M. soleus*, a predominantly slow oxidative muscle, of laboratory rats (*Sprague Dawley*) euthanized by cervical dislocation after 2-3 min of carbon dioxide anesthesia and from dogs used in other studies at Texas A&M University. Muscle samples were placed either into 2% glutaraldehyde fixative or frozen in liquid nitrogen immediately upon collection. Samples remained in the fixative for a minimum of 48 hours but no longer then 14 days before they were transferred and stored in 0.1 M cacodylate buffer pH 7.4. Frozen samples are stored at -70°C until analysis for citrate synthase activity, *B*-hydroxyacyl CoA dehydrogenase activity and myoglobin concentration.

Electron Microscopy of Muscle Samples. Fixed muscle samples were rinsed in cacodylate buffer and post-fixed for 2 hours in a 1% solution of osmium tetra oxide. They were stained 'en bloc' with 2% uranyl acetate overnight in a refrigerator. After dehydration with increasing concentrations of ethanol (50-100%), they were passed through propylene oxide and increasing concentrations of epoxy (50-100%). The samples were finally embedded in fresh epoxy and allowed to polymerize overnight at 60°C. Thick sections (1 mm) were cut with a Leica Ultratome and stained with toulidine blue to determine fiber orientation. Ultrathin (50-70 nm), transverse sections will be cut and contrasted with lead citrate from four randomly chosen blocks per muscle. Micrographs will be taken with a Phillips 201 transmission electron microscope. The number of micrographs per muscle analyzed will range from 25 and 40, yielding relative standard errors of less than 10% in all muscles. Determination of the volume density of mitochondria, myofibrils and lipid droplets will be performed at a final magnification of x18,150 using standard point counting procedures (Hoppeler et al 1981, Mathieu et al 1981).

Citrate Synthase, B-hydroxyacyl CoA dehydrogenase Lactate dehydrogenase and Myoglobin Assays of Muscle Samples.

Frozen muscle samples will be thawed, weighed and then homogenized at 0°C in buffer containing 1 $mmol^{-1}$ EDTA, 2 $mmol^{-1}$ $MgCl_2$ and 50 $mmol^{-1}$ imidazole, pH 7.6 at 37° C. The homogenates will be spun for 4-5 minutes at 10,000 g, and the supernatant will be used for the assay. The enzymes that will be assayed are citrate synthase (CS), important in the citric acid cycle, β-hydroxyacyl CoA dehydrogenase (HOAD), and indicator for the β-oxidation of fatty acids, and lactate dehydrogenase (LDH), needed for the conversion of pyruvate to lactate in anaerobic glycolysis. Enzyme activities will be measured with a Bio-Tek PowerWave 340x microplate reader. Assay temperature will be maintained at 37 ° C within the microplate reader. The assay conditions will be as follows. Lactate dehydrogenase (LDH; EC 1.1.1.27): 50 $mmol^{-1}$ imidazole; 0.15 $mmol^{-1}$ NADH, pH 7.0 at 37° C; 1 $mmol^{-1}$ pyruvate; ΔA_{340}, millimolar extinction coefficient • $_{340}$ = 6.22. β-hydroxyacyl CoA dehydrogenase (HOAD; EC 1.1.1.35); 50 $mmol^{-1}$ imidazole, 1 $mmol^{-1}$ EDTA, 0.1 $mmol^{-1}$ acetoacetyl CoA, and 0.15 $mmol^{-1}$ NADH, pH 7.0 at 37° C; ΔA_{340}, • $_{340}$ = 6.22. Citrate synthase (CS; EC 4.1.3.7): 50 $mmol^{-1}$ imidazole; 0.25 $mmol^{-1}$ 5,5• -dithiobis(2-nitrobenzoic acid) (DTNB), 0.4 $mmol^{-1}$ acetyl CoA and 0.5 $mmol^{-1}$ oxaloacetate, pH 7.5 at 37° C; ΔA_{412}, • $_{412}$=13.6. Specific enzyme activities (μmol min^{-1} g^{-1} wet mass muscle) will be calculated from the rate of change of the assay absorbance at the maximal linear slope. Enzyme ratios (CS:HOAD, LDH:CS) will be calculated to asses the relative importance of different metabolic pathways in the muscle: the LDH:CS ratio provides an index of relative anaerobic versus aerobic metabolic capacities, and the CS: HOAD ratio yields an index of the relative potentials from fat versus overall aerobic metabolism. Aliquots from the biochemical supernatant will be used for myoglobin assays. The aliquot will be diluted with phosphate buffer (0.04 M, pH 6.6) and the resulting mixture centrifuged for 50 min at 28,000 g at 4° C. The method of Reynafarje (1963) will be used to determine myoglobin concentration. The supernatant will be bubbled with 99.9% carbon monoxide (CO) for 3 minutes to convert the myoglobin to carboxymyoglobin. After bubbling, the absorbance of the supernatant at 538 and 568 nm will be measured using a Bio-Tek PowerWave 340x microplate reader. A myoglobin standard (Horse myoglobin, Sigma-Aldrich, St. Louis, MO.) will be run with each set of samples. The myoglobin concentration will be calculated as described by Reynafarje (1963) and expressed in milligrams per gram of fresh tissue.

Statistical Analysis. Results will be expressed as the mean ± one standard error. We will use a crossover repeated measures approach that will allow statistical comparisons within any one group of seals between diet and season. Statistical software (SYSTAT) will be used to analyze the crossover method. The relative proportions of fatty acids from blubber samples of seals in the controlled feeding study will be used as a basis for generating tree-based models (using S-Plus; StatSci, Seattle) of groups or classes of samples such that new samples (obtained via BIOSAMPLING) can be compared with the modeled classes to decide their membership, i.e. obtain a classification of their "diet". Similarly, classification and regression trees will be used to screen the set of prey fatty acids and choose a subset of those fatty acids which can be used to classify the "diets" of seals based the patterns of fatty acid proportions in their blubber.

3. Blubber and Muscle Samples Obtained from the BIOSAMPLING Program in Prince William Sound.

Samples from the main swimming muscles (*L. dorsi*), blubber and splanchnic organs of 10 wild harbor seals were obtained during the BIOSAMPLING Program. The entire muscle was removed and weighed, and three transverse sections were taken along the muscle bundle. Each section of the swimming muscle was precisely labeled for its orientation and location within the animal. These were then further sub-sampled along points on a circular grid using a stainless steel borer, averaging 15 samples per muscle section. Paired cores of tissues weighing 200 and 300 mg were removed for enzyme assays and fiber typing. Fiber typing (see below for details) muscle samples were incubated in a sucrose/glycerol-based cryoprotectant for 30 min, placed on a section of cork, then covered with OCT freezing compound. The cork-mounted muscle was dipped into liquid nitrogen-cooled isopentane for 15-20 sec. Muscle for fiber typing and enzyme analysis were stored at –70°C until immunohistochemistry. A spectrophotometric technique will be used to determine myoglobin, citrate synthase, and β-hydroxyacyl CoA dehydrogenase concentration (see above for details). When complete, detailed contour maps and statistical tests for all enzyme concentrations, myoglobin concentration and fiber type will be made using a PC based program (Surfer, Golden Software, Inc., Colorado). Blubber samples were obtained from the same approximate anatomical location as on animals used in the captive studies and stored frozen at -70°C. Blubber samples will be analyzed according to the protocols described in Section 2 of this proposal. Samples were also taken from the heart, liver, kidneys and small intestine. They will be analyzed for mitochondrial volume density, lipid-droplet density and enzyme activities (citrate synthase, B-hydroxyacyl CoA dehydrogenase lactate dehydrogenase) using the same techniques as the muscle samples.

Immunohistochemical technique for identifying muscle fiber types. Transverse sections of the swimming muscles (*L. dorsi*) will be cut into serial thin sections (7-9 μm) with a cryotome maintained at –20°C. Sections will be placed onto glass slides, 3 serial sections per slide. Transverse orientation will be verified using a standard light microscope. Slides will be fixed in ice-cold alcohol-formalin acetic acid fixative, washed with phosphate-buffered saline (PBS), and a proteinaceous blocking agent will be applied to each section to minimize non-specific antibody binding. Marking a circle around each section with a water-repellent PAP pen will isolate the 3 sections per slide. A series of monoclonal antibodies specific to myosin heavy chain isoforms Type I, Type IIa, and Type IIb will be applied to one section on each of the slides and incubated overnight in a humidity chamber at -4°C. Serial amplification of the primary antibody will be accomplished using an incubation of biotinylated secondary antibody for 20 minutes, followed

by a series of PBS washes and then a 20 min incubation with alkaline-phosphotase streptavidin conjugate (Carson 1990). After washing with PBS, Fast Red substrate will be applied to the slides. When adequate color development is seen, the slides will be washed in water to stop the reaction. The slides will be counterstained with Mayer's hematoxylin, washed in water, and a coverslip will be mounted onto the slide.

SCHEDULE

Measurable Project Tasks for FY 02

2001	
Sept-Dec	Analyze remaining blubber and muscle samples.
2002	
Jan-Mar	Statistical analysis and integration of data, including health and body condition results from Dr. Michael Castellini (Harbor Seal Recovery. Phase II: Controlled Studies of Health and Diet).
Apr-June	Prepare Final Report and begin manuscripts.
June-Aug	Complete manuscripts and submit to peer-reviewed journals. Five manuscripts are anticipated at this time.

B. Completion Date

This project will finish on September 30, 2002.

PUBLICATIONS AND REPORTS

Since this is a new project, there are no current publications. We anticipate at least five publications by 2002 on the effects of diet on fatty acids in blubber and the aerobic capacity and lipid metabolism in harbor seal muscle. The manuscripts are tentatively entitled:

Manuscript 1: Effects of diet on the fatty acid signature in the blubber of harbor seals.

Manuscript 2. Effects of diet on the aerobic capacity and lipid content of harbor seal muscle.

Manuscript 3: Spatial distribution of aerobic enzymes for lipid metabolism in the muscles of harbor seals.

Manuscript 4: The skeletal muscles of harbor seals are composed solely of oxidative fibers: implications for lipid metabolism during exercise and diving.

Manuscript 5: Aerobic capacity and lipid droplet density in the heart, liver, kidneys and small

intestine of harbor seals.

PROFESSIONAL CONFERENCES

The PI requests funds to attend the annual EVOS workshop. We also request funds to present results at the Society for Marine Mammalogy Conference that will be held in Vancouver, Canada in November 2001. Four papers/posters will be submitted entitled: 1) "Spatial distribution of aerobic enzymes for lipid metabolism in the muscles of harbor seals", 2) "The skeletal muscles of harbor seals are composed solely of oxidative fibers: implications for lipid metabolism during exercise and diving", 3) "Aerobic capacity and lipid droplet density in the heart, liver, kidneys and small intestine of harbor seals", and 4) "Effect of diet on the fatty acid signature in the blubber of harbor seals".

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

We are working in close coordination with Dr. Michael Castellini (PI on Harbor Seal Recovery. Phase II: Controlled Studies of Health and Diet) on data interpretation and preparation of the final report and manuscripts.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

As stated above, we have collected 331 blubber samples, 41 dietary samples, and 140 muscle samples from eight harbor seals during the two year feeding trial (see Table 1 above for details). In addition, we collected 500 muscle samples for enzyme and myoglobin analysis, 250 muscle samples for fiber typing and 40 organ samples for mitochondrial volume density and enzyme analysis from 10 wild harbor seals as part of the BIOSAMPLING Program in Prince William Sound. The analysis of this very large set of samples has occupied our lab for he past 18 months. However, additional funds will be necessary to complete this extensive analysis. We requested these funds during the third year of this project, but the EVOS Trustee Council deferred our request. This proposal will enable us to complete the analysis of our samples and incorporate the results into the final report and manuscripts.

PROPOSED PRINCIPAL INVESTIGATOR

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PRINCIPAL INVESTIGATOR

Randall Davis, Ph.D., specializes in the physiology and metabolism of marine mammals. He is a Professor of Marine Biology at Texas A&M University and has worked in this field for over 24 years. In 1989, Dr. Davis was the Project Leader for Exxon's Oiled Sea Otter Rehabilitation Program in Prince William Sound.

Publications by Dr. Randall Davis relevant to the proposed research:

Kanatous SB, Davis RW, DiMichele LV, Cowan DF. (1999) High aerobic capacities in the skeletal muscles of seals, sea lions and fur seals: An adaptation to diving hypoxia. Journal of Applied Physiology 86:1247-1256

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OTHER KEY PERSONNEL

Dr. Shane Kanatous is a NIH Post-doctoral University of Texas Medical Branch in Dallas. He has conducted research on the aerobic scope and enzymatic adaptations in the skeletal muscles of marine mammals. His role will be to measure mitochondrial volume densities and lipid droplet densities in muscle samples from harbor seals in the captive study and to prepare this section of the draft final report. He will also be a co-author on the manuscript dealing with this part of the study

Dr. Tammy Adams is currently working for the National Marine Fisheries Service in Silver Springs, Washington, D.C. She has conducted research on the fatty acid composition of marine mammal blubber and how it is affected by diet. Her role will be to analyze the fatty acid data from blubber and dietary samples and to prepare this section of the draft final report. She will also be a co-author on the manuscript dealing with this part of the study

Lori Polasek is currently a graduate student at Texas A&M University. She measured the enzyme activities in muscle samples from both captive and wild harbor seals. Her role will be to analyze the myoglobin concentration in the muscle samples and to prepare the draft final report on enzyme activities and myoglobin concentration in harbor seal muscle. She will also be a co-author on the manuscript dealing with this part of the study.

Rebecca Watson is currently a graduate student at Texas A&M University. She is determining fiber type in muscle samples from wild harbor seals and will prepare this section of the draft final report. She will also be a co-author on the manuscript dealing with this part of the study.

Amanda Fuson is currently a graduate student at Texas A&M University. She is determining mitochondrial volume densities, lipid droplet densities and enzyme activities in organ samples (heart, liver, kidney and small intestine) from wild harbor seals and will prepare this section of the draft final report. She will also be a co-author on the manuscript dealing with this part of the study.

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2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 200' ptember 30, 2002

Prepared 4/10/01

Budget Category:	Authorized FY 2001	Proposed FY 2002	LONG RANGE FUNDING REQUIREMENTS					
						Estimated FY 2003		
Personnel	$50.8	$29.4						
Travel	$2.5	$2.9						
Contractual	$7.8	$11.6						
Commodities	$8.8	$7.0						
Equipment	$0.0	$0.0						
Subtotal	$69.9	$50.9						
Indirect @ 25%	$17.5	$12.7						
Project Total	$87.4	$63.6						
Full-time Equivalents (FTE)		1.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

Indirect costs are calculated at 25% of Modified Total Direct Cost. The indirect cost rate was renegotiated to 25% by the EVOS Trustee Council and Texas A&M University, Department of Health and Human Services in July, 2000.

Fringes are calculated at 15.5% of Salaries and Wages for the Principal Investigator and Research Assistant. 8.25% is the calculation for the Graduate Research Assistant. Included in the fringe category is a fixed rate for medical insurance. The rate is a calculation based on the percentage of effort. The Principal Investigator is calculated at $431/mo. The Research Assistant and Graduate Research Assistant are calculated at $221/mo.

FY02

Project Number: 02441
Project Title: Harbor Seal Recovery Phase III: Effects of Diet on Lipid Metabolism and Health: Completion of Sample Analysis and Manuscript Preparation. Submitted under the BAA
Name: Texas A&M Research Foundation

FORM 4A
Non-Trustee
SUMMARY

Project 02441

Prepared 4/10/01

2002 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 200[illegible] - September 30, 2002

Personnel Costs (Including Benefits):			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2002
R. Davis	Principal Investigator		1.0	9116.6		9,116.6
L. Polasek	Graduate Research Assistant		4.5	1501.6		6,757.2
R. Watson	Graduate Research Assistant		4.5	1501.6		6,757.2
A. Fuson	Graduate Research Assistant		4.5	1501.6		6,757.2
						0.0
Justification:						0.0
R. Davis will assume overall responsibility for completing this project and preparing the final report and manuscripts.						0.0
L. Polasek will measure myoglobin concentration in harbor seal muscle. R. Watson will determine fiber type and						0.0
contribute to this section of the final report. A. Fuson will measure mitochondrial volume densities, lipid droplet						0.0
densities and enzyme activities in organ samples from wild harbor seals and contribute to this section of the final						0.0
report. All three will co-author the manuscripts dealing with their part of the study.						0.0
						0.0
	Subtotal		14.5	13621.4	0.0	[illegible]
					Personnel Total	$29.4

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2002
To Anchorage, AK for EVOS Workshop	1000.0	1	4	155.0	1,620.0
To attend Marine Mammal Conference in Vancouver, Canada	700.0	1	4	155.0	1,320.0
					0.0
Other Justification:					0.0
Four papers/posters will be submitted entitled:					0.0
1) Spatial distribution of aerobic enzymes for lipid metabolism in the					0.0
muscles of harbor seals					0.0
2) The skeletal muscles of harbor seals are composed solely of					0.0
oxidative fibers: implications for lipid metabolism during exercise and diving					0.0
3) Aerobic capacity and lipid droplet density in the heart, liver, kidneys and					0.0
small intestine of harbor seals					0.0
4) Effect of diet on the fatty acid signature in the blubber of harbor seals					0.0
				Travel Total	$2.9

Project 02441

FY02

Project Number: 02441
Project Title: Harbor Seal Recovery Phase III: Effects of Diet on Lipid Metabolism and Health: Completion of Sample Analysis and Manuscript Preparation. Submitted under the BAA
Name: Texas A&M Research Foundation

FORM 4B
Personnel
& Travel
DETAIL

2002 EXXON VALDEZ TRU COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Prepared 4/10/01

Contractual Costs:	Proposed
Description	FY 2002
Electron Microscope Analysis (Professional Service by S. Kanatous)	2,500.0
Justification: For interpretation of electron micrographic images of muscle samples from captive harbor seals fed a controlled diet of herring and pollock; and provide assistance with final report and manuscript preparation.	
Gas Chromatograph Analysis (Texas A&M Univ. Gas Chromatograph Lab): 163 blubber and fish samples @ $40/sample	6,520.0
Justification: As detailed in the original proposal, blubber and dietary samples from captive and wild harbor seals will be analyzed for fatty acid signatures using gas chromatography.	
Interpretation of Fatty Acid Data (Professional Service by Dr. Tammy Adams)	2,500.0
Justification: For CART analysis of fatty acid composition of blubber samples during controlled diets of herring and pollock. To also provide assistance with final report and manuscript preparation	
Communications - Long Distance Phone Charges	100.0
Justification: Funds for long distance phone charges are requested for communicating with the EVOS office in Anchorage and M. Castellini (Calloraborating PI on Harbor Seal Study) at U of A in Fairbanks.	
Contractual Total	$11.6

Commodities Costs:	Proposed
Description	FY 2002
Expendable supplies and chemicals	5,950.0
Justification: Electron Microscope expendable supplies: 330 samples x $10/sample = $3,300 Analysis of tissue enzyme activities: 40 x $10/sample = $400 Misc. expendable supplies and gases: $1,000 Fiber typing expendable supplies: 125 samples x $10/sample = $1,250	
Publications and Page Charges for manuscripts that will appear in FY01	1,000.0
Justification: Manuscript 1: Effects of Diet on the Fatty Acid Signatures in the Blubber of Harbor Seals Manuscript 2: Effects of Diet on Aerobic Capacity and Lipid Content of Harbor Seal Muscle Manuscript 3: Spatial Distribution of Aerobic Enzymes for Lipid Metabolism in Muscles of Harbor Seals Manuscript 4: Implications for Lipid Metabolism during Exercise and Diving Manuscript 5: Aerobic Capacity and Lipid Droplet Density in the Heart, Liver, Kidneys, and Small Intestine	
Commodities Total	$7.0

Project 02441

FY02

Project Number: 02441
Project Title: Harbor Seal Recovery Phase III: Effects of Diet on Lipid Metabolism and Health: Completion of Sample Analysis and Manuscript Preparation. Submitted under the BAA
Name: Texas A&M Research Foundation

FORM 4B
Contractual & Commodities DETAIL

Prepared 4/10/01

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2002
			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	

FY02

Project Number: 02441
Project Title: Harbor Seal Recovery Phase III: Effects of Diet on Lipid Metabolism and Health: Completion of Sample Analysis and Manuscript Preparation. Submitted under the BAA
Name: Texas A&M Research Foundation

FORM 4B
Equipment
DETAIL

Project 02441