19.09.04 (3 of 4)

Approved TC 8-3-00

The *Exxon Valdez* Oil Spill: Guidance for Future Research Activities

Project Number:	01360-BAA
Restoration Category:	Monitoring
Proposer:	C. Elfring/Polar Research Board, NRC
Lead Trustee Agency:	NOAA
Cooperating Agencies:	None
Alaska SeaLife Center:	No
New or Continued:	Cont'd
Duration:	2nd yr. 3 yr. project
Cost FY 01:	$241.6
Cost FY 02:	$90.0
Geographic Area:	All
Injured Resource/Service:	All

ABSTRACT

The National Research Council's Polar Research Board and Board on Environmental Studies and Toxicology have appointed a special committee to review the scope, content, and structure of the Trustee Council's two GEM (Gulf Ecosystem Monitoring) documents, the draft Science Program and the draft Research and Monitoring Plan. To provide context for their review, the committee will become familiar with the relevant body of scientific knowledge, including that developed by activities sponsored by the Trustee Council. The committee will prepare an interim report on the Science Program, which will help the Trustee Council in development of the Research and Monitoring Plan. The committee will then prepare a final report analyzing whether the Research and Monitoring Plan is complete, scientifically sound, and is likely to meet the expectations of the Trustee Council. Both reports will contain conclusions and recommendations intended to give guidance on the nature and scope of future research and monitoring activities in the northern Gulf of Alaska.

INTRODUCTION

The Polar Research Board (PRB) and Board on Environmental Science and Toxicology, units of the National Research Council (NRC), propose to review the scope, content, and structure of the draft Science Program and draft 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. To provide context for reviewing the drafts, the committee will become familiar with the relevant body of scientific knowledge, including but not limited to information developed from activities sponsored by the Trustee Council in the past. The committee will prepare an interim report on the adequacy of the Science Program. The committee will then prepare a final report analyzing whether the Research and Monitoring Plan is complete, scientifically sound, and meets the expectations of the Trustee Council.

This study will be conducted by a special committee of volunteer experts, supported by a small staff and following standard NRC procedures regarding committee selection, committee operation, and report review. The committee will be composed of approximately 12 people selected to have appropriate expertise and experience for the task. The committee will meet six times over a period of 20 months to gather information, deliberate, and produce an interim report and a final report with guidance about the design and implementation of the research and monitoring program. This proposal seeks support for this activity in the amount of $315,980 for year two.

Because of the postponement of delivery of the original draft GEM plan for review, spending of FY 00 project funds for this project is below original year one projections. To date, funds have been spent on staff time to conduct the committee selection process and for the study director to attend the 2000 Restoration Workshop, and are projected to be used for tasks related to holding committee meetings in June and September. This is less activity than originally proposed and will require some shifting of resources from year one to year two.

NEED FOR THE PROJECT

A. Statement of the Problem

The Exxon Valdez Oil Spill Trustee Council is one-third of the way through a three-year process of developing, reviewing, and adopting a Science Program and a Research and Monitoring Plan. The Trustee Council requires independent peer review of the Science Program and the detailed Research and Monitoring Plan as part of its development and implementation process. The first implementation projects are to be funded by the Council no earlier than October of 2002. The Science Program and the Research and Monitoring Plan are expected to guide the Trustee Council's activities as it moves beyond the era of short-term oil spill damage assessment and restoration investigations. 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.

A program rooted in the science of a large-scale ecological disaster may be uniquely suited to form the foundation for ecosystem-based management. Knowledge and experience gained during ten years of biological and physical studies on the aftermath of the Exxon Valdez oil spill taught the Trustee Council that a solid historical context is essential to guide decisions. The context provided by research and monitoring permit understanding of the origins and consequences of changes in valued natural resources and the ecosystem that supports those resources. The history of the oil spill and its science are part of the background necessary to understand the science program and the research and monitoring plan.

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). These include: (1) pink salmon; (2) Pacific herring; (3) Prince William Sound ecosystem assessment (SEA); (4) sockeye salmon; (5) cutthroat trout, Dolly Varden trout, rockfish, and pollock; (6) marine mammals; (7) nearshore ecosystem communities (NVP); (8) seabird/forage fish and related resources (APEX); (9) archaeological resources; (10) subsistence resources; (11) reduction of marine pollution; (12) habitat improvement; and (13) ecosystem synthesis. Extensive research has been conducted in each of these areas over the decade, making this the most studied cold water marine oil spill in history.

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. Three ecosystem-based studies, the Sound Ecosystem Assessment (SEA), the Nearshore Vertebrate Predator projects, and the Avian Predator Ecosystem Experiments (APEX), have advanced understanding of food web relations among organisms at a range of trophic levels, the influences of atmospheric and oceanographic processes on productivity of key species, ecological energetics among key species, flow of carbon across trophic levels and among geographic regions, marine-terrestrial linkages, and many other topics.

Many other scientific studies conducted by entities not associated with the Trustee Council are relevant to the NRC committee's efforts. An important body of information is formed by the investigations known as Outer Continental Shelf Environmental Assessment Program (OCSEAP) conducted with the support of the federal Minerals Management Service. The pace of advances in fisheries oceanography, atmospheric sciences, and biological and physical oceanography of the Gulf of Alaska during the past 15 years also has been great. Advances in knowledge in the Bering Sea have been particularly intense over the past two decades, and much of this knowledge is relevant to the Gulf of Alaska due to physical and biological linkages between these regions.

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 charged to conduct this study will establish contact with the relevant communities so they are aware of our activity, most likely through the Public Advisory Group or the community liaisons. 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 study will 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 will:

- 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 will convey its guidance in two products: first, it will prepare a short interim report commenting on the draft Science Program. After that, when 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.

The committee will not examine land acquisition or habitat protection efforts, except where essential to its evaluation of the Science Program and the Research and Monitoring Plan.

B. Methods

This study will be conducted by a multidisciplinary committee of approximately 12 members that includes 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 reimbursement for travel and direct expenses only. They will be 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. Nominations for committee members will be sought from the involved boards, the National Academy of Sciences and the National Academy of Engineering, the Trustee Council, the research community, and relevant agencies and nongovernmental organizations. All members will be subject to standard NRC procedures regarding bias and conflict of interest.

The committee will meet 6 times over an 20 month period, first to become familiar with existing research activities and then to review the draft Science Program and the draft Research and Monitoring Plan, and to foster communications with the people and the region to be served by the program and plan. The committee may seek assistance from experts not on the committee to help understand past activities or context. Close and timely coordination with the Trustee Council staff will be necessary so the committee's review is timed to meet the Council's needs and for assistance in locating materials and information.

From its information-gathering activities and deliberations, the committee will develop an interim and final report with conclusions and recommendations about the draft plan for future long-term monitoring and research in the Gulf of Alaska. The report development process will conform fully with the review procedures of the NRC.

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, preliminary discussion of possible conflict of interest issues).
April 2000:	Committee slate announced and posted for public comment

	period. Draft Science Program to be conveyed to committee.
May-June 2000:	First meeting: orientation to history of program and to Science Program; information-gathering activities.
September 2000:	Second meeting: information-gathering activities, deliberation on Science Program.

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

November 2000:	Third meeting: deliberations; finalize interim report.
Dec - Jan 2000/01:	Interim report to outside review; response to review; Academy approval process.
February 2001:	Interim report delivered and discussed
March 2001:	Trustee Council to deliver the Research and Monitoring Plan
April 2001:	Fourth meeting: information gathering activities; deliberations on the Research and Monitoring Plan
June 2001:	Fifth Meeting: deliberations on the Research and Monitoring Plan
August 2001:	Sixth Meeting: report-writing workshop; finalize conclusions and recommendations.
September 2001:	Final report submitted for Academy outside review process.

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

October 2001:	Response to review
November 2001:	Final revisions; Academy approval process
November 2001:	Report delivery (prepublication copies) with dissemination activities as needed.
January 2002:	Published volume available.

B. Project Milestones and Endpoints

In the first three meetings, the committee will gain an overview of the research and monitoring activities conducted to date, be briefed by interested parties in Alaska, and become familiar with the content of the draft Science Program sufficient to produce an interim report. At the fourth meeting, dependent on availability of the Research and Monitoring Plan from the Trustee Council, the committee will begin deliberations on the Research and Monitoring Plan. 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 the overall effectiveness of the Trustee Council's program and plan for guiding continued efforts to understand biological change in the Gulf of Alaska.

C. Completion Date

The committee's final report will be delivered to the Trustee Council and released to the public in November 2001. The delivery of the interim report in February 2001 will be 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, expected by November 2001. The committee will provide periodic progress reports, noting the committee's activities and 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 2001 and 2002 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 will be 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.

Approved 7-3-00

FY 01 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Budget Category:	Authorized FFY 2000	Proposed FFY 2001
Personnel		$0.0
Travel		$0.0
Contractual		$225.8
Commodities		$0.0
Equipment		$0.0
Subtotal		$225.8
General Administration		$15.8
Project Total		$241.6
Full-time Equivalents (FTE)		
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FFY 2002
$90.0

Dollar amounts are shown in thousands of dollars.

Comments:

2001

Project Number: 01360
Project Title: Guidance for Future Research Activities
Agency: ADF&G

FORM 3A
SUMMARY

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 2000	Proposed FY 2001	LONG RANGE FUNDING REQUIREMENTS					
Personnel	$73,754.0	$89,621						
Travel	$103,890.0	$102,586						
Contractual	$12,721.0	$16,744						
Commodities	$600.0	$1,200						
Equipment	$0.0	$0						
Subtotal	$190,965.0	$210,151				Estimated FY 2002		
Indirect	$95,642.0	$105,829						
Project Total	$286,607.0	$315,980				$84,234		
Full-time Equivalents (FTE)	0.8	0.9						
	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 $90,150 from FY00 to FY01. Therefore, the requirements for year two will be $225,830.

FY01

Prepared: 4/4/2000

Project Number: 01360
Project Title: Exxon Valdez Oil Spill Study
Name: The National Academies/Polar Research Board

FORM 4A
Non-Trustee
SUMMARY

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2001
Chris Elfring	Director, PRB		12.0	2777.0		33,324.0
David Policansky	Sr. Staff Officer, BEST		12.0	1809.6		21,715.2
Robert Greenway	Project Assistant		12.0	898.3		10,779.6
Toni Greenleaf	Administrative Associate		12.0	128.9		1,546.8
						0.0
	Fringe Benefits for above @ 26.86%					18,095.0
						0.0
Student Intern/TBD	Research/Staff Assistant		2.0	1600.0		3,200.0
Editor/TBD	Editor (3 days)		0.0			960.0
						0.0
						0.0
						0.0
	Subtotal		50.0	7213.8	0.0	
					Personnel Total	$89,620.6

Travel Costs:			Ticket	Round	Total	Daily	Proposed
Description			Price	Trips	Days	Per Diem	FY 2001
Anchorage	Workshop in Winter 2001 (2 committee/1staff)		1000.0	3	15	140.0	5,100.0
Anchorage	Committee Meeting/Data Gathering/Low Season		1000.0	17	68	140.0	26,520.0
TBD	Chair and Staff to discuss strategy for the committee						0.0
	report (Domestic rates negotiated		1148.0	2			2,296.0
	with ONR/combine air and per diem)						0.0
TBD	Writing Meeting/Not in Alaska		1331.0	15			19,965.0
	(Domestic rates negotiated with ONR/combine air and per diem)						0.0
Anchorage	Committee Meeting/Deliberations on plan/High Season		1000.0	15	60	229.0	28,740.0
TBD	Report-Writing Workshop/Full Committee		1331.0	15			19,965.0
	(Domestic rates negotiated with ONR/combine air and per diem)						0.0
							0.0
							0.0
						Travel Total	$102,586.0

FY01

Prepared: 4/4/2000

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

FORM 4B
Personnel
& Travel
DETAIL

2000 EXXON VALDEZ TRUSTE UNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Contractual Costs:	Proposed
Description	FY 2001
Photocopies	2,849.0
Postage/Delivery	1,504.0
Technology/Communications	6,251.0
Meeting Expense (room rental, breaks, transportation)	6,000.0
Publications/computer research/searches	140.0
Contractual Total	$16,744.0

Commodities Costs:	Proposed
Description	FY 2001
Office Supplies	1,200.0
Commodities Total	$1,200.0

FY01

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

FORM 4B
Contractual & Commodities DETAIL

Prepared: 4/4/2000

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

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	

FY01

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

FORM 4B
Equipment
DETAIL

Prepared: 4/4/2000

Approved TC 8-30

Improved Salmon Escapement Enumeration Using Remote Video and Time-Lapse Recording Technology

Project Number:	01366-CLO
Restoration Category:	Research
Proposer:	E. Otis/ADFG
Lead Trustee Agency:	ADFG
Cooperating Agencies:	None
Alaska SeaLife Center:	No
New or Continued:	Cont'd
Duration:	3rd yr. 3 yr. project
Cost FY 01:	$11.3
Cost FY 02:	$0.0
Geographic Area:	Lower Cook Inlet
Injured Resource/Service:	Salmon

ABSTRACT

Salmon resources and services within the spill area, and particularly within Prince William Sound, were injured by the oil spill and have not fully recovered. To monitor the recovery of salmon stocks in the spill area and improve escapement information used to set spawning escapement goals, this project will develop remote video and time-lapse recording technology for enumerating salmon escapement. Remote video has the potential to provide accurate, archivable documentation of salmon escapements well beyond the capacity of aerial survey indices, and well below the cost of weir and sonar projects. Videotapes can be retrieved and reviewed weekly to facilitate in-season management of commercial fisheries. Funding in FY 01 is for preparation of a final report and possibly a publication.

INTRODUCTION

Aerial survey has been used to monitor salmon escapement in clear streams throughout Alaska for over 35 years (Bevan 1961). This technique is favored for remote and marginally productive drainages which otherwise may go unassessed due to the high cost of intensive monitoring methods (e.g., weir, sonar) relative to the stream's modest escapement. However, aerial survey has several drawbacks. Observer experience, water clarity, stream morphology and habitat type, timing of survey flights, and stream residency are just a few factors shown to influence the accuracy and precision of aerial survey estimates of salmon escapement (see Bevan 1961, Evzerov 1981, Neilson and Geen 1981, Cousens et al. 1982, Shardlow et al. 1987, Perrin and Irvine 1990, Hill 1997, and Bue et al. 1998a). At best, aerial survey provides consistent indices of in-river escapement among years. It does not provide accurate, reliable estimates of spawner-abundance, particularly when in-river exploitation of salmon is high and observer efficiency and stream residency are not precisely known (Perrin and Irvine 1990, Bue et al. 1998a).

Accurate, reliable estimates of spawner abundance are required to monitor the recovery of damaged salmon resources, set appropriate spawning escapement goals for individual streams, and manage commercial fisheries in season. Because aerial survey cannot always provide this level of information and more accurate methods are prohibitively expensive for streams with marginal escapements, a niche exists that remote video technology may be able to fill. Fishery biologists have long considered the potential for photographic enumeration to eliminate the biases inherent to human derived aerial and tower counts of salmon escapement. In the late 1940's and early 1950's, researcher's experimented with aerial and tower based photography to count sockeye salmon in the Bristol Bay area (see Kelez 1947, Eicher 1953, and Mathisen 1962). While these early experiments showed promise, their feasibility was reduced by the state of technology of cameras and recording equipment from this era.

Many technological advancements have occurred since that time and recent video and time-lapse recording systems have proven effective for capturing remote images of adult (Hatch et. al 1994) and juvenile salmonids in controlled field situations (Irvine et. al 1991). In Chignik, Alaska, researchers are using underwater video equipment to facilitate enumeration of adult salmon passing a deep-water weir (Dave Owens, ADF&G Kodiak, personal communication). The Chignik system is powered by a gas generator and maintained by a field crew. In the Pacific Northwest, researchers are experimenting with stand-alone underwater video systems associated with partial weirs (P. Mundy, P. Mundy and Assoc., personal communication). An unmanned underwater system is not practical for most Alaskan streams because the camera would be vulnerable to inquisitive bears and other mammals. In FY99 we propose to develop an unmanned

video system that can be deployed above small streams, out of the reach of bears. The video system will document sockeye, pink, and coho salmon escapement into Delight Lake. Time-lapse images will be recorded onto a VCR powered by 12-volt batteries. Solar and hydropower generators will maintain the batteries. A weir will be operated concurrently to determine the accuracy of video counts. In FY00 we will evaluate the camera's performance counting pink and chum salmon escapement in a short, intertidal stream.

NEED FOR THE PROJECT

A. Statement of Problem

Salmon resources and services were injured by the 1989 *Exxon Valdez* oil spill. Accurate, reliable estimates of spawner abundance are required to monitor the recovery of damaged salmon resources, set appropriate spawning escapement goals for individual streams, and manage commercial fisheries in season. Aerial survey estimates of spawning escapement are often biased by conditions (e.g., observer experience/efficiency, timing of flights, etc.) that are difficult to account for, leading to imprecise indices of spawning escapement. Because accurate escapement monitoring is so important for salmon management and documenting the recovery of salmon resources and services, reliable, cost-effective techniques should be developed to improve escapement estimation where aerial survey is currently used.

B. Rationale/Link to Restoration

Salmon resources throughout the spill area, and particularly in Prince William Sound (Bue et al. 1996, Bue et al. 1998b) were damaged by the 1989 *Exxon Valdez* oil spill (EVOS) and have not fully recovered (1998 EVOS Trustee Council Status Report). This project has potential for improving long-term monitoring and management of salmon stocks within the spill area and statewide. Improved escapement monitoring will enable more effective evaluation of recovery efforts. It will also facilitate improved in-season management of fisheries, which will help restore injured sport and commercial fishing services.

C. Location

Development of this improved escapement monitoring technology will occur in Lower Cook Inlet (Southern Kenai Peninsula). However, project benefits could be realized throughout the spill area

and anywhere in Alaska where aerial survey is currently being used to monitor salmon escapement in small, clear streams.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Although McCarty Fiord and much of the Kenai Peninsula's outer coast is contained within Kenai Fiords National Park (KFNP), Delight Lake and its outlet stream (Delight Creek) are owned by the Port Graham Corporation (PGC). Port Graham residents report a long history of using these salmon resources for commercial and subsistence purposes and are concerned for the area's continuing productivity. Although the remote video system could be evaluated elsewhere, a unique opportunity exists at Delight Lake to fulfill PGC and KFNP requests to provide improved monitoring of salmon escapement and production.

PROJECT DESIGN

A. Objectives

1. (FY99): Determine the accuracy and reliability of a remote video system for estimating sockeye salmon escapement in small streams, and
2. (FY00): Determine the accuracy and reliability of a remote video system for estimating pink and chum salmon escapement in tidally influenced streams where intertidal spawning occurs.

B. Methods

Not applicable- report writing only; no field or lab activities (closeout year).

C. Cooperating Agencies, Contracts, and other Agency Assistance

Not applicable

SHEDULE

A. Measurable Project Tasks for FY99

October-January:	Purchase video equipment and associated materials.
January-April:	Fabricate strongbox for video equipment; arrange logistics for field camps and weir installation.
June:	Deploy camp, weir, and video equipment.
June-August:	Operate weir camp, maintain camera equipment, review tapes.
September:	Evaluate camera's performance against weir counts.

B. Measurable Project Tasks for FY00

November:	Present first year results at AFS meeting in Kodiak.
January-April:	Present poster at Annual EVOS workshop; turn in EVOS Annual Report, DPD, and budget for FY01 activities.
Late June:	Deploy camp, weir, and video equipment.
July-August:	Operate weir camp, maintain camera equipment, review tapes.
September:	Evaluate camera's performance against weir counts

C. Measurable Project Tasks for FY01

November 2000:	[1]Present second year results at AFS meeting in Fairbanks.
January-April 2001:	Present poster at Annual EVOS workshop; turn in EVOS draft final report for review.
May-September 2001:	Complete any necessary revisions of EVOS final report. [2]Prepare and possibly submit manuscript for publication

[1]If analyses can be completed in time and it fits into the PI's schedule.

[2]The PI will attempt to complete the manuscript before the end of FY01, but submittal and page costs may get deferred to FY02.

D. Project Milestones and Endpoints

September 1999	Objective 1:	Determine video system's accuracy and reliability by comparing video counts against weir counts.
September 2000	Objective 2:	Determine feasibility of using remote video to count pink and chum salmon escapement in tidally influenced streams.

September 2001 Obj. 1-2: Complete project final report.

E. Completion Date

All project objectives will have been met by the end of FY00 and the project will close out in FY01. If remote video proves to be a reliable and cost-effective method for improving upon aerial survey estimates of spawning escapement, ADF&G may use normal agency funding to replace aerial surveys with video, where suitable. The ADF&G may also pursue development of microwave technology to transmit digital images directly to field stations, and image-recognition software to facilitate auto-enumeration.

PUBLICATIONS AND REPORTS

Internal (ADF&G) and external (EVOS Trustee Council, Chief Scientist, etc.) peer review of project documents (DPD, Annual and Final Reports) will occur throughout the project's duration. In April FYO1, we will submit our Project Final Report. The PI also may choose to submit a manuscript for publication at that time, as partial fulfillment of his final reporting requirements to the EVOS TC. If a manuscript cannot be completed by April FY01, the PI plans to submit one for publication in FY02. Our intention is to submit an article entitled "Reliability and performance of a remote video system for monitoring salmon escapement in Alaska", most likely to Transactions of the American Fisheries Society or the North American Journal of Fisheries Management. Page costs have been requested in our FY01 budget, but these costs may get deferred to FY02 if the manuscript is not published by September 2001.

PROFESSIONAL CONFERENCES

Travel funds have been requested to attend the EVOS annual workshop in Anchorage, where we plan to present a poster. If analyses can be completed in time, FY00 results may be presented at the 2000 Annual Meeting of the Alaska Chapter of the American Fisheries Society, held in Fairbanks in November. If the PI's schedule does not allow this, that portion of the requested travel funds will not be spent.

NORMAL AGENCY MANAGEMENT

Along with monitoring the recovery of injured resources, the proposed project will improve the department's ability to assess and manage salmon resources within the spill area and elsewhere in Alaska. The department has few resources with which to develop new technology; without the Trustee Council's financial support, this project will not be funded in the near future. A unique opportunity exists for the EVOS Trustee Council to add to their legacy by supporting ADF&G's development of a new salmon counting technique that is likely to improve salmon management throughout Alaska.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The PI has presented our FY99 results at two professional meetings, including one with scientists from other disciplines (EVOS Workshop). Our intention was to advertise remote video's potential for improving restoration and monitoring efforts of fish and wildlife resources. Partly through attendance at these meetings, we have maintained an active dialogue with other professionals interested in remote video applications (e.g., Arthur Kettle, USFWS, Barren Islands seabirds; Mike O'Meara, Pratt Museum, seabirds; Kathy Frost, ADF&G, PWS harbor seals, and Daniel Zatz, SeeMore Wildlife, Chiswell Island sea lions). Following the successful completion of this evaluation study, the PI may solicit professionals in other disciplines to submit a joint proposal to include remote video technology in the GEM Program.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

Does not apply.

PROPOSED PRINCIPAL INVESTIGATOR

Edward O. Otis
Alaska Department of Fish and Game
3298 Douglas Place
Homer, AK 99603
(907) 235-1723
(907) 235-2448

ted_otis@fishgame.state.ak.us

PRINCIPAL INVESTIGATOR

Edward O. Otis, Asst. Area Research Biologist for Lower Cook Inlet, Alaska Department of Fish and Game, Commercial Fisheries Division (CF), 3298 Douglas Place, Homer, AK 99603. **Education**: Master of Science, Fisheries Science, University of Arizona, 1994. Bachelor's of Science, Environmental Science, University of New Hampshire, 1988. **Professional Experience:** April 1996-present: Asst. Area Research Biologist for Lower Cook Inlet, Alaska Department of Fish and Game, CFMD, Homer, AK. Supervised by William R. Bechtol. Responsible for assessment and forecasting of Kamishak Bay herring stock; directs salmon and herring catch/escapement-sampling programs; forecasts Lower Cook Inlet salmon returns. April 1994-March 1996: Fishery Biologist, Kenai Fishery Resources Office, U.S. Fish and Wildlife Service, Kenai, AK. Supervised by Gary Sonnevil. Project leader for Andreafsky River (Yukon) adult salmon enumeration project: constructed and deployed resistance board/floating weir to count adult salmon; project leader for Kenai River rainbow trout radio-telemetry project: surgically implanted radio transmitters and tracked fish using mobile receivers and remote data loggers. June 1991-March 1994: Graduate Research Asst., Univ. of Arizona, Dept. of Renewable Natural Resources, Tucson, AZ. Supervised by Dr. O. Eugene Maughan. Designed and implemented field studies to assess the composition, abundance, and distribution of fishes in streams tributary to the Colorado River in Grand Canyon. Designed and implemented field study to inventory aquatic habitat available to stream fishes in Grand Canyon. August 1987-June 1991 (intermittent): Field biologist/technician, Kenai Fishery Resources Office, U.S. Fish and Wildlife Service, Kenai, AK. Supervised by Gary Sonnevil. Project Leader or team member on various field projects including: assessing adult salmon returns using weirs (Uganik R, Kodiak); developing new approaches to aging dolly varden and lake trout otoliths; enumerating emergent salmon fry (Tustumena Lake); investigating steelhead distribution and angler effort (Cold Bay); investigating run-timing and migration rates of chinook salmon (Kuskokwim River); and inventorying salmon spawning habitat (Ayakulik R., Kodiak).

Selected Publications:

Weiss, S.J., **E.O. Otis**, and O.E. Maughan. 1998. Spawning ecology of flannelmouth sucker *Catostomus latipinnis* (Catostomidae) in two small tributaries of the lower Colorado River. Environmental Biology of Fishes.

Otis, E.O. and W.R. Bechtol. 1997. Forecast of the Kamishak herring stock in 1997. Alaska Dept. of Fish and Game, Regional Information Report No. 2A97-03.

Otis, E.O. 1997. Lower Cook Inlet pink salmon forecast for 1997. Alaska Department of Fish and Game Regional Information Report No. 2A97-09.

Otis, E.O., W.R. Bechtol, and W.A. Bucher. 1998. Coping with a challenging stock assessment situation: the Kamishak Bay sac-roe herring fishery. In Proceedings of the International Stock Assessment Symposium, 1997 Lowell Wakefield Conference (*in press*).

Otis, E.O., W.R. Bechtol, and W.A. Bucher. 1998. Abundance, age, sex, and size statistics for sockeye salmon in Lower Cook Inlet, 1995. Alaska Department of Fish and Game Regional Information Report No. 2A98-07.

Otis, E.O., and M.S. Dickson. 1999. Abundance, age, sex, and size statistics for sockeye, chum, and pink salmon in Lower Cook Inlet, 1996. Alaska Department of Fish and Game Regional Information Report No. 2A99-09.

OTHER KEY PERSONNEL

Project Manager: Mark Dickson, Fish and Wildlife Technician IV. Mr. Dickson has been employed as a fish culturist and fish and wildlife technician with the Alaska Department of Fish and Game for the past 20 seasons. He has considerable experience managing salmon escapement related field projects, including: the *EVOS* Trustee Council funded Delight and Desire Lakes project (97254) and currently, the Port Dick Creek Restoration project (97139A2).

LITERATURE CITED

Bevan, Donald E. 1961. Variability in aerial counts of spawning salmon. Journal of the Fisheries Research Board of Canada 18(3):337-348.

Bucher, W.A., and L.F. Hammarstrom. 1997. 1996 Lower Cook Inlet annual finfish management report. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Anchorage.

Bue, B. G., S. Sharr, S.D. Moffitt, and A. Craig. 1996. Effects of the Exxon Valdez oil spill on pink salmon embryos and preemergent fry. Pages 619-627 *in* Rice et al. (1996).

Bue, B.G., S.M. Fried, S. Sharr, D.G. Sharp, J. Wilcock, and H.J. Geiger. 1998a. Estimating salmon escapement using area-under-the-curve, aerial observer efficiency, and stream-life estimates: the Prince William Sound pink salmon example. North Pacific Anadromous Fisheries Commission Bulletin 1:240-250.

Bue, B. G., S. Sharr, and J.E. Seeb. 1998b. Evidence of damage to pink salmon populations inhabiting Prince William Sound, Alaska, two generations after the *Exxon Valdez* oil spill. Transactions of the American Fisheries Society 127:35-43.

Cousens, N.B.F., G.A. Thomas, D.G. Swann, and M.C. Healey. 1982. A review of salmon escapement techniques. Canadian Technical Report of Fisheries and Aquatic Sciences 1108:129 pp.

Dickson, M., W. Bucher, and G. Coble. 1999. Tributary restoration and development project: Port Dick Creek, Lower Cook Inlet, Alaska, Exxon Valdez oil spill restoration project 1998 annual report (Restoration Project 98139-A2), Alaska Department of Fish and Game, Homer, Alaska.

Edmundson, J., M. Dickson, and W. Bucher. 1998. Limnology and fishery investigations concerning sockeye salmon production in Delight and Desire lakes, EVOS Restoration Project 97254 Final Report submitted by the Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development.

Eicher, G.J. 1953. Aerial methods of assessing red salmon populations in western Alaska. Journal of Wildlife Management 17(4):521-527.

Evzerov, A.V. 1981. An evaluation of the errors occurring in salmon census by aerial survey. Canadian Translations of Fisheries and Aquatic Sciences 4714:1-5. Translated from Salmonidae of the Far East, 1975 CVI:82-84.

Hatch, Douglas R., M. Schwartzberg, and P.R. Mundy. 1994. Estimation of pacific salmon escapement with a time-lapse video recording technique. North American Journal of Fisheries Management 4:626-635.

Hatch, D.R., J.K. Fryer, M. Schwartzberg, D.R. Pederson, and A. Wand. 1998. A computerized editing system for video monitoring of fish passage. North American Journal of Fisheries Management 18: 694-699.

Hill, R.A. 1997. Optimizing aerial survey count frequency for the area-under-the-curve method of estimating escapement. North American Journal of Fisheries Management 17:461-466.

Irvine, J.R., B.R. Ward, P.A. Teti, and N.B.F. Cousens. 1991. Evaluation of a method to count and measure live salmonids in the field with a video camera and computer. North American Journal of Fisheries Management 11:20-26.

Kelez, G.B. 1947. Measurement of salmon spawning by means of aerial photography. Pacific Fisherman 45:46-51.

Mathisen, O.A. 1962. Photographic enumeration of red salmon escapement. Pages 349-372 in Koo, T.S.Y (ed.) Studies of Alaska Red Salmon. Univ. of Wash. Publ. In Fish. New Ser. 1: 449 pp.

Neilson, J.D. and G.H. Geen. 1981. Enumeration of spawning salmon from spawner residence time and aerial counts. Transactions of the American Fisheries Society 110:554-556.

Perrin, C.J. and J.R. Irvine. 1990. A review of survey life estimates as they apply to the area-under-the-curve method for estimating the spawning escapement of Pacific salmon. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1733. 49 pp.

Shardlow, T., R. Hilborn, and D. Lightly. 1987. Components analysis of instream escapement methods for Pacific salmon (Oncorhynchus spp.). Canadian Journal of Fisheries and Aquatic Sciences 44:1031-1037.

Revision 6-16-00
approved 8-3-00

2001 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001	LONG RANGE FUNDING REQUIREMENTS					
Personnel	$28,000.0	$6,900.0						
Travel	$1,500.0	$2,220.0						
Contractual	$4,370.0	$1,100.0						
Commodities	$1,825.0	$0.0						
Equipment	$6,500.0	$0.0						
Subtotal	$42,195.0	$10,220.0				Estimated FY 2002		
General Administration	$4,300.0	$1,069.5						
Project Total	$46,495.0	$11,289.5						
Full-time Equivalents (FTE)	0.5	0.1						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

See accompanying cover letter re: publication page costs.

FY01

Prepared:

Project Number: 01366
Project Title: Using Remote Video and Time Lapse Recording...
Agency: Alaska Department of Fish and Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2001
						0.0
						0.0
Mark Dickson (or equivelant)	Fish and Wildlife Technician IV	13J	1.5	4600.0		6,900.0
						0.0
	Assistance in preparing the final report and manuscript for publication					0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.5	4600.0	0.0	
					Personnel Total	$6,900.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
Annual EVOS Restoration Workshop					0.0
Homer-Anchorage and return (for Ted Otis and Mark Dickson).	180.0	2	6	42.0	612.0
Lodging			3	130.0	390.0
					0.0
Annual Alaska Chapter AFS Meeting in Fairbanks					0.0
Homer-Fairbanks and return (for Project PI)	500.0	1			500.0
Food per diem- 1 person for 3.5 days			4	42.0	168.0
Lodging- 1 person for 3 nights			3	150.0	450.0
Registration Fee					100.0
					0.0
					0.0
					0.0
				Travel Total	$2,220.0

FY01

Prepared:

Project Number: 01366
Project Title: Using Remote Video and Time Lapse Recording...
Agency: Alaska Department of Fish and Game

FORM 3B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed FY 2001
Description	
We are removing our FY01 request for publication page costs because we cannot guarantee we would meet the TC's requirement that the manuscript is published in FY01. However, we do intend to publish a manuscript entitled "Reliability and performance of a remote video escapement recorder (RVER) for monitoring salmon escapement in Alaska" in the North American Journal of Fisheries Management in FY02. Note: see accompanying cover letter.	
Photo developing and digitizing, graphic art design, poster costs, etc.	1,100.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$1,100.0

Commodities Costs:	Proposed FY 2001
Description	
Commodities Total	$0.0

FY01

Prepared:

Project Number: 01366
Project Title: Using Remote Video and Time Lapse Recording...
Agency: Alaska Department of Fish and Game

FORM 3B
Contractual & Commodities DETAIL

2001 EXXON VALDEZ TRUS' COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

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	Inventory Agency
Personal computers	2	ADF&G

FY01

Project Number: 01366
Project Title: Using Remote Video and Time Lapse Recording...
Agency: Alaska Department of Fish and Game

FORM 3B
Equipment
DETAIL

Prepared:

Approved TC 8-3-00

Effects of Harbor Seal Metabolism on Stable Isotope Ratio Tracers

Project Number:	01371-CLO
Restoration Category:	Research
Proposer:	D. Schell/UAF
Lead Trustee Agency:	ADFG
Cooperating Agencies:	None
Alaska SeaLife Center:	Yes
New or Continued:	Cont'd
Duration:	3rd yr. 3 yr. project
Cost FY 01:	$92.9
Cost FY 02:	$0.0
Geographic Area:	Prince William Sound, Gulf of Alaska
Injured Resource/Service:	Harbor seal

ABSTRACT

A major concern when using stable isotope tracers in ecosystem studies is the fidelity with which isotope ratios are transferred up food chains. Use of specific habitats or prey cannot be assessed because geographic gradients in isotope ratios confound trophic effects and/or prey switching. To remove these problems, this project developed complex analytical protocols to isolate amino acids from harbor seals which were pulse-labeled with ^{15}N-amino acids. Subsequent samples of blood plasma and red blood cells over time allowed for estimation of nitrogen incorporation rates. The goals of the final year are to identify pathways of rapid versus slower turnover and to investigate determination of habitat biomarkers. [NOTE: The principal investigator has indicated that additional closeout funds (no amount specified) may be requested for FY 02.]

INTRODUCTION

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

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

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

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

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

NEED FOR THE PROJECT

A. Statement of Problem

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

B. Rationale/Link to Restoration

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

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

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

C. Location

The research efforts are underway at the Alaska SeaLife Center and the University of Alaska Fairbanks. The instrumental analyses, specifically the development of the amino acid isolation protocols, has been conducted at UAF on samples collected during the dietary studies and sampling at ASLC by Dr. Castellini's group. We are now performing the isolations of both derivatized and free amino acids from seal samples and conducting the mass spectrometry.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

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

PROJECT DESIGN

A. Objectives

The null hypotheses to be tested are as follows:

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

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

The objectives of this study are divided into three elements, which have been modified as the study progressed:

1. Year 2, now underway, consists of developing methods and protocols for the isolation of metabolites from harbor seal blood and tissue samples to be employed during the following controlled diet studies. The Institute of Marine Science has purchased a new GC-IRMS (gas chromatograph–isotope ratio mass spectrometer) that has been used to determine isotope ratios in the individual amino acids isolated from serum samples. These amino acids are separated using high performance liquid chromatography using semi-preparative columns and inorganic buffers. Testing for essential amino acids in harbor seals has been initiated using blood samples acquired from seals being used by Dr. Michael Castellini for food

assimilation efficiency studies. By feeding ^{15}N and ^{13}C-labeled glycine to the seals prior to blood sample collection, it will be evident if the label has been transaminated to amino acids and to what extent. If some amino acids remain unlabeled, the corresponding labeled amino acid will be administered to see if transamination occurs in the reverse direction. Conservative amino acids will be prime candidates for environmental biomarkers.

2. The second component will be a study of the effects of suboptimal versus optimal diet on the fractionation of carbon and nitrogen isotopes in harbor seals. Diets of known amount and composition (isotopic and energetic) are being fed to the seals at ASLC and blood samples are being monitored for composition and isotope ratios. Dr. M. Castellini is closely coordinating this research with studies of controlled diet/assimilation efficiencies in harbor seals so that minimal animal handling and sampling will be necessary. The first trial of the feeding study began in December 1998 and the second will commence in May 2000.

3. The third component was to determine source prey for isotopically distinct fatty acids or other metabolites. The identification of specific fatty acids that carry a conservative signal to top consumers (birds, cetaceans, fissipeds) would yield an extraordinarily valuable tool to follow food web transfers or to identify specific habitat importance. This aspect of the work has also been undertaken by study 00441 and we have shifted our emphasis to the nitrogen metabolism and amino acids. Protocol development for amino acid mass spectrometry has taken longer than anticipated and we are planning intense effort over the remaining time on this aspect. If time allows we will undertake fatty acid extractions and identifications during the final year. Many of the prey species samples are already archived and analysis can begin as soon as primary goals are attained.

B. Methods

Isotopic Analysis of Blood Protein Amino Acids

The proteins and free amino acids in blood serum samples from captive harbor seals and muscle protein from native harvested seals are hydrolyzed with 0.6 N HCl in sealed ampoules to free proteinaceous amino acids. This procedure provides several essential amino acids for mammals but if time permits we will use multiple procedures to optimize amino completeness, such as acid and basic hydrolysis. An investigation of the use of proteolytic enzymes is no longer being considered because of time constraints. Once isolated the free amino acids will be separated by HPLC (high performance liquid chromatography) either as derivatives of orthophthalaldehyde (OPA) or as underivatized amino acids. The latter procedure is preferable but will require modification of the HPLC system. This equipment for these modifications is on order and will be employed as they come online in late spring 2000. The aliquots with individual amino acids will be taken to dryness. These samples will then be run on an elemental analyzer coupled to the isotope ratio mass spectrometer and the nitrogen and carbon dioxide liberated in the elemental analyzer will be separated by gas chromatography and run individually in the IRMS. Preliminary data on seal amino acids are presented in the accompanying annual report.

In the past feeding experiment, we intravenously dosed 2 seals on different diets with ^{15}N-labeled glycine and the appearance of the label in the serum and red blood cells was followed over time in the total amino acid spectrum. This experiment has already demonstrated the in vivo appearance of the label and provided an approximate turnover time for free amino acids in the blood serum of the seals. Preliminary data are shown in the FY00 annual report. Samples of

the blood are currently being processed for individual amino acid analysis. Those amino acids remaining free of the label will be identified as probable essential amino acids derived solely from diet that would constitute conservative biomarkers. Mobilization and isotopic fractionation of these amino acids will be tested further in reverse dietary studies in summer 2000 wherein the labeled amino acid will be infused and the rate of transamination followed in feeding and fasting seals.

Isotope Fractionation During Fasting and Suboptimal Diets

Many marine mammals undergo periods of fasting or suboptimal diets such as during molt or reproduction. Nothing is known regarding the effects of these periods on the fractionation of either carbon or nitrogen isotopes in harbor seal tissues. The amino acid threonine, for example, has been shown to become very isotopically depleted in ^{15}N during starvation, with lesser effects on glycine and serine (Hare et al., 1991). In coordination with studies of dietary effects on blood hormones or other work requiring harbor seal blood samples at ASLC, we will analyze aliquots as described above for shifts in the isotope ratios. We have completed collection of blood samples from unlabeled seals (used as controls in the experiments), which showed shifts in the natural abundance of isotope ratios over the feeding experiment with constant diet. These physiologically induced shifts probably arise from mobilization of amino acids in molting or onset of breeding behavior. We plan to coordinate our summer 2000 sampling with that of Dr. Castellini. All procedures will be approved by the ASLC scientific committee and conducted as required by the IACUC (Institutional Animal Care and Use Committee) of the University of Alaska and ASLC.

This project will complete the sampling program in the next feeding trial beginning in May 2000. We do not anticipate the need for ASLC bench space or office space in FY 01. We do include funds for one trip for the PI and graduate student to the ASLC for finalization of sampling and any necessary clean up. The analytical work will be undertaken at UAF and the remainder of the project duration will be in Final Report preparation and the submission of manuscripts detailing our findings. We have already presented initial findings at the EVOS meeting in January 2000 and anticipate submission of more complete findings at the next EVOS meeting in 2001.

Sources of Essential Amino Acids in the Diets of Harbor Seals

We are fortunate in having a wide suite of potential prey samples derived from the Prince William Sound region and offshore Gulf of Alaska from past EVOS studies. Additional samples are also available from the Bering Sea region to allow geographic contrast in isotope ratios. The APEX program supported by EVOS will be a source of samples, as will other opportunistic cruises in the spill and control areas. Herring, sand lance, pollock and capelin will be special targets, given their importance in the food chains of Prince William Sound.

Ms. Liying Zhao is the Ph.D. candidate is undertaking the experimentation on this project. Ms. Zhao has an exceptionally strong background in chemistry and has been undertaking the daunting task of developing the methodologies needed to isolate sufficient individual amino acids to provide an isotope ratio for each of the approximately ten essential amino acids. The task has required a triple approach – isolation of derivatized amino acids, isolation of free underivatized amino acids and an integrated GC-MS procedure that would eliminate the need for HPLC processing. To date, the first procedure offers the best results and cleanest separations but complicates the calculations of isotope ratios through the addition of the derivatizing carbon. This requires back calculation of the apparent isotope ratio of the free amino acid. We hope to

circumvent this obstacle in the next few months through the purchase of a larger semi-preparative scale HPLC with much larger capacity and an ion-exchange column. The costs for this instrumentation are being obtained from other sources.

The biochemical expertise and advisement of Ms Zhao are from her graduate committee of which the PI is the chair. Other members include:
Dr. Michael Castellini, Professor of Marine Science, has his background in biochemistry and is currently involved in studies of marine mammal nutrition at the ASLC.
Dr. Larry Duffy, Professor of Biochemistry and Chemistry, is the current Head of the Chemistry and Biochemistry Program.
Dr. Susan Henrichs, Professor of Marine Science, is a chemist specializing in the microbial biochemistry of amino acids in marine environments.
Dr. Bruce Finney, Professor of Marine Science is experienced with the environmental aspects of ocean chemistry and stable isotope methodology.

The above committee is assisting in experimental design and review of protocols as well as assist with scoping.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

M. Castellini is concurrently working on Project 00341 for related work on blood hormones and food assimilation efficiency studies at the Alaska SeaLife Center. This project will be completely coordinated with his work to optimize sampling and mutual assistance.

SCHEDULE

A. Measurable Project Tasks for FY 01 (October 1, 2000–September 30, 2001) and
B. Project Milestones and Endpoints

FY 01

October - February:	Continue amino acid analyses on samples acquired from final feeding trials, summer 2000. These will constitute reverse labeling with phenylalanine and valine to study transamination efficiencies of essential amino acids.
March - July:	Continue analytical work, prepare prey samples for analysis. Write manuscripts, outline Final Report.
August–September:	Prepare Final Report, submit manuscripts, clean up data gaps, outline needs for future work.

C. Completion Date

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

PUBLICATIONS AND REPORTS

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

Annual Reports: These reports will detail progress and preliminary findings and notable achievements. The annual report due April 2000 (18-month progress) is submitted with this proposal. The next report will be the Final Report as scheduled below.

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

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

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

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

PROFESSIONAL CONFERENCES

The results of this project will be communicated at appropriate meetings. The biennial meeting of the Society for Marine Mammalogy or the American Society for Limnology and Oceanography (ASLO) is typical for this type of presentation, as are specific workshops and meetings emphasizing application of isotope techniques to biological problems. The next opportunity will be the annual meeting of ASLO or ad hoc meeting on marine mammals in 2001.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Resources and Services – We have been fortunate to have full coordination and assistance of the ASLC staff and Dr. Michael Castellini for the animal handling requirements of this project. The infusions of amino acids, coordination with known diets and sample handling have been very efficient and helpful. This has allowed full time effort on the difficult and complex analytical aspects at UAF and assured high quality samples for our work. The final label infusions, feeding, and blood collection will occur in FY00 (summer 2000) and we will spend the

remaining program resources on completion of the analytical work and publication of results. No ASLC bench or office space will be needed in FY01.

PROPOSED PRINCIPAL INVESTIGATOR

Donald M. Schell
Institute of Marine Science
School of Fisheries and Ocean Sciences
University of Alaska Fairbanks
Fairbanks, AK 99775-7220
Phone: (907) 474-7115
Fax: (907) 474-7204
E-mail: schell@ims.alaska.edu

PRINCIPAL INVESTIGATOR

D. M. Schell has been involved in stable isotope studies for over 25 years. His research has included natural abundance tracer studies and enrichment experiments. His work on bowhead whales and geographic gradients in stable isotope ratios has been published and extended to the assessment of ecosystem carrying capacity in the Bering Sea and to the assessment of trophic dynamics and feeding of harbor seals in the EVOS region.

Dr. Schell oversees the Stable Isotope Ratio Mass Spectrometry Facility on the UAF campus. This consists of three working instruments, which are dedicated to specific elements, as demand requires. A Europa automated continuous flow system will be used for most samples but back-up analytical capability is available. A new HPLC is being ordered from other sources that have the ability to handle separations of larger quantities of amino acids and will be available for this project. As PI, Schell will oversee the Quality Assurance/Quality Control aspects of this project. Protocols for sampling for mass spectrometry have been established and working standards are cross-calibrated with other nationally recognized laboratories.

OTHER KEY PERSONNEL

Machine operations are the responsibility of Norma Haubenstock, mass spectrometry technician. She is well trained and has more than 11 years experience with mass spectrometers. She will oversee laboratory operations, assist in sample preparation, and archive all isotope data. Ph.D. student Liying Zhao is responsible for the amino acid identification and separation, sample preparation for mass spectrometry and for synthesis of data in cooperation with the PI.

LITERATURE CITED

Best, P.B. and D. M. Schell 1996. Stable isotopes in southern right whale (*Eubalaena australis*) baleen as indicators of seasonal movements, feeding and growth. *Mar. Biol.* 124:483-494

Dunton, K.H., S.M. Saupe, A.N. Golikov, D.M. Schell and S.V. Schonberg. 1991. Trophic relationships and isotopic gradients among arctic and subarctic marine fauna. Mar. Ecol. Prog. Ser. 56:89–97.

Hare, P.E. M.L. Fogel, T.W. Stafford, A.D. Mitchell and T.C. Hoering. 1991. The isotopic composition of carbon and nitrogen in the individual amino acids isolated from modern and fossil proteins. J. Archaeological Science 18:277–292.

Hobson, K.A. and H. Welch. 1992. Determination of trophic relationships within a high arctic marine food web using $\delta^{13}C$ and $\delta^{15}N$ analysis. Mar. Ecol. Prog. Ser. 84:9–18.

Michener, R.H. and D.M. Schell. 1994. The use of stable isotopes in tracing marine aquatic food webs. In: R. Michener and K. Ljatha (eds.). *Stable Isotopes in Ecology and Environmental Research*, p. 138–157. Blackwell Scientific, Cambridge.

Saupe, S.M., D.M. Schell and W.B. Griffiths. 1989. Carbon-isotope ratio gradients in western arctic zooplankton. Mar. Biol. 103:427–432.

Schell, D.M., S.M. Saupe and N. Haubenstock. 1989. Bowhead whale (*Balaena mysticetus*) growth and feeding as estimated by techniques. Mar. Biol. 103: 433–443.

Vinette, K.A. 1992. Carbon and nitrogen isotope ratios in bowhead whales and their zooplankton prey as indicators of feeding strategy and environmental change. M.S. Thesis, University of Alaska Fairbanks. 147 p.

Approved TC 8-3-00

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$0.0						
Travel		$0.0						
Contractual		$86.8						
Commodities		$0.0						
Equipment		$0.0						
Subtotal		$86.8			Estimated	Estimated		
General Administration		$6.1						
Project Total		$92.9						
Full-time Equivalents (FTE)		1.4						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY01

Project Number: 01371
Project Title: Effects of Harbor Seal Metabolism on Stable Isotope Ratio Tracers
Agency: Alaska Department of Fish and Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

[redacted]pared:

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001	[redacted]					
Personnel		$53.1						
Travel		$4.9						
Contractual		$9.0						
Commodities		$2.4						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal		$69.4			Estimated	Estimated		
Indirect		$17.4						
Project Total		$86.8						
Full-time Equivalents (FTE)		1.4	[redacted]					
			Dollar amounts are shown in thousands of dollars.					
Other Resources								

Comments:

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

Student personnel costs include resident tuition of $3,006 per year.

FY01

Prepared:

Project Number: 01371
Project Title: Effects of Harbor Seal Metabolism on Stable Isotope Ratio Tracers
Name: Donald M. Schell

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 2000
Donald M. Schell (PI, Director, IMS; Professor)			1.7	11.8		20.1
Norma Haubenstock, Technician			3.0	5.2		15.6
Ph.D. Student (TBA)			12.0	1.5		17.4
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		16.7	18.5	0.0	
					Personnel Total	$53.1

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 2000
Fairbanks to national meeting		1.2	1	8	0.1	2.3
Fairbanks to Anchorage (EVOS meeting)		0.3	1	5	0.1	1.0
Fairbanks to Seward		0.8	2	7	0.1	1.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$4.9

FY01

Prepared:

Project Number: 01371
Project Title: Effects of Harbor Seal Metabolism on Stable Isotope Ratio Tracers
Name: Donald M. Schell

FORM 4B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed
Description	FY 2000
Mass spectrometry (400 samples @ $18/sample)	7.2
Final report preparation, page charges	1.6
Communications, photocopying	0.2
Contractual Total	$9.0

Commodities Costs:	Proposed
Description	FY 2000
HPLC column, chemicals, expendables	2.2
Project supplies (computer software)	0.2
Commodities Total	$2.4

FY01

Prepared:

Project Number: 01371
Project Title: Effects of Harbor Seal Metabolism on Stable Isotope Ratio Tracers
Name: Donald M. Schell

FORM 4B
Contractual & Commodities
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	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:	Number	
Description	of Units	
		[redacted]

FY01

Prepared:

Project Number: 01371
Project Title: Effects of Harbor Seal Metabolism on Stable Isotope Ratio Tracers
Name: Donald M. Schell

FORM 4B
Equipment
DETAIL

Revision 7-31-00
Approved TC 8-3-00

Partnering with NOAA to Quantify and Monitor Environmental Attributes of Kachemak Bay

Project Number:	01385
Restoration Category:	Ecosystem Synthesis, General Restoration (suggested)
Proposer:	Kachemak Bay National Estuarine Research Reserve (ADFG/KBNERR)
Lead Trustee	ADFG
Duration:	2-year project
Cost FY 01:	$11.0
Cost FY02 +:	Unknown, open for discussion
Geographic Area:	Kachemak Bay, Lower Cook Inlet, and Gulf of Alaska
Injured Resource/Service:	Kachemak Bay includes all resources injured by the oil spill (except cutthroat trout, Dolly Varden, and AB Killer Whale pod), intertidal communities, and all the lost or reduced services.

ABSTRACT

The increasing number of stresses on marine and estuarine ecosystems has challenged scientists and resource managers to find methods for determining temporal rates and spatial extents of ecological responses to changes in environmental conditions. This project will provide the necessary match for the Kachemak Bay Research Reserve to establish a monitoring program of oceanographic environmental attributes in Kachemak Bay. Results of on-going studies will then be able to link patterns of oceanographic changes to patterns of biodiversity in the marine and estuarine intertidal and subtidal habitats of Kachemak Bay.

INTRODUCTION

The marine ecology of the Pacific Northwest coast has been extensively studied, yet the scales of spatial and temporal variability of marine populations are poorly understood. The rich variety of seashore life along the coast is due partly to the many different habitats that are represented. Within the Kachemak Bay/Lower Cook Inlet area are rocky shores with reefs, tide pools and boulders, and sandy beaches exposed to heavy surf. These habitats are of utmost importance to society in terms of spawning and rearing habitats of commercial and sport fisheries, subsistence and commercial harvests of invertebrates, breeding and feeding grounds for shorebirds and seabirds, and for esthetic and recreational opportunities. However, the abundance of these populations is highly variable in space and time, and possibly linked to fluctuations in oceanic water properties and circulation patterns.

The Kachemak Bay Research Reserve acknowledges the importance of a long-term time series of environmental data and information dissemination through the support of the NOAA National Estuarine Research Reserve System (NERRS) System-Wide Monitoring Program (SWMP). The goal of the SWMP is to "identify and track short-term variability and long-term changes in the integrity and biodiversity of representative estuarine ecosystems and coastal watersheds for the purpose of contributing to effective national, regional and site specific coastal zone management". This comprehensive program consists of three phased components:

(1) marine and estuarine water quality monitoring,
(2) biodiversity monitoring, and
(3) terrestrial and marine habitat change analysis.

NEED FOR THE PROJECT

Statement of Problem

Evidence from research in the Pacific Northwest suggests that patterns of marine community structure such as rocky intertidal communities, sediment communities, nearshore kelp bed communities (kelp, urchins, sea otters), and some seabird populations are trophically linked to oceanic processes and physical characteristics of the shoreline. For example, differences in primary productivity, salinity, and water temperature are often reflected in the composition of intertidal and nearshore flora and fauna communities. It is difficult to quantify boundaries of salinity or water temperature due to the large temporal and spatial changes caused by precipitation, surface runoff, groundwater flow, and evaporation. While nearshore regions have physical patterns that can be quantified, the difficulty lies in the trade off between temporally intensive vs. spatially extensive data collection. We need time series data to assess change over the relevant scales of temporal change, and spatially extensive data to assess the generality of the temporal changes.

Rationale/Link to Restoration

In addition to benefiting injured resources and services affected by the spill (see introduction), is a response to a request for new projects in Invitation to Bid under Ecosystem Synthesis: "Innovative Tools and Strategies to Improve Monitoring." With the physical oceanographic studies we hope to begin with NOAA and other funds, this will be an important step to monitoring biological diversity and changes in intertidal communities and abundance of associated fish and wildlife resources over time.

Other links to the restoration effort are summarized below in relation to the policies of the Trustees Council.

Ecosystem Approach, Policies 1 and 2 – A primary focus of this project is to develop and implement a strategy to promote an ecosystem approach towards restoration, management, and use of Kachemak Bay. The study area includes the Kachemak Bay Watershed, encompassing those lands purchased by the Trustee Council on the north and south side of the Bay.

Injuries Addressed by Restoration, Policies 3, 4, and 6 – This project addresses restoration and monitoring environmental conditions related to injured species and services. Many of the injured species and services have substantial economic, cultural, and subsistence value to the state, regional, and local economies.

Location of Restoration Actions, Policy 8 – Kachemak Bay is in the spill-affected area.

Restoring a Service, Policy 9 – Most of the injured services occur within the Kachemak Bay area.

Efficiency, Policies 11 and 14 – This project provides significant cost sharing. The EVOS restoration effort can gain significant benefits from this product with relatively little expense.

Partnerships, Policy 15 – The project will both establish partnerships with NOAA and provide strong foundation for future collaborations.

Clear, Measurable, and Achievable Endpoint – This project will be completed at the end of the fiscal year. All data will be available to managers, researchers, local governments, and the public.

Access to Information and Data, Policy 20 – This project will make information available to the public, agencies, and managers though a CD and the Internet.

Normal Agency Activities – The NERR System requires minimal monitoring efforts, and Reserve's are required to obtain non-federal match. We are establishing partnerships and

combining resources with other agencies to bring this important long-term monitoring project to bear on the EVOS restoration effort.

C. Location

The location of this study is the Kachemak Bay/Lower Cook Inlet/Gulf of Alaska Area. The immediate benefits of this study will be realized in the greater Kachemak Bay area, but can be applied to other geographic areas. The most directly affected communities include the areas/communities of Homer, Seldovia, Halibut Cove, Port Graham, and Nanwalek.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

This project (as revised) with involve minimal community involvement.

PROJECT DESIGN

A. Objectives

(1) marine and estuarine water quality monitoring,
(2) nearshore biodiversity monitoring, and
(3) change detection analysis.

B. Methods Summary

With funds provided by NOAA, the Kachemak Bay NERR will purchase equipment to begin to develop its monitoring program. EVOS funds will be used as match to partially support staff time necessary to install these instruments to get this program started.

This will likely include establishing an instrumented water quality monitoring site at the end of the Homer Spit to continuously measure salinity, temperature, DO, PAR, and chlorophyll fluorescence. Nearby meteorological instruments will measure wind speed and direction. These sensors will transmit data streams to a computer for storage and to allow access to the information in real time.

Standard time series analyses (Fourier and Wavelet) will be conducted on these data sets to determine the frequencies of dominant patterns.

We also propose to measure the chlorophyll fluorescence, salinity, temperature and transmissivity and/or PAR distributions by conducting periodic profiles over a 1 km grid over Kachemak Bay. We anticipate purchasing a Seabird SEALOGGER CTD *SBE 25*

profiler with a WetStar Fluorometer (or similar) and a small field computer. Reserve staff will provide a boat and personnel for data collection and analysis. The data will be downloaded and entered into a GIS and web accessible maps will be produced to show the spatial attribute fields for the inner and outer bay. These data will be used to locate sites for future additional instrument arrays with potential deployments near Halibut Cove and Seldovia.

C. Cooperating Agencies, Contracts, and other Agency Assistance

Cooperating Agencies/Contracts: ADFG is the only trustee agency requesting financial assistance under this award. There will be no contracts to other Trustee Agencies.

Other Agency Assistance:

NOAA/Office of Ocean and Coastal Resource Management/Research Reserve Division (RRD) – As part of its operations award from NOAA, RRD will provide limited funds to participate in the National Estuarine Reserve System's (NERRS's)) System-wide Monitoring Program. This monitoring program currently includes the deployment and maintenance of data sondes (to measure salinity, temperature, dissolved oxygen, pH, and turbidity) and a weather station. As a new reserve, the KBNERR will be defining its participation in this program next fiscal year. Most of the operations funds for this program this year will go to staff time in designing the program. This program will provide the necessary non-federal match to NOAA's $25,000 for purchase of several data sondes in Kachemak Bay.

In addition, NOAA has agreed to provide an additional $25,000 next year to the KBNERR – over and above operations funds – for purchase of several data sondes for deployment in Kachemak Bay. These funds are provided on a 70% federal/30% non-federal basis, although we could not have met this requirement without the EVOS funds. The proposed EVOS project (#01385) will allow us to satisfy this match requirement and begin deployment of this equipment in Federal FY01.

SCHEDULE

A. Measurable Project Tasks for FY01

- December 2000 – complete draft plan for deployment of data sondes and a weather station in Kachemak Bay
- June 2001 – deploy data sondes.

B. Project Milestones and Endpoints (tasks funded in part by EVOS)

Overall Products (from two-year effort, includes portion funded by EVOS)

1. Start Kachemak Bay NERR monitoring program.

C. Completion Date

For purposes of expediency, to keep costs down, and respond to Trustee Staff comments, this project has been drastically reduced. A large scale monitoring program should be considered to more fully assess and monitor natural and human changes to the ecosystem. The KBNERR will begin this process in FY01 through initial development of the KBNERR's participation in the NERRS's system-wide monitoring program.

PUBLICATIONS AND REPORTS

No publication are anticipated based on this small project.

PROFESSIONAL CONFERENCES

No professional conferences will be attended based on this small project.

NORMAL AGENCY MANAGEMENT

Neither ADFG nor NOAA requires the Kachemak Bay Research Reserve by statute, regulation, or policy to undertake habitat monitoring and modeling. The KBNERR does not receive adequate operation funds for this purpose, which are largely dedicated to Research Reserve Administration and system-wide research and education initiatives. Consequently, the Research Reserve must seek other sources of funding and create parternerships to complete these tasks.

COORDINATION AND INTEGRATION WITH THE RESTORATION EFFORT

Coordination with the EVOS Restoration Effort:

USGS/Biological Research Division (BRD) – The KBNERR will be using the oceanographic information developed by John Piatt, BRD, in Kachemak Bay. With Dr. Piatt winding down his studies in the region, we anticipate utilizing his phytoplankton and related oceanographic data as part of the proposed project and related NERR efforts. While the details are still being developed, this coordination will save BRD and EVOS Trustees money and help continue and expand important data sets funded by these programs.

FWS (potential) – The KBNERR has submitted a proposal under the FWS Coastal Management Program to continue and expand Dr. John Piatts work to measure the chlorophyll fluorescence. Since primary production drives all other trophic levels, a partial list of resources enhanced by the proposed work include: fisheries with commercial stocks of salmon, rockfish, crabs, and shellfish, kelp bed communities (kelp, urchins, sea otters), seabirds and shorebirds.

Other Funds/Major Contributors:

Please see "C. Cooperating Agencies, Contracts, and Other Agency Assistance" for contributions from NOAA and FWS (potential contributor). A summary of other funds and in-kind contributions are also summarized in the budget.

PRINCIPAL INVESTIGATOR

Carl Schoch, Ph.D.
Research Coordinator
Kachemak Bay Research Reserve
202 W. Pioneer Ave.
Homer, Alaska 99603

Phone: 235-4799
Fax: 235-4794
E-mail: carl_schoch@fishgame.state.ak.us

Qualifications:

Dr. Schoch has extensive experience on oceanographic cruises and developed the SCALE methods of shoreline habitat modeling (see attached resume). Dr. Schoch will be responsible for designing the instrument deployment and the collection, processing and delivery of all oceanographic data.

OTHER KEY PERSONNEL

Not applicable.

Revision 1-19-00
approved TC 3-00

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

Budget Category:	Authorized FY 2000	Proposed FY 2001
Personnel		$9.0
Travel		$0.0
Contractual		$0.0
Commodities		$0.6
Equipment		$0.0
Subtotal	$0.0	$9.6
General Administration		$1.4
Project Total	$0.0	$11.0
Full-time Equivalents (FTE)		0.2
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
Estimated FY2002	Estimated FY2003				

Dollar amounts are shown in thousands of dollars.

Comments:

FY01

Prepared:

Project Number: 01385
Project Title: Modeling Biodiversity in Kachemak Bay: A Proposal to Map Marine Nearshore Habitats at Nested Spatial Scales
Agency: Alaska Department of Fish and Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUS' :OUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2001
G. Carl Schoch, Ph.D.	Research Coordinator	18A	1.8	5.0		9.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.8	5.0	0.0	
					Personnel Total	$9.0

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
				Travel Total	$0.0

FY01

Prepared:

Project Number: 01385
Project Title: Modeling Biodiversity in Kachemak Bay: A Proposal to Map Marine Nearshore Habitats at Nested Spatial Scales
Agency: Alaska Department of Fish and Game

FORM 3B
Personnel
& Travel
DETAIL

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

Contractual Costs:	Proposed FY 2001
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 2001
Description	
Boat Gas and Related Supplies	0.6
Commodities Total	$0.6

FY01

Prepared:

Project Number: 01385
Project Title: Modeling Biodiversity in Kachemak Bay: A Proposal to Map Marine Nearshore Habitats at Nested Spatial Scales
Agency: Alaska Department of Fish and Game

FORM 3B
Contractual & Commodities DETAIL

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

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	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:	Number	Inventory
Description	of Units	Agency
Personal Computers or Workstations	2	ADFG
22 Foot Boat for Field Surveys	1	ADFG

FY01

Prepared:

Project Number: 01385
Project Title: Modeling Biodiversity in Kachemak Bay: A Proposal to Map Marine Nearshore Habitats at Nested Spatial Scales
Agency: Alaska Department of Fish and Game

FORM 3B
Equipment
DETAIL

Approved TC 8-3-00

3-D Ocean State Simulations for Ecosystem Applications from 1995-1998 in Prince William Sound (PWS), AK

Project Number:	01389
Restoration Category:	Research
Proposer:	University of Alaska Fairbanks
Lead Trustee Agency:	ADFG
Cooperating Agencies:	
Alaska Sea Life Center:	No
Duration:	2nd year, 2-year project
Cost FY 01:	$142.5 (includes: $69,184 plus 12K for computer and $52,080 subcontract plus ADFG GA)
Geographic Area:	Prince William Sound, Gulf of Alaska
Injured Resource/Service:	3-D Modeling of PWS Ecosystem

ABSTRACT

Using data collected from 1995–98 in PWS and the forcing of tide, coastal current inflow/outflow, freshwater discharge, and wind stress, a 3-D PWS model will be developed to produce continuous 4-year, 3-D fields of velocity, temperature, salinity, and mixing coefficients for resource managers, fishing industry, and biological applications. The interannual variability of PWS ocean circulation, and temperature and salinity due to interannually variable atmospheric forcing will also be studied. Thus, we can identify the key environmental parameters to be included in a long-term monitoring program to assist resource managers.

The supplement work (see the new task) for FY01 is to rescue the Sound Ecosystem Assessment (SEA) database and install it on a new server at IMS-IARC/UAF. The new server will serve future modeling studies for the Gulf Ecosystem Monitoring (GEM) program.

INTRODUCTION

In the SEA program, extensive observations of phytoplankton and zooplankton, and oceanography, were made during 1995–98 (Cooney, 1996, 1997; McRoy et al. 1997; Thomas et al. 1997; Vaughan et al. 2000). Fish larvae and schools of selected species were also studied (Stokesbury et al. 1997). The 3-D ocean circulation model explains some, but not all of the mechanisms and applications to biology (Mooers and Wang 1998). For example, oceanic advection and diffusion can only explain the existing phytoplankton and zooplankton movement, while spring blooms and occasional later summer blooms (i.e., second bloom in the year) due to the ecosystem dynamics, cannot be explained by a physical-only model.

In 1998-99, substantial progress was made for the PWS ocean circulation modeling in the following areas:

1. We implemented a freshwater discharge of a line source into PWS (Wang et al. 1999) with support from SEA funding for Dr. M. Jin and continued conducting seasonal (12-month) simulations under climatological forcing and under seasonal forcing (1996) collaborating with Dr. S. Vaughan. The tidal forcing was also implemented to the forcing function (Fig. 1).

2. We conducted a (1996) seasonal 3-D simulation for Dr. T. Cooney of PWS zooplankton over wintering, releasing the particles from the depths below 400m on February 1 through July 30, 1996 (see Fig. 2), with an assumed mortality rate of 6% day^{-1}. The simulated results are consistent with what was been observed in 1996, according to Dr. T. Cooney.

3. We conducted a (1996) seasonal simulation for Dr. B. Norcross of spawning larvae migration along the a few selected locations (Fig. 3). The duration larvae retention in PWS has been found shorter by the change of the spawning location due to the 1989 T/V *Exxon Valdez* oil spill event. The mortality rate of 5% day^{-1} was assumed.

4. We also provided 3-D velocity fields to E. Brown for her research (Brown et al. 1999). Brown found that physical forcing from the 3-D model fits well with her biological data. Thus, she strongly urges us to provide four consecutive years (1995–98) of the 3-D current velocity, temperature and salinity for her continuous proposal to EVOS.

5. Most recently, we collected the wind data from 1995–98 at a mid-Sound station (see Fig. 4) and other stations (not shown) with the efforts of Dr. Vince Patrick, Jenny Allen, and Stephen Bodnar (the first-year subcontract). These data have a 30min interval. We will average them to hourly or 3-hourly interval to drive the model and use that to examine the year-to-year variability of the circulation due to wind forcing.

NEED FOR THE PROJECT

A. Statement of Problem

1. Use 1995–98 CTD observations combined with the historical CTD observation from 1975–94 to produce updated climatology of T and S for each levels (such as surface, 5m, 10m, etc.). This will be collaborated with Alaska Digital Graphics.

2. Use 1995–98 wind speeds and directions at nine weather stations around PWS to produce four-year spatial varying wind fields. This will be collaborated with Alaska Digital Graphics.

3. Calculate 1995–98 freshwater discharge using a hydrological model under forcing of air temperature, river runoff, and precipitation.

4. Using 1-3 the above as forcing, we will simulate the 3-D PWS ocean circulation, T, S, etc. using the 3-D-PWS model (Wang et al. 1999 a,b) to provide biologists and resource managers with applications of the physical forcing model.

5. Analyse continuous 48-month interannual variability of PWS circulation, T, S, and other variables under atmospheric forcing.

6. Rescue the SEA database by moving it to a new server to be located at IMS-IARC/UAF.

B. Rationale/Link to Restoration

Prince William Sound (PWS or the Sound) is located along Alaska's south central coast, north of the Gulf of Alaska (GOA). PWS is a combination of fjords and estuaries along the coast of Alaska, which was formed by a combination of preglacial erosion, glacial excavation, and tectonics. Because of its rich natural resources, i.e., sea birds, mammals, salmon, forage fish, etc., a systematic numerical simulation (study) of the physical oceanography and ecosystem in the region is essential and timely. It is necessary to understand the physical-biological system in order to provide sound scientific knowledge and information to the state government, local communities and others whose decisions or use affect the health and vitality of the Sound.

There were few historical observational studies of PWS before 1989. When North America's largest oil spill by T/V *Exxon Valdez* (March 24, 1989) seriously damaged the PWS ecosystem and the adjacent downstream waters, such as Cook Inlet and Kachemak Bay, extensive observational programs were begun in region. The SEA (Sound Ecosystem Assessment) project is one of the major programs. This interdisciplinary project started in 1994 with major focus on pink salmon, Pacific herring habitat, ecology, and physical oceanography. As the physical component of this project, effort was placed on field programming and numerical modeling.

After the implementation of 3-D-PWS model and a passive tracer simulation were accomplished (Mooers and Wang 1998; Deleersnijder et al 1998), a seasonal simulation (12 consecutive months) was followed up by Wang et al. (2000) using the SEA observations of 1996 only (Fig. 1). However, field observations in physical and biological oceanography from 1995–98 during the SEA program have not been fully validated. In addition, the interannual variability as observed (Vaughan et al. 2000) cannot be explained in terms of numerical modeling alone. Thus, after SEA it is necessary to synthesize both observations and multi-year modeling simulations for 1995–98.

Therefore, it is highly appropriate to use the data that has already been collected during the SEA project synthesized with data from other sources for this multi-year oceanographic model simulation. The simulated results will be valuable to assist resource managers to forecast pink salmon and Pacific herring abundance and to anticipate or understand changes in the ecosystem. In addition, key elements

will be identified that will be pertinent to include in a long-term monitoring program, leading to an establishment of a nowcast/forecast system in PWS using this 3D-PWS model.

C. Location

The research conducted for the ecosystem of Prince William Sound, Alaska will help us understand the basic physical forcing of the Sound and greatly benefit the biological research community and resource managers. The observed data used in the model are from the observations conducted in PWS between 1995–98. The modelling will be done using the resources of the University of Alaska Fairbanks and IARC-Frontier.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

Research institutions such as IMS and IARC of UAF and local community organizations such as the Regional Citizens' Advisory Council (RCAC) in Cordova and around Cook Inlet will be involved in this project. Both groups are concerned with possible long-term oil spill impact on the ecosystem and on the local communities as well.

PROJECT DESIGN

A. Objectives

1. Using the 3D-PWS model to simulate 1995–98 ocean circulation, T, S, vertically mixing coefficients using 2.5 turbulence closure model. The model validation will be conducted using actual observations during the four years.

2. Provide biologists and resource managers the 3-D fields (longitude, latitude, and depth) of velocity, T, S, etc. of 1995–98.

3. Conduct 48-month simulation of zooplankton over wintering for each year to compare the early spring distribution, the late spring-summer distribution, and the year-to-year difference (interannual variability).

4. Rescue the SEA database from PWSSC and install it with new data and information on a new server located at IMS-IARC/UAF.

B. Methods

The above objective will be implemented with the method of physical and biological data analysis and 3-D PWS numerical model.

1. Forcing data

   i. Winds. The hourly wind speeds and directions will be analysed at the nine stations around PWS used in Wang et al. (1999). Using nine wind-fetch empirical models, the winds will

be interpolated into the model grids from 1995–98. This work will be subcontracted to Alaska Digital Graphics.

ii. The SEA CTD data from 1995–98. All the CTD data from SEA, both physical oceanography observations and biological observations will be collected to produce seasonal T and S distribution from 1995–98. This work will be also collaborated with Dr. Vaughan at PWSSC to provide us the data.

iii. The hydrological model for freshwater discharge into PWS will be run to produce the 4-year daily runoff. The work will be done at UAF.

iv. Monthly heat flux for the same period will be extracted from the COADS.

v. The monthly inflow/outflow will be fixed to the observations of Niebauer et al. (1994).

2. Model simulations

The ocean circulation (physical) model should refer to the studies of Wang and Ikeda (1996), Wang et al. (1997), Mooers and Wang (1998), and Wang et al. (1999).

A continuous 48-month simulation will be conducted under the forcing described above and tidal forcing, beginning from January 1995 to December 1998. The outputs will be validated based on actual observations. Then, the model outputs (velocity, T, S, mixing coefficients, etc.) will be provided in 3D grids to biologists to verify their phytoplankton and zooplankton data. The four years interannual variability will be analysed to confirm what (i.e., which forcing factor) causes interannual variability, and their relative importance for interannual variability.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Data preparation will be subcontracted to Alaska Digital Graphics. The observations of SEA Project in 1995–98 were collected by them and we had very fruitful collaboration during the course of this project.

The PI was also recently funding by the Oil Spill Recovery Institute (OSRI) for one-year ($50K) of the two-year proposal titled "A 3-D coupled biological-physical model for the ecosystem in PWS, Alaska." This project will benefit the present proposed research by paying half of the time for Dr. Jin, who will be doing the intensive modeling work.

SCHEDULE

A. Measurable Project Tasks for FY 01 (October 1, 2000 – September 30, 2001)

December 31:	Complete tide simulation and validation with the four years of observations
January 18–28 (3 of these days):	Attend Annual Restoration Workshop
March 31:	Complete preparing the forcing data of the four years

August 31:	Complete the modelling of 1995–1998
September 15:	Submit manuscript to peer viewed journal

B. Project Milestones and Endpoints

March 15, 2001:	Complete the analysis of interannual variability of the ocean circulation and the ecosystem in PWS
April 15, 2001:	Submit annual report (FY 00)
August 15, 2001:	Complete the modelling of zooplankton over wintering
September, 30, 2001:	Submit final report and second manuscript

(New Task for 2001)
Please note that in the first year proposal, the PI (Wang) only proposed a one year subcontract to Dr. Vince Patrick, Jenny Allen and Stephen Bodnar formerly of the Prince William Sound Science Center, now Alaska Digital Graphics. Now, with the realization that PWSSC SEA server has been down since Patrick, Allen and Bodnar left the Center, much of the data has not been retrieved and may be lost if we do not immediately rescue the database collected during the SEA program.

Therefore, I propose to apply for 2001 budget from EVOSTC that includes funding for a subcontract to Alaska Digital Graphics to transfer the database from PWSSC to a new server located at IMS-IARC/UAF. The new task includes:

1) Budgeting for a UNIX workstation ($12K) to sit at IMS-IARC/UAF as a server for SEA database and be available for future GEM modeling projects.
2) Allen: 2.5 month for making the 1995-98 model outputs into the database and adding new data to the new computer server;
   Bodnar: 1.5 months for retrieving the SEA database and installing in on the new server;
   Patrick: 1.5 months for retrieving the SEA Information System and installing it on the new server.

The retrieved database in the IMS-IARC/UAF server will be serve incoming GEM projects with a focus on numerical simulations and provide a level of continuity that would not be available without this data. The breakdown of the SEA Information System and the server at PWSSC after a five-year investment by EVOSTC is a lesson we all should learn. Thus, it is very important to keep alive the data that scientists have collected during the last five-year SEA project.

C. Completion Date

September 30, 2001

PUBLICATIONS AND REPORTS

Manuscript titled "Tidal current and tidal residual current in PWS" (to be submitted to the *Journal of Geophysical Research-Oceans*) will be prepared and submitted to a refereed journal for formal publication. I may present the results and publish another paper in the book titled *Computer Modeling of Seas and Coastal Regions, V, 2001* in which I serve as a member of the International Advisory Committee for three years now. In the second year, we plan to submit a paper titled "Simulating

interannual variability of ocean circulation of PWS, Alaska" to the *Journal of Geophysical Research*, another manuscript titled *Impact of Ocean Circulation on Ecosystem in PWS, 1995-1998*.

PROFESSIONAL CONFERENCES

The PI and Dr. Jin plan to attend the annual EVOS meeting, 2000 Fall AGU Meeting in San Francisco, presenting the updated research results. This is an excellent way to communicate with our colleagues and to get recognised in the ocean science community. During the first year, we will travel to Anchorage discussing with Allen (or Allen will visit Fairbanks) regarding data processing and analysis.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This proposed research will be co-ordinated with 1) E. Brown's project (if her proposal gets funded) by providing her with the model outputs; 2) S. Vaughan's proposal for continuous monitoring project; 3) J. Allen's proposal for animation of 3-D model outputs, and other potential proposals for the restoration effort. We are willing to provide our 4-year simulation outputs to all EVOS-funded proposals by putting our simulation results on our web in both digital and graphic formats.

PROPOSED PRINCIPAL INVESTIGATOR

Jia Wang
Institute of Marine Science and IARC
University of Alaska Fairbanks
P.O. Box 757335
Fairbanks, Alaska 99775-7335
907-474-2685
907-474-2643
jwang@iarc.uaf.edu

PRINCIPAL INVESTIGATOR

Dr. Jia Wang, the PI, will be involved in the entire course of the project, providing scientific guidance to the project, without claiming salary. (The PI's salary will be funded by IARC-Frontier funds.) The PI needs one graduate student to conduct hydrological modeling to produce 48-months of freshwater runoff along the PWS coasts. Also, the PI will oversee the rescue of the SEA database and addition of new information into the new server.

OTHER KEY PERSONNEL

Dr. Meibing Jin, who is currently working on this EVOS-funded project awarded to the PI (Wang), will continue conducting the simulation and will be partially supported by the OSRI fund for six months.

The data preparation and server construction for rescuing the SEA database will be subcontracted to Dr. Patrick, Allen and Bodnar of Alaska Digital Graphics. Their collaboration will be essential for success of this proposed research.

LITERATURE CITED

Brown, E.D., J. Wang, S.L. Vaughan, and B.L. Norcross, 1999. Identifying seasonal spatial scale for the ecological analysis of herring and other forage fish in Prince William Sound, Alaska. *In Ecosystem Approaches for Fisheries Management*, Alaska Sea Grant College Program AK-SG-99-01 (in press)

Cooney, T. 1996. SEA–An Integrated Science Plan for the Restoration of Injured Species in Prince William Sound. EVOS FY 1996 Annual Report.

Cooney, T. 1997. SEA–An Integrated Science Plan for the Restoration of Injured Species in Prince William Sound. EVOS FY 1996 Annual Report.

Deleersnijder, D., J. Wang, and C. Mooers. 1998. A two-compartment model for understanding the simulated three-dimensional circulation in Prince William Sound, Alaska. *Cont. Shelf Res.*, 18: 279–287.

Eslinger, D.L. 1997. Biological modeling and validation through remote sensing. *In* Chapter 5, SEA–An Integrated Science Plan for the Restoration of Injured Species in Prince William Sound. T. Cooney (ed.). EVOS FY 1997 Annual Report.

McRoy, C.P. 1997. Sound ecosystem analysis: phytoplankton and nutrients. *In* Chapter 3, SEA–An Integrated Science Plan for the Restoration of Injured Species in Prince William Sound. T. Cooney (ed.). EVOS FY 1997 Annual Report.

Mooers, C.N.K. and J. Wang. 1998. On the implementation of a 3-D circulation model for Prince William Sound, Alaska. *Cont. Shelf Res.*, 18: 253–277.

Niebauer, H.J., T.R. Royer, and T.J. Weingartner, 1994. Circulation of Prince William Sound, Alaska. *J. Geophys. Res.*, 99: 14,113–14,126.

Stokesbury, K.D.E., E.D. Brown, R.J. Foy, and B.L. Norcross. 1997. Juvenile herring growth and habitats. *In* Chapter 11, SEA–An Integrated Science Plan for the Restoration of Injured Species in Prince William Sound. T. Cooney (ed.). EVOS FY 1997 Annual Report.

Thomas, G.L., K. Jay, G. Steinhart, and N. Peters. 1997. Nekton-plankton acoustics. *In* Chapter 10, SEA–An Integrated Science Plan for the Restoration of Injured Species in Prince William Sound. T. Cooney (ed.). EVOS FY 1997 Annual Report.

Vaughan, S.L. C.N.K. Mooers, J. Wang, S.M. Gay, and L.B. Tuttle. 2000. Physical processes that influence the biological components of Prince William Sound (submitted to the SEA Synthesis Volume)

Wang, J. and M. Ikeda. 1996. A 3-D ocean general circulation model for mesoscale eddies-I: meander simulation and linear growth rate, *Acta Oceanologica Sinica*, 15: 31–58.

Wang, J., C.N.K. Mooers, and V. Patrick. 1997. A three-dimensional tidal model for Prince William Sound, Alaska. *In* Computer Modelling of Seas and Coastal Region III, J.R. Acinas and C.A. Brebbia (eds.), Computational Mechanics Publications, Southampton, pp 95–104.

Wang, J., V. Patrick, J. Allen, and M. Jin. 1999a. Modeling seasonal ocean circulation of Prince William Sound, Alaska using freshwater of a line source. *In* Computer Modelling of Seas and Coastal Region IV, C.A. Brebbia, et al. (eds.), Computational Mechanics Publications, Southampton (in press).

Wang, J., M. Jin, V. Patrick, J. Allen, C. Mooers, D. Eslinger, and T. Cooney. 2000. A simulation of the seasonal ocean circulation patterns/regimes of Prince William Sound, Alaska, 1996. *Fisheries Oceanography* (SEA Synthesis Volume; conditionally accepted).

Approved TC 8-3-00

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$0.0						
Travel		$0.0						
Contractual		$133.2						
Commodities		$0.0						
Equipment		$0.0						
Subtotal		$133.2			Estimated	Estimated		
General Administration		$9.3						
Project Total		$142.5						
Full-time Equivalents (FTE)		1.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY01

Prepared:

Project Number: 01389
Project Title: 3-D Ocean State Simulations for Ecosystem Applications from 1995-1998 in Prince William Sound (PWS), AK.
Agency: Alaska Department of Fish and Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001						
Personnel		$43.7						
Travel		$2.2						
Contractual		$52.1						
Commodities		$0.9						
Equipment		$12.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal		$110.9			Estimated	Estimated		
Indirect		$22.3						
Project Total		$133.2						
Full-time Equivalents (FTE)		1.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

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

Student personnel costs include non-resident tuition of $5,868 per year.

FY01

Prepared:

Project Number: 01389
Project Title: 3-D Ocean State Simulations for Ecosystem Applications from 1995-1998 in Prince William Sound (PWS), AK.
Name: Jia Wang

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 2000
M. Jin	Research Assistant Professor		6.0	4.8		28.8
TBA	Graduate Student		9.3	1.6		14.9
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		15.3	6.4	0.0	
					Personnel Total	$43.7

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 2000
R/T Fairbanks to San Francisco (AGU Meetings)		0.6	1	4	0.2	1.4
R/T Fairbanks to Anchorage		0.5	1	3	0.1	0.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$2.2

FY01

Prepared:

Project Number: 01389
Project Title: 3-D Ocean State Simulations for Ecosystem Applications from 1995-1998 in Prince William Sound (PWS), AK.
Name: Jia Wang

FORM 4B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUST OUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed
Description	FY 2000
Subcontract: Alaska Digital Graphics	52.1
Contractual Total	$52.1

Commodities Costs:	Proposed
Description	FY 2000
Project Supplies (Telephone, Copying, Postage, Etc.)	0.9
Commodities Total	$0.9

FY01

Prepared:

Project Number: 01389
Project Title: 3-D Ocean State Simulations for Ecosystem Applications from 1995-1998 in Prince William Sound (PWS), AK.
Name: Jia Wang

FORM 4B
Contractual & Commodities DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 2000
Workstation/Server	1	12.0	12.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$12.0

Existing Equipment Usage:	Number
Description	of Units

FY01

Project Number: 01389
Project Title: 3-D Ocean State Simulations for Ecosystem Applications from 1995-1998 in Prince William Sound (PWS), AK.
Name: Jia Wang

FORM 4B
Equipment
DETAIL

Prepared:

Approved TC 8-3-00

Cook Inlet Information Management/Monitoring System

Project Number:	01391
Restoration Category	Monitoring
Proposer:	ADEC/ADNR
Lead Trustee Agency	ADEC/ADNR
Cooperating Agencies	USEPA, USGS, USFS, ADF&G
Alaska SeaLife Center	N/A
Duration:	1 Year (3rd year of 3-year project) December 1999 – September 30, 2001
Cost FY 01:	$239.0
Geographic Area	Cook Inlet
Injured Resource/Service:	All

ABSTRACT

The Cook Inlet Information Management/Monitoring System (CIIMMS) will permit a wide range of users with the opportunity to share and access valuable information and data about the Cook Inlet watershed and Cook Inlet-related projects and activities. CIIMMS potential users include educators, scientists, students, researchers, resource managers, private organizations and individual citizens. CIIMMS will provide an *interactive* website for the Cook Inlet community to efficiently and effectively contribute, identify, and access relevant information from a distributed network of providers. The CIIMMS website is at *http://www.dec.state.ak.us/ciimms*.

INTRODUCTION

The Cook Inlet Information Management/Monitoring System (CIIMMS), Project 99391 was funded in FY 99 to conduct a User Needs Analysis and develop a prototype system as an evaluation tool useful for development of a final set of system specifications. Deliverables associated with the FY99 effort include:

1. User Needs Analysis – completed February 28, 1999.
2. Identification and Preliminary Prioritization of Datasets – completed February 1999.
3. Prototype – completion date, September 30, 1999.
4. Preliminary System Specifications - completion date, January 15, 2000.

To ensure CIIMMS is a valuable tool for a diverse community of information users and providers, the CIIMMS Project Team conducted an extensive User Needs Analysis that included:

- Compiling a database of probable users and/or information suppliers.
- Distributing a comprehensive 60-question survey to all contacts in the database, compiling and analyzing the results.
- Conducting project briefings and discussion groups in communities and organizations in the watershed.
- Conducting follow-up interviews with various survey respondents and participants.

The investigations of the User Needs Analysis covered the following topics:

- Inventory of products and/or output generated.
- Future activities
- Information/data description
- Information processing.
- Vision or wish list for information management.
- Inventory of software, hardware, and telecommunications capabilities.

Information gained from these investigations was provided to participants at a User Needs Workshop held in January of 1999. Over 100 people attended the workshop to validate survey results and address the following design questions:

- What questions should CIIMMS address?
- Which users should CIIMMS accommodate?
- What information should be included in CIIMMS?
- What should CIIMMS accomplish (system functions)?
- What products should CIIMMS be able to generate?
- What system design should CIIMMS adopt?
- How can we make CIIMMS happen?
- What kind of user interface should CIIMMS have?
- What information should be included in CIIMMS?

The results of this extensive user needs analysis formed the basis for a pilot phase implementation plan, completed May 18, 1999. The implementation of the pilot phase focuses on short term priorities identified in the User Needs Analysis process in a limited geographic area, the Kenai River watershed (Appendix A: "The CIIMMS Prototype: Sample Web Pages"). Results of the user survey and workshop (Post Workshop Report) as well as the detailed *Pilot Phase Implementation Plan* (CIIMMS Implementation Plan) can be found on the CIIMMS web site at http://www.dec.state.ak.us/ciimms (see the *About CIIMMS* link).

Short-term (Year 1 and prototype) priorities included in the prototype:

- Categorical indexes for Cook Inlet information inventory
- Keyword and boolean searching capabilities
- Restoration project activities
- Ability to view, download, and print static maps and web documents (for not more than 10 priority data themes selected for use in the prototype)
- Data documentation (metadata) records linked to actual data and summary information (e.g., fact sheets)
- Hotlist of related offsite links
- Form for suggesting information and links to add to CIIMMS
- Data documentation (metadata) entry tool to populate CIIMMS

In the Initial Production Phase of CIIMMS (FY 00), with the prototype "framework" in place, the CIIMMS project team will focus on making additional datasets and information available to the CIIMMS community. The specifications for this phased-in approach to data and information integration will be implemented according to the specifications developed from the results of the prototype evaluation. Medium term priorities, as identified at the January 1999 user needs workshop (and refined with feedback gained from prototype), will be integrated into the CIIMMS system during FY 2000 (CIIMMS year 2).

Medium-term (FY2000) priorities include the following:

- Expansion of access to knowledge, information, and data, including traditional ecological knowledge, building on the datasets available via the prototype, to include data for various watersheds throughout the Cook Inlet basin (see Step 4 , page 11-12, for details);

- Expansion of search capabilities to include a tool to find different types of information for one geographic area (map based search tool); this may be a gazetteer, built according to the emerging standards for geospatial libraries (National Research Council, 1999).

- Expansion of the browse capabilities to include more refined categories, and a locational and originator browse tree;

- Refinement of User Interface to enhance navigation and ease of use in response to peer review comments and user input.

- Support the population of the FGDC-compliant metadata databases (state and federal) and CIIMMS database (non-FGDC-compliant metadata) for priority datasets for the watersheds throughout the Cook Inlet basin;
    - coordination with Alaska DNR and the ASGDC to get metadata training for the appropriate data providers (metadata training costs provided by separate Federal grant, awarded to ADNR in FY2000);
    - coordination with the EVOS Principle Investigators who have been involved with TEK projects as well as data collection within the Cook Inlet basin; to identify those data/databases which might be made available;

- Coordinate with the Alaska Geographic Data Committee (AGDC) on their work towards implementation of an on-line mapping tool;

- Refinement of data provider and contributor guidelines, in cooperation with the AGDC;

- Replace the search of the WorldCat database with a search of the Anchorage Municipal Libraries' server, which includes the ARLIS holdings, and all the EVOS project reports;

- Add the capability to search the UAF Library server when in becomes available early in 2000;

- Add the capability to search EPA's Envirofacts data warehouse (on-line access to environmental information from EPA databases on Air, Chemicals, Facility Information, Hazardous Waste, Superfund, Toxic Releases, Water Permits, Drinking Water, and Drinking Water Contaminant Occurrence, just to name a few)

- Add the capability to search the Capital City Library server, which includes the Alaska State Library, when it becomes available;

- Coordinate efforts by ADEC to develop an on-line water quality data management system, and make it accessible via CIIMMS;

- Outreach activities will include educating the stakeholders on the use of CIIMMS, as well as educating data providers on the steps necessary to make their data available, via the CIIMMS site, or preferably from their own server.

CIIMMS Long-Term Vision (FY2001 and beyond)

CIIMMS will mature into a geographically distributed decision support system with tools for data visualization and analysis and information synthesis. CIIMMS will provide a framework for collaboration, access to and sharing of data. As an information resource, providing access to both current and historical data and information, CIIMMS can contribute to the success of many

future projects within the spill area including the Gulf Ecosystem Monitoring project being funded with the Restoration Reserve.

CIIMMS cannot be realized overnight. As people benefit from CIIMMS, the incentive to contribute to CIIMMS will increase. Agencies will realize cost savings associated with the dissemination of information and distribution of data as more information and data is made available through CIIMMS. CIIMMS will provide a valuable tool for past and future EVOS funded efforts by providing access to data and information related to EVOS funded projects as well as providing a nexus for future research and restoration collaborations.

NEED FOR THE PROJECT

Statement of Problem

In most large, intensively used and managed watersheds, such as Cook Inlet, some stakeholders collect and analyze samples and generate data, while others rely on data to monitor resources, conduct research, or make management and policy decisions. Each year, industry, government, the scientific community and citizen watchdog groups generate and aim to use large quantities of information about the Cook Inlet watershed and its resources. This information may be used to focus on a single resource, issue, or problem, requiring data management techniques specific to that need. Watershed management, meanwhile, has a scope that requires evaluation of a much broader spectrum of factors within a defined geographic area. Watershed managers and other information users can't necessarily access data generated for more narrowly defined purposes.

Management and planning for development within these large areas calls for participation by federal, state and local governments as well as the public. Multiple stakeholders and scientists from many disciplines may be involved and need access to relevant data used in making and or reviewing management and policy decisions. Potential users of CIIMMS include Federal, State, borough, and municipal government agencies, industry, scientists, the environmental community, and public oversight groups with an interest or mandate to manage the watershed. Many of these entities have already generated datasets relevant to management of the watershed that may be considered for inclusion in the system.

Projects that are characterized by complex data relationships, such as recovery monitoring of species populations and ecological processes, need efficient data access, in order to *begin* the difficult task of integration and analysis. Currently, this is a difficult and time-consuming task. This is also true of ecosystem-level research projects, watershed management and monitoring, and planning and regulation of development activities conducted over large geographic areas. These activities become more efficient when relevant data is made accessible, through the CIIMMS search, and related, via the CIIMMS categorized browse capabilities. Managers are more likely to make decisions which benefit injured resources and services and their associated habitats if they can access data and information (primary or summarized) about resources and relationships between resources and proposed development.

B. Rationale/Link to Restoration

"Realistic ecological assessment" of the recovery of resources/services injured by the *Exxon Valdez* oil spill "requires long-term monitoring of salient patterns and processes at appropriate spatial and temporal scales using sound sampling design and statistical analyses" (Michener 1997). This strategy was echoed by the Chief Scientist (Spies 1997) in his description of a "...permanent, adaptive, interdisciplinary monitoring and research program that would track, and eventually help predict ecosystem changes, and provide a basis and mechanism for long-term restoration, enhancement, and wise management of marine resources in the northern Gulf of Alaska."

This plan is supported by the Trustee Council's increased emphasis on "integration and synthesis of what has been and is being learned from various restoration projects and the earlier work conducted during the damage assessment phase." As Stated in the Ecosystem Synthesis section of the 2000 RFP (Trustee Council 1999): "The integration and synthesis of project results will enable the Council, the scientific community, and the public to view the effects of the oil spill and the long-term restoration and management of injured resources/services in broad, ecological contexts. Having the benefit of these perspectives not only aids interpretation of past results in regard to injury and recovery, but also provides an improved framework for development of long-term restoration, research, monitoring, and management plans."

CIIMMS will contribute toward recovery of the *Exxon Valdez* oil spill injured resources and services by facilitating data sharing, resource management and planning within the Cook Inlet watershed. CIIMMS can make Trustee Council-funded research readily available to resource managers by improving access to information relative to injured resources/services and their habitats in the Inlet.

CIIMMS will help recovery of injured resources/services by facilitating management and monitoring efforts by providing:

1. access to more complete resource information for decision-makers and the public.
2. access to maps, publications, data, and *knowledge* pertinent to injured species' habitats, movement corridors and environmentally sensitive areas.
3. EVOS researchers and agency resource managers the ability to easily access and view a variety of information, data documentation (metadata) and datasets specific to the Cook Inlet watershed--where data covers the entire spill area, it will not be subsetted;
4. broad access to information used by regulators to help them review permit applications with recovery of injured resources/services in mind.
5. a framework for analysis capabilities by providing access to much of the relevant data within the watershed;
6. an easy tool for EVOS researchers and agency resource managers to contribute and share information on projects, reports, data, and funding sources, for coordination purposes.

C. Location

Design and development components of the project will take place in Juneau and Anchorage. Project benefits will be realized throughout the Cook Inlet watershed. Communities that may be affected by the project include Anchorage, Homer, Kenai, Nanwalek, Nikiski, Ninilchik, Port Graham, Seldovia, Soldotna, and Tyonek.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

To ensure that the proposed system will deliver the appropriate information in a format useful to stakeholders in the watershed and to ensure effective technical system implementation, a CIIMMS Advisory Group has been established to provide direction and feedback. This group will provide practical advice on design and implementation issues, and will help ensure that the system will remain usable in the future.

Membership of the advisory group was initially derived from an existing group, known as the Cook Inlet Coalition, and supplemented by representatives from other stakeholder groups. The Cook Inlet Coalition is an organization facilitated by EPA to encourage the exchange of information and coordinate management and research efforts in Cook Inlet.

By the end of CIIMMS' year two, the advisory group membership will be comprised of the following:

- A broad array of stakeholders to ensure that all potential users of CIIMMS information, from public citizens to government agencies, are represented
- Providers of spatial and non-spatial data (*all* data-providing and information-generating agencies and organizations should be represented, to the degree that this is possible)
- Providers of summary level information, such as public outreach materials
- Participants involved in all aspects of resource information management, from using information to creating databases.

The CIIMMS Advisory Group most recently met on November 18, 1999. During the later part of the Initial Production Phase, this group will need to develop stronger direction and more defined operating procedures, in order to ensure that the long-term vision of stakeholders is achieved. This group is currently chaired by a member of the CIIMMS Project Team.

Traditional Ecological Knowledge

A year two priority of the stakeholders which surfaced at the CIIMMS user needs analysis workshop was the need to provide a tool for collecting and accessing traditional ecological knowledge (TEK). The University of Alaska Institute of Social and Economic Research (ISER) has just created an on-line database of Alaska Traditional Knowledge and Native Foods. The databases cover the entire EVOS area and other locations statewide. It contains information on existing measures of contaminants in species of fish and animals harvested by Alaska Natives,

harvest and consumption data, nutrition data, descriptions of the role of harvest and Native food consumption in communities, and examples of community projects taken in response to concerns about environmental change. CIIMMS is currently negotiating with the ISER project team to coordinate the long-term access to and growth of these databases. CIIMMS is also ideally suited to provide tools to involve the Cook Inlet community in contributing their own traditional ecological knowledge to the ISER databases.

A. Objectives

The CIIMMS' objective is to provide a way for the Cook Inlet community (resource managers, scientists and researchers, educators, students, industry, and individual citizens) to identify, share and access, and contribute (on-line) valuable knowledge, information, and data about the Cook Inlet watershed from a distributed network of data resources and information providers.

B. Methods

The method and tasks outlined below encompass the design and further development of a web-based information system, utilizing a hybrid centralized/distributed database design for both primary data and summarized information. Metadata for non-geospatial data, including project documentation, and geospatial data with no existing FGDC-compliant metadata, will reside primarily on the CIIMMS site, in abbreviated form. FGDC-compliant geospatial metadata created as a result of the CIIMMS project will be stored and accessed on one of the two Alaska clearinghouses, currently in existence for that exact purpose.

The proposed approach for implementing the Initial Production Phase (FY2000) of the Cook Inlet Information Management/Monitoring System includes the following steps:

Step 1: Further iterative evaluation and revisions to CIIMMS prototype (deliverable 99391).

Step 2. Review preliminary system specifications (deliverable 99391).

Step 3: Initial Production Phase implementation plan including long term operations and maintenance strategic plan (FY 00).

Step 4: Apply prioritization model for access and documentation of datasets (FY 00-01).

Step 5. Finalize data documentation and data access processes (FY 00).

Step 6: Provide guidance and documentation assistance to CIIMMS' data providers (FY 00-01).

Step 7: Expand number of distributed sites for access, including the Cook Inlet watershed (FY01).

Step 8: Design, develop and deploy geographically-based query tools (FY 00-01)

Step 9: Develop a long range implementation and maintenance plan (FY 00-01).

Step 1. Further iterative evaluation and revisions to CIIMMS prototype – complete.

Evaluation of the prototype developed as part of FY 99, 99391 continued through the first quarter of FY 00 in order to ensure that a large cross-section of the user community was given the opportunity to provide feedback. Training of potential users and subsequent evaluation of prototype functionality was carried out by staff of DNR, DEC, and Cook Inlet Regional Citizen's Advisory Council.

The following workshops or meetings were held by CIIMMS project team members, or attended by team members, for the purpose of educating users and obtaining feedback from stakeholders:

DATE	FUNCTION
September 17, 1999	Cook Inlet RCAC Quarterly Meeting, CIIMMS Overview, Kenai
September 24, 1999	CIIMMS Prototype Open House, Kenai Peninsula College, Kenai
September 25, 1999	CIIMMS Prototype Open House, Kachemak Bay University, Homer
October 13, 1999	Preliminary demo at Restoration Office, Anchorage
October 14, 1999	EPA Indian Grants Assistance Training, Anchorage
October 15, 1999	CIIMMS Prototype Open House, Anchorage
October 21, 1999	Interagency Hydrology Committee Meeting, CIIMMS demo, Anchorage
October 22, 1999	CIIMMS Prototype Open House, Juneau
October 26, 1999	EVOS Public Advisory Group, CIIMMS demo, Anchorage
November 3, 1999	Alaska Oil & Gas Association meeting, CIIMMS demo, Anchorage
November 9, 1999	Cook Inlet Oceanography Workshop, CIIMMS demo, Kenai
November 18, 1999	CIIMMS Advisory Group/Cook Inlet Coalition demo, Anchorage

The development and evaluation of the prototype has involved numerous reviews by project participants. Throughout this iterative process, deficiencies were identified and enhancements incorporated into the final system specifications. In addition, the site itself provides interactive tools for users to provide feedback to the CIIMMS project team. The CIIMMS project team is continually evaluating user feedback and responding to their constituents. Appendix B provides a summary of the results of these evaluation sessions.

Step 2. Review preliminary system specifications.

The preliminary system specification (entitled "Pilot Phase Implementation Plan,") developed as part of project 99391, was posted on the CIIMMS web site for review and comment by the user community. Preliminary system specifications matured into "DRAFT - Initial Production Phase Implementation Plan," February 28, 2000 available on the CIIMMS web site for review. http://www.dec.state.ak.us/ciimms/project/impplan2000.pdf. Following feedback and review, it is expected that the final Initial Production Phase Implementation Plan will be completed by June 1, 2000.

Step 3. Initial Production Phase Implementation Plan.

After short-term functions are accepted in the pilot phase (see Appendix A: "The CIIMMS Prototype: Sample Web Pages"), the Initial Production Phase will be implemented. This phase will occur between December 16, 1999, and April 15, 2001. During this phase, all short- and medium-term functions will be operational for the entire Cook Inlet watershed (see pages 3-4 for listings of short-, medium and long-term priorities).

The CIIMMS design will employ a hybrid centralized/distributed system, more centralized in the prototype stage, and then migrating towards a more distributed design in year two and beyond. In the Pilot Phase (FY99), a few distributed sites were made accessible via CIIMMS. Examples of these are the Alaska DNR's WELTS database, which was made accessible via an SAIC server (in Virginia), both the Alaska geospatial data clearinghouses (one is at USGS in Anchorage, the other is at ADNR in Anchorage), as well as a server at Alaska Department of Fish & Game, where the 1998 Anadromous Streams and Anadromous Species datasets have been made accessible, and downloadable. As soon as the ARLIS server is operational, the ARLIS holdings will be searchable via CIIMMS. As more and more agencies and organizations become successful at providing access to their own data and information using new web technologies, CIIMMS will provide the 'front door' search and browse tools, as well as guidelines and technical support, to enable access to these data providers' sites. The pioneer sites, made accessible via the CIIMMS Prototype, will provide guidance to organizations interested in making data and information available via CIIMMS.

As part of the Production Phase Implementation Plan, a strategic plan for the long term operation and maintenance (O&M) of CIIMMS will be developed. This plan will address maintenance of the system, and transferring, relating, integrating and updating data or metadata over the long run. The plan will include staffing, training, hardware and software, application and networking recommendations. Finalization of the plan will take place at the end of the production phase (April 2001).

Data and information provided via CIIMMS is provided on an 'as is' basis. After the data within the Cook Inlet basin has been identified, and made accessible, the work on data visualization, and ultimately, data analysis, can begin. The work on data visualization and analysis is beyond the scope of CIIMMS in the first two years, since the first steps are to identify and make accessible all relevant data.

Step 4. Apply prioritization model for access and documentation of datasets (FY 00-01).

Workshop discussions confirmed that there are a wide range of individuals, organizations, academic institutions, and government agencies that contribute to and use Cook Inlet information. This diverse user group generates and seeks access to all levels of information, including public documents, research and management documents, summarized public documents, processed or summarized data, and primary data.

The CIIMMS year two data access strategy will determine data priorities using the data priorities document generated with findings from the User Needs Questionnaire, and later prioritized by the User Needs Workshop participants (see Appendix C: "CIIMMS Information Priorities"). Using this list, the project team will further rank these datasets for inclusion, using the following criteria:

- Importance to the success of the project
- Resources needed to acquire the data
- Effort required incorporating the data in CIIMMS
- Update/long term maintenance requirements
- Geographic extent

These ranking criteria will be applied to the data sequentially, and used to create a prioritized list of data and data types for inclusion in CIIMMS. Using the prioritization scheme as guidance, access to the data and information will be incorporated into CIIMMS.

Throughout this process, the CIIMMS website will be used to poll users on current data needs, to be sure we are still in step with stakeholders' requirements. Following is a list of some of CIIMMS data priorities, organized by source:

FY 00

- EVOS-funded project data, or data documentation, first priority is Cook Inlet, but where PWS and Kodiak/Alaska Peninsula EVOS project data can be added with little incremental cost, we will do so;
- Offer long-term access and update solutions, via CIIMMS, to the new Traditional Knowledge/Native Foods database, initiated by the University of Alaska Anchorage Institute of Social and Economic Research
- Expansion of the CIIMMS project database to include entry of more on-going projects across the entire Cook Inlet;
- Provide on-line discovery and/or access to the Matanuska-Susitna Borough's data, via CIIMMS on-line data documentation tools;
- Provide on-line discovery and/or access to Minerals Management Service extensive marine resources data for the Cook Inlet, via the CIIMMS on-line data documentation tools;

FY 01

- Continue support to ADF&G for access to high priority datasets (habitat, EVOS data, etc), via their server, through CIIMMS;
- ADEC's Underground Storage Tank database*;
- ADEC's Solid Waste Sites database*;
- ADEC's Contaminated Sites database*;

**CIIMMS will provide on-line access to these ADEC databases, but actual development and maintenance of these systems is the responsibility of the ADEC.*

Step 5. Finalize Data Documentation and Data Access Processes (FY00-01).

Metadata, or data documentation, standards for geospatial data have already been established by the FGDC (Federal Geographic Data Committee). These standards are time consuming, and require a considerable effort by the data provider to complete, for each dataset. The CIIMMS project proposes to help data providers as much as possible with this daunting task, and to work in cooperation with the Alaska State Geospatial Data Clearinghouse and DNR to target the appropriate data providers with training and funding (from FGDC metadata grants) to complete metadata for key datasets. Beyond this, the CIIMMS site now provides an on-line metadata entry tool for entering a brief set of information on a particular dataset, strictly for the purpose of making that dataset discoverable. This could be the first step in determining what data people want access to, to help us prioritize where metadata creation efforts would best be focused. Automated counting mechanisms will be put in place on the CIIMMS site to keep track of what metadata (and therefore datasets) are the most sought after.

Data documentation and data access procedures will be presented in the form of guidelines for data providers and stakeholders. The guidelines will include, but not be limited to, the following:

1) different types of metadata entry tools available on-line, via CIIMMS;
2) ways to make your data or information (including websites) accessible via CIIMMS (this will include a set of metatag standards, developed by the Dublin Core, specific to websites);
3) explanation of different ways to make your data or information downloadable, or accessible on-line (including spatial data downloads, or making spreadsheets or databases query-able or accessible on-line);
4) hardware and software requirements for above options;

The above guidelines would include cost estimates to the data provider, including set-up time, hardware and software costs, etc. Based upon user needs and input, project staff will adopt standards for process and content as required to meet user needs. The CIIMMS Advisory Group will provide ongoing review and feedback as guidelines are developed. These guidelines will set a target for data providers to meet.

Step 6. Provide guidance and data documentation assistance to CIIMMS' data providers (FY00-01).

Using the CIIMMS web-accessible data documentation tools, the project team and strategic members of the CIIMMS Advisory Group will provide training, and data documentation entry services where needed in order to populate the CIIMMS database. Where FGDC-compliant metadata for geospatial datasets are created, they will be uploaded to the AGDC (Alaska Geospatial Data Clearinghouse) or ASGDC (Alaska State Geospatial Data Clearinghouse), whichever is deemed appropriate.

A considerable effort will be made by the CIIMMS project team to document non-digital data, so that it may be made discoverable via CIIMMS. Guidelines will be provided (see Step 5, page 12),

as well as technical assistance where necessary, to help make summarized information, as well as priority data sets, accessible via CIIMMS.

Step 7. Expand number of distributed sites for access (FY00-01).

Primary and high priority datasets that are in compliance with documentation, either FGDC-compliant, or using the CIIMMS brief on-line documentation tool, will be made accessible to the system. Other compatible datasets, accompanied by documentation files, will be linked to the system as time and budget constraints allow. Updates to existing datasets and new datasets will be evaluated and brought into the system over time.

Project participants recognize the complexity of data management tasks including data cleanup, QA/QC, conversion, integration and documentation. The CIIMMS project team will focus on the identification, data access and data documentation part of the entire data management process, keeping in mind that these processes will help facilitate the creation of standards, and eventually integration. It is reasonable to expect that a substantial effort may well be invested in these activities. Responsibilities for data cleanup, QA/QC, and conversion activities rest with the data provider. The estimated budget provides conservative controls on identification, access, and data documentation efforts.

Step 8. Design, develop and deploy geographically-based query tools (FY00-01).

Cook Inlet stakeholders have expressed the need for a map-based "area of interest" tool to aid in the search for CIIMMS' data and information. Gazetteer or map-based tools make it easier for all types of users to find data, data documentation (metadata), and information in the web environment. These queries will allow the user to define an area of interest based on several different spatial techniques, such as:

- Map interface with user ability to draw a rectangle to depict area of interest;
- Place name search (using USGS geographic place names database);
- Clickable maps with various known boundaries (start with watershed boundaries or HUCs, and then expand to township/range, USGS quadrangles, etc.).

The CIIMMS approach to the geographically-based (or map-based) query is similar to the gazetteer approach implemented by the Alexandria Digital Library. The gazetteer is a list of geographic names, together with their geographic locations and other descriptive information. We define the minimum components of a gazetteer entry as (1) a geographic name, (2) a footprint or geographic location represented by coordinates and (3) a type designation (i.e., city, hydrologic feature, etc.). With these attributes, the gazetteer can function as a tool for indirect spatial location identification through names and types. An example of a gazetteer is the USGS Geographic Names Information System (GNIS).

The gazetteer will support several functions of a map-based query for data and information:

- It will answer the question, for example, "What data and information are available for the Kenai River Watershed?"

- It will translate between geographic names and locations so that a user can locate metadata and information by matching the footprint of a geographic name to the footprints of the metadata, or data documentation.

- During metadata creation, it will allow a user to locate particular types of geographic features in a designated area, and pass these as keywords to the metadata.

The map-based query tool will provide a front-end to the CIIMMS middleware component (Blue Angel Technology Metastar Enterprise) that provides multiple clients with a uniform view of multiple heterogeneous metadata servers. The CIIMMS principal mechanism by which this uniform view is achieved is as follows:

- Clients formulate queries in terms of keywords.
- The middleware server translates and forwards queries to the metadata servers.
- Metadata servers are responsible for evaluating the queries in ways that are meaningful for their respective collections.

The overall implementation characteristics of the proposed CIIMMS map-based query tool are:

1. A conceptual set of contents (e.g., "any geographic locations or regions associated with collection items");
2. A set of allowable representations for the contents (using a phased approach, begin with clickable watershed boundaries, and time and funding permitting, proceed with user-defined rectangles, township/range boundaries, etc.);
3. A set of query operators (e.g., overlaps and contains); and
4. A name (e.g., geographic location) that uniquely identifies the geographic feature and its conceptual contents, allowable representations, and query operators.

Step 9. Finalize Long Term Operation and Maintenance (O&M) plan (FY00-01)..

Finalization of the long term operations and maintenance plan, as outlined in the Production Phase Implementation Plan (see Step 3, page 10-11). Deliverables associated with Step 9 include CIIMMS Long Range Implementation and Maintenance, System Documentation, and On-line Help tools.

ADEC has committed to the long-term maintenance of the information management/monitoring system subsequent to completion of this project. To this end ADEC has committed the following hardware and software resources to this project at a cost of $25,000. The CIIMMS Database Server is a Compaq 2500 SQL Server with three 9 gigabyte SCSI Drives (RAID5) and 128 Megabytes of memory. The CIIMMS Internet Server will be a Compaq with three 4.5

gigabyte SCSI Drives (RAID5) and 128 Megabytes of memory. Both systems are backed up nightly. The system is housed at the Alaska Department of Environmental Conservation in Anchorage, Alaska. The operating system for the CIIMMS Database Server is Windows NT. The CIIMMS metadata database will be developed in Microsoft SQL Server 7.0. The Internet Server runs Microsoft's Internet Information Server (IIS) on Windows NT. In addition to CIIMMS these servers run additional ADEC processes. Both servers will be monitored to ensure that there is adequate capacity to handle the growth of CIIMMS, and incremental upgrades will be made as needed.

The ADNR Commissioner has committed the agency to maintaining the associated geospatial coverages supporting this application as part of their on-going role in maintaining a National Geospatial Data Clearinghouse node at ADNR. Staff have been identified to work directly with the contractor to ensure that a complete understanding of the system resides with the agencies and that long-term maintenance requirements are reasonable and within the budgetary scope of each agency.

Regarding database maintenance, "metadata" housed on the CIIMMS server will be maintained by the ADEC as part of ADEC's long term maintenance of the system. Any data being housed by CIIMMS will eventually be migrated to its owner's server, and as CIIMMS evolves to a more distributed system, distributed databases accessed by CIIMMS will be maintained by the agencies serving the data.

In addition, the project team will pursue through the CIIMMS Advisory Group the creation of a cooperative relationship with participating state and federal agencies, municipal entities and other organizations designed to foster the ongoing development and maintenance of CIIMMS. Through this cooperative relationship, the project team will pursue financial contributions in relationship to services provided for long term development efforts.

The project team is currently pursuing grant funding for future development efforts. Potential funding sources include EPA 319 grant program, the USGS, FGDC grant cycle, MMS grant cycle, the Global Disaster Information Network (GDIN), as well as other funds established through federal court settlements.

C. Cooperating Agencies, Contracts and Other Agency Agreements

The Alaska Department of Environmental Conservation and the Alaska Department of Natural Resources will be jointly responsible for project implementation, drawing upon the expertise within each agency. Both agencies will work cooperatively with technical consultants in the areas of hardware and software upgrade requirements, data acquisition and translation support, application development, and staff training. ADEC will focus primarily on maintenance of the CIIMMS website and server, development and incorporation of DEC databases for access by CIIMMS, and water quality issues and database design. ADNR will lend assistance in the areas of geo-referenced data issues, visualization tools, and resource management issues.

ADEC will assist the technical contractor in the design and development of the relational database engine. In keeping with its objective to develop a statewide watershed approach, ADEC will operate and maintain the information-monitoring system subsequent to completion of this project. This long-term commitment will allow the Trustee Council, the scientific community, resource managers and the public to access information on the recovery of injured resources and services.

ADNR has established a National Geospatial Data Clearinghouse node at the Alaska Department of Natural Resources. The "Alaska State Geospatial Clearinghouse" (ASGDC) has provided an electronic pathway to meet public and inter-agency demands for state and local geospatial data. Data is documented according to the FGDC requirements to ensure consistency and discovery on line. The ADNR Clearinghouse project focuses on and will complement the Alaska Geographic Data Clearinghouse (AGDC) site developed and maintained by USGS. (The CIIMMS search tools will access geospatial metadata from both clearinghouses.)

Alaska Department of Fish & Game (ADFG) will participate with the CIIMMS project in order to incorporate critical habitat areas data, including EVOS related data: oil samples, stream surveys, fish surveys, etc. Many of these datasets were identified during the User Needs Analysis Workshop as high priorities. Efforts to get ADFG data into a format that's compatible with public access via CIIMMS include metadata creation, 'gatekeeper' scripts (for monitoring access) and web accessibility. A significant effort will be made to incorporate the Alaska Habitat Management Guides for Cook Inlet. The Regional Guides are one of the most comprehensive sources of historic fish and wildlife information available. The Regional Guides provide detailed information in mapped and narrative form describing select fish and wildlife species' life functions and habitat requirements, geographical distribution, and human uses of fish and wildlife. ADFG data that was published on the EVOS Research and Restoration CD-ROM, along with other EVOS data (seabirds, bald eagles, sea otters etc.) will be made accessible through the ADNR Alaska State Geospatial Data Clearinghouse.

As a member of the CIIMMS project team, US Geological Survey (USGS) will chair the CIIMMS Advisory Group, ensuring there is a bridge between technical, management, and end-user concerns. They will provide technical and practical assistance in system design, implementation, and will help ensure that the system will remain usable in the future. USGS water databases are being made available, via the web, in the early part of 2000, and will be made accessible by CIIMMS as well.

As a collaborator on the project, EPA will provide technical assistance in system design as well as access to the EPA Contractor responsible for designing similar systems in other states. As part of the overall EPA and ADEC objective of a statewide watershed approach, emphasis will be placed on assuring that the project is complementary to the concept of a state-wide "Environmental Information Clearinghouse." EPA will also serve as the facilitator for involvement in the project of other Federal natural resource agencies and will contribute its organizational and leadership skills to ensure continued Cook Inlet Coalition and the CIIMMS Advisory Group involvement. EPA has also agreed to make all of its Water Quality and Permits

databases (Permits and Compliance System) available to the Cook Inlet Information Management/Monitoring System.

The US Forest Service will provide technical assistance in project design in order to ensure agency concerns and project compatibility issues are addressed. USFS will contribute staff resources as needed to address management and scientific needs of the agency in the development of this project.

A consultant will be utilized to refine the CIIMMS site, based on the medium term priorities discussed previously. We are working with EPA and will continue to utilize Science Applications International Corporation (SAIC), a National Contractor under contract to EPA with extensive experience in projects of this nature. Similar projects have been implemented by this contractor in Colorado, Montana, Chesapeake Bay, Arizona, and Jordan.

SAIC will build final system specifications, develop and implement a map-based search tool (see Step 8, Page 13), implement access to certain distributed data systems, and will build enhancements to the user interface and access tools. Where applications can be purchased off-the-shelf, CIIMMS will do so, in order to ensure that future upgrades to the system are automatic, and not dependent on the contractor. This strategy will ensure that contractual dollars are spent on areas where the contractor already has extensive experience, enabling us to benefit from knowledge and products they have developed elsewhere. This strategy will also ensure that project development goes beyond a single agency approach. Alaska agency staff familiar with the data, its limitations, location, and structure will be responsible for most routine data management tasks as well as local coordination and dissemination of information. Agency staff is closely involved in application development, data integration and user interface development, in order to ensure that maintenance of the system can be accomplished without contractor support.

SCHEDULE

Initial Production Phase (Year 2 and 3)
Measurable Project Tasks for FY 2000 (December 15, 1999 – September 30, 2000)

December 1999	Initial Evaluation of CIIMMS prototype complete. (Step 1, page 8)
December 1999	Review of Preliminary System Specifications. (Step 2, page 10)
January 2000	Finalize System Specifications and Implementation Plan (Step 3, page 10)
January 2000	Begin Implementation of Final System Specifications. Initiate integration of prioritized databases, related information and associated metadata (documentation); continue agency staff training as an ongoing evaluation tool. (Steps 4-8, pages 11-14)
July 2000	Refinement of User Interface
January 2001	Access to specified databases completed. Data documentation (metadata) completed.
February 2001	Develop On-line User Help, Technical Specifications/System Documentation, including Long-Term Maintenance. (Step 9, page 14)
March 2001	Public outreach.
April 2001	Completion of Initial Production Phase of CIIMMS
September, 2001	Completion of Final Report

Project Milestones and Endpoints

Initial Production Phase (Years 2 and 3)
(FY 99 October 1, 1999 to September 30, 2001)

December 1999	Preliminary System Specifications Due.

January 2000	Final System Specifications and Implementation Plan Due (including Long Term Operation and Maintenance (O&M) Strategic Plan.
July 2000	Refinement of User Interface
January 2001	Integration/Access to databases, information and metadata, etc.
February 2001	On-line User's Manual and Technical Specifications/System Documentation (including Long Term Operation & Maintenance (O&M) plan).
March 2001	Public Outreach.
April 2001	Completion of Initial Production Phase of CIIMMS
April 30, 2001.	Project Complete
September 2001	Final Report Due.

NORMAL AGENCY MANAGEMENT

Resource agency management mandates in the Cook Inlet watershed do not specifically address recovery monitoring or management of injured resources/services or their habitats. Only projects that have been funded by the *Exxon Valdez* Oil Spill Trustee Council have focused on injured resources and services as an objective. Although pollution tracking, permitting, and regulatory activities are normal agency management activities, they are not carried out with the benefit of research specifically addressing injured resources and associated services.

Agency regulatory actions are generally focused on single resource management strategies or individual project implementation. These actions are not necessarily focused on watershed management. Ecosystem or watershed-level management requires access and integration of a diverse array of data from disparate sources. In order for agencies to consider the impact of management and regulatory actions on injured resources and services and their associated habitats, the agencies must be able to integrate and utilize the data and information collected about these resources. Agencies do not normally consider, or have the capability to consider, the impact of management and permitting decisions on injured resources and services.

A comprehensive approach to restoration of injured resources/services with habitats in Cook Inlet would include not only affected species populations, but also consideration of relevant ecological elements on a watershed scale. From a technical perspective, management at the watershed level allows for evaluation and control of pollution and development impacts that would affect recovery of injured resources/services.

In the case of land managers responding to requests for permits in Cook Inlet tidelands, as required by statute, the CIIMMS would allow staff to access, and eventually view existing human uses in the area as well as information concerning habitats of injured resources and services. A decision could be made that factors in the potential impact such an activity could have on injured resources or services. If the location requested by the applicant is deemed unsuitable, state law requires that an alternative must be located or proposed. CIIMMS could be used to direct permitting toward less sensitive areas.

Internet access to data and information used by agencies for permitting and planning decisions would allow the public to become better informed and thereby better able to comment and provide input to federal and state decision-makers. At the present time it is very difficult for the public and even individuals in other government agencies to locate and access data and information even though the agencies are obligated to make this information available, i.e. FOIA requests.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Key Principal Investigators will be surveyed and asked to evaluate and test the system for usefulness and the ability to accommodate results of their research. It is extremely important that key information derived from EVOS studies be included in this system if end users are to be able to include information relative to injured resources and services in their decision making processes. In addition, coordination with SEA, APEX and NVP, will avoid duplication of effort and ensure that pertinent data and information from those projects can be incorporated into this system.

A project funded in FY00 entitled "An Evaluation of the Data System for the Long Term Monitoring Program," will benefit from the framework built by CIIMMS. As year two progresses, CIIMMS can provide access to the resources available in the Cook Inlet and other parts of the spill area. Access to this data will be necessary for a complete and thorough evaluation to take place. The collaboration of the CIIMMS project team with the principle investigators on the above mentioned project is ongoing.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

Based on results of the User Needs Analysis phase of CIIMMS, which included the January 1999 User Needs Workshop, the scope of this project has been narrowed to address more specific needs of Cook Inlet users with regard to *access* to data *and information*, as opposed to the actual *integration* of data.

The CIIMMS vision is to enable a wide-range of users (not just scientists and agency personnel) to share and access valuable information about the Cook Inlet watershed and Cook Inlet-related activities. Available information will range from primary data (geospatial, tabular) to reports,

project descriptions, and other documents across a variety of themes, such as habitat, land-use, resource management, pollution, and water quality. CIIMMS will provide an interactive website for the Cook Inlet community to efficiently and effectively contribute, identify, and access relevant information from a distributed network of providers.

One of the goals of CIIMMS in FY2000 is to evolve to a more distributed system. With respect to visualization tools and geographic data, the technology to achieve this capability, in a distributed environment, is beginning to emerge as the standards developed by the Open GIS Consortium (OGC) are realized by the major software vendors. The implementation of these OGC standards will enable web-based mapping systems to integrate local geospatial data with data served on the Internet. The AGDC is currently conducting an effort to implement this web-based map server technology. The CIIMMS project team and the AGDC exchange information on a routine basis, thus, as this effort moves forward and agencies begin to serve GIS data according to OGC standards, CIIMMS will aim to provide access to this data through commercial-off-the-shelf (COTS) visualization tools.

This process of accessing information and building a distributed network of data/information providers, via the web, is an iterative one. There is a plan, but the practice of adaptive management will be crucial to the success of CIIMMS. We must be open to user input, changes in technology, and able to alter, within reason, the specifications put forth in this document.

PRINCIPAL INVESTIGATORS

Jeff Hock

Jeff Hock has a Bachelor's degree in Environmental Sciences from the University of Virginia with significant coursework in civil engineering. He has been employed in various capacities with the State of Alaska since 1975 with both the Alaska Department of Fish & Game ('75-79) and the Department of Environmental Conservation ('79-Current). He currently manages the development and implementation of the Air & Water Quality Data & Monitoring statewide database program. Mr. Hock's past responsibilities include developing and implementing ADEC's watershed approach by working with local stakeholders, and participating on various statewide water quality planning committees. He was involved in the design and implementation of a variety of monitoring projects and has extensive ADEC experience in quality assurance, project plan development and review, and sampling methodology. He was instrumental in exploring and implementing new technologies within ADEC including modeling software, rapid bioassessment protocols, satellite telemetry, global positioning technology, geographic information systems, and automated water quality data acquisition and telemetry systems.

Russell Kunibe

Russell Kunibe has an MS and BS in Physiology from UC Davis and has 9 years of experience with the Department of Environmental Conservation both as an Environmental Specialist and as an Analyst Programmer. He is currently responsible for CIIMMS coordination within ADEC, and is the CIIMMS database administrator. In addition, he coordinates all work of technical nature on the CIIMMS website. He has served as the department representative to the Statewide GIS committee and Webmasters committee, and was responsible for the initial development of the ADEC website. He has managed the Spill Prevention and Response Division's data management tasks.

In addition Mr. Kunibe has a working knowledge of the Cook Inlet and Prince William Sound areas. He successfully owned and operated his own commercial fishing, boat charter, and dive shop businesses in Homer prior to the *Exxon Valdez* Spill. During the response to the *Exxon Valdez* Spill, Mr. Kunibe managed the DEC Field Office in Homer.

Kelly Zeiner

Kelly Zeiner has a Master of Science in Spatial Information Science and Engineering from the University of Maine, Orono, and a Bachelor's Degree in Management Information Systems from Northeastern University, Boston, MA. She has extensive experience with Arc/Info, ArcView, and a variety of programming languages (AML, DIBOL, COBOL, BASIC) and computer operating systems (UNIX, Windows). As part of her graduate program she designed and taught a series of 3-day ArcView/Avenue course exercises and lectures at the University of Maine. This

experience is invaluable in communicating with potential system users, managers, and scientists and interpreting and understanding their information and analytical needs. She is currently responsible for coordinating the work of the CIIMMS project team, and most aspects of outreach on the CIIMMS project.

Prior to her experience with ADNR, Ms Zeiner was employed for five years in the private sector and worked in business programming application development. Responsibilities related to programming included user needs analysis, systems design, coding, testing, and implementation of new and in-place applications.

Ms. Zeiner has been employed at DNR since 1992 and has extensive experience with *Exxon Valdez* Oil Spill data and project demands. Final products of her work on EVOS related projects include applications ("EVOS Oil Spill Research & Restoration Information Project"), maps, slides, and reports on analyses performed. Ms. Zeiner has also designed and built a prototype application using ArcView 3.0 for viewing and querying ADNR's statewide parcel-level database, including an SQL connection to a massive land records database. In addition, Ms. Zeiner has designed a prototype application based on the State of Florida's Oil Spill Contingency Planning tool using ArcView 3.0 adapted for use in the State of Alaska.

Leslie Patrick

Leslie Patrick has an MS in Science Management and BS in Geology from the University of Alaska. She has been employed in various capacities with the USGS since 1975. Many of her current responsibilities focus on ensuring that project planning and results adapt to modern technology while retaining scientific integrity. Her career experiences span scientific, technical, supervisory, administrative, and management functions. She has been categorized by titles such as project hydrologist, database manager, computer programmer, GIS specialist, systems analyst, project coordinator, operations manager, and facilitator. Whatever the actual function, she has served as a catalyst of change, moving from old processes to new.

KEY PERSONNEL

Greg Kellogg
Alaska Watershed Program Manager
US EPA, Alaska Watershed Program
222 W. 7th Ave., #19
Anchorage, AK 99513
Kellogg.Greg@EPAMAIL.EPA.GOV
Phone: (907) 271-6328

Lowell Suring
US Dept. of Agriculture
United States Forest Service
Chugach National Forest
3300 C Street, Suite 300

Anchorage, AK 99503
lsuring/r10_chugach@fs.fed.us
Phone: (907) 271-2836

Nancy Tileston
Systems Librarian
ARLIS (Alaska Resources Library & Information Services)
3150 C St., Suite 100
Anchorage, AK 99503
Nancy@arlis.org
Phone: (907) 271-4579

Jim Haga
US Geological Survey/EROS Data Center
4230 University Drive
Anchorage, AK 99508
haga@usgs.gov
Phone: (907) 786-7035

LITERATURE CITED

Alaska Department of Natural Resources. 1996. Proposed Oil and Gas Lease Sale 85A: Cook Inlet Exempt, Preliminary Finding of the Director. Alaska Department of Natural Resources, Division of Oil and Gas, Anchorage, AK.

Alaska Department of Natural Resources. 1995. Geographic Information Systems, Database Summary. Alaska Department of Natural Resources, Division of Support Services, Anchorage, AK.

Alaska Department of Natural Resources, National Oceanic and Atmospheric Administration. 1997. *Exxon Valdez* Oil Spill; Research and Restoration Information Project. Alaska Department of Natural Resources, Division of Support Services, Anchorage, AK

Alaska Department of Natural Resources. 1999. Alaska State Geospatial Data Clearinghouse. Alaska Department of Natural Resources, Division of Support Services, Anchorage, AK.

Exxon Valdez Oil Spill Trustee Council. Invitation to Submit Restoration Proposals for Federal Fiscal Year 2000. *Exxon Valdez* Oil Spill Restoration Office, Anchorage, AK.

Federal Geographic Data Committee. "Content Standards for Digital Geospatial Metadata Workbook (Describes the June 8, 1994 version of the metadata standard) Workbook Version 1.0, March 1995.

Michener, W.K. 1997. Quantitatively Evaluating Restoration Experiments: Research Design, Statistical Analysis, and Data Management Considerations. Restoration Ecology 5:324-337.

Minerals Management Service. 1996. Final Environmental Impact Statement for the Cook Inlet Planning Area Oil and Gas Lease Sale 149. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage, AK.

National Research Council, National Academy of Sciences, 1999. Distributed Geolibraries/Spatial Information Resources, National Academy Press, Washington, DC.

Novotny, V. and H. Olem. 1994. Water quality: prevention, identification, and management of diffuse pollution. Van Nostrand Reinhold, New York.

Resource Data, Inc., 1997. Data Repository Analysis prepared for Alaska Department of Environmental Conservation, Anchorage, AK.

Samuels, W.B., J.G. Parker, W.N. Ganter, and G. Currey. 1997. Development of the Colorado Watershed Data Integration System. Science Applications International Corporation, McLean, VA.

Science Applications International Corporation. 1999. Cook Inlet Information Management & Monitoring System (CIIMMS), Requirements and Recommendations. Science Applications International Corporation, McLean, VA.

Science Applications International Corporation. 1999. Cook Inlet Information Management & Monitoring System (CIIMMS), Pilot Phase Implementation Plan. Science Applications International Corporation, McLean, VA.

Science Applications International Corporation. 1996. Chesapeake Bay Program Information Management Requirements and Recommendations. Science Applications International Corporation, McLean, VA.

Spies, R.B. 1997. Science and the Restoration Reserve. Memo to Molly McCammon. Applied Marine Sciences, Livermore, CA.

The Nature Conservancy, 1998. Framework for Water Quality Monitoring of the Kenai River.

U.S. Environmental Protection Agency. 1997. Designing an Information Management System for Watersheds. EPA841-R-97-005. Office of Water (4503F), United States Environmental Protection Agency, Washington, D.C.

U.S. Geological Survey. 1998. Alaska Geospatial Data Clearinghouse. U.S. Geological Survey, Anchorage, AK.

APPENDIX A

THE CIIMMS PROTOTYPE:
Sample Web Pages

CIIMMS: Kenai River - Microsoft Internet Explorer

File Edit View Go Favorites Help

CIIMMS
COOK INLET INFORMATION MANAGEMENT/MONITORING SYSTEM

HOME | BROWSE | SEARCH | CONTRIBUTE | FEEDBACK

About CIIMMS

Information Profiles:
Kenai River

Information Sources

Cook Inlet Links

Cook Inlet Contacts

CIIMMS in the News

CIIMMS Contributors & Guidelines

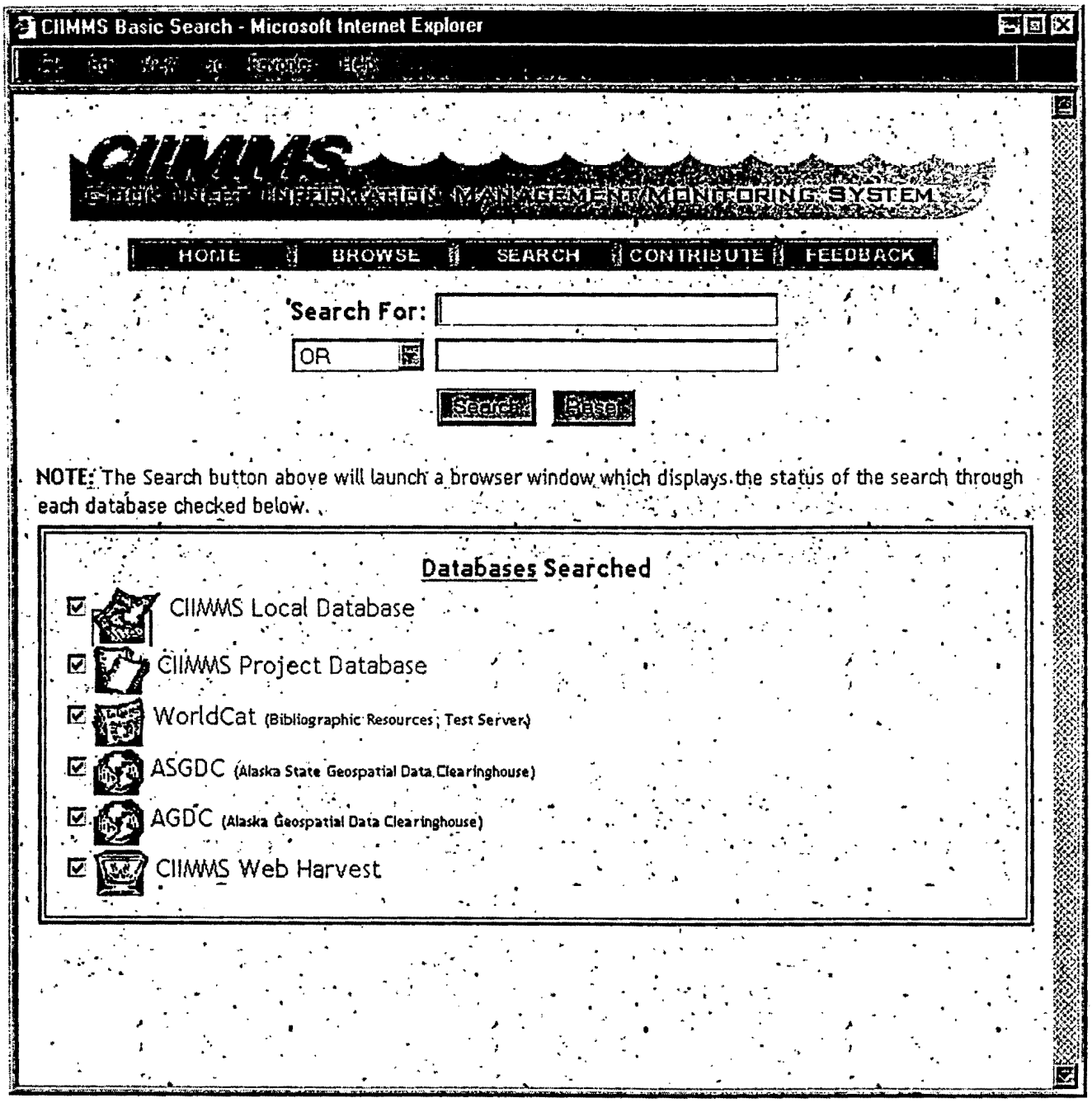
Glossary

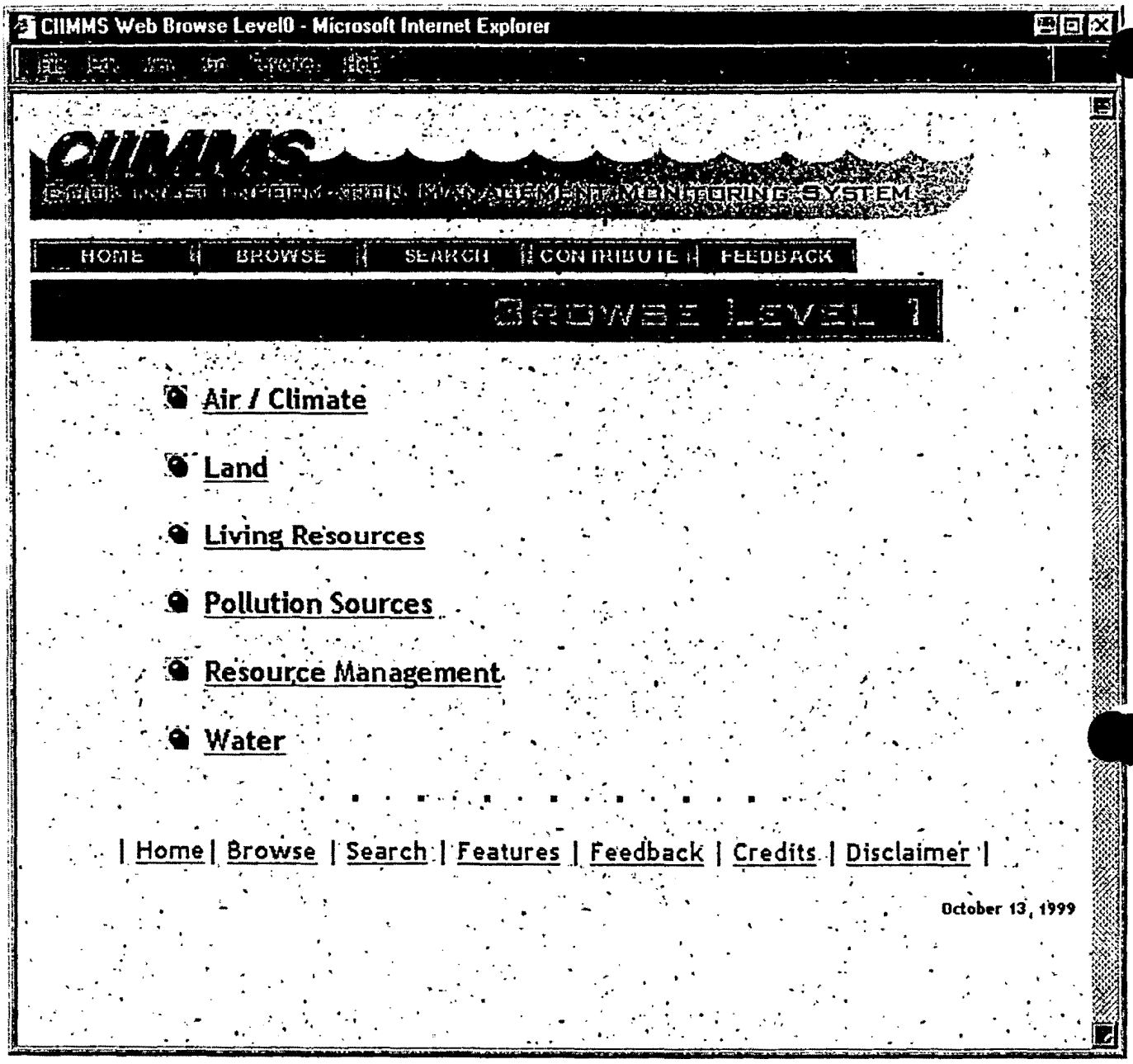
Contact us:
Phone:
(907) 269-8856
Fax:
(907) 269-8920
Email:
kellyz@dnr.state.ak.us

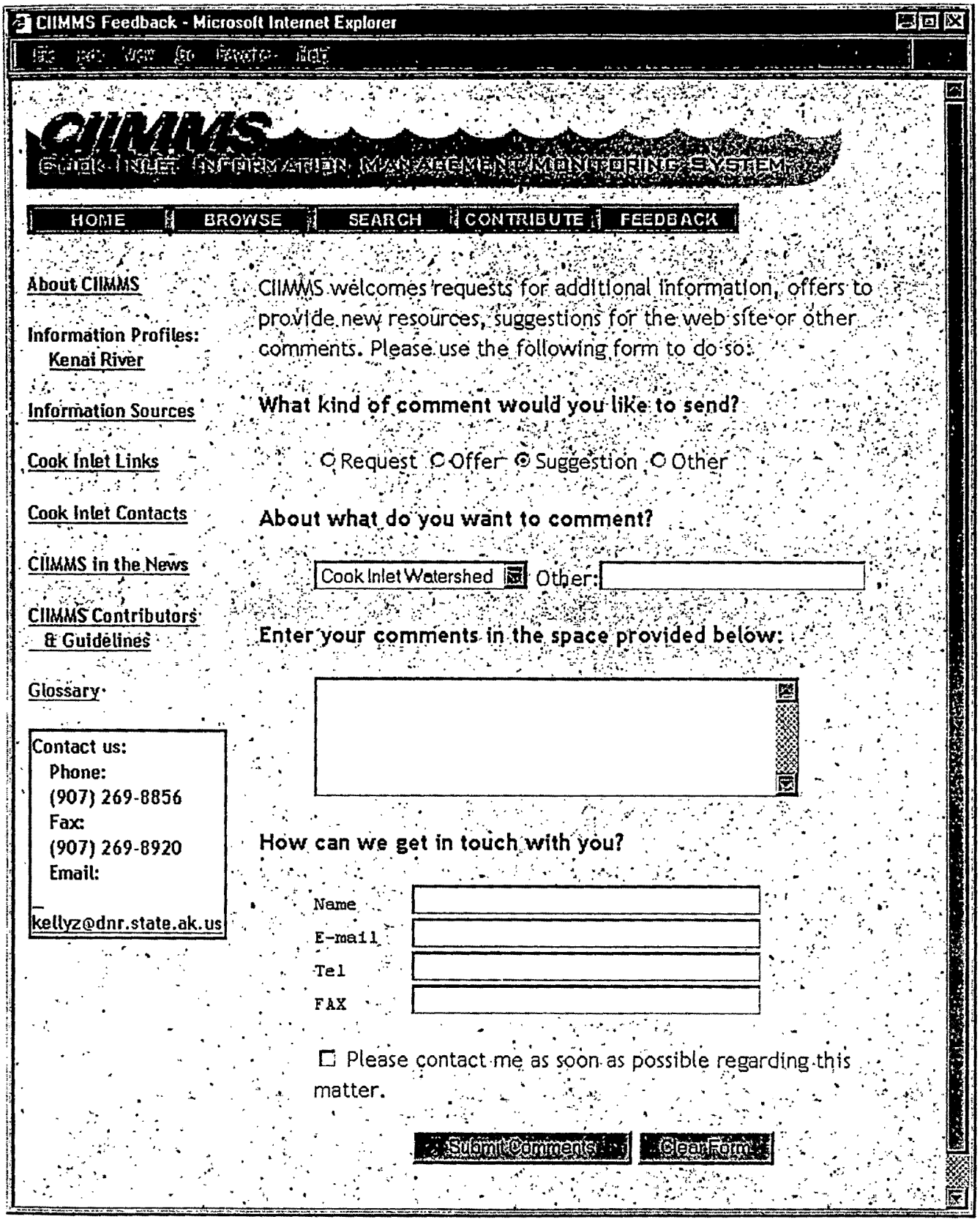
Kenai Watershed "Information Profiles"

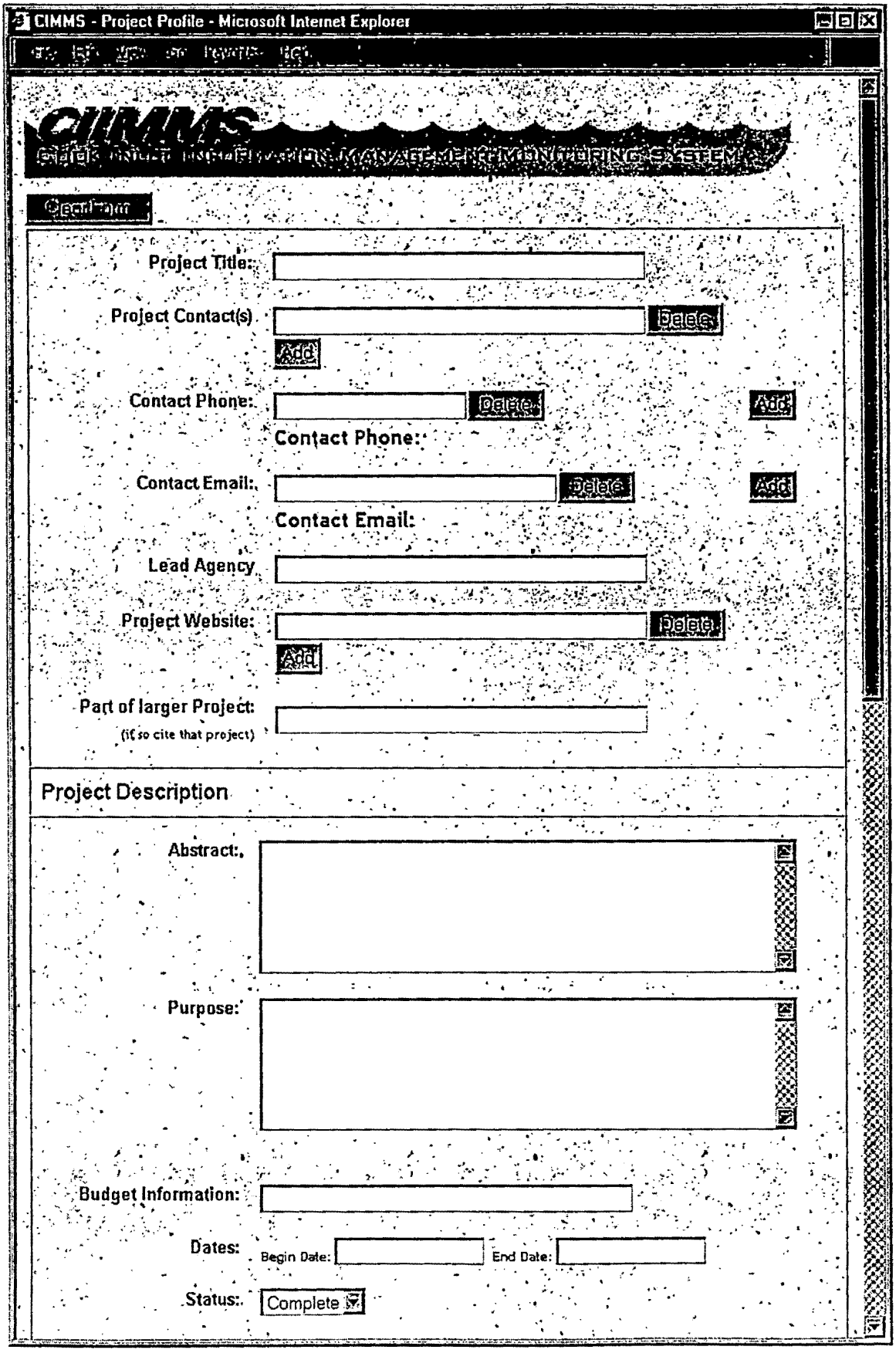
The following information profiles have been chosen for the prototype to give the users examples of how different "types" of the information related to the same theme can be discovered, accessed and/or displayed via CIIMMS:

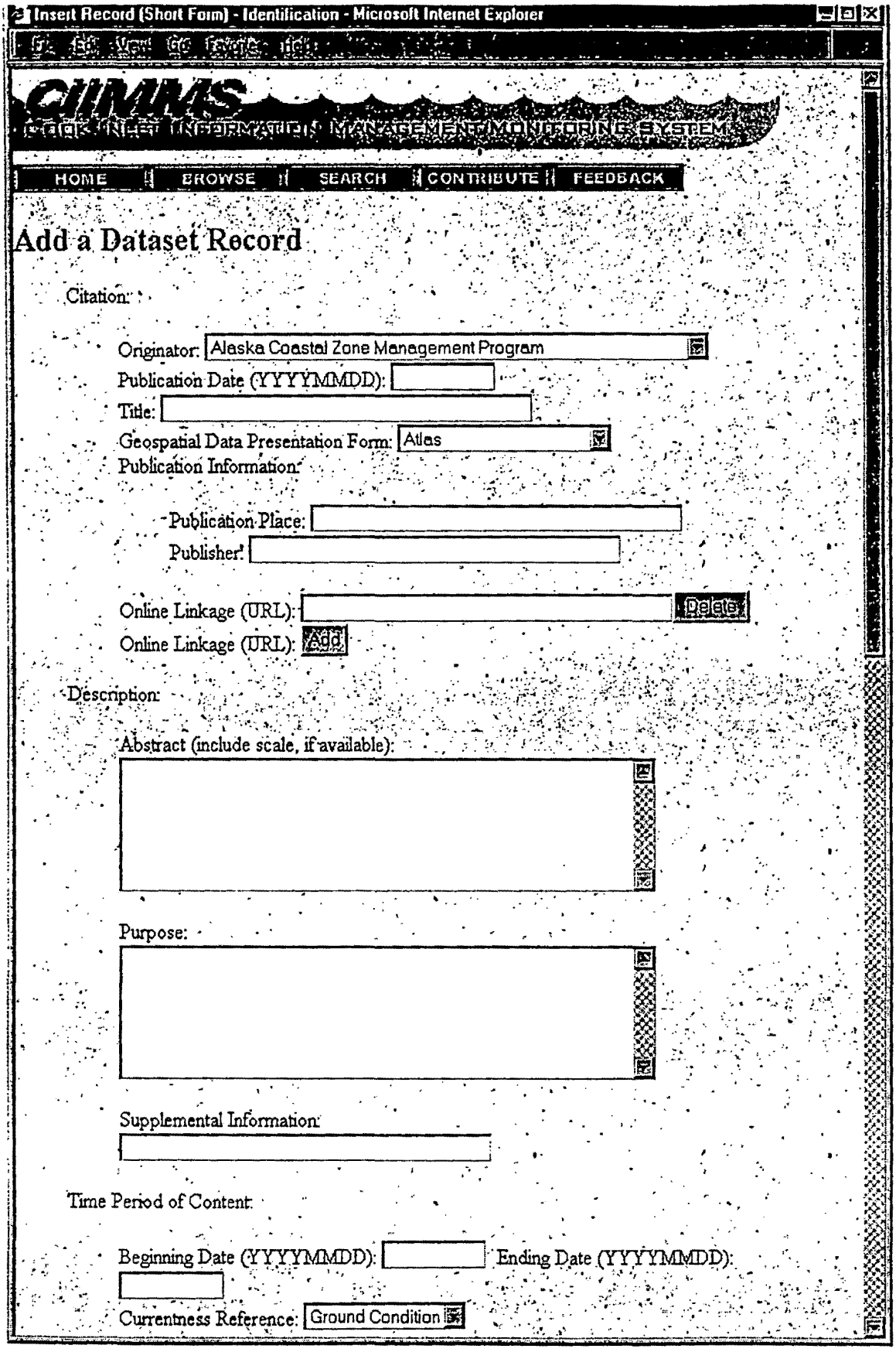
- Spruce Bark Beetle (forestry scenario)
- Well Log Tracking System (WELTS) (profile, database)
- *Exxon Valdez* Oil Spill Projects
- Wetlands
- Anadromous Fish Streams


CIIMMS Basic Search - Microsoft Internet Explorer
CIIMMS
HOME
BROWSE
SEARCH
CONTRIBUTE
FEEDBACK
Search For:
OR
Search
Reset
NOTE: The Search button above will launch a browser window which displays the status of the search through each database checked below.
Databases Searched
CIIMMS Local Database
CIIMMS Project Database
WorldCat (Bibliographic Resources; Test Server)
ASGDC (Alaska State Geospatial Data Clearinghouse)
AGDC (Alaska Geospatial Data Clearinghouse)
CIIMMS Web Harvest


CIIMMS Web Browse Level0 - Microsoft Internet Explorer
CIIMMS
HOME
BROWSE
SEARCH
CONTRIBUTE
FEEDBACK
BROWSE LEVEL 1
Air / Climate
Land
Living Resources
Pollution Sources
Resource Management
Water
| Home | Browse | Search | Features | Feedback | Credits | Disclaimer |
October 13, 1999


CIIMMS Feedback - Microsoft Internet Explorer
CIIMMS
Cook Inlet Information Management Monitoring System
HOME
BROWSE
SEARCH
CONTRIBUTE
FEEDBACK
About CIIMMS
Information Profiles:
Kenai River
Information Sources
Cook Inlet Links
Cook Inlet Contacts
CIIMMS in the News
CIIMMS Contributors & Guidelines
Glossary
Contact us:
Phone:
(907) 269-8856
Fax:
(907) 269-8920
Email:
kellyz@dnr.state.ak.us
CIIMMS welcomes requests for additional information, offers to provide new resources, suggestions for the web site or other comments. Please use the following form to do so:
What kind of comment would you like to send?
Request
Offer
Suggestion
Other
About what do you want to comment?
Cook Inlet Watershed
Other:
Enter your comments in the space provided below:
How can we get in touch with you?
Name
E-mail
Tel
FAX
Please contact me as soon as possible regarding this matter.
Submit Comments
Clear Form


CIMMS - Project Profile - Microsoft Internet Explorer
CIMMS
Project Title:
Project Contact(s)
Delete
Add
Contact Phone:
Delete
Add
Contact Phone:
Contact Email:
Delete
Add
Contact Email:
Lead Agency
Project Website:
Delete
Add
Part of larger Project:
(if so cite that project)
Project Description
Abstract:
Purpose:
Budget Information:
Dates:
Begin Date:
End Date:
Status:
Complete


Insert Record (Short Form) - Identification - Microsoft Internet Explorer
CIMMS
HOME
BROWSE
SEARCH
CONTRIBUTE
FEEDBACK
Add a Dataset Record
Citation:
Originator: Alaska Coastal Zone Management Program
Publication Date (YYYYMMDD):
Title:
Geospatial Data Presentation Form: Atlas
Publication Information:
Publication Place:
Publisher:
Online Linkage (URL):
Delete
Online Linkage (URL):
Add
Description:
Abstract (include scale, if available):
Purpose:
Supplemental Information:
Time Period of Content:
Beginning Date (YYYYMMDD):
Ending Date (YYYYMMDD):
Currentness Reference: Ground Condition

APPENDIX B

BRIEF SUMMARY OF EVALUATOR'S COMMENTS

Types/number of users who responded during CIIMMS "Open House" sessions:

resource manager (9) citizen (6) scientist (8) technical (16) non-technical (4)

Actual Evaluation Questions, followed by summary of responses:

Did the site respond quickly enough to your requests?

- OK-uncertain on some browses when all data had been completed
- No- Timeouts prevented access
- Very quickly-but the college must have a T-1 line
- Unable to evaluate effectively due to timeout problems
- Slow searching
- No
- Yes, very fast on initial browses the database searches timed out a lot
- Yes
- Yes
- Yes
- Yes
- Yes
- Yes-very intuitive
- Yes
- Yes
- Sometimes
- Responded quickly but didn t necessarily provide the information I was looking for
- Yes
- Fairly slow
- Somewhat slow, but used to a fast network and cable modems
- Yes (one J-run error)
- Yes

How could we improve the content or layout of web pages in the following sections: (i.e. word choice, sentence brevity/clarity, help aids, more visual clues, larger text etc.)

SEARCH:

- Glossary of terms would be helpful
- Briefly describe the difference between search and browse
- The result count showed 3 results but could only see the first one, need a stop button on search
- View search page needs previous back next buttons at top and bottom of page
- Couldn t really see any final results-didn t work
- Ability to refine search by data source
- Need to be able to search on multiple works
- Allow ability to perform an advanced search
- Would be nice to have either back or home options from all screens

- Make sure it is not case-sensitive
- Seem to all work very well-timeouts happen fairly fast for ease of use
- Temporal-only want new additions to query by date submitted
- More defined icons for databases
- Slow
- World Cat.-Subsistence search got me Paraguay-not limited to Cook Inlet

BROWSE:

- Couldn t get to several data sources was interested in
- Timeout function adjustable to retries-look forward to next generation
- Nicely set-up
- Didn t work
- Expand amount of sites being searched-keep local sources first-good priority of sites in subjects searched
- No query defined error from Air Quality Monitoring browse ->search
- having the ability to view more than 10 results from a search
- kept receiving search undefined error
- Slow

CONTRIBUTE:

- Good window for Your insights are needed!
- Like the link to You may also use CIIMMS feedback form for more detailed comments
- Provide-suggestions on how to do searches
- Need ability to enter metadata for data (rather than just info related to overall projects)-looking forward to seeing this feature
- Did not evaluate
- Really liked the ability to contribute web links but maybe move entry box to higher page

How could we improve the structure/organization of the section as a whole, in terms of where and how pages link to one another (e.g., too many links? missing links? page A should link to page B. etc.)?

- Seems like the links are numerous-It may not be worth the time to get too organized
- Kenai wetlands connects to the ADEC website-what about other sources like the National Wetlands Inventory program
- Some basic instructions for viewing spatial data-can all images be viewed on screen w/o downloading etc.
- Be good to add a description and link to the Cook Inlet Subarea Contingency Plan and the same for the CI Geographic Response Strategies, the first batch to be completed and reviewed this winter
- Index or categorize links to other sites
- Scope of data/purpose is a little unclear initially

- Keep focus on Cook Inlet

What is your overall impression of the site?

- Wow!
- Thinks it is very good-a few bugs, but that is expected
- Might be time consuming to learn
- Looks like it will be very helpful once the bugs are worked out
- Great
- When finished, should provide a valuable resource
- Difficult to assess site-if all the links worked, it would provide a wealth of info
- Liked the site and will find it useful
- Most interested in the database searches not timing out if the request is too big
- Good start
- Strong preference for geographically based information because that is how decisions are made
- Great idea with potential-still a way to go
- So far, so good
- Think it will be very useful when it is completed
- Has potential
- Looks like it is coming along well-am looking forward to future capabilities
- Like it
- Pretty cool
- Looks good-very promising
- Good
- Looks useful-requires more review on my part
- Good
- Coming along well-good connections to local and state site
- Great
- Excellent

Is there anything we still should include which you did not see in your review of the section?

- Additional websites-link to EPA and COE s databases
- Have readily available link searches
- Statement on the front page that guides a prospective data holder to offer a link to his/her site and/or data
- Water quality, mussels(NOAA s status and trends mussel water study), on-line well logs
- USGS Well inventory
- Sort by area (geographic)
- Identify format examples for websites where a person using your system can view metadata and download real spatial data
- WELIS-Link available to put in ADL/LAS # and get case info
- Q&A-part of Metadata-puts out metadata in an English format
- Breakdown Jeff s map-small view/click to large view
- EPA data on subsistence species and containments

Do you have information or data that you would like to contribute to CIIMMS, and if so, what is it?

- How about an oil & gas facility inventory?
- Minimize use of acronyms-general public might not know what they mean
- Trying to determine what type of data we will be able to contribute
- Kenai Borough has quite a bit of info which could be incorporated
- CIAA conducts annual fishery and water quality monitoring of several drainages throughout the Cook Inlet drainage. Type of information collected include basic water chemistry (D.O., temp., nutrients, metals), salmon smolt and adult migration with age, weight and length measurements, macroinvertebrate populations. We also collect and maintain a limited amount of habitat data.
- EPA and DEC drinking water, well inventories
- DEC UST LUST Data
- Rare Species data
- Lists of tracked species by AK Heritage Program
- More Forestry public documents and maps

APPENDIX C

CIIMMS INFORMATION PRIORITIES

Desired Information Type	Priority		
	Short Term (Weighted Score) (≤1 year)	Medium Term (Weighted Score) (2-5 years)	Long Term (Weighted Score) (≥6 years)
Biological			
Air Quality			
Ambient air quality	55	18	3
Emissions sources	75	15	3
Habitat			
ADFG habitat and species maps	115	3	0
Beetle kill areas / Forest Damage Area	65	24	0
Important habitats for wildlife species	90	12	2
Species range and migration routes	60	30	2
Biological stream types (clear water, tanin, glacier)	50	30	4
Anadromous streams (ADFG)	90	15	1
Critical habitat areas	100	9	1
Nearshore migration corridors	70	27	2
Wetland delineation criteria, types, locations	95	18	0
Population			
Species lists/population/inventories/distributions/trends/harvests	65	27	1
Human pop/density	65	24	1
Aquatic			
Fish distribution and abundance	75	18	0
Salmon escapement./harvest layer	60	24	0
Fish catalog information	70	27	0
Forage fish population and distributions	40	27	3
Fish catch reports	40	27	2
Timing of fishery events (spawning, out-migration)	65	12	3
Marine mammals distribution	65	21	1
Stream invertebrates and habitat	40	30	1
Marine invertebrates	35	21	4
Terrestrial			
Wildlife changes by watershed	45	27	2
Species demographics layer	50	27	2
Human demographics (population density) layer	60	27	2
Brown bear data (coming soon)	20	36	4
Seabirds, bald eagle, sea otter usage areas	75	18	2
Caribou distribution	50	27	3
Seabird – feeding habits, foraging locations	70	18	2
Toxicity			
Water Quality			
Turbidity, Nitrate, Silicon, Dissolved Oxygen, Phosphorus, natural turbidity	50	18	3
Groundwater	50	21	2
Precipitation	60	12	2

Desired Information Type	Priority		
	Short Term (Weighted Score) (≤1 year)	Medium Term (Weighted Score) (2-5 years)	Long Term (Weighted Score) (≥6 years)
Impaired water bodies layer (EPA/DEC)	70	15	1
CIK hydrocarbon analyses	50	24	1
Wells	50	30	0
USGS NAWQA	50	27	0
Storm sediment loads	35	30	2
Fecal coliform	50	24	3
EVOS hydrocarbon data	50	24	1
Vegetation			
Distribution	65	24	0
Forest types	55	30	0
National wetlands inventory	80	15	0
Forest conditions layer	35	30	3
Human Effects			
Infrastructure (& plans)			
Roads and trails	95	3	1
Mining and timber development activities / locations	85	12	1
Human development areas	85	6	1
Oil / gas / drilling development activities / locations	95	6	1
Tanker / shipping routes	75	12	3
Current and planned timber sales	80	12	2
Waterbody designated use	75	12	2
Land Status			
Land use	115	3	0
Land ownership	100	9	0
Permitted users	85	15	0
Existing / planned activities	80	18	0
Land management zones	85	15	1
Timber sales / leases	65	15	2
Real estate development	75	18	2
Harvests	65	18	0
Land	60	12	0
Planning and Cultural			
Tax rolls	25	24	5
Current permits / stipulations	75	12	3
Recreation ops / public access and navigability	35	21	6
Commercial leasing	40	23	3
Developments opportunities	20	33	4
Areas considered for mariculture	40	24	3
Political Boundaries			
Jurisdictions	75	15	3
Federal and state management units	90	15	1
Pollution Sources			
Oil and gas	75	18	0

Desired Information Type	Priority		
	Short Term (Weighted Score) (≤1 year)	Medium Term (Weighted Score) (2-5 years)	Long Term (Weighted Score) (≥6 years)
NPDES discharge sites / data / impacts	75	21	0
Superfund sites	75	15	1
ADEC's contaminated sites	75	15	1
ADEC's facilities	30	24	3
Geophysical and other permits	40	27	2
Storm water permits	45	27	2
Discharge monitoring reports (DMR's)	30	33	2
Land clearing	35	27	2
Integrated Information Systems			
Monitoring stations by agency	50	21	0
Metadata	85	0	0
Historical data	45	18	2
Community information	40	15	5
Bibliography of CI articles, studies, and resource inventory	55	9	3
Coastal management plans	50	27	0
Appropriate agency contacts	90	3	0
Ongoing studies	65	12	0
General watershed information	60	9	2
BLM's Aquatic Resources Information System	45	9	2
Linked video	0	21	6
STORET	30	6	6
Analyses: land-use / wq correl.; biosystems integrity; critical habitats; species-specific timing periods; environmental assessments; habitat value of a site	20	12	1
Physical / Geological Base			
Boundaries			
Coastline layer (incl. "h and l shoreline"), coastal morphology	65	12	1
NOAA ESI maps data (shoreline geomorph)	55	15	1
HUCs			
Climatology			
Rainfall	70	12	1
Temperature	60	15	1
"Climate"	50	18	1
Snowpack	50	21	1
Weather	60	12	1
Fog	45	21	1
Winds	60	15	1
Snow	60	15	1
Grids			
Hazards			
Hydrography / Water Quantity			
Stream flow	70	15	0

Desired Information Type	Priority		
	Short Term (Weighted Score) (≤1 year)	Medium Term (Weighted Score) (2-5 years)	Long Term (Weighted Score) (≥6 years)
Baseflow	60	15	0
Hydrology	65	15	0
DNR and USGS QW datasets	40	18	0
Ground water / surface water flow	60	18	1
Geology			
Land Cover			
Land forms	45	15	1
Aerial photographs	45	15	3
Satellite images	35	15	3
CIK 1:63,360 wide imagery	35	6	2
High altitude photography	20	21	3
Terrain (topography, slope, aspect, etc.)	60	9	1
DEMs	25	12	1
DOQs	15	15	3
Oceanography			
Tidal / current data	60	12	0
Bathymetry	50	18	0
Currents and circulation	60	12	0
Plankton	35	21	0
Temperature	40	18	0
Salinity	40	18	0
Updated marine charts	55	15	1
Bottom substrate	40	18	1
Sea ice	40	15	3
Rip tides	45	18	1
Soils			
Soils data layer	55	12	0

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Approved TC 8-3-00

Budget Category:	Authorized FY 1999	Proposed FY 2001	PROPOSED FY 2000 TRUSTEE AGENCIES TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
			$56.4	$27.1	$142.0	$0.0	$13.5	
Personnel	$166.7	$112.7						
Travel	$4.0	$16.6						
Contractual	$130.0	$80.5						
Commodities	$0.2	$0.4						
Equipment	$0.0	$6.3	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$300.9	$216.5				Estimated		
General Administration	$34.1	$22.5				FY 2002		
Project Total	$335.0	$239.0			$0.0	$0.0		
Full-time Equivalents (FTE)	0.0	1.6						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$0.0	$0.0			$0.0	$0.0		

Comments:

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Lead Agency: ADEC/ADNR

FORM 2A
MULTI-TRUSTEE
AGENCY
SUMMARY

Prepared:
4/[redacted]0

2001 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 1999	Proposed FY 2001						
Personnel	$74.4	$34.8						
Travel	$2.9	$9.8						
Contractual	$0.0	$6.0						
Commodities	$0.2	$0.2						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$77.5	$50.8			Estimated FY 2001	Estimated FY 2002		
General Administration	$11.2	$5.6						
Project Total	$88.7	$56.4						
Full-time Equivalents (FTE)		0.4						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: Alaska Department of Environmental Conservation

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared:
4/12/00

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 2001
Jeff Hock	Environmental Specialist IV	20	1.0	7.2		7.2
Russell Kunibe	Analyst Programmer IV	20	4.0	6.9		27.6
TBD						0.0
Nadeem Siddiqui						0.0
TBD						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		5.0	14.1	0.0	
					Personnel Total	$34.8

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
					0.0
Travel to Anchorage to work with cooperators and conduct training	0.5	4	19	0.2	5.8
Travel to Kenai to work with cooperators and conduct training	0.1	2	6	0.2	1.4
Travel to Homer to work with cooperators and conduct training	0.2	1	6	0.2	1.4
Travel to Mat-Su to work with cooperators and conduct training	0.0	1	6	0.2	1.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$9.8

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: Alaska Department of Environmental Conservation

FORM 3B
Personnel
& Travel
DETAIL

Prepared:
4/12/00

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

Contractual Costs:	Proposed FY 2001
Description	
CIIMMS Z39.50 search engine maintenance	6.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$6.0

Commodities Costs:	Proposed FY 2001
Description	
Office Supplies (paper, toner cartridges, etc. for report preparation)	0.2
	0.0
	0.0
	0.0
Commodities Total	$0.2

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: Alaska Department of Environmental Conservation

FORM 3B
Contractual & Commodities DETAIL

Prepared:
4/12/00

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

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
			0.0
			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
4 Computer Workstations with Software contributed by DEC,	$14,000		
DEC SQL Server w/Software, contributed by DEC	$15,000		
Laptop PC, contributed by DEC,	$3,500		
Internet WEB Server, contributed by DEC	$10,000		
Total DEC Equipment Contribution	$42,500		

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: Alaska Department of Environmental Conservation

FORM 3B
Equipment
DETAIL

Prepared:
4/12/00

2001 EXXON VALDEZ TRUS..EE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 1999	Proposed FY 2001	LONG RANGE FUNDING REQUIREMENTS					
Personnel	$86.0	$43.3						
Travel	$0.7	$6.2						
Contractual	$130.0	$74.5						
Commodities	$0.0	$0.0						
Equipment	$0.0	$6.3						
Subtotal	$216.7	$130.3			Estimated FY 2001	Estimated FY 2002		
General Administration	$22.0	$11.7						
Project Total	$238.7	$142.0						
Full-time Equivalents (FTE)		0.7						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: Alaska Department of Natural Resources

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared:
4/12/00

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 2001
	Analyst Programmer III	18	5.0	6.0		30.0
	Analyst Programmer IV	20	1.5	5.8		8.7
	Student Intern	12	2.0	2.3		4.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		8.5	14.1	0.0	
					Personnel Total	$43.3

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
					0.0
Travel to Homer, Kenai, Soldotna	0.2	8	12	0.2	4.0
Travel to Juneau	0.5	2	6	0.2	2.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$6.2

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: Alaska Department of Natural Resources

FORM 3B
Personnel
& Travel
DETAIL

Prepared:
4/12/00

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

Contractual Costs:		Proposed
Description		FY 2001
Implement access to distributed data systems		36.0
Consulting Services for development and implementation of Final System Specifications	$36.0	36.0
Develop detailed plan for long term maintenance.	$12.0 (in Oct-Dec 01)	
Develop System documentation	$12.0 (in Oct-Dec 01)	
Develop On line help	$12.0 (in Oct-Dec 01)	
Final Report Production		2.5
When a non-trustee organization is used, the form 4A is required.	**Contractual Total**	$74.5

Commodities Costs:		Proposed
Description		FY 2001
	Commodities Total	$0.0

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: Alaska Department of Natural Resources

FORM 3B
Contractual & Commodities DETAIL

Prepared:
4/12/00

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2001
			0.0
			0.0
Additional storage capacity for existing UNIX server	1	1.3	1.3
MetaManager Software	1	5.0	5.0
			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**	$6.3

Existing Equipment Usage: Description		Number of Units	Inventory Agency
DNR contribution of existing hardware, software, and other data management infrastructure with a value of:	$55.0		
2 Workstations, software, and peripherals	$10.0		
2 PCs and software	$6.0		
Total ADNR equipment contribution:	$71.0		

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: Alaska Department of Natural Resources

FORM 3B
Equipment
DETAIL

Prepared:
4/12/00

2001 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 1999	Proposed FY 2001						
Personnel		$23.4						
Travel		$0.0						
Contractual		$0.0						
Commodities		$0.2						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$23.6			Estimated FY 2001	Estimated FY 2002		
General Administration		$3.5						
Project Total	$0.0	$27.1						
Full-time Equivalents (FTE)		0.4						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: Alaska Department of Fish & Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared:
4/12/00

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 2001
	Cartographer	16	3.0	5.0		15.0
	Analyst Programmer	20		6.7		0.0
	Habitat Biologist	18	1.0	6.2		6.2
	Research Analyst II	16	0.5	4.3		2.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		4.5	22.2	0.0	
					Personnel Total	$23.4

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

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: Alaska Department of Fish & Game

FORM 3B
Personnel
& Travel
DETAIL

Prepared:
4/12/00

2001 EXXON VALDEZ TRUS . __ COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed FY 2001
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 2001
Description	
Office supplies, digital storage and transfer media, phone, fax, software upgrades	0.2
Commodities Total	$0.2

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: Alaska Department of Fish & Game

FORM 3B
Contractual & Commodities DETAIL

Prepared:
4/12/00

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

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

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: Alaska Department of Fish & Game

FORM 3B
Equipment
DETAIL

Prepared:
4/12/00

2001 EXXON VALDEZ TRUS[illegible]COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 1999	Proposed FY 2001	[redacted]
Personnel	$6.3	$0.0	
Travel	$0.4	$0.0	
Contractual		$0.0	
Commodities		$0.0	
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS
Subtotal	$6.7	$0.0	Estimated FY 2001 / Estimated FY 2002
General Administration	$0.9	$0.0	
Project Total	$7.6	$0.0	
Full-time Equivalents (FTE)		0.0	[redacted]
	Dollar amounts are shown in thousands of dollars.		
Other Resources			

Comments:

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: US Forest Service

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared:
4/12/00

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 2001
						0.0
Lowell Surring	Wildlife Biologist	12		6.3		0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		0.0	6.3	0.0	
					Personnel Total	$0.0

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

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: US Forest Service

FORM 3B
Personnel
& Travel
DETAIL

Prepared:
4/12/00

Contractual Costs:	Proposed FY 2001
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 2001
Description	
Commodities Total	$0.0

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: US Forest Service

FORM 3B
Contractual & Commodities DETAIL

Prepared:
4/12/00

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

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

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: US Forest Service

FORM 3B
Equipment
DETAIL

Prepared:
4/12/00

2001 EXXON VALDEZ TRUS[illegible] COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 1999	Proposed FY 2001						
Personnel		$11.2						
Travel		$0.6						
Contractual		$0.0						
Commodities		$0.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$11.8			Estimated FY 2001	Estimated FY 2002		
General Administration		$1.7						
Project Total	$0.0	$13.5						
Full-time Equivalents (FTE)		0.1						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: US DOI, USGS

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared:
4/12/00

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 2001
						0.0
Leslie Patrick	Assistant District Chief, Water Resources Division					0.0
	Supervisory Hydrologist	13-6	1.0	11.2		11.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.0	11.2	0.0	
					Personnel Total	$11.2

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
					0.0
Travel to Homer, Kenai, Soldotna	0.2	1	2	0.2	0.6
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.6

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: US DOI, USGS

FORM 3B
Personnel
& Travel
DETAIL

Prepared:
4/12/00

Contractual Costs:	Proposed FY 2001
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 2001
Description	
Commodities Total	$0.0

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: US DOI, USGS

FORM 3B
Contractual & Commodities DETAIL

Prepared:
4/12/00

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

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

FY01

Project Number: 01391
Project Title: Cook Inlet Information Management/Monitoring
Agency: US DOI, USGS

FORM 3B
Equipment
DETAIL

Prepared:
4/12/00

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

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

Comments:

FY00

Project Number:
Project Title:
Agency:

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared:
4/12/00

Revision 7-5-00
Approved TC 8-3-00

Assessment of Spot Shrimp Abundance in Prince William Sound

Project Number:	01401
Restoration Category:	General Restoration
Proposer:	C. Hughey/ Valdez Native Tribe, C. O'Clair/ NOAA
Lead Trustee Agency:	NOAA
Cooperating Agencies:	None
Alaska SeaLife Center:	No
New or Continued:	Cont'd
Duration:	3rd yr. 4 yr. project
Cost FY 01:	$94.4
Cost FY 02:	$33.0
Geographic Area:	Prince William Sound
Injured Resource/Service:	Subsistence

ABSTRACT

This project will determine whether the spot shrimp population in Prince William Sound is recovering from depletion. FY 00 results (October 1999) are consistent with those of the Alaska Department of Fish and Game annual survey and indicate a cessation in the apparent decline of spot shrimp abundance in western Prince William Sound that had taken place from 1992 to 1998. Evidence of the beginning of recovery of the spot shrimp population, though encouraging, is inconclusive. In FY 01, the project will provide a second estimate of the abundance of spot shrimp, and continue the studies of spot shrimp population structure and reproductive potential, to determine whether the indications of population recovery are real. An added objective in FY 01 is an estimate of recruitment potential through assessment of the relative abundance of juveniles. Project closeout in FY 02 will include providing input into the development of a shrimp management plan with the Alaska Department of Fish and Game.

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. However, these values were not significantly greater than those obtained by ADF&G in 1998. These results indicate that although the decline in spot shrimp CPUE between 1989 and 1998 did not continue into 1999, there is yet clear evidence of the beginning of recovery in the spot shrimp population in western PWS.

This proposal covers year three 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. The second full year of the study (FY'01) will, in addition to estimating spot shrimp relative abundance, population structure and reproductive potential, determine recruitment potential of the spot shrimp population by expanding the depth range of the sampling into shallow water to assess the relative abundance of juveniles in the population.

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 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. Shrimpers in

Valdez participate in the project, providing vessels, crew, shrimp pots, buoys, line, etc.

PROJECT DESIGN

Two important considerations enter 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 will accomplish two ends: 1) It will allow 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 and, to the extent possible, will participate in the sampling. 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 that used in the proposed study are modified after Trowbridge (1992, 1994). Shrimp pots will be fished at six sites in northern and western PWS previously surveyed by ADF&G (Figure 1). The sampling sites will be 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

At least two strings of shrimp pots will be set at each site. Each string will consist of 11 pots spaced 18.9 m (62 ft) apart along a groundline and buoyed at both ends. Standard, round, nesting pots will be used. The diameter of the base and of the top of each pot is 107 cm (42 in) and 91 cm (36 in), respectively. The frame of the pot is 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 are two opposing tunnels in the side of each pot which have a 7.6 cm (3 in) opening. These pots differ 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 will be 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 will be made in the depth range 0-27 m (0-15 fm) to assess the abundance of juvenile spot shrimp. The pots will be similar in design to the larger nesting pots described above but will be 71 cm (28 in) in diameter and covered with mesh with 5 mm openings. Each tunnel entrance will have an opening of 5 cm (2 in).

Upon retrieval of the pot strings all pandalid shrimp in each pot will be speciated. Spot shrimp will be 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*) will be counted. All non-shrimp bycatch will be speciated and counted. The carapace length of all spot shrimp will be measured to the nearest mm. Carapace length will be measured with calipers except when catches are large in which case the shrimp will be photographed with a digital camera and carapace length determined with image analysis. A subsample of each catch will be collected for staging and sexing. Additional observations of ovigerous spot shrimp will include egg condition (eyed vs uneyed) and egg color. The egg clutches of a total of 30 ovigerous females will be 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)] will be recorded. Breeding dress indicates a mature female.

The sampling cruise will be 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 FY01 (October 1, 2000 - September 30, 2001)

October 1 - 31	Sample spot shrimp at ADF&G sampling sites as well as six additional sites.
November 1 - March 31	Process egg samples and analyse data on spot shrimp 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 an annual report. Analyse spot shrimp fecundity and juvenile abundance at the study sites in year three.

B. Project Milestones and Endpoints

October 15, 2000	Complete sampling for spot shrimp in second full sampling year.
February 20, 2001	Complete estimates of abundance, sex and size composition, and relative number of egg-bearing females of spot shrimp at the study sites in year three.
April 15, 2001	Submit annual report (FY01 findings)
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

An annual report will be submitted on 15 April FY01. 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 two individuals at the annual Exxon Valdez Restoration Workshop in January 2001.

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 proposal and subsequent reports to improve their quality and to increase their relevance to management goals.

The Prince William Sound Economic Development Council has coordinated other projects for EVOS in the past. Recent 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 circular pots were substituted for the rectangular pots that ADF&G uses. These circular pots will be used again in the fall of 2000. 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

Charles E O'Clair
National Marine Fisheries Service
Auke Bay Laboratory
11305 Glacier Highway

Mandy Lindeberg
National Marine Fisheries Service
Auke Bay Laboratory
11305 Glacier Highway

Juneau, AK 99801-8626
Tele: (907) 789-6016, FAX: (907) 789-6094
email: chuck.o'clair@noaa.gov

Juneau, AK 99801-8626
Tele: (907) 789-6616
email: mandy.lindeberg@noaa.gov

Charles Hughey, Valdez Native Tribe
P. O. Box 1108
Valdez, AK 99686
Tele: (907) 835-4951
FAX: (907) 835-5589

Sue Cogswell, Executive Director
Prince William Sound EDC
P. O. Box 2353
Valdez, AK 99686
Tele: (907) 835-3775, FAX (907) 835-5770
E-mail pwsedc@alaska.net

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.

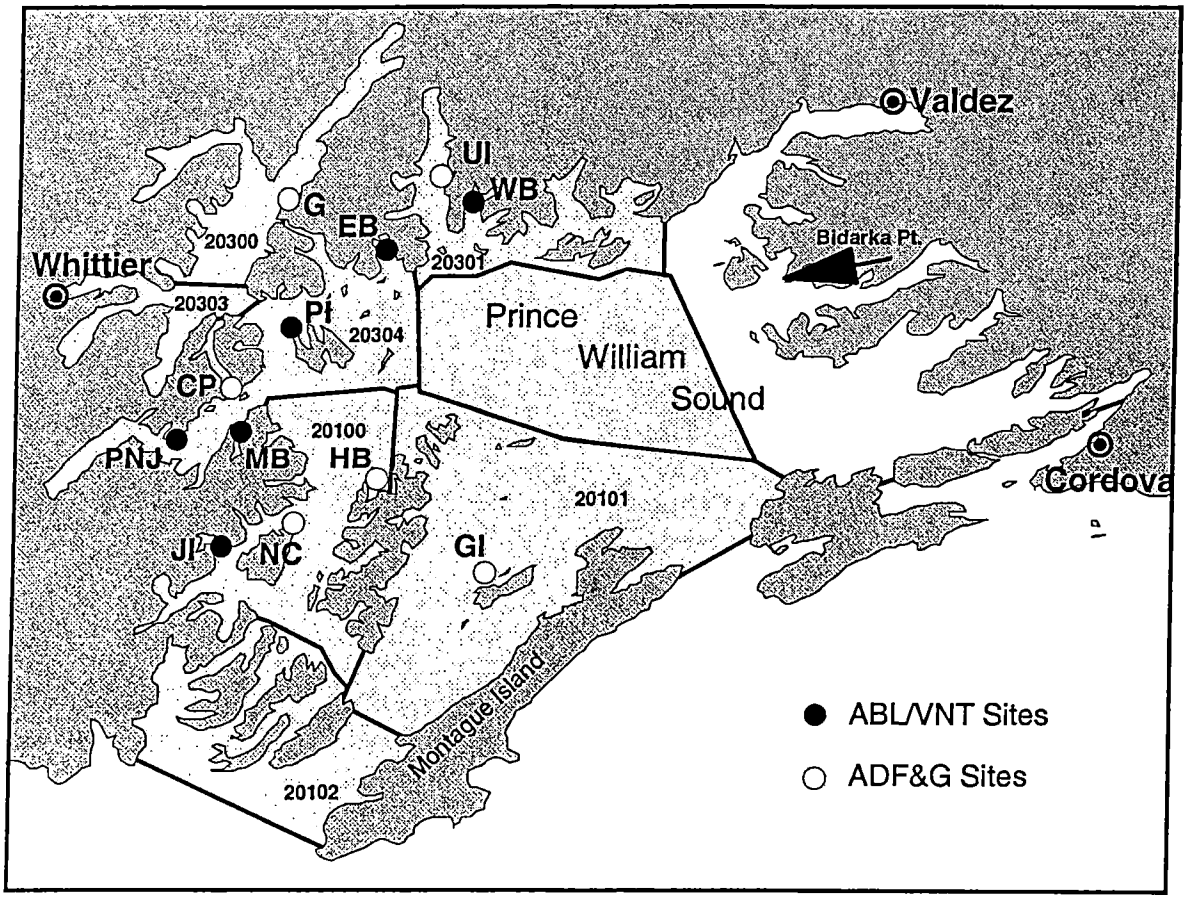


Figure 1. Location of spot shrimp study sites in Prince William Sound. The Alaska Department of Fish and Game (ADF&G) sites are those traditionally sampled during the ADF&G annual survey. The Auke Bay Lab/Valdez Native Tribe (ABL/VNT) sites were added in October 1999. The ADF&G major statistical areas 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.

Revision 1 - 11/00
Approved TC - 3-00

2001 EXXON VALDEZ TRUSTE UNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001
Personnel		$39.3
Travel		$3.5
Contractual		$41.1
Commodities		$1.7
Equipment		$0.0
Subtotal	$0.0	$85.6
General Administration		$8.8
Project Total	$0.0	$94.4
Full-time Equivalents (FTE)		0.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
			Estimated FY 2002		
			$33.0		

Dollar amounts are shown in thousands of dollars.

Comments:

The Prince William Sound Economic Council will administer the contract with the Valdez Native Tribe who will supply the survey vessel including fuel, Captain, deck hand, gear, and food.

NOAA's Contribution:
Pincepal Investigator, Fisheries Research Biologist Charles E. O'Clair (5mos @ $9.2/mo), Fisheries Research Biologist Mandy Lindeberg (2mos @ $5.1/mo).

Other:

FY01

Prepared: 7/5/00

Project Number: 01401
Project Title: **Assessement of Spot Shrimp Abundance in PWS**
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUSTE)UNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2001
Charles E. O'Clair	Fisheries Research Biologist	GS-12-10	1.5	9.2		13.8
Mandy Lindeberg	Fisheries Research Biologist	GS-9-3	5.0	5.1		25.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		6.5	14.3	0.0	
					Personnel Total	$39.3

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
					0.0
RT Juneau - PWS	0.7	3	2	0.2	2.5
					0.0
RT Juneau - Anchorage	0.6	1	2	0.2	1.0
EVOS Trustee workshop					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$3.5

FY01

Prepared: 7/5/00

Project Number: 01401
Project Title: **Assessement of Spot Shrimp Abundance in PWS**
Agency: NOAA

FORM 3B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUSTE)UNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed FY 2001
Description	
Vessel Charter	26.6
Temporary Labor Laboratory processing of samples	12.0
Temporary Labor Field sampling	2.5
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$41.1

Commodities Costs:	Proposed FY 2001
Description	
shrimp pots for juvenile fishing (12 @ $90 ea)	1.1
replacement long-line	0.3
misc. fishing gear	0.3
Commodities Total	$1.7

FY01

Prepared: 7/5/00

Project Number: 01401
Project Title: **Assessement of Spot Shrimp Abundance in PWS**
Agency: NOAA

FORM 3B
Contractual & Commodities DETAIL

2001 EXXON VALDEZ TRUSTE)UNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed 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: Description	Number of Units	Inventory Agency
Shrimp Pots		2.5
long line		0.5
scale		10
misc fishing gear		0.5
computer (2)		5

FY01

Prepared: 7/5/00

Project Number: 01401
Project Title: **Assessement of Spot Shrimp Abundance in PWS**
Agency: NOAA

FORM 3B
Equipment
DETAIL

Revision 7-20-00
Approved 7-8-3-00

Patterns and Processes of Population Change in Selected Nearshore Vertebrate Predators

Project Number:	01423
Restoration Category:	Research
Proposer:	J. Bodkin, D. Esler/USGS-BRD, T. Dean/CRA, Inc.
Lead Trustee Agency:	DOI
Cooperating Agencies:	None
Alaska SeaLife Center:	Yes
New or Continued:	Cont'd
Duration:	3rd yr. 4 yr. project
Cost FY 01:	$505.4
Cost FY 02:	
Geographic Area:	Prince William Sound
Injured Resource/Service:	Sea otter, harlequin duck

ABSTRACT

Sea otters and harlequin ducks have not fully recovered from the oil spill. This project will explore links between oil exposure and the lack of population recovery, with the intent of understanding constraints to recovery of these species and the nearshore environment. In FY 01, sea otter work will include estimation of age-specific survival rates and monitoring of CYP1A expression. Harlequin duck field studies will examine the relationship between survival and CYP1A. Captive experiments on harlequin ducks will examine the relationships between oil exposure and CYP1A induction, and metabolic and behavioral consequences of exposure. [NOTE: This project also requested funds ($250,000) for FY 03.]

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). 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). 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 work previously proposed and approved as part of Project 00423, we are proposing a new component: CYP1A biomarker monitoring of sea otters. We are also requesting salary for the sea urchin PI for closeout of the sea urchin component conducted as part of 99423 & 00423. The costs for all components are identified in a table under "Explanation of changes in continued projects".

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; 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 are 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 **(aerial surveys suspended in 2001)**? (2) has survival of sea otters returned to pre-spill rates? and (3) has exposure of sea otters to residual oil declined over time?

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 and 2003. *This element is a continuation of work proposed and approved in Project 99423, and initiated in Project 99423.*

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 (supplementary funding provided in February 2000). We propose that carcass surveys be conducted again in 2001.

Question 3 is a new element for FY2001, which will be addressed by monitoring CYP1A expression in sea otters in WPWS for comparison with 1996-98 data. Depending on results of surveys and year 2001 measures of CYP1A, it may not be necessary to continue CYP1A measures beyond 2001.

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). Proposed survey work by the Alaska Department of Fish and Game would aid interpretation of field studies and would also monitor population recovery.

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 relation between population status and oil contamination, and evaluation of population status.

In addition to observations made directly on predator species, as part of the NVP project, we

have observed an apparent response among several invertebrates to reduced sea otter densities. This finding represents a shift in the ecological processes structuring the nearshore community and provides a unique opportunity to test predictions related to sea otter recovery and their prey. We also have an opportunity to test the application of this novel approach as a tool for monitoring predators through prey that may have broader ecological applications.

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; Dean et al. 2000; USGS unpub. data), although our power to detect change is lower for these surveys.

Aerial survey data of sea otter abundance have provided the foundation for assessment of recovery status in WPWS. However, pre-spill data of abundance are few, and there are known biases in pre-spill estimates that preclude using pre- vs. post-spill comparisons in making a definitive quantitative assessment of the extent of recovery. Furthermore, recovery status could not be based solely on post-spill comparisons of oiled and unoiled areas because there are recognized differences in habitat between these areas, and it is uncertain whether sea otters in oiled areas could ever achieve population densities observed in unoiled parts of the Sound. As a result, in the NVP study, we examined prey populations as an ancillary means of assessing recovery.

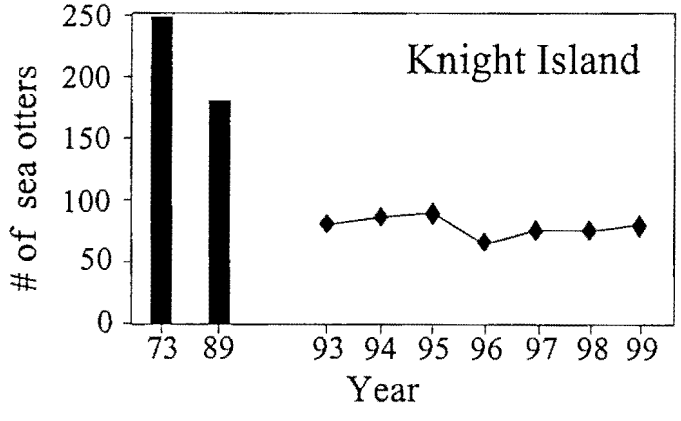


Figure 1. Estimated sea otter abundance at northern Knight Island.

This approach was based on the knowledge that sea otters have a profound and predictable effect on the structure of prey populations (reviewed in Riedman and Estes 1990). Generally, as sea otters reoccupy an area, they first consume the largest members of the most energetically profitable prey, eventually switching to smaller sizes and different species as preferred species and the larger size classes become rare (Estes and Palmisano 1974, Duggins 1980, Estes and Duggins 1995). Based on these findings, we hypothesized that a reduction in otter abundance would be accompanied by an increase in the abundance and average size of prey. We concluded

that the status of recovery of impacted populations of sea otters might therefore be assessed by examining the abundance and size-distributions of prey within impacted areas, and by comparing these with estimates from an unaffected area where otters and their prey were considered to be in equilibrium. Full recovery would be indicated by similar abundances and size distributions of prey in oiled and unoiled areas.

NVP comparisons of most invertebrate prey populations between Knight Island (oiled) and Montague Island (unoiled) identify differences in prey population structure consistent with lack of recovery of the sea otter population at the oiled site (Dean et al. 1999). At the sites where sea otter populations were greatly reduced, we found significantly greater proportions of large individuals among most species of clams, urchins and mussels. Prey assessment (sea urchins only) was continued as part of 99423 and 00423, to further test this approach to estimating the status of a predator population. We predicted that differences in prey sizes between areas should diminish when sea otter populations near complete recovery. However, sampling intensity in the past two seasons has been less than during the NVP project, and variation in size of sea urchins has been high. Thus, at this time, we do not propose further monitoring of the size and abundance of sea urchins in oiled and unoiled areas of WPWS to assess the recovery status of sea otters, and are requesting only funds to close out this component in FY01.

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 2001, as an additional tool for monitoring sea otter recovery in PWS.

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 propose to 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 will also be captured to provide a non-exposed reference sample.

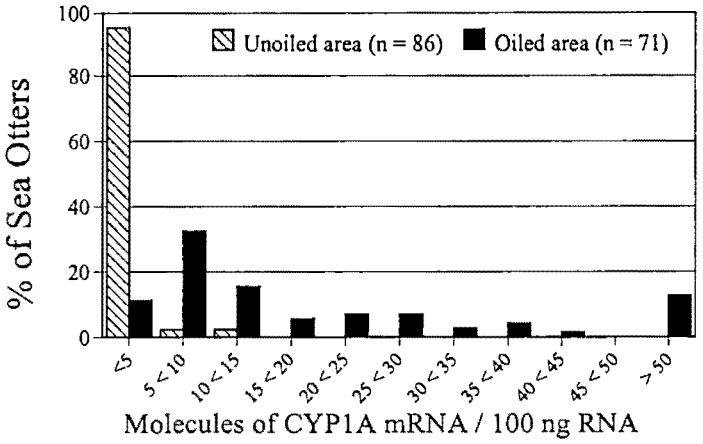


Figure 2. Measurement of cytochrome P4501A induction (RT-PCR technique) in sea otters in western Prince William Sound, 1996-98.

In summary, we propose continued monitoring of sea otter distribution and abundance, survival rates and oil exposure (CYP1A) 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 3). 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 4; 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.

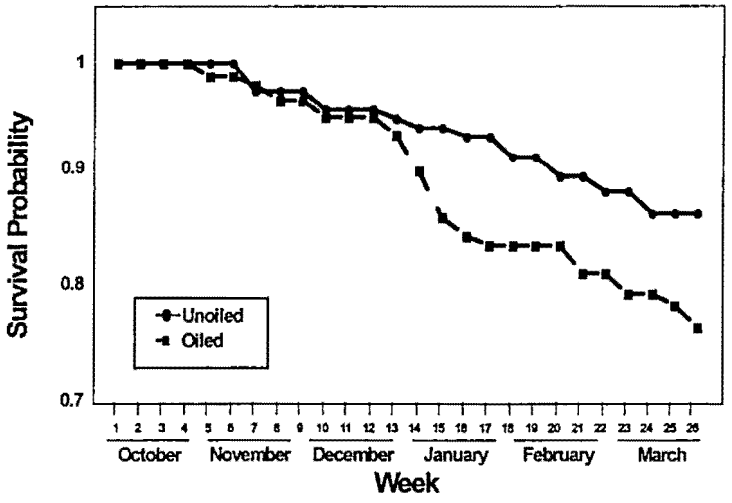


Figure 3. Survival probabilities of harlequin ducks.

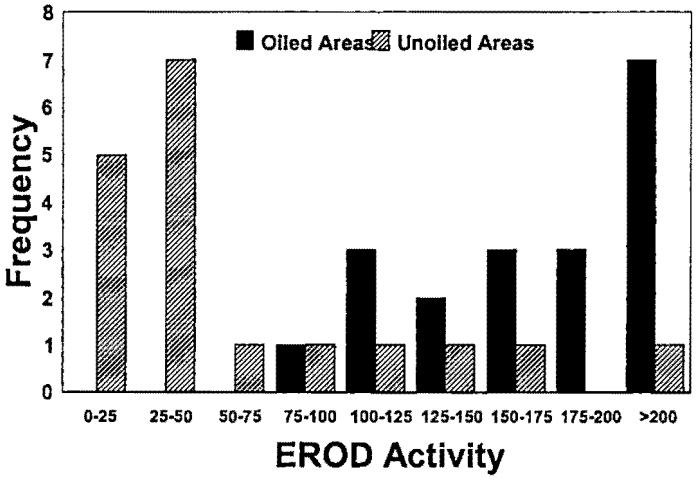


Figure 4. Comparison of CYP1A induction (hepatic EROD activity) in harlequin ducks from Prince William Sound.

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

<u>Sea Otters</u>

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 (**suspended in 2001**).

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

3. Monitor CYP1A induction in sea otters in oiled and unoiled areas, as an additional measure of population recovery.

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-dosed, captive harlequin ducks.

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

B. Methods

The proposed research employs field studies on sea otters, 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, and sampling of intertidal green sea urchins to assess sea otter-prey interactions. These approaches will provide information on recovery status of the population, assessed by growth rates and prey structuring. Additional components proposed for 2001 are collection of carcasses for determination of ages at death, to be used in estimation of survival rates, and monitoring of CYP1A levels in sea otters as an indication of chronic oil exposure.

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 PWS every two years beginning in 1999, and in alternate years, conduct a survey of WPWS. 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 1999 (except in 2001).

Carcass surveys--Age specific survival estimates will be generated based on age distributions of the dying portion of the population, will be 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.

Cytochrome P450 1A--In summer 2001, we will capture 30 sea otters in oiled and unoiled areas (15 per area). We will capture in the same general locations (Knight and Montague islands) that were sampled in the NVP project so that data can be directly compared to previous (1996-98) results. In addition, we will attempt to capture otters in the vicinity of shorelines known to be contaminated with oil (Hays and Michel 1999; Fukuyama et al. in press) and mussel beds being monitored as part of Restoration Project 00090 (Harris et al. 2000). Capture and handling methods will be similar to those employed previously (Bodkin et al. 1999). Sea otters will be sedated, body measurements taken, a tooth collected for age determination, and a blood sample taken by jugular venipuncture. Each otter will be tagged with two color-coded, numbered flipper tags. Following reversal, sea otters will be released in the same vicinity as captured.

In the NVP study, the RT-PCR assay (quantitative reverse transcriptase PCR assay; Vanden Heuvel et al. 1993, 1994) was adapted to measure CYP1A levels in sea otters. This assay quantifies the messenger RNA (m-RNA) that codes for the CYP1A protein. Initially, the RT-PCR assays required the isolation, cloning and sequencing of the PCR product, and the development of sea otter specific primers for CYP1A (Snyder et al. 1999); that work is now complete. Results of the assay are reported as the molecules of mRNA per 100 ng of RNA. We will continue to use peripheral blood mononuclear cells collected from live otters for the assay. The peripheral blood lymphocytes will be isolated by a ficoll gradient technique, cryopreserved in liquid nitrogen and shipped to Dr. P. Snyder at Purdue University for analyses. In addition, duplicate slides of whole blood will be made for hematology, and blood from each otter will be processed to obtain serum, which will be frozen and later submitted for serology analysis.

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 3). 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 and sex cohorts used in survival estimation will not be as restricted as in NVP studies. We will radio birds of both genders and all age classes older than hatch-year. Age and sex 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) will be used to assess presence of external oil.

For field studies, work in FY00 includes ordering radios (and designing a transmitter that avoids problems with extrusion [Mulcahy et al. 1999]), building winter traps, and other preparations (i.e., researching boat and air charter options, etc.). Field work will begin in early FY01 (November 2000).

Captive Studies

Captive bird studies will examine metabolic, behavioral, and biomarker responses to known oil-dosing 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, birds will be flown to the Alaska SeaLife Center in Seward. We intend to use approximately 20 birds each year for 2 years (winters 2000-01 and 2001-02). Captured individuals will undergo quarantine and adjustment periods prior to any experimental manipulation or dosing. Captive birds will be housed in outdoor pens to expose them to natural climatic and photoperiod conditions. Dosing will be designed to simulate long-term, intermittent exposure, which is likely similar to exposure experienced by wild birds. Numbers of dosing levels, amounts of doses, and frequency of dosing will be determined as part of literature review efforts proposed for FY00. Dosing 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 dosing), 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 dosing 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 dosing groups.

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 dosed than undosed 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. A metabolic chamber for harlequin ducks will be built during FY00 preparations; an oxygen analyzer is on site at the Alaska SeaLife Center. BMR of all birds will be measured throughout the winter, including prior to any dosing 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.

FY00 effort will include research to determine appropriate dosing regime, preparation of facilities at the SeaLife Center to house birds and conduct experiments, construction of an appropriate metabolic chamber for oxygen consumption measurements, field work to catch birds to establish the first winter's captive flock, and refinement of the experimental design and protocol. Experimental work will commence in early FY01 (fall 2000).

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 Coastal Resources (Dr. Tom Dean) for close out of the sea otter invertebrate prey monitoring component.

Contract with Dr. Paul Snyder at Purdue University for assays of RT-PCR CYP1A, sea otter CYP1A monitoring (WPWS population and captive sea otters at ASLC).

SCHEDULE

A. Measurable Project Tasks for FY01

Sea Otters

December-March:	Coordinate and plan aerial surveys, carcass collections, sea otter capture, community involvement, prepare equipment. Obtain/update marine mammal permits.
April-May:	Collection of beach-cast carcasses for survival estimates.
July:	Aerial surveys of sea otters in PWS (**suspended in 2001**). Capture of sea otters in WPWS for biosampling, to monitor CYP1A.

Harlequin Ducks

Oct-March:	Conduct studies of captive flock at the Alaska SeaLife Center, with birds captured during late FY00.
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, build winter trap, contact biosample contractors, etc.). Prepare for year 2 captive bird studies (coordinate with Alaska SeaLife Center personnel, determine year 2 dosing regime, arrange boat and air charters, etc.).
August - Sept.:	Capture birds during wing molt for creation of year 2 captive flock and initiate adjustment period.

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 (carcass surveys, CYP1A monitoring) are scheduled to occur from April through July, 2001. Aerial surveys will be repeated in the summers of 2002 and 2003. Sea urchin monitoring will be closed out by September 2001. Carcass surveys and CYP1A monitoring will be repeated in April and July 2002, if warranted based on previous years of data.

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 FY01 activities will be submitted to the Restoration Office on or before 15 April 2002. 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 2nd North American Duck Conference, 11-15 October, Saskatoon, Saskatchewan, to present a paper entitled, "Harlequin Ducks and the *Exxon Valdez* Oil Spill: Collision of a Sensitive Life History and a Major Anthropogenic Perturbation." B. Ballachey attendance at Environmental Toxicology and Chemistry meeting, session: "Effects and Trends of Contaminants in Marine Mammals", 12-16 November 200, Nashville, TN, to present on

comparison of techniques for measuring cytochrome P4501A in sea otters exposed to petroleum hydrocarbons.

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 01423 proposal from projections in the 00423 proposal include increases in salary: three additional months for Dan Esler, PI on the harlequin ducks studies (as per correspondence of July 1999, D. Bohn and S. Schubert), to more accurately reflect the time needed to supervise and conduct this research, and one month for Tom Dean, PI on the sea urchin studies, to support data analyses and interpretation, and preparation of the final report on the prey assessment component (we are not proposing that prey monitoring continue beyond FY00). The 01423 proposal also includes a new component, monitoring of the CYP1A biomarker in sea otters in western PWS. In addition, the carcass recovery surveys, approved as an amendment to 00423, are proposed again for 2001.

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. Because aerial surveys are suspended only for 2001 they were not removed from this revised DPD, but highlighted as suspended.

harlequin duck field and captive studies (previously approved)

PROPOSED PRINCIPAL INVESTIGATORS

James Bodkin
Alaska Biological Science Center
USGS-Biological Resources Division
1011 E. Tudor Rd., Anchorage, Alaska 99503
PHONE: (907) 786-3550
FAX: (907) 786-3636
james_bodkin@usgs.gov

Dan Esler
Alaska Biological Science Center
USGS-Biological Resources Division
1011 E. Tudor Rd., Anchorage, AK 99503
PHONE: (907) 786-3485
FAX: (907) 786-3636
daniel_esler@usgs.gov

Tom Dean
Coastal Resources Associates, Inc.
1185 Park Center Drive, Suite A
Vista, CA 92083
PHONE: (760) 727-2004
FAX: (760) 727-2207
coastal_resources@compuserve.com

Brenda Ballachey
Alaska Biological Science Center
USGS-Biological Resources Division
1011 E. Tudor Rd., Anchorage, Alaska 99503
PHONE: (907) 786-3512
FAX: (907) 786-3636
brenda_ballachey@usgs.gov

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 20

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 Research Wildlife Biologist with the Alaska Biological Science Center, USGS Biological Resources Division. He has conducted waterfowl research in arctic and subarctic regions of Alaska and Russia for the past 11 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 is currently enrolled as a doctoral candidate at Oregon State University. 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 25 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.

KEY COOPERATORS

Sea Otters

Daniel Monson
Alaska Biological Science Center
USGS-Biological Resources Division
1011 E. Tudor Rd.
Anchorage, AK 99503
PHONE: (907) 786-3449
FAX: (907) 786-3636
daniel_monson@usgs.gov

Paul W. Snyder, DVM, PhD.
Department of Veterinary Pathobiology
Purdue University
West Lafayette, IN 470907-1243
PHONE: (765) 494-9676
FAX: (765) 494-9830
pws@vet.purdue.edu

Harlequin Ducks

Kim Trust
U. S. Fish and Wildlife Service
Ecological Services
605 W. 4th Avenue, Room G62
Anchorage, AK 99501
(907) 271-2783
kim_trust@mail.fws.gov

Daniel Mulcahy, DVM, PhD.
Alaska Biological Science Center
USGS-Biological Resources Division
1011 E. Tudor Rd.
Anchorage, AK 99503
(907) 786-3451
daniel_mulcahy@usgs.gov

LITERATURE CITED

Babcock, M.M., G.V. Irvine, P.M. Harris, J.A. Cusick, and S.D. Rice. 1996. Persistence of oiling in mussel beds three and four years after the *Exxon Valdez* oil spill. Am. Fish. Soc. Symp. 18:286-297.

Ballachey, B.E., J.L. Bodkin, S. Howlin, K.A. Kloecker, D.H. Monson, A.H. Rebar and P.W. Snyder. 1999a. Appendix BIO-01 in NVP Draft Final Report (Project 950 Hematology and serum chemistry of sea otters in oiled and unoiled areas of Prince William Sound, Alaska, from 1996-98. 25-99025).

Ballachey, B.E., J.J. Stegeman, P.W. Snyder, G.M. Blundell, J.L. Bodkin, T.A. Dean, L. Duffy, D. Esler, G. Golet, S. Jewett, L. Holland-Bartels, A.H. Rebar, P.A. Seiser, and K.A. Trust. 1999b. Oil exposure and health of nearshore vertebrate predators in Prince William Sound following the *Exxon Valdez* oil spill. Chapter 2 *in* NVP Draft Final Report (Project 95025-99025).

Bodkin, J.L. and M.S. Udevitz. 1999. An aerial survey method to estimate sea otter abundance. In: Garner GW, Amstrup SC, Laake JL, Manly BJF, McDonald LL, Robertson DG (eds) Marine mammal survey and assessment methods. AA Balkema, Rotterdam, p 13-26.

Bodkin, J.L., J.A. Ames, R.J. Jameson, A.M. Johnson, and G.E. Matson. 1997. Estimating age of sea otters with cementum layers in the first premolar. J. Wild. Manage. 61(3):967-973.

Bodkin, J.L., B.E. Ballachey, T.A. Dean, S. Jewett, L. McDonald, D. Monson, C. O'Clair, and G. VanBlaricom. 1999. Recovery of sea otters in Prince William Sound following the *Exxon Valdez* oil spill. Chapter 3A *in* NVP Draft Final Report (Project 95025-99025).

Boehm, P. D., P. J. Mankiewicz, R. Hartung, J. M. Neff, D. S. Page, E. S. Gilfillan, J. E. O'Reilly, and K. R. Parker. 1996. Characterization of mussel beds with residual oil and

the risk to foraging wildlife 4 years after the *Exxon Valdez* oil spill. Env. Toxicol. and Chem. 15:1289-1303.

Bunck, C. M., C-L. Chen, and K. H. Pollock. 1995. Robustness of survival estimates from radio-telemetry studies with uncertain relocation of individuals. J. Wildl. Manage. 59:790-794.

Burnham, K. P., and D. R. Anderson. 1998. Model selection and inference: a practical information theoretic approach. Springer-Verlag, New York, New York, USA.

Clarkson, P., and R.I. Goudie. 1994. Capture techniques and 1993 banding results for moulting harlequin ducks in the Strait of Georgia, B.C. Pages 11-14 in Proc. 2nd Harlequin Duck Symp., Hornby Island, B.C.

Dean, T.A., J.L. Bodkin, A.K. fukuyama, S.C. Jewett, D.H. Monson, C.E. O'Clair, and G.R. VanBlaricom. 1999. Food limitation and the recovery of sea otters in Prince William Sound. Chapter 3B *in* NVP Draft Final Report (Project 95025-99025).

Dean, T.A., J.L. Bodkin, S.C. Jewett, D.H. Monson and D. Jung. 2000. Changes in sea urchins and kelp following a reduction in sea otter density as a result of the *Exxon Valdez* oil spill. Marine Ecology Progress Series. In press.

Doak, D.F. and W.F. Morris. 1999. Detecting population-level consequences of ongoing environmental change without long-term monitoring. Ecology 80:1537-1551.

Duffy, L. K., M. K. Hecker, G. M. Blundell, and R. T. Bowyer. 1999. An analysis of the fur of river otters in Prince William Sound, Alaska: oil related hydrocarbons 8 years after the *Exxon Valdez* oil spill. Polar Biol. 21:56-58.

Duggins, D.O. 1980. Kelp beds and sea otters: an experimental approach. Ecology 61:447-453.

Dzus, E. H., and R. G. Clark. 1996. Effects of harness-style and abdominally implanted transmitters on survival and return rates of mallards. J. Field Ornith. 67:549-557.

Eadie, J. M., F. P. Kehoe, and T. D. Nudds. 1988. Pre-hatch and post-hatch brood amalgamation in north American Anatidae: a review of hypotheses. Can. J. Zool. 66:1709-1721.

Esler, D., T.D. Bowman, K.A. Trust, B.E. Ballachey, T.A. Dean, S. Jewett, and C. O'Clair. 1999. Harlequin duck perspective: Mechanisms of impact and potential recovery of nearshore vertebrate predators. Chapter 4 *in* NVP Draft Final Report (Project 95025-99025).

Esler, D., J. A. Schmutz, R. L. Jarvis, and D. M. Mulcahy. 2000a. Winter survival of adult female harlequin ducks in relation to history of contamination by the Exxon Valdez oil spill. Journal of Wildlife Management 64: in press.

Esler, D., D. M. Mulcahy, and R. L. Jarvis. 2000b. Testing assumptions for unbiased estimation of survival of radio-marked harlequin ducks. Journal of Wildlife Management 64:591-598.

Estes, J.A. and J. F. Palmisano. 1974. Sea otters: their role in structuring nearshore communities. Science 185:1058-1060.

Estes, J.A., N.S. Smith and J.F. Palmisano. 1978. Sea Otter Predation and Community Organization in the Western Aleutian Islands, Alaska. Ecology 59(4):822-833.

Estes, J. A. and D. O. Duggins. 1995. Sea otters and kelp forests in Alaska: generality and variation in a community ecological paradigm. Ecological Monographs 65(1):75-100.

Exxon Valdez Oil Spill Trustee Council. 1996. *Exxon Valdez* Oil Spill Restoration Plan. Draft Update on Injured Resources & Services. Anchorage.

Fischer, J. B. 1998. Feeding behavior, body condition, and oil contamination of wintering

harlequin ducks at Shemya Island, Alaska. M.S. Thesis, Univ. of Mass., Amherst.
Fukuyama, A.K., G. Shigenaka and R.Z. Hoff. In press. Effects of residual *Exxon Valdez* oil on intertidal Prototheca staminea: mortality, growth and bioaccumulation of hydrocarbons in transplanted clams. Mar. Poll. Bull.
Galt, J. A., W. J. Lehr, and D. L. Payton. 1991. Fate and transport of the *Exxon Valdez* oil spill. Environ. Sci. Technol. 25:202-209.
Garrott, R.A., L.L. Eberhardt and D.M. Burns. 1993. Mortality of sea otters in Prince William Sound following the *Exxon Valdez* oil spill. Mar. Mam. Sci. 9:343-359.
Garshelis, D. L. 1997. Sea otter mortality estimated from carcasses collected after the Exxon Valdez oil spill. Conservation Biology. 11(4):905-916.
Goudie, R. I., and C. D. Ankney. 1986. Body size, activity budgets, and diets of sea ducks wintering in Newfoundland. Ecology 67:1475-1482.
Goudie, R. I., S. Brault, B. Conant, A. V. Kondratyev, M. R. Petersen, and K. Vermeer. 1994. The status of sea ducks in the North Pacific rim: toward their conservation and management. Proc. North Am. Wildl. and Nat. Res. Conf. 59:27-49.
Haramis, G. M., D. G. Jorde, and C. M. Bunck. 1993. Survival of hatching-year female canvasbacks wintering in Chesapeake Bay. J. Wildl. Manage. 57:763-771.
Harris, P., M. Carls, and C. Brodersen. 2000. Monitoring of oiled mussel beds in Prince William Sound (abstract). 2000 Restoration Workshop, January 18-19, 2000. EVOS Trustee Council, Anchorage.
Hayes, M.O. and J. Michel. 1999. Factors determining the long-term persistence of Exxon Valdez oil in gravel beaches. Marine Pollution Bulletin 38(2):92-101.
Holland-Bartels, L. et al. 1997. Mechanisms of impact and potential recovery of nearshore vertebrate predators. Exxon Valdez Oil spill restoration project annual report 96025. April, 1997.
Holland-Bartels, L. et al. 1998. Mechanisms of impact and potential recovery of nearshore vertebrate predators. Exxon Valdez Oil spill restoration project annual report 97025. April, 1998.
Holmes, W. N., J. Cronshaw, and J. Gorsline. 1978. Some effects of ingested petroleum on seawater-adapted ducks (*Anas platyrhynchos*). Env. Res. 17:177-190.
Holmes, W. N., J. Gorsline, and J. Cronshaw. 1979. Effects of mild cold stress on the survival of seawater-adapted mallard ducks (*Anas platyrhynchos*) maintained on food contaminated with petroleum. Env. Res. 20:425-444.
Johnson, A. M. 1987. Sea otters of Prince William Sound, Alaska. U.S. Fish and Wildlife Service, Alaska Fish and Wildlife Research Center, Unpublished Report. 86pp.
Kaiser, G. W., A. E. Derocher, S. Crawford, M. J. Gill, and I. A. Manley. 1995. A capture technique for marbled murrelets in coastal inlets. J. Field Ornithol. 66:321-333.
Korschgen, C. E., S. J. Maxson, and V. B. Kuechle. 1984. Evaluation of implanted radio transmitters in ducks. J. Wildl. Manage. 48:982-987.
Korschgen, C. E., K. P. Kenow, A. Gendron-Fitzpatrick, W. L. Green, and F. J. Dein. 1996. Implanting intra-abdominal radio transmitters with external whip antennas in ducks. J. Wildl. Manage. 60:132-137.
Lebreton, J. D., and J. Clobert. 1991. Bird population dynamics, management, and conservation: the role of mathematical modeling. Pages 105-125 in Perrins, C.M., J. D. Lebreton, and G. J. M. Hirons (eds.). Bird population studies: relevance to conservation

and management. Oxford Univ. Press.
Limpert, R. J. 1980. Homing success of adult buffleheads to a Maryland wintering site. J. Wildl. Manage. 44:905-908.
Mather, D. D., and D. Esler. 1999. Evaluation of bursal depth as an indicator of age class of harlequin ducks. Journal of Field Ornithology 70:200-205.
Monson, D.H., D.F. Doak, B.E. Ballachey, A. Johnson, and J.L. Bodkin. 2000. Long-term impacts of the *Exxon Valdez* oil spill on sea otters, assessed through age-dependent mortality patterns. Proc. Nat'l. Acad. Sciences, USA 97(12):6562-6567.
Mulcahy, D. M., and D. Esler. 1999. Surgical and immediate postrelease mortality of harlequin ducks implanted with abdominal radio transmitters with percutaneous antennae. Journal of Zoo and Wildlife Medicine 30:397-401.
Mulcahy, D. M., D. Esler, and M. K. Stoskopf. 1999. Loss from harlequin ducks of abdominally implanted radio transmitters equipped with percutaneous antennas. Journal of Field Ornithology 70:244-250.
Olsen, G. H., F. J. Dein, G. M. Haramis, and D. G. Jorde. 1992. Implanting radio transmitters in wintering canvasbacks. J. Wildl. Manage. 56:325-328.
Paquette, G. A., J. H. Devries, R. B. Emery, D. W. Howerter, B. L. Joynt, and T. P. Sankowski. 1997. Effects of transmitters on reproduction and survival of wild mallards. J. Wildl. Manage. 61:953-961.
Pietz, P. J., G. L. Krapu, R. J. Greenwood, and J. T. Lokemoen. 1993. Effects of harness transmitters on behavior and reproduction of wild mallards. J. Wildl. Manage. 57:696-703.
Pollock, K. H., S. R. Winterstein, C. M. Bunck, and P. D. Curtis. 1989a. Survival analysis in telemetry studies: the staggered entry design. J. Wildl. Manage. 53:7-15.
Pollock, K. H., S. R. Winterstein, and M. J. Conroy. 1989b. Estimation and analysis of survival distributions for radio-tagged animals. Biometrics 45:99-109.
Reidman, M.L. and J.A. Estes. 1990. The sea otter (*Enhydra lutris*): Behavior, ecology and natural history. Biological Report 90(14). U.S. Fish and Wildlife Service, Washington, D.C. 126 pp.
Robertson, G.J. 1997. Pair formation, mating system, and winter philopatry in harlequin ducks. PhD dissertation, Simon Fraser University, Vancouver, B.C.
Rotella, J. J., D. W. Howerter, T. P. Sankowski, and J. H. Devries. 1993. Nesting effort by wild mallards with 3 types of radio transmitters. J. Wildl. Manage. 57:690-695.
Savard, J-P. L., and J. McA. Eadie. 1989. Survival and breeding philopatry in Barrow's and common goldeneyes. Condor 91:198-203.
Short, J. W., and M. M. Babcock. 1996. Prespill and postspill concentrations of hydrocarbons in mussels and sediments in Prince William Sound. Am. Fish. Soc. Symp. 18:149-166.
Schmutz, J. A., R. F. Rockwell, and M. R. Petersen. 1997. Relative effects of survival and reproduction on population dynamics of emperor geese. J. Wildl. Manage. 61:191-201.
Snyder, P.W., T. Kondratyuk, B.E. Ballachey and J. Vanden Heuvel. 1999. CYP1A gene expression in sea otters (Enhydra lutris): a quantitative reverse transcriptase-polymerase chain reaction to measure CYP1A mRNA in peripheral blood mononuclear cells. Appendix BIO-02 *in* NVP Draft Final Report (Project 95025-99025).
Stubblefield, W. A., G. A. Hancock, W. H. Ford, and R. K. Ringer. 1995. Acute and subchronic toxicity of naturally weathered *Exxon Valdez* crude oil in mallards and ferrets. Env.

Toxicol. and Chem. 14:1941-1950.
Trust, K. A., D. Esler, B. R. Woodin, and J. J. Stegeman. 2000. Cytochrome P450 1A induction in sea ducks inhabiting nearshore areas of Prince William Sound, Alaska. Marine Pollution Bulletin 40:397-403.
Udevitz, M.S., B.E. Ballachey and D.L. Bruden. 1996. A population model for sea otters in western Prince William Sound. Exxon Valdez oil spill restoration project final report (restoration project 93043-3), National Biological Service, Anchorage, AK. 34pp.
Vanden Heuvel, J.P., G.C. Clark, C.L. Thompson, Z. McCoy, C.R. Miller, G.W. Lucier, and D.A. Bell. 1993. CYP1A mRNA levels as a human exposure biomarker: use of quantitative polymerase chain reaction to measure CYP1A expression in human peripheral blood lymphocytes. Carcinogenesis 14(10):2003-2006.
Vanden Heuvel, J.P., G.C. Clark, M.C. Kohn, A.M. Tritscher, W.F. Greenlee, G.W. Lucier, and D.A. Bell. 1994. Dioxin-responsive genes: Examination of dose-response relationships using quantitative reverse transcriptase-polymerase chain reaction. Cancer Research 54:62-68.
Ward, D. H., and P. L. Flint. 1995. Effects of harness-attached transmitters on premigration and reproduction of brant. J. Wildl. Manage. 59:39-46.
White, G. C., and K. P. Burnham. 1999. Program MARK -- survival estimation from populations of marked animals. Bird Study 46 Supplement:120-138.

Revision 7-2-00
Approved TC 8-3-00

2001 EXXON VALDEZ TRUSTI JUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001
Personnel	$19.3	$161.8
Travel	$4.6	$9.2
Contractual	$30.8	$127.7
Commodities	$1.2	$29.2
Equipment	$0.6	$1.0
Subtotal	$56.5	$328.9
General Administration	$3.5	$33.2
Project Total	$60.0	$362.1
Full-time Equivalents (FTE)		2.7
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

		Estimated FY 2002	Estimated FY 2003		
		$363.7	$250.0		

Dollar amounts are shown in thousands of dollars.

Comments:

+ ASLC bench fees $141.3

PROJECT TOTAL $505.4

FY01

Prepared: July 20, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI--USGS

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUSTI)UNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2001
J. Bodkin (ss)	Research Wildlife Biologist	GS 13-4	0.5	7.2		3.6
D. Monson (ss)	Research Wildlife Biologist	GS 9-02	6.0	4.2		25.2
B. Ballachey (sb)	Research Physiologist	GS 12-4	3.0	7.0		21.0
						0.0
D. Esler (hd)	Research Wildlife Biologist	GS 12	9.0	6.8		61.2
K. Trust (hd)	Biologist	GS 11	2.0	5.3		10.6
Biotechnician (hd)	Biotechnician	GS 7	8.0	3.3		26.4
D. Mulcahy (hd)	Veterinarian	GS 13	1.0	6.0		6.0
Biotechnician (hd)		GS 5	3.0	2.6		7.8
						0.0
						0.0
						0.0
	Subtotal		32.5	42.4	0.0	
					Personnel Total	$161.8

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
Field crew/gear to Whittier (sb/sw)	0.1	10	20	0.1	3.0
Boat transportation to Whittier (sb)	0.7	1			0.7
					0.0
Esler - Seward (hd)			25	0.1	2.5
Field crew/gear to Whittier (molt) (hd)	0.5	1			0.5
Field crew/gear to Whittier (winter) (hd)	0.5	1			0.5
Meetings (1 hd, 1 so)					2.0
					0.0
					0.0
					0.0
				Travel Total	$9.2

FY01

Prepared: July 20, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI

FORM 3B
Personnel
& Travel
DETAIL

Contractual Costs:	Proposed

2001 EXXON VALDEZ TRUSTI)UNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Description	FY 2000
Cytochrome P450 assays, Purdue University - 30 @ $125 (sb)	3.8
4A Linkage #1 Coastal Resources Associates (su)	7.2
Blood assays, CCL Portland - 30 @ $60 (sb)	1.8
Charter vessel, sea otter beach walks - 10 days @ $1200 (sw)	12.0
Charter vessel, sea otter capture - 15 days @ $1200 (sb)	18.0
Matson's Laboratory - tooth ages, 75 @ $5 (sw, sb)	0.4
Doubly-labelled water assays - 20 @ $350 (hd)	7.0
EROD activity - 70 @ $140 (hd)	9.8
Charter vessel, duck capture (late summer) - 9 days @ $1500 (hd)	13.5
Aircraft charter - transport birds to Seward - 10 hours @ $250 (hd)	2.5
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
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$127.7

Commodities Costs:	Proposed
Description	FY 2001
Misc field/office supplies (sb - 3.0, hd 1.0)	4.0
Fuel (sb)	2.0
Vet supplies (hd)	4.5
Oxygen consumption materials (hd)	1.0
Biosampling materials (hd)	0.8
Kayak rental - 6 @ $150 (hd)	0.9
Molt trap maintenance (hd)	0.5
Captive flock maintenance - 6 months @ $450 (hd)	2.7
Winter trap maintenance (hd)	0.5
Radio transmitters - 50 @ $225(hd)	11.3
Metabolic chamber materials (hd)	1.0
Commodities Total	$29.2

FY01

Prepared: July 20, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI--USGS

FORM 3B
Contractual & Commodities
DETAIL

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

Equipment maintenance and repair (sb)			1.0
			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**	$1.0

Existing Equipment Usage:		
Description	Number of Units	Inventory Agency

FY01

Prepared: July 20, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: DOI

FORM 3B
Equipment
DETAIL

Budget Category:	Authorized FY 1999	Proposed FY 2001	

2001 EXXON VALDEZ TRUSTE)UNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel		$4.0
Travel		$0.0
Contractual		$0.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$4.0
Indirect		$3.2
Project Total	$0.0	$7.2
Full-time Equivalents (FTE)		0.0

LONG RANGE FUNDING REQUIREMENTS

		Estimated FY 2001	Estimated FY 2002		

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

FY01

Prepared: July 20, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: USGS --contract to Coastal Resources, Assoc.

FORM 4A
Non-Trustee
SUMMARY

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2001

2001 EXXON VALDEZ TRUSTE)UNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

	T. Dean	Biologist		0.5	8.0		4.0
	Indirect costs						0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
		Subtotal		0.5	8.0	0.0	
						Personnel Total	$4.0

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
					Travel Total	$0.0

FY01

Prepared: July 20, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: USGS--CRA contract

FORM 4B
Personnel
& Travel
DETAIL

Contractual Costs:	Proposed
Description	FY 2001

Contractual Total	$0.0

Commodities Costs:	Proposed
Description	FY 2001
Commodities Total	$0.0

FY01

Prepared: July 20, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: USGS--CRA contract

FORM 4B
Contractual & Commodities
DETAIL

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	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	

FY01

Prepared: July 20, 2000

Project Number: 01423
Project Title: Pattern and Process of Population Change in Selected Nearshore Vertebrates
Agency: USGS--CRA contract

FORM 4B
Equipment
DETAIL

FY 01 EXXON VALDEZ TRUST OUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Budget Category:	Authorized FFY 2000	Proposed FFY 2001
Personnel		$0.0
Travel		$0.0
Contractual		$133.9
Commodities		$0.0
Equipment		$0.0
Subtotal		$133.9
General Administration		$9.4
Project Total		$141.3
Full-time Equivalents (FTE)		
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FFY 2002

Dollar amounts are shown in thousands of dollars.

Comments:

2001

Project Number: 01423
Project Title: Alaska SeaLife Center Bench Fees
Agency: ADF&G

FORM 3A
SUMMARY

Approved TC 8-3-00

Exxon Valdez Oil Spill Restoration Reserve

Project Number:	01424
Restoration Category:	Restoration Reserve
Proposer:	All Trustee agencies
Duration:	Ongoing
Cost FY 01:	$12,000,000
Cost FY 02:	$12,000,000
Geographic Area:	Oil spill area
Injured Resource/Service:	Multiple resources and services

ABSTRACT

In recognition of the fact that complete recovery from the oil spill may not occur for decades, the Trustee Council established the Restoration Reserve to hold funds to be used for restoration after the last annual payment is received from Exxon Corporation in September 2001. The $12 million recommended for deposit in FY 01 would be the eighth deposit into the reserve account, and would bring the total in the account to $96 million. The final deposit of $12 million in FY 02, plus any other unobligated settlement funds as of October 1, 2002, should provide a reserve of roughly $180 million.

INTRODUCTION

In recognition of the fact that complete recovery from the oil spill may not occur for decades, the Trustee Council established the Restoration Reserve to hold funds to be used for restoration after the last annual payment is received from Exxon Corporation in September 2001.

Consistent with the March 1, 1999 resolution adopted by the Trustee Council, funds in the Restoration Reserve and other remaining unobligated settlement funds available October 1, 2002 (roughly $180 million), will be allocated in the following manner, unless otherwise provided by unanimous resolution:

- $55 million of the estimated funds remaining on October 1, 2002 and the associated earnings thereafter will be managed as a long-term funding source for habitat protection, with a significant proportion of these funds to be used for small parcels; and
- The remaining balance of the funds on October 1, 2002, will be managed so that the annual earnings, adjusted for inflation, will be used to fund annual work plans that include a combination of research, monitoring, and general restoration.

NEED FOR THE PROJECT

A. Statement of Problem

The Chief Scientist and other investigators working on the restoration program have identified a need to maintain restoration activities in the years following Exxon's last scheduled payment in 2001. The collection of long-term data sets is increasingly recognized as essential to understanding the results from any one year of work. In addition, there continues to be strong public interest in the Trustee Council's habitat protection efforts.

B. Rationale/Link to Restoration

To be effective, restoration activities may have to span more than one generation. For example, some salmon return in cycles of four to six years while other resources have lives that are much longer. In addition, oceanographic influences on the health and survival of numerous injured species under investigation are only just beginning to be understood. Work under the major ecosystem studies (SEA, NVP, APEX), while providing significant new insight into the status of recovery and health in the spill area, has also brought attention to new questions that may require continuing efforts long into the future. This includes the identification of key areas or times of year (spatial or temporal refuges) and processes critical to the long-term recovery of injured resources and associated services.

C. Location

Oil spill area.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

The Trustee Council is committed to public input and public outreach as vital components of the long-term restoration program.

PROJECT DESIGN

A. Objectives

The essential objective of the Restoration Reserve is to ensure that funds are available to support restoration activities beyond the end of the settlement payment period.

B. Methods

This proposed $12 million would be the eighth payment to the Restoration Reserve. Based on previous Trustee Council action, the total principal after this deposit would be $96 million. The additional deposit of $12 million in FY 02 would provide a reserve of $108 million plus interest earned by investment of these funds. The Restoration Reserve and other remaining unobligated settlement funds available October 1, 2002 are anticipated to be roughly $180 million.

Funds in the Restoration Reserve are currently invested within the Court Registry Investment System. In accordance with Public Law 106-113, the funds may be deposited in the United States Department of the Interior Natural Resource Damage Assessment and Restoration Fund or accounts outside the United States Treasury or both. During Fiscal Year 2000, the Trustee Council will be moving the funds in the reserve, along with other joint settlement funds, out of the Court Registry Investment System to a settlement fund in the Alaska Department of Revenue. In concert with this action, the Trustee Council has adopted Investment Policies (February 2000) and an Asset Allocation Policy (April 2000).

Any spending from the Restoration Reserve must be consistent with the Consent Decree and the Memorandum of Understanding between the state and federal governments.

C. Cooperating Agencies, Contracts and Other Agency Assistance

Not applicable.

SCHEDULE

A. Measurable Project Tasks for FY 01

The $12 million proposed for FY 01 will be allocated to the Restoration Reserve Fund when such funds are available.

B. Project Milestones and End Points

Not applicable.

C. Completion Date

Not applicable.

PUBLICATIONS AND REPORTS

Not applicable.

PROFESSIONAL CONFERENCES

Not applicable.

NORMAL AGENCY MANAGEMENT

Not applicable.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Not applicable.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

Not applicable.

PROPOSED PRINCIPAL INVESTIGATOR

Molly McCammon
Executive Director
Exxon Valdez Oil Spill Trustee Council
645 G Street
Anchorage, Alaska 99517
phone: 907/278-8012
fax: 907/276-7178

Approved TC 8-3-00

Harbor Seal Recovery: Effects of Diet on Lipid Metabolism and Health

Project Number:	01441-CLO
Restoration Category:	Research
Proposer:	R. Davis/Texas A&M Univ.
Lead Trustee Agency:	ADFG
Cooperating Agencies:	None
Alaska SeaLife Center:	Yes
New or Continued:	Cont'd
Duration:	3rd yr. 3 yr. project
Cost FY 01:	$93.5
Cost FY 02:	$0.0
Geographic Area:	Prince William Sound
njured Resource/Service:	Harbor seals

ABSTRACT

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, data is needed for seals on diets that vary in nutritional composition. Working with the Alaska SeaLife Center, this project will determine how fatty acid profiles in the blubber of captive harbor seals change over time during controlled diets of herring and pollock. In addition, the project will assess the aerobic capacity and lipid metabolism of skeletal muscle in harbor seals fed controlled diets and in wild harbor seals in Prince William Sound. The results will enhance understanding of the nutritional role and assessment of dietary fat for harbor seals.

ACCOMPLISHMENTS FOR THE FIRST 18 MONTHS (OCT. 1998 TO MARCH 2000)

Feeding trials for eight harbor seals began in early September 1998 at the Alaska SeaLife Center. Six seals (two groups of three) received an alternating diet of either herring or pollock. To date, four feeding trials have been completed and the fifth is ongoing. Six feeding trials are planned. A separate control group of two seals will receive a mixed diet of half herring and half pollock throughout the study.

CROSS-OVER REPEATED MEASURES FEEDING TRIALS
FOR HARBOR SEALS

Period	Feeding Trail #	Herring Diet	Pollock Diet
Sept-Dec 1998	1	Seals A,B,C	Seals D,E,F
Jan-April 1999	2	D,E,F	A,B,C
May-Aug 1999	3	A,B,C	D,E,F
Sept-Dec 1999	4	D,E,F	A,B,C
Jan-April 2000	5	A,B,C	D,E,F

At the mid-point and end of each feeding trial, blubber samples only were taken at two sites from each seal. Skeletal muscle samples were also taken at the end of each trail. Half of each muscle sample was placed in fixative, and the remainder along with the blubber samples were frozen at –70° C. The muscle samples were sent to the University of California at San Diego where analysis (% fiber type, volume density of lipid droplets and mitochondria, lipid enzyme activities, and myoglobin concentration) is underway. Blubber samples are being analyzed for fatty acid profiles at Texas A&M University. In June of 1999, we obtained extensive muscle, blubber and splanchnic organ samples from eight harbor seals through the BIOSAMPLING Program in Prince Williams Sound. These samples are under analysis at Texas A&M University and will form the basis for two Doctoral and one Masters dissertation. Preparations have been made for obtaining additional harbor seal samples from the BIOSAMPLING Program in June 2000. This collaborative effort with the Native community has been very successful for our program.

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 (1). 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 (1). In a study of harbor seal foraging ecology (Project 117-BAA; Harbor seal blubber and lipids) supported by the Restoration Program, Iverson, et al (2) 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 (3), 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 study 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 *B*-hydroxyacyl CoA dehydrogenase (an enzyme important for lipid metabolism) as indicators of aerobic capacity and the *B*-oxidation of fatty acids, respectively.

The Restoration Program has supported the population monitoring component of health assessment, diving behavior and food preferences of harbor seals in Prince William Sound. Now, with controlled feeding studies of harbor seals underway at the Alaska SeaLife Center, we will continue our studies of the effects of diet on fatty acid signatures in blubber and the metabolic function of muscle, especially with regards to lipid. The results will improve our understanding of harbor seal feeding ecology and the effects of diet on health and metabolism.

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 has been 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 more completely 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 that will quantify the nutritional value of several key Alaskan fish species for harbor seals and will follow health indices over time in both healthy and

rehabilitation animals. That project, which has been underway at the Alaska SeaLife Center for 18 months, will feed controlled diets of fish to harbor seals to examine changes in body condition, health, assimilation efficiency and blood chemistry biomarkers. Of particular interest will be the health and body condition effects of diets containing nutritionally poor (compared to herring) fish such as pollock, the so-called "junk food" hypothesis for explaining the decline of certain pinniped stocks. In the current study, we will continue (four feeding Trials are completed and the fifth will be completed in May 2000) to take advantage of the controlled feeding studies at the Alaska SeaLife Center to examine the effects of diet on: 1) fatty acid markers in the blubber, 2) muscle condition and 3) lipid metabolism. In addition, we will use samples of blubber and muscle obtained by the BIOSAMPLING Program in Prince William Sound for comparison with captive seals fed known diets. This important work will augment already funded investigations of diet and health to provide a more in depth understanding of the nutritional role and assessment 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 propose to augment this study by examining changes in fatty acid profiles in seal blubber and muscle lipid content during controlled feeding studies where fish species composition is known. In addition, we will quantify the aerobic capacity and activities of enzymes that are crucial for muscle lipid metabolism and which may be affected by nutritional stress.

C. Location

The experiments for this project will be conducted at the Alaska SeaLife Center in Seward. We will collaborate with existing projects that will examine the detailed metabolic alternations in stable isotope ratios (Schell/Project 170) and changes in body condition and health indices (Castellini/Project 341) in harbor seals that occur under different feeding regimes.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Native communities have assisted Field studies of harbor seals in conjunction with the BIOSAMPLING program (Project 96244). We will continue that collaboration by analyzing samples of muscle, blubber and other tissues taken as part of subsistence hunting.

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.

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 and *B*-hydroxyacyl CoA dehydrogenase 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.

2. Harbor Seal Feeding Trials Conducted at the Alaska SeaLife Center (ASLC).

Animals. Eight harbor seals have been acquired by the ASLC for the feeding trials that began in September 1998. Dr. Michael Castellini developed dietary protocols for EVOS Project 99341. During the staggered feeding trials, the diet will be changed every four months. During these

dietary manipulations, we will obtain serial blubber samples every two months and muscle biopsies every four months from two sites on each animal.

Design for Feeding Trials. A detailed matrix of the feeding schedule developed by Dr. Castellini is shown below. The procedure will use a cross-over repeated measures approach and will allow statistical comparisons within any one group of seals between diet and season. Statistical software (SYSTAT) will be used to analyze the cross-over method. However, there are several considerations that must be addressed using this matrix.

CROSS-OVER REPEATED MEASURES ANOVA FEEDING TRIALS
FOR HARBOR SEALS

Period	Herring	Pollock	Condition
Sept-Dec 1998	Seals A,B,C	Seals D,E,F	Molting
Jan-April 1999	D,E,F	A,B,C	Spring
May-Aug 1999	A,B,C	D,E,F	Breeding
Sept-Dec 1999	D,E,F	A,B,C	Molting
Jan-April 2000	A,B,C	D,E,F	Spring
May-Aug 2000	D,E,F	A,B,C	Breeding

This feeding matrix allows each group of seals to experience a different diet at similar physiologically relevant times of the year. Group A,B,C for example, will receive a herring diet during the molting season in Year 1 and a high pollock diet in Year 2. After training during the summer of 1998, the seals accepted a pollock diet that was 100% pollock. Two additional control seals will receive a diet of half herring and half pollock throughout the study.

A problem with cross-over ANOVA designs is that residual or carry-over effects from previous treatments can complicate the analysis. We correct for this with long test periods and phased cross-overs. That is, since each feeding trial will last for four months, several weeks of diet switching will be allowed. This provides the additional advantage of allowing us to study the impact of the phased switch on blubber and muscle lipid content and composition, and on muscle lipid metabolism.

Blubber Biopsies. Blubber samples will be obtained through the full depth of blubber layer with a 6-mm punch biopsy inserted through a small incision in the skin. Samples will be immediately transferred to liquid nitrogen and stored at -70° C until analysis. Total lipids will be extracted in chloroform according to Folch et al. (4) as modified by Iverson (5). 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 will be 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 will be 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 will be 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. Muscle samples will be placed either into 2% glutaraldehyde fixative or frozen in liquid nitrogen immediately upon collection. Samples will remain in the fixative for a minimum of 48 hours but no longer then 14 days before being transferred and stored in 0.1 M cacodylate buffer pH 7.4. Frozen samples will be 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 will be rinsed in cacodylate buffer and post-fixed for 2 hours in a 1% solution of osmium tetra oxide. They will be stained 'en bloc' with 2% uranyl acetate overnight in a refrigerator. After dehydration with increasing concentrations of ethanol (50-100%), they will be passed through propylene oxide and increasing concentrations of epoxy (50-100%). The samples are finally embedded in fresh epoxy and allowed to polymerize overnight at 60 ° C. Thick sections (1 mm) will be 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 x19,250 using standard point counting procedures (6, 7).

Citrate Synthase, B-hydroxyacyl CoA dehydrogenase and Myoglobin Assays of Muscle Samples. Frozen muscle samples will be weighed and then homogenized at 0° C in 1 ml of buffer containing 1 mmol L^{-1} EDTA, 2 mmol L^{-1} $MgCl_2$, and 75 mmol L^{-1} Tris-HCl, pH 7.6 at 25 ° C (8). The homogenates will be spun at 2,900 g for 30 minutes at 4° C. 500 ml from each supernatant will be prepared for myoglobin assay and the rest will be used for the analysis of citrate synthase. Citrate synthase and *B*-hydroxyacyl CoA dehydrogenase will be assayed on a Beckman DU series 64 spectrophotometer according to the method of Reed et al. (1994). Assay temperature will be maintained at 37 ° C using a constant temperature water bath and a water-jacketed cuvette holder. The assay conditions for citrate synthase (CS; EC 4.1.3.7) will be 50 mmol L^{-1} imidazole, 0.25 mmol L^{-1} 5,5-dithiobis (nitrobenzoic acid, DTNB), 0.4 mmol L^{-1} acetyl CoA, and 0.5 mmol L^{-1} oxaloacetate, at pH 7.5; DA_{412}, e_{412} = 13.6 (8). For *B*-hydroxyacyl CoA dehydrogenase (HAD; EC 1.1.1.35), the assay conditions will be 50 mmol L^{-1} imidazole, 1 mmol L^{-1} EDTA, 0.1 mmol L^{-1} acetoacetyl CoA, and 0.15 mmol L^{-1} NADH, pH 7.0 at 37° C; DA_{340}, e_{340} = 6.22 (9). Enzyme activities (mmol min^{-1} g^{-1} wet mass muscle) will be calculated from the rate of change in absorbance at the maximum linear slope. Myoglobin will be assayed according to the method of Reynarfarje (1963) with the following modifications. A portion (500 ml) of the supernatant is further diluted with 1 ml of phosphate buffer (0.04 M, pH 6.6). The resulting mixture is centrifuged

for 50 min at 28,000 g at 4°C. The supernatant is bubbled with carbon monoxide for three min. Spectrophotometric absorbance will be measured at 538 and 568 nm, and the concentration of myoglobin in milligrams g^{-1} wet mass of muscle will be calculated as:

$$(Abs_{538} - Abs_{568}) \times 5.865 [(1.5/0.5) \times (\text{mass of sample})]$$

Statistical Analysis. Results will be expressed as the mean ± one standard error. We will use a cross-over 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 cross-over 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, blubber and splanchnic organs of 16 harbor seals will be obtained during BIOSAMPLING Program. The entire muscle will be removed and weighed, and three transverse sub-samples will be taken along the muscle bundle. Each sub-sample of the swimming muscle will be precisely labeled for its orientation and location within the animal. These will then be further sub-sampled along points on a circular grid using a stainless steel borer, averaging 35 samples per muscle section. Cores of tissues weighing 200 and 300 mg will be removed for assay. A spectrophotometric technique will be used to determine myoglobin, citrate synthase, and *B*-hydroxyacyl CoA dehydrogenase concentration (see above for details). Detailed contour maps and statistical tests for all concentrations will be made using a PC based program S-Plus (Stat-Sci, Seattle). Blubber samples will also be 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 will also be taken from the liver, kidneys, stomach, small intestine, diaphragm and brain. They will be analyzed using the same techniques as the muscle samples.

SCHEDULE

A. Measurable Project Tasks for FY 99 (October 1, 1998 - September 30, 1999), FY 00 (October 1, 1999 - September 30, 2000) and FY 01 (October 1, 2000 – September 30, 2001)

Each feeding trial will take four months beginning in September, 1998.

1998	
September	Set up fatty acid analysis and muscle lipid and enzyme analysis
September-December	Trial 1 of staggered feeding protocol at ASLC. Obtain blubber and muscle biopsies. Status- completed on schedule.
1999	
January-April	Trial 2 of staggered feeding protocol. Obtain blubber and muscle samples. Status- completed on schedule.
May-August	Trial 3 of staggered feeding protocol. Obtain blubber and muscle samples. Status- completed on schedule. Obtain blubber and muscle samples from wild harbor seals in Prince William Sound in conjunction with BIOSAMPLING Program. Status- completed on schedule.
September-December	Trial 4 of staggered feeding protocol at ASLC. Obtain blubber and muscle biopsies. Status- completed on schedule.
2000	
January-April	Trial 5 of staggered feeding protocol. Obtain blubber and muscle samples. Status- underway and on schedule
May-August	Trial 6 of staggered feeding protocol. Obtain blubber and muscle samples. Planned and on schedule Obtain blubber and muscle samples from wild harbor seals in Prince William Sound in conjunction with BIOSAMPLING Program. Planned and on schedule.
September-December	Complete analysis of blubber and muscle samples.
2001	
January-September	Analyze data and prepare Final Report. Prepare and submit manuscripts. Two manuscripts are anticipated at this time.

B. Project Milestones

FY 99:	Obtain blubber and muscle samples during first four feeding studies at ASLC and the BIOSAMPLING Program in Prince William Sound.
FY 00:	Continue to obtain blubber and muscle samples during feeding studies at ASLC; obtain blubber and muscle samples from seals in Prince William Sound in conjunction with BIOSAMPLING Program.
FY 01	Complete analysis and prepare Final Report and manuscripts by September.

C. Completion Date

This project will finish on September 30, 2001.

PUBLICATIONS AND REPORTS

Since this is a new project, there are no current publications from the proposed research. However, the results from a preliminary study of the aerobic capacity and lipid content of muscles from harbor seals in Prince William Sound were be published in the Journal of Applied Physiology in April 1999. We do not anticipate any referred articles in FY 00. However, by FY 2001 most of the data will be analyzed and manuscripts in preparation. Because samples will continue to be collected through September 2000, we request an additional year (Oct. 2000 to September 2001) to complete data analysis and prepare the Final Report and manuscripts. We anticipate at least two publications by 2001 on the effects of diet on fatty acids in blubber and the aerobic capacity and lipid metabolism in harbor seal muscle.

PROFESSIONAL CONFERENCES

The PI requests funds to attend the annual EVOS workshops each year.

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) and staff at the Alaska SeaLife Center (see attached letter). Dr. Castellini is supervising the controlled diet studies. We have coordinated our blubber and muscle samples with the veterinary staff at ASLC. Samples obtained from the BIOSAMPLING program will be coordinated with Ms. Monica Riedel of the Alaska Native Harbor Seal Commission.

PROPOSED PRINCIPAL INVESTIGATOR

Dr. Randall Davis
Dept. Marine Biology
Texas A&M University at Galveston
Galveston, TX 77553
Phone: 409-740-4712
Fax: 409-740-5002
email: davisr@tamug.tamu.edu

Revision 7-27-00
Approved TC 3-00

2001 EXXON VALDEZ TRUST OUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001
Personnel		$0.0
Travel		$0.0
Contractual		$87.4
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$87.4
General Administration		$6.1
Project Total	$0.0	$93.5
Full-time Equivalents (FTE)		1.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
			Estimated FY 2002		
			$0.0		

Dollar amounts are shown in thousands of dollars.

Comments:
This revised budget was prepared following the recommendations of the EVOS TC FAX MEMO dated 18 July 2000. (wjh)

NOTE: An additional $38.6 is deferred to Dec. 2000.

FY01

Prepared:

Project Number: 01441
Project Title: Harbor Seal Recovery Phase III: Effects of Diet on Lipid Metabolism and Health
Agency: Alaska Department of Fish and Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$50,780.4						
Travel		$2,520.0						
Contractual		$7,800.0						
Commodities		$8,800.0						
Equipment		$0.0						
Subtotal	$0.0	$69,900.4				Estimated FY 2002		
Indirect @ 25%		$17,475.1						
Project Total	$0.0	$87,375.5						
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 $412/mo. The Research Assistant and Graduate Research Assistant are calculated at $331/mo.

FY01

Prepared: 4/11/00
Project No.: 01-441

Project Number: 01441
Project Title: Harbor Seal Recovery Phase III: Effects of Diet on Lipid Metabolism and Health
Name: Texas A&M Research Foundation

FORM 4A
Non-Trustee
SUMMARY

2001 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2001
	R. Davis	Principal Investigator	3.0	9100.0		27,300.0
	To Be Named	Research Assistant	6.0	2338.4		14,030.4
	To Be Named	Graduate Research Assistant	3.0	3150.0		9,450.0
			.3125/FTE			0.0
	Justification:					0.0
	Funding for R. Davis and a Graduate Student are similar to that requested in Years 1 and 2.					0.0
	However, relative to Years 1 and 2, we request an additional 6 mo (12 mo total) for a Research Assistant to help analyze samples and assist in preparation of a final report and two (2) manuscripts for publication in peer-reviewed journals in FY 01.					0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	12.0	14588.4	0.0	
					Personnel Total	$50,780.4

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2001
	To Anchorage, AK for EVOS Workshop	700.0	1	3	140.0	1,120.0
	To Fairbanks, AK to coordinate Final Report with M. Castellini	1000.0	0	0	130.0	0.0
	To National Scientific Meeting to present results	700.0	1	5	140.0	1,400.0
	(Biennial Meeting of the Marine Mammal Society, 2001)					0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$2,520.0

FY01

Prepared: 04/11/00
Project No.: 01-441

Project Number: 01441
Project Title: Harbor Seal Recovery Phase III: Effects of Diet on Lipid Metabolism and Health
Name: Texas A&M Research Foundation

FORM 4B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed FY 2001
Description	
Electron Microscope Analysis (Subcontract to S. Kanatous): 153 tissue samples @ $16/samples (not including supplies)	2,500.0
Justification: As detailed in the original proposal, muscle samples from captive and wild harbor seals will be analyzed for mitochondrial volume density using electron microscopy. Although some samples have been analyzed, the majority will be analyzed once all samples have been obtained by the Alaska SeaLife Center in September 00.	
Gas Chromatograph Analysis (Texas A&M Univ. Gas Chromatograph Lab): 63 blubber and fish samples @ $80/sample (includes all supplies)	5,000.0
Justification: As detailed in the original proposal, blubber and dietary samples from captive and wild harbor seals will be analyzed for fatty acid signitures using gas chromatography. Although some samples have been analyzed, the majority will be analyzed once all samples have been obtained by the Alaska SeaLife Center in September 00.	
Communications - Long Distance Phone Charges ($25/mo x 12 mo)	300.0
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	$7,800.0

Commodities Costs:	Proposed FY 2001
Description	
Expendable supplies and chemicals	7,500.0
Justification: Electron Microscope expendable supplies: 153 samples x $6/sample = $918 Analysis of tissue enzyme activities:750 x $8/sample = $6000 Misc. expendable supplies and gases: $630	
Liquid nitrogen and shipping of final frozen samples from Alaska SeaLife Center	300.0
Justification: Final blubber, muscle and dietary samples will be taken in late September or early October FY00 and shipped to Texas A&M for analysis.	
Publications and Page Charges for manuscripts that will appear in FY01	1,000.0
Justification: Manuscript 1: Effects of Diet on the Fatty Acid Signitures in the Blubber of Harbor Seals Journal: Canadian Journal of Zoology Submission/Publication Date: FY01 Manuscript 1: Effects of Diet on the Mitochondrial Volume Density and Fatty Acid Oxidation Potential in Harbor Seals Journal: Journal of Experimental Biology Submission/Publication Date: FY01	
Commodities Total	$8,800.0

FY01

Prepared: 04/11/00

Project Number: 01441
Project Title: Harbor Seal Recovery Phase III: Effects of Diet on Lipid Metabolism and Health
Name: Texas A&M Research Foundation

FORM 4B
Contractual & Commodities DETAIL

2001 EXXON VALDEZ TRUS COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Project No.: 01-441

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
			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		

FY01

Project Number: 01441
Project Title: Harbor Seal Recovery Phase III: Effects of Diet on Lipid Metabolism and Health
Name: Texas A&M Research Foundation

FORM 4B Equipment DETAIL

Prepared: 04/11/00

Approved TC 8-3-00

Pink Salmon Recovery: Evidence and Consequences of Persistent Oil Contamination in Pink Salmon Natal Habitats

Project Number:	01454
Restoration Category:	Research
Proposer:	Stanley Rice, Mark Carls, Ron Heintz NMFS Auke Bay Laboratory ABL Program Manager: Dr. Stan Rice NOAA Project Manager: Bruce Wright
Lead Trustee Agency:	NOAA
Cooperating Agencies:	-
Alaska SeaLife Center:	-
Duration:	2 years *(Final year of a 2 year project)*
Cost FY01:	$103,200
Geographic Area:	Prince William Sound, and Little Port Walter on Baranof Island (Southeast Alaska)
Injured Resource:	Pink salmon

ABSTRACT

Reports of persistent oil contamination in natal pink salmon streams in Prince William Sound (PWS), and adverse biological effects at parts per billion oil concentrations stimulated this study in FY00. Preliminary results demonstrate evidence of continued hydrocarbon contamination in some previously oiled streams. Fry from PWS and experimentally dosed fish have been collected for examination of a biomarker, cytochrome P4501A. When analyses are completed, data will be inspected for correlations between the biomarker, growth, predator avoidance, and marine survival. These results will be integrated with past research to reexamine the recovery status of pink salmon and their spawning habitat.

INTRODUCTION

The recovery status of pink salmon in Prince William Sound (PWS) is problematic, because population levels as a whole are relatively high and include fish from large areas with little or no oil-exposure history), while the banks of specific natal streams remain contaminated with oil (Murphy et al. In press). Part per billion sensitivities to oil have been documented in early life stages (Heintz et al. 1999), and elevated egg mortalities in oiled streams were reported by ADF&G as late as 1997. Recovery at the stream level is unknown, and the definition of recovery for pink salmon needs to be re-examined. This proposal will "close the loop" on past pink salmon oil toxicity research by examining the status of oil contamination and egg/alevin exposure at oiled benchmark streams. The use of the biomarker P4501A will be used in field and laboratory tests, and the biological significance of the biomarker will be determined in short-term responses (tissue abnormalities), intermediate responses (growth of cultured fish), and in returning adult pink salmon from previous exposures (brood year 1998).

This project is designed to examine the natal habitat of pink salmon in PWS for evidence of exposure to polynuclear aromatic hydrocarbons (PAHs) derived from *Exxon Valdez* oil. When the project was initiated in FY00 we suggested that direct measurement of biologically available PAHs in the natal habitats 10 years after the spill would be difficult, but possible with the proposed detection technology (plastic membrane devices). Two types of plastic membrane devices (PMDs) were used, semi-permiable membrane devices (SPMDs) and low density polyethylene (LDPE) strips[1]). Preliminary PMD results indicate that oil is present in at least 2 of 6 previously oiled PWS streams. Confirmatory analysis of naturally spawned eggs for PAH is in progress, and sediments will also be analyzed.

Further, we will look for biological evidence of oil exposure by measuring cytochrome P4501A in pre-emergent alevins collected from the streams in spring 2000. These measurements will be the first complete set of observations of this kind made in the oil-contaminated streams. The measurement of oil in the stream banks [repeating the Murphy et al. (1999) study] will permit the extension of the habitat contamination recovery model by 4 years. Demonstration of detectable amounts of PAHs in these environments (or their absence) will provide a direct basis for relating earlier field studies to recent laboratory studies aimed at cataloging the effects of incubating in oiled stream environments. In addition, examination of the incubating environments for evidence of contamination will provide the Trustees with a rational basis for evaluating the recovery status of pink salmon at the stream level, rather than be dependent on population levels that include hatchery production and many streams with little or no oil-exposure history.

Biomarkers like P4501A have been used before as biological evidence of oil exposure (e.g., Wiedmer et al. 1996), but the biological significance of induction is seldom known. We

---

[1]The SPMDs are commercially produced samplers that consist of an LDPE tube enclosing a triolene reservoir. The LDPE strips had the same surface area as the SPMDs. LDPEs and SPMDs were always deployed in groups, so that sampling results were directly comparable.

propose to measure cytochrome P4501A activity in emergent fry from oil-contaminated streams and compare to measurements of fry with known exposures and known biological consequences. By using fish from graded exposures and following them through the delayed impacts on marine growth, we can ascribe a biological significance (consequence) to the P4501A measurements. The experimental exposures are nearly complete; fry emerging from the incubators are being sampled and ponded for growth study. Further, by sampling emergent fish from project 99426 in spring 1999, we can correlate marine survival and reproductive fitness to the three exposure doses that will be released to the field (returning as adults in fall 2000). In past laboratory studies, aqueous PAH concentrations as low as 4 ppb induced cytochrome P4501A activity (Marty et al. 1997), and embryo mortality was elevated at 1 ppb (Heintz et al. 1999). However, none of these experiments were designed to identify a lowest effective concentration (LOEC) for P4501A induction, and these studies did not establish the biological meaning of exposure by relating induction to demonstrable effects. We will relate differing levels of P4501A activity to long-term effects on salmon growth because growth is a relatively inexpensive criterion to measure, and it effectively integrates most of the long-term effects that are likely to be experienced by those fish that survive the exposure period.

Lastly, the definition of pink salmon recovery, relative to habitat contamination and biological consequences will be examined. The project here will synthesize the present study results, along with other concurent and past studies to give a definitive status of pink salmon recovery.

NEED FOR THE PROJECT

A. Statement of the Problem

The definition of pink salmon recovery in PWS, currently based on broad geographic populations that include fish from hatcheries and streams with little or no oil-exposure history, is not compatible with measurements of persistent oil effects in wild salmon streams. This study will provide field and laboratory evidence of pink salmon exposure in natal streams, where oil impacts have been measured as late as 1997. Interpretation of results will help to determine if wild pink salmon in PWS continue to be contaminated by EVO, or if they have recovered.

This project examines two questions: are the natal habitats of pink salmon still being contaminated by PAHs derived from the *Exxon Valdez*, and can biomarkers index injury as well as identify exposure. The first question derives from three important observations. First, pink salmon mortalities have been shown to increase at aqueous TPAH concentrations as low as 1.0 ppb (Heintz et al. 1999). Second, oiled gravel is still recoverable near several pink salmon streams in the affected sections of PWS, and third, elevated embryo mortality in oil-contaminated streams was identified as late as 1997. These observations suggest that oil from the *Exxon Valdez* may still be injuring pink salmon in contaminated streams. Consequently, pink salmon are only classified as a recovering species, despite apparently healthy escapement levels in the southwestern district. This project seeks to examine the potential for ongoing injury by quantifying the exposure experienced by pink salmon in their natal streams and identifying what sort of injury can be expected from the observed exposure levels.

The question of continuing exposure in pink salmon streams is examined in three ways. First we have measured the availability of PAHs to incubating pink salmon by measuring the levels of contamination in interstitial waters; stream sediment and streambanks will also be analyzed. Second, evaluation of the uptake of PAHs in eyed pink salmon eggs collected from oiled streams is in progress. Finally, fry from oil-contaminated streams will be examined for evidence of PAH exposure by measuring cytochrome P4501A activity in their tissues and the biological significance of these exposures will quantified with laboratory studies.

B. Rationale/Link to Restoration

Pink salmon are listed as a recovering species, and before they can be added to the list of recovered species evidence for continued exposure to oil from the *Exxon Valdez* must be considered. The original criterion the Trustees proposed to use for listing the recovery of pink salmon was the absence of demonstrable effects for two complete reproductive cycles. In 1994 through 1996, pink salmon embryos in oiled and unoiled streams had similar mortality rates, suggesting they had recovered. However, since the criterion was established it has become clear that oil can still be found near natal habitats, and that pink salmon embryos are significantly more sensitive to PAHs than previously believed. These factors may explain the elevated embryo mortalities in oiled streams observed in 1997. Thus, the original criterion for recovery should be reconsidered. We propose to ascertain the recovery status by determining if exposures are still taking place and by relating observed exposures to those known to cause injury.

Direct measurement of PAH concentrations in the natal pink salmon environments in FY00 has demonstrated the plausibility of an exposure mechanism proposed by Heintz et al. (1999), and measurements in pink salmon tissues will likely demonstrate exposure. The hypothesized exposure mechanism suggests that PAHs leach from oil reservoirs buried in beaches alongside and above the stream channels into salmon redds via interstitial water flow. This mechanism has not previously been verified in the field, and PAH concentrations in pink salmon tissues have not been monitored.

The final field research, study of hydrodynamics at two representative PWS streams, will be completed in summer 2000. The purposes of the hydrological survey are to 1) map the physical characteristics of two representative PWS streams, 2) characterize hydraulic gradients, and 3) provide evidence of water exchange between sediment in stream banks, stream water, and salmon redds. Before analysis in PWS, a local stream in Southeast Alaska will be sampled to test and refine sampling techniques. Although we expect the rates and volume of exchange between stream water and bank water will vary among streams, exchange of water between banks and stream may be generalized from a single stream.

The activity of cytochrome P4501A in pre-emergent fry is an alternative method for demonstrating exposure to PAH. Cytochrome P4501A is an important enzyme system used by fish to metabolize PAHs. Elevated cytochrome P4501A activity was identified in fish taken from oiled streams as late as 1991 (Weidmer 1996) indicating exposure occurred despite the absence of detectable PAHs in the streambed gravel (Brannon et al. 1995). Although activity of P4501A was verification that salmon embryos were exposed, the relationship between P4501A

induction and injury has not been evaluated. Thus, we initiated a study in FY00 to examine the relationships between P4501A induction, TPAH exposure concentration, and biological response of salmon embryos under laboratory conditions.

C. Location

Field samples have been collected from the spill zone in western PWS. The laboratory phase of this project is underway at Little Port Walter (LPW), a research hatchery operated by NMFS in southeastern Alaska. This laboratory has been the site of many of the Trustee laboratory studies on oil toxicity to pink salmon. The facility at LPW provides easy access to the intertidally spawning pink salmon stock that has been the subject of previous experiments. In addition, the exposure apparatus requires a simulated intertidal environment and such a system is in operation at LPW.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Field collections were dependent on chartering vessel and air support. Contaminated pink salmon streams have been identified by local residents. We will continue to provide information to interested public (primarily fishermen) who visit our laboratory.

PROJECT DESIGN

A. Objectives

This project has three main themes, each with specific objectives. *(Progress to date is indicated in italics.)*

1. Examination of persistent *Exxon Valdez* oil in natal habitats of pink salmon in PWS, and evaluation of current contamination of eggs and alevins.
    - A. Determine how rapidly the incubating environments are recovering
        1. Measure oil in banks adjacent to bench-mark streams last sampled in 1995 by fast-screening procedures to extend the recovery model to 2000. *(Samples have been collected.)*
        2. Measure the availability of PAHs in the incubating environment *(Analysis of PMDs indicates 2 of 6 PWS streams remain contaminated by oil.)*
    - B. Measure oil in stream sediment by gas chromatography and mass spectrometry (GC/MS) to verify there is little or no contaminant directly in the stream.
        1. Measure aqueous oil contamination in salmon redds with buried PMDs to verify oil transport interstitially to salmon redds. *(Analysis of PMDs indicates 2 of 6 PWS streams remain contaminated by oil.)*
        2. Verify method sensitivities by measuring oil in a stream with a known natural oil seep. *(Initial sampling failed; devices were destroyed by water flow or bear activity.)*

C. Measure exposure of eggs and fry to PAH
   1. Directly measure oil concentrations in eggs by GC/MS, and compare to concentrations in SPMD's. *(Hydrocarbon analysis of eggs is in progress.)*
   2. Inspect eggs for indirect evidence of exposure to oil using the biomarker cytochrome P4501A as an index of exposure and compare to PAH concentrations in eggs and SPMD's. *(Pre-emergent fry were collected in March 2000; those most likely to be exposed to oil will be examined for P4501A activity.)*

2. Examination of the usefulness of the biomarker cytochrome P4501A as a predictor of the biological impacts of oil exposure
   A. Controlled laboratory test with graded oil doses to establish a dose-response curve at part per billion levels. *(Dosing is nearly complete. Fry are emerging from incubators. Mortality measurement at eyeing suggests eggs were sensitive part-per-billion PAH concentrations. Supportive hydrocarbon analyses are underway.)*
   B. Influence of exposure level on the prevalence of cytochrome P4501A activity and embryo tissue
      1. Inspect emergent fry for gross and histological lesions *(Sample collection is in progress.)*
      2. Determine P4501A induction in organ tissues. *(Tissue mounting is in progress.)*
   C. Initiation of cytochrome P4501A activity in developing pink salmon
      1. At one dose, measure P4501A response at four developmental stages to determine the onset of induction. *(Sample collection is nearly complete.)*
   D. Relation between cytochrome P4501A activity and short and long-term effects
      1. Relate P4501A induction to growth of experimental fish cultured at LPW (brood year 99) from the graded series of oil exposures. *(Experimental fish are being ponded for additional growth and predation study.)*
3. Relate P4501A induction to ocean survival (brood year 98) and reproductive fitness of returning adults to parts per billion exposures from the companion pink salmon toxicity study 99476.
   A. Synthesis of this project, and long-term impact data from other projects, to redefine pink salmon recovery in PWS, and provide a status of that recovery. *(This task will be completed after completion of sampling and data analysis.)*

The first theme provides a basis for testing the hypothesis that pink salmon, incubating in previously oiled streams, continue to be exposed to PAHs derived from the *Exxon Valdez*. Testing this hypothesis entails three major tasks: 1) determine how rapidly oil reservoirs are being depleted by sampling gravel from the deltas of streams identified as benchmarks in 1989 and resampled again in 1995 (Murphy et al. In press); 2) measure the availability of PAHs in the incubating environment by sampling the water flowing through salmon redds for PAHs using PMDs, and characterizing the PAH levels in gravels alongside, above, and in the stream channels; 3) establish the availability of PAHs to the eggs by measuring PAH concentrations in eyed eggs and activity of cytochrome P4501A in emerging fry. This latter task will be limited to those sites identified with highest risk as determined by fast screening methods. Each of these

tasks will be performed in oiled and unoiled streams selected on the basis of their contamination histories. In addition, the sensitivity of these approaches will be examined by duplicating these approaches in a stream outside PWS, but known to contain a natural oil seep. The seep stream will be an "oiled control."

The second theme tests the hypothesis that increasing PAH levels increase the prevalence of cytochrome P4501A activity and result in long-term injury. P4501A has long been known to document exposure, but the biological consequences are unknown. This hypothesis requires a laboratory study designed to determine 1) when cytochrome P4501A activity becomes detectable in developing embryos, 2) how exposure level influences the prevalence of cytochrome P4501A activity in specific tissues, and 3) the relationship of P4501A activity to both short- and long-term biological response. We propose to incubate pink salmon eggs in variety of TPAH concentrations and examine them periodically for evidence of cytochrome P4501A activity. Prevalence is defined as the product of the intensity of staining and occurrence in histologic sections of tissue examined for P4501A activity by immunochemical staining. The first task is required, because the time of onset may be a better predictor of long-term effects than prevalence at emergence. Induction prevalence will be related to the dosing histories to develop a dose-response curve. The relationship between long-term effects and prevalence will be examined by holding fish from the same exposure groups in captivity and examining them for dose related differences in growth rate.

Synthesis of the first two research themes will provide a rational basis for judging whether or not wild pink salmon stocks in PWS have recovered from the *Exxon Valdez* oil spill. The study will determine if pink salmon eggs are currently being exposed to hydrocarbons in oil-contaminated streams, and how quickly these sensitive environments are recovering. In addition, the development of a relationship between cytochrome P4501A activity and long-term effects will provide a basis for further evaluating the severity of the exposures indicated by P4501A activity in salmon embryos in first two years after the spill.

B. Methods

Theme 1. Examination of persistent *Exxon Valdez* oil in natal habitats of pink salmon in PWS, and evaluation of current contamination of eggs and alevins.

Determine how rapidly the incubating environments are recovering

Gravel samples from each of the 9 oiled index sites identified in Murphy et al. (In press) were collected using the procedures described in that report. In addition, oil reservoirs identified in 1995 were sampled to determine how rapidly they are weathering. All samples were collected from sites sampled in 1989 and 1995. All the gravel samples will be analyzed by ultraviolet fluorescence, a fast screening procedure that can be used to identify samples with sufficient amounts of oil to warrant more detailed analysis by GC/MS. The fast screening results as well as the more detailed analyses can be compared to similar data collected in 1995. These data will be combined with those reported by Murphy et al (1999) to extend their recovery model.

Measure the availability of PAHs in the incubating environment

Exposure levels in streams contaminated by the *Exxon Valdez* oil spill were monitored previously 6 streams identified with high embryo mortality rates in 1997. The Katalla slough stream, which has a naturally occurring oil seep (Bue et al. 1998) was also sampled, but water flow or bear activity destroyed the samplers. The existence of oil in Katalla slough will provide a measure of the sensitivity of our analyses for detecting petrogenic PAHs in interstitial waters and pink salmon tissues.

Sampling protocols applied to each stream followed the general procedure of Bue et al. (1996). Streams were divided into four sections based on their position above mean lower low water, and sampling transects were established in each section using maps developed by Bue et al. (1998). Transect locations coincided with those used in 1997. Personnel with ongoing experience conducting egg-dig transects in PWS were contracted (i.e., the same crew that ADF&G uses).

Sampling began prior to the arrival of adult pink salmon in 1999. Gravel samples were collected from the stream banks 1 m upstream from either end of each transect and from the streambed in the center of each transect. Dissolved PAHs were sampled by burying SPMDs and LDPEs in two pits dug into the streambed along each transect. All PMDs were recovered about 54 d after installation. The depths of sampler burial were similar to the depths of redds constructed by pink salmon.

PAH levels membrane sample devices was determined by gas chromatography and mass spectrometry (GC/MS) using the methods described by Short et al. (1996). Prior to analysis, sediment samples will be fast-screened to determine the concentrations of total petroleum hydrocarbons (PHCs) by ultraviolet fluorescence. Samples with detectable levels of PHCs will be further analyzed by GC/MS. PAH levels in stream bank sediments and streambed gravels will be used to map the distribution of oil in the incubating habitat, while PAH observations collected from membrane devices will be used to examine the transport of PAHs to incubating habitats.

Measure exposure of eggs and fry to PAH

Availability of PAH's to eggs and fry will be measured in two ways, by PAH concentration in egg tissue, and induction of cytochrome P4501A. Measurement of PAH uptake is in progress for eyed eggs sampled along the PMD transects. In October 1999, each transect was visited to collect eyed eggs. The procedure was repeated in March 2000 to obtain a set of pre-emergent fry for analysis of cytochrome P4501A activity and hydrocarbon concentrations. Eyed eggs and pre-emergent fry will be obtained by hydraulic sampling along the established transects using methods described by Pirtle and McCurdy (1977). Preferred samples of eyed eggs and pre-emergent fry will come from locations nearest each of the SPMDs. The eyed eggs were frozen immediately after collection to be examined for PAHs by GC/MS. Pre-emergent fry were preserved in formalin in individual cassettes for later processing to determine cytochrome P4501A induction using immunohistochemical staining. Samples will be analyzed blind.

The only samples of eyed eggs and pre-emergent fry to be processed will be those with the greatest likelihood of having detectable PAHs or P4501A induction. Sample sets will be selected on the basis of the analytical results of oil deposits in associated streambank gravel and PMD samples. Levels of PAH observed in eyed eggs will be used to demonstrate exposure levels and these will be compared with those observed in laboratory studies described by Heintz et al. (1999).

Theme 2. Examination of the usefulness of the biomarker cytochrome P4501A as a predictor of the biological impacts of oil exposure

Controlled laboratory test with graded oil doses

Developing pink salmon eggs were exposed to oil contaminated water using the laboratory methods described in Marty et al. (1997). Approximately 18,000 eggs were exposed to each of 5 doses, in order to provide sufficient numbers of fry for examining long-term affects on growth. Procedures used to determine embryo mortality rates and quantify exposure levels will follow previously described methods (Marty et al. 1997).

Influence of exposure level on the prevalence of cytochrome P4501A activity and organ tissue

Emerging fry are being counted, inspected for gross lesions and sampled to examine the presence of cytochrome P4501A activity. Aliquots of 12 fry from each dose will be retained for analysis of cytochrome P4501A induction with immunohistochemical staining. Fry will be retained in individual cassettes in buffered formalin and shipped to UC Davis for processing. Histological sectioning and determination of cytochrome P4501A induction will follow the procedures described in Marty et al. (1997). Sections of preserved fry will be cut to ensure staining of at least the gill, pharynix, kidney, intestine, heart, liver epidermis and yolk sac. Scores for staining intensity and occurrence will be compared by regression to exposure history to determine which tissue or combinations of tissues are the best indicators of exposure level. Additional specimens are being preserved in alcohol for genetic analysis.

Initiation of cytochrome P4501A activity in developing pink salmon

Alevins from the highest exposure level have been sampled across time to determine when cytochrome P4501A activity is initiated during development.

Relation between cytochrome P4501A activity and long-term effects

Two methods will be used to relate induction of P4501A to long-term biological effects, including marine survival (1998 brood year) and growth of cultured fish (1999 brood year). Marine survival and reproductive fitness of returning adults will be determined for fish in a previous experiment (study number 99476), where the number of oil exposures was limited to two, but P4501A induction will be determined in eyed eggs and emergent fry sampled prior to release (spring 1999).

Experimental fry from the 1999 brood year are being cultured in net pens for 3-4 months to determine the value of P4501A activity for predicting long-term effects of embryonic exposure to PAHs on marine growth. Fry are being transferred to separate containers depending on their exposure histories and cultured until they are large enough to tag with passive integrated transponder (PIT) tags. Fry transferred to the culture containers will be measured to determine each group's average weight and length. At tagging the length and weight of each individual will be recorded and growth will be calculated as the difference in the logs of the weight at tagging and the group's initial mean weight divided by the number of elapsed days. After tagging, individual growth records for each fish will be developed by periodically sampling the tagged population. Mean growth rates for each exposure group will be compared to their exposure history and the average combined score for intensity and occurrence for cytochrome P4501A activity in the given exposure group at emergence.

C. Cooperating Agencies, Contracts and Other Agency Assistance

No field trips are necessary for the second year of this close-out project. Analysis of cytochrome P4501A will be completed by contract with UC Davis.

SCHEDULE

April 1999 — Completed collection of emergent fry for P4501A analysis from exposed fish (brood year 98)

Aug 1999 — Completed deployment of samplers in stream beds, sediment collection, and laboratory experimental setup.

Fall 1999 — Completed collection of SPMDs and eyed eggs from PWS streams.
Completed collection of eyed eggs to determine onset of P4501A activity (lab)

Winter 99/00 — Nearly completed GC/MS analysis of PMDs. GC/MS analysis of eggs and sediment is underway.
Completed collection of experimental alevins for P4501A induction.

Spring 2000 — Completed collection of PWS fry samples for P4501A
Nearly completed is collection of emergent fry for final P4501A samples and evaluation of surviving fry (laboratory).

Begin analysis of fry for cytochrome P4501A activity, and growing out fry exposed in laboratory.

Summer 2000 — Monitor growth of experimentally exposed fry.
Complete predator studies using experimentally exposed fry.

Fall 2000	Complete GC/MS analysis of remaining samples, and complete analyses of growth. Complete histopathologica/MFO analysis of fry
Jan 2001	Report preliminary results at Trustee workshop
Winter 2001	Complete data analysis.
Spring 2001	Draft manuscripts complete.
Summer 01	Submit manuscripts for publication
Oct 2001	Submit final report.

B. Project Milestones

Fall 2000:	Complete sample analyses
Jan. 2001:	Report to Trustees
Summer 01:	Submit manuscripts to journals
Oct 2001	Submit final report.

C Completion Date

Final Report will be submitted on Oct 1, 2001.

PUBLICATIONS AND REPORTS

Final Report

Peer-reviewed manuscripts:

Carls, M.G. et al. 2001. Hydrocarbon contamination and recovery of pink salmon spawning areas a decade after the *Exxon Valdez* oil spill. Journal unknown.

Carls, M.G. et al. 2001. Persistent exposure of pink salmon to *Exxon Valdez* oil a decade after the spill. Journal unknown.

Heintz, R. et al. 2000. Feasibility of using biomarkers to regulate water quality. Journal Unknown.

Heintz, R. et al. 2001. Relation of P4501A biomarker in alevin pink salmon to long-term growth and reproductive fitness. Journal unknown.

Lilly, M. 2001. Hydraulic relationships between stream and intertidal ground water. Journal unknown.

Marty, G.D. et al. 2001. Developmental appearance of P4501A biomarker in pink salmon eggs and larvae. Journal unknown.

Rice, S.D. et al. 2001. Long-term biological and ecosystem recovery for pink salmon after the *Exxon Valdez* oil spill. Journal unknown..

Rice, S.D. et al. 2001. P450: Biomarker of exposure or predictor of impacts?

PROFESSIONAL CONFERENCES

Attendence of the SETAC conference is planned in FY01, and travel to 2001 Trustee workshop is included.

NORMAL AGENCY MANAGEMENT

This project seeks to determine the recovery status of pink salmon through a cooperative relationship between NMFS and the Trustees. There is no charge for project support costs which include management of the LPW facility and project budget.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The design of this project has been coordinated with the work performed in the past by ADF&G under Restoration 191A, and the work performed by NMFS under 191B and 194. Investigators and agencies will coordinate by sharing data. NOAA/NMFS will coordinate with the Trustees by providing labor requirements and laboratory overhead. This project also coordinates with pink salmon reproductive fitness project 99426 by collecting emergent fry for P4501A analysis (brood year 98).

PRINCIPAL INVESTIGATOR

Name	Dr. Stan Rice
Affiliation	NMFS
Address	Auke Bay Laboratory 11305 Glacier Hwy. Juneau, AK 99801
Phone	907-789-6020
Fax	907-789-6094

E-mail jeep.rice@noaa.gov

GS-14 Physiologist - Stanley D. Rice

Received BA (1966) and MA (1968) in Biology from Chico State University, and PhD (1971) in Comparative Physiology from Kent State University. Employed at Auke Bay Fisheries Laboratory since 1971 as a research physiologist, task leader and Habitat Program Manager since 1986. Rice has researched oil effects problems since 1971, and has published over 100 papers, including over 75 on oil effects. Studies have ranged from field to lab tests, behavioral to physiological to biochemical studies, from salmonids to invertebrates to larvae to meiofauna. Rice has conducted and managed soft funded projects since 1974, including the Auke Bay Laboratory *Exxon Valdez* damage assessment studies since 1989. Activities since the oil spill have included leadership and management of up to 10 damage assessment projects, field work in PWS, direct research effort in some studies, establishment of state of the art chemistry labs and analyses in response to the spill, quality assurance procedures in biological-chemical-statistical analyses, establishment of hydrocarbon database management, servicing principal investigators and program managers in NOAA and other agencies with reviews and interpretations, direct input into agency decisions, interaction with other agencies in various ways (logistics coordination, critique experimental designs, interpret observations, etc.), and lead editor of the first Trustee symposium proceedings.

PRINCIPAL INVESTIGATOR

Name	Mark G. Carls
Affiliation	NMFS
Address	Auke Bay Laboratory
	11305 Glacier Hwy
	Juneau, AK 99801
Phone	(907) 789-6019
Fax	(907) 789-6094
email	mark.carls@noaa.gov

Mark G. Carls (GS-12 Fishery Biologist)

Received BA (1975) in Biology from Gustavus Adolphus College, St. Peter, MN, and MS (1978) in Biological Oceanography from Dalhousie University, Halifax, Nova Scotia. Mark has been employed at the Auke Bay Fisheries Laboratory since 1979. His principal involvement has been in research of petroleum hydrocarbon toxicology to marine fish and invertebrates, including egg, larval, and adult life stages. Mark has published 17 papers, and has 5 *Exxon Valdez* damage assessment papers in preparation or pending publication. Since 1989, he has been involved as a principal investigator and co-investigator on several studies resulting from the *Exxon Valdez* oil spill involving Pacific herring, pink, and chum salmon, and mussels.

PRINCIPAL INVESTIGATOR

Name	Ron A. Heintz
Affiliation	NMFS
Address	11305 Glacier Hwy.
	Juneau, AK. 99801
phone	907-789-6058
Fax	907-789-6094
email	ron.heintz@noaa.gov

Ron A. Heintz (GS-12 Fishery Biologist)

PRINCIPAL INVESTIGATOR

Ron Heintz obtained his BS in Ecology, Ethology & Evolution from the University of Illinois in 1979 and his MS Fisheries Science from the University of Alaska in 1986. He has worked for the National Marine Fisheries Service, Auke Bay Laboratory since 1985 and been actively involved with Trustee sponsored research since 1992. He is a co-investigator in two pink salmon studies, the first examines the effects of incubating in oiled gravel on reproductive capacity, and the other examines the effects on homing fidelity. The first of these projects established the plausibility of effects on pink salmon fry observed in the Sound after the EVOS, including the existence of long-term effects on growth, marine survival and reproductive ability. He was also a co-author of the final report for Subtidal 8, which examined all of the Trustee Hydrocarbon data for the presence of EVO. This work is of substantial importance to the trustees, by providing evidence for the presence of oil on the beaches of PWS. His efforts in this project led to a detailed understanding of the utility of multi variate methods for analyzing GC/MS data.

OTHER KEY PERSONNEL

Jeff Short will assist in data collection, analysis, and interpretation. Robert Bradshaw is responsible for culturing fish through the summer 2000.

LITERATURE CITED

Brannon EJ, Moulton LL, Gilbertson LG, Maki AW and Skalski JR. 1995. An assessment of oil spill effects on pink salmon populations following the *Exxon Valdez* oil spill - part 1: early life history. In *Exxon Valdez* Oil Spill: Fate and Effects in Alaskan Waters. *ASTM STP* 1219. American Society for Testing and Materials. Philadelphia, PA, USA. pp 548-584.

Bue, B. G., S. Sharr, S. D. Moffitt, and A. Craig. 1996. Injury to salmon eggs and preemergent fry due to the T/V *Exxon Valdez* oil spill. *In* S.D. Rice, R.B. Spies, D.A. Wolfe, and B. A. Wright (Eds.). *Exxon Valdez* Oil Spill Symposium Proceedings. American Fisheries Society Symposium Number 18.

Craig, A.K., B.G. Bue, and T.M. Willette. 1997. Injury to salmon embryos and preemergent fry in Prince William Sound, *Exxon Valdez* Oil Spill Restoration Project Annual Report (Restoration Project 96170), Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Anchorage, Alaska.

Heintz, R. A. , M. Wiedmer and S. D. Rice. 1995. Laboratory Evidence for Short and Long-term

Damage to Pink Salmon Incubating in Oiled Gravel. Proceedings of the 16th Northeast Pacific Pink and Chum Workshop. Bellingham Wa.

Heintz, R., Short, J. W., Rice, S. D. (1999). Sensitivity of Fish Embryos to Weathered Crude Oil: Part II. Incubating downstream from weathered *Exxon Valdez* crude oil caused increased mortality of pink salmon (*Oncorhynchus gorbuscha*) embryos . Env. Tox. And Chem. 18(3):494-503.

Marty, G. D., J. W. Short, D. M. Dambach, N. H. Willits, R. A. Heintz, S. D. Rice, J.J. Stegeman and D. E. Hinton. 1997. Ascites, premature emergence, increased gonadal cell apoptosis, and cytochrome P4501A induction in pink salmon larvae continuously exposed to oil-contaminated gravel during development. Can. J. Zool. 75:989-1007.

Murphy, M. L., Heintz, R. A., Short, J. W., Larsen, M. L., Rice, S. D. (In press). Recovery of pink salmon spawning areas after the *Exxon Valdez* oil spill. Trans. Am. Fish. Soc.

Pirtle, R. B, and McCurdy, M. L. 1977. Prince William Sound general districts 1976 pink and chum salmon aerial and ground escapement surveys and consequent brood year egg deposition and preemergent fry index programs. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 9, Juneau, Alaska.

Short JW, Jackson TJ, Larsen ML, and Wade TL. 1996. Analytical methods used for the analysis of hydrocarbons in crude oil, tissues, sediments, and seawater collected for the natural resources damage assessment of the Exxon Valdez oil spill. *Proceedings,* Exxon Valdez Oil Spill Symposium. Anchorage, AK, USA, February 2-5, 1993. pp 140-148.

Wiedmer, M, Fink, M. J., Stegeman, J. J., Smolowitz, R., Marty, G. D., and Hinton, D. E. 1996. Cytochrome P-450 induction and histopathology in preemergent pink salmon from oiled spawning sites in Prince William Sound. *In* S.D. Rice, R.B. Spies, D.A. Wolfe, and B. A. Wright (Eds.). *Exxon Valdez* Oil Spill Symposium Proceedings. American Fisheries Society Symposium Number 18.

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

Approved TC 8-3-00

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001
Personnel	$41.7	$74.0
Travel	$2.9	$3.5
Contractual	$1.5	$6.2
Commodities	$3.0	$8.0
Equipment		$0.0
Subtotal	$49.1	$91.7
General Administration	$6.4	$11.5
Project Total	$55.5	$103.2
Full-time Equivalents (FTE)		0.9
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
Estimated FY 2002					

Dollar amounts are shown in thousands of dollars.

Comments:
This project is a closeout project. The budget reflects the need for sample collection, analysis and manuscript preparation

NOAA Contribution: Research Chemist, Marie Larsen 1 months @ 7K; Fishery Biologist Mark Carls 2.0 0 mo @ 16.4K, Chemist, Larry Holland .5 mo @ 3.5K and Fishery Biologist Ron Heintz 1 mo @ 7.7K for a total NOAA contribution of 34.6 K

FY01

Prepared: 4/10/00

Project Number: 01454
Project Title: Evidence & Consequences of Persistent Oil Contamination in Pink Salmon Natal Habitats
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUSTE UNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2001
Rice	Program Manager	GS/14	0.5	12.2		6.1
Carls	Fishery Biologist	GS12/6	2.8	8.2		23.0
Heintz	Fishery Biologist	GS12/5	1.0	7.7		7.7
						0.0
Holland	Chemist	GS11/7	1.0	7.0		7.0
Larsen	Chemist	GS11/7	1.0	7.0		7.0
Lunasin	Chemist	GS 9/7	4.0	5.8		23.2
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		10.3	47.9	0.0	
					Personnel Total	$74.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 2001
						0.0
RT Juneau - Anchorage	EVOS Trustee workshop	0.4	2	4	0.2	1.6
						0.0
SETAC meeting		1.0	1	2	0.2	1.4
registration				1	0.5	0.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$3.5

FY01

Prepared: 4/10/00

Project Number: 01454
Project Title: Evidence & Consequences of Persistent Oil Contamination in Pink Salmon Natal Habitats
Agency: NOAA

FORM 3B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed FY 2001
Description	
Dr Gary Marty	2.2
Dr. Robert Thomas	2.0
Michael Lilly	2.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$6.2

Commodities Costs:	Proposed FY 2001
Description	
Supplies for the hydrocarbon analysis in the chemical laboratory - chemicals and glassware	8.0
Commodities Total	$8.0

FY01

Prepared: 4/10/00

Project Number: 01454
Project Title: Evidence & Consequences of Persistent Oil Contamination in Pink Salmon Natal Habitats
Agency: NOAA

FORM 3B
Contractual & Commodities DETAIL

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	Inventory Agency
GCMS		NOAA
HPLC		NOAA
LPW Facility		NOAA

FY01

Prepared: 4/10/00

Project Number: 01454
Project Title: Evidence & Consequences of Persistent Oil Contamination in Pink Salmon Natal Habitats
Agency: NOAA

FORM 3B
Equipment
DETAIL

Approved TC 8-3-00

Effect of Disease on Pacific Herring Population Recovery in Prince William Sound

Project Number:	01462-CLO
Restoration Category:	Research
Proposer:	G. Marty/Univ. of California Davis
Lead Trustee Agency:	ADFG
Cooperating Agencies:	None
Alaska SeaLife Center:	No
New or Continued:	Cont'd
Duration:	3rd yr. 3 yr. project
Cost FY 01:	$86.0
Cost FY 02:	$0.0
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pacific herring, commercial fishing, subsistence

ABSTRACT

The Pacific herring population of Prince William Sound has not recovered from severe population decline in 1993. The two most important diseases in these fish are associated with viral hemorrhagic septicemia virus and the fungus-like organism *Ichthyophonus hoferi*. Prevalence of *Ichthyophonus* has been fairly constant since 1994, but virus prevalence has been highly variable. High prevalence of virus and associated ulcers in 1998 was related to decreased biomass and closure of most fisheries in 1999. All Pacific herring fisheries are closed in 2000. To determine if disease is limiting recovery, this project will continue to monitor the two major diseases in Pacific herring in Prince William Sound through spring 2001.

INTRODUCTION

The population of Pacific herring (*Clupea pallasi*) in Prince William Sound (PWS), Alaska has not recovered since the estimated spawning biomass decreased precipitously from over 100,000 tons in 1992 to less than 20,000 tons in 1994 (Figure 1). Study of the population since 1993 revealed that viral hemorrhagic septicemia virus (VHSV) and the fungus-like organism *Ichthyophonus hoferi* cause the two major diseases in Pacific herring, and that VHSV probably contributed most to population decline in 1993 (Meyers et al. 1994; Marty et al. 1998). Prince William Sound Pacific herring fisheries were severely curtailed in 1993, and were never opened in 1994 or 1995. The population began to recover in 1996, and a small bait fishery was opened in November of 1996. All fisheries were opened in 1997, but an unexpected increase in prevalence of VHSV in spring samples (15% in 1997 vs. 0% in 1996) was associated with abnormal spawning activity. In 1998, continued high virus prevalence (15%) was associated with increased ulcer prevalence (0% in 1997, 3.2% in 1998; Figure 2).

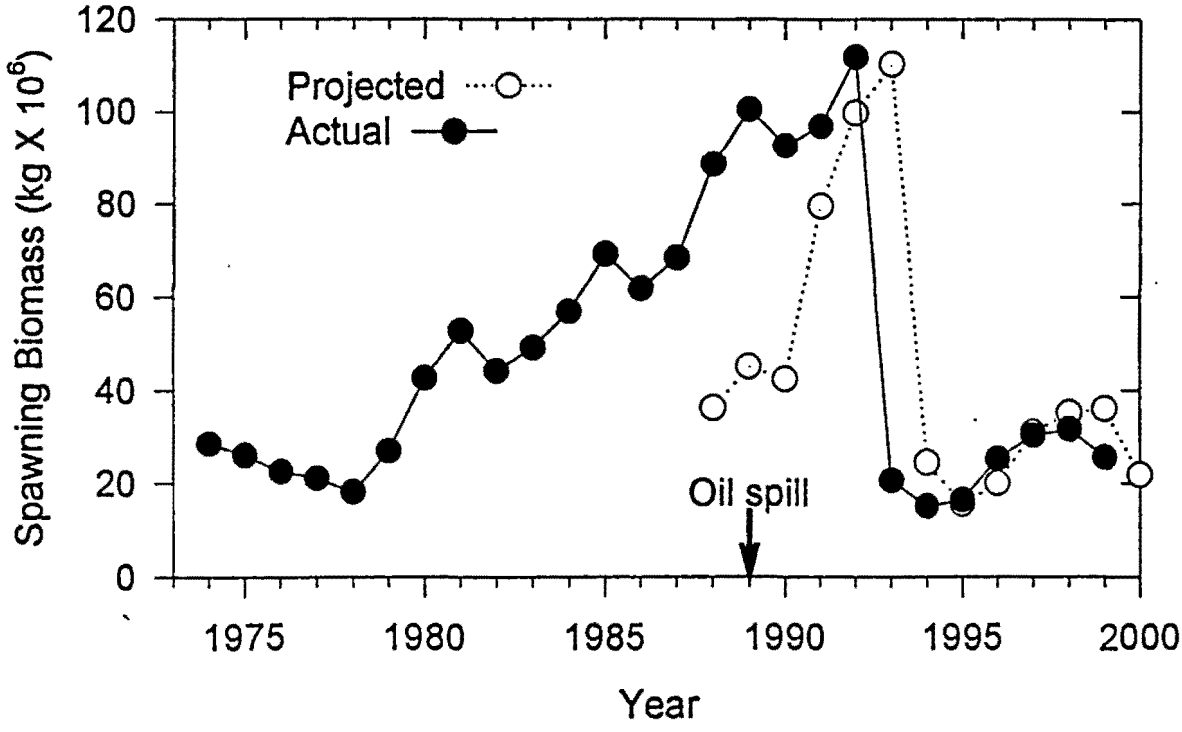


Figure 1. Biomass estimates of mature Pacific herring in Prince William Sound, Alaska. Unexploited spawning biomass is estimated using an age-structured assessment model.

After the major crash of 1993, the Pacific herring population continued to decline in 1994 and project 94320-S was initiated under emergency conditions to determine causes of herring morbidity (sickness), with particular emphasis on the role of VHSV. Beginning in 1995, a 4-year multidisciplinary project was initiated to explore the role of VHSV, *Ichthyophonus hoferi*, and other parasites on population change (95320-S, 96162, 97162, and 98162). Study in 1995 and 1996 included examination of fish from a reference site, Sitka Sound, in which the herring fishery was strong and there was no history of a large oil spill. Although 1998 was the final field season

for project \\162, the high ulcer and virus prevalence in 1998 provided strong evidence that the population was at high risk of disease-related decline. Therefore, this project (\\462) was proposed and funded for 3 years to continue research on the effect of disease on Pacific herring population recovery.

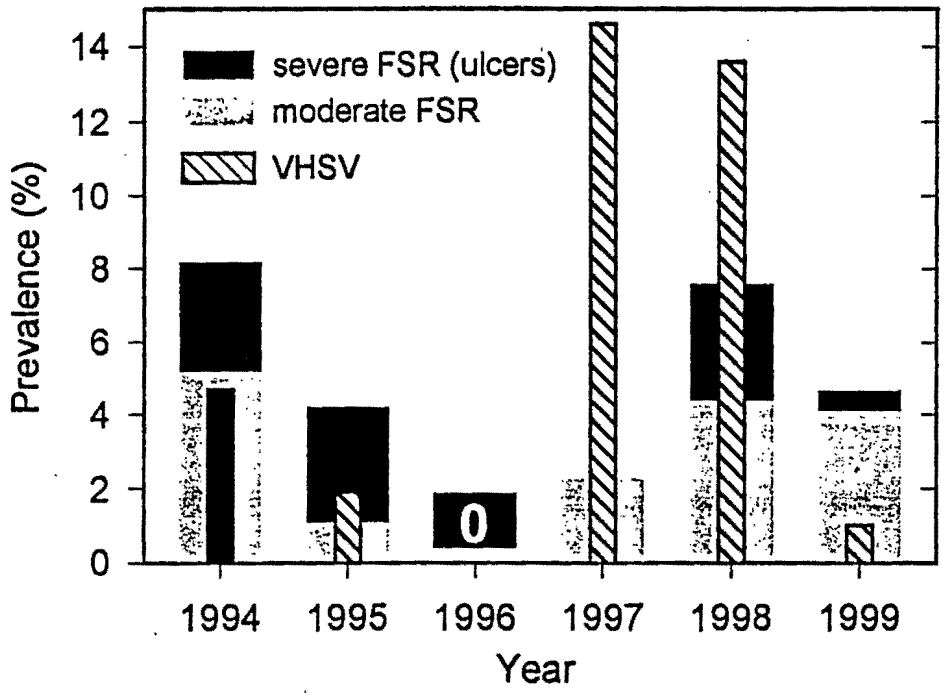


Figure 2. Prevalence of focal skin reddening (FSR; if the fish had ulcers, FSR = severe) and viral hemorrhagic septicemia virus (VHSV) in adult Pacific herring sampled from Prince William Sound, Alaska.

The foresight of funding this study was immediately obvious in its first year, 1999. The Alaska Department of Fish and Game had predicted increasing biomass, and a fishery was scheduled for April 1999. But poor returns closed most of the fisheries, including the most valuable sac roe fisheries. Unlike in 1993—when the population crashed but Pacific herring damage assessment studies were not funded—in 1999 disease study was fully funded and we were able to document a fairly healthy population in 1999 (virus prevalence was only 1%). The continuous series of high quality disease information allowed us to determine that most of the population decline occurred in 1998, nearly a year before the decline was detected by biomass estimates. Note that the best biomass estimates are made on prespawning aggregations in early April, but spawning itself can result in high mortality of susceptible fish. Spawning-related mortality in 1998 was not detected until the next prespawning aggregation in 1999.

Results from long-term disease study supported by the Trustee Council have broad significance beyond the herring population of PWS. We are answering basic questions about how disease contributes to mortality of free-ranging, schooling, marine fish. To more fully answer these basic questions, the U.S. National Science Foundation (Biological Oceanography) funded a 3-year project to augment continued disease research in PWS. The NSF project is closely linked to this project (01462). This proposal asks the Trustee Council to continue to fund fish necropsy, tissue

sampling, and virus analysis. NSF has committed to fund analysis of blood and tissues (histopathology) as well as a modeling component through Dr. Terrance Quinn of the University of Alaska, Fairbanks. Both organizations benefit from high quality, multiyear research, but at a fraction of the cost of supporting the entire project. The NSF component of the project cannot continue unless the Trustee Council continues to fund sample collection. In funding the sampling and virus analysis components of the study, the Trustee Council will have access to the same types of data generated from 1994-1999, with the addition of a modeling component to determine the role of disease in stock assessment. We propose to continue monitoring the health of the Pacific herring population in PWS through spring of 2002.

Preliminary surveys suggested that the 1994 or 1995 year-classes were the most likely to recruit at numbers large enough for population recovery by 1999 or 2000. Unfortunately, the prevalence of VHSV increased to 15% among all Pacific herring sampled in spring 1997 (Figure 2), and 23% of the fish from 1994 year-class had VHSV (Figure 3). In 1998, the prevalence of VHSV remained high (14%), and 28% of the fish from 1995 year-class had VHSV (Figure 3). The effect of the VHSV outbreak on population biomass in 1997 and 1998 was not as severe as in 1993, but the viral outbreak limited the contribution of the 1994 and 1995 year-classes to population recovery. Fortunately, viral prevalence decreased to only 1% in 1999. This project is not closely linked to any other project, because this is the only funded project that addresses Pacific herring.

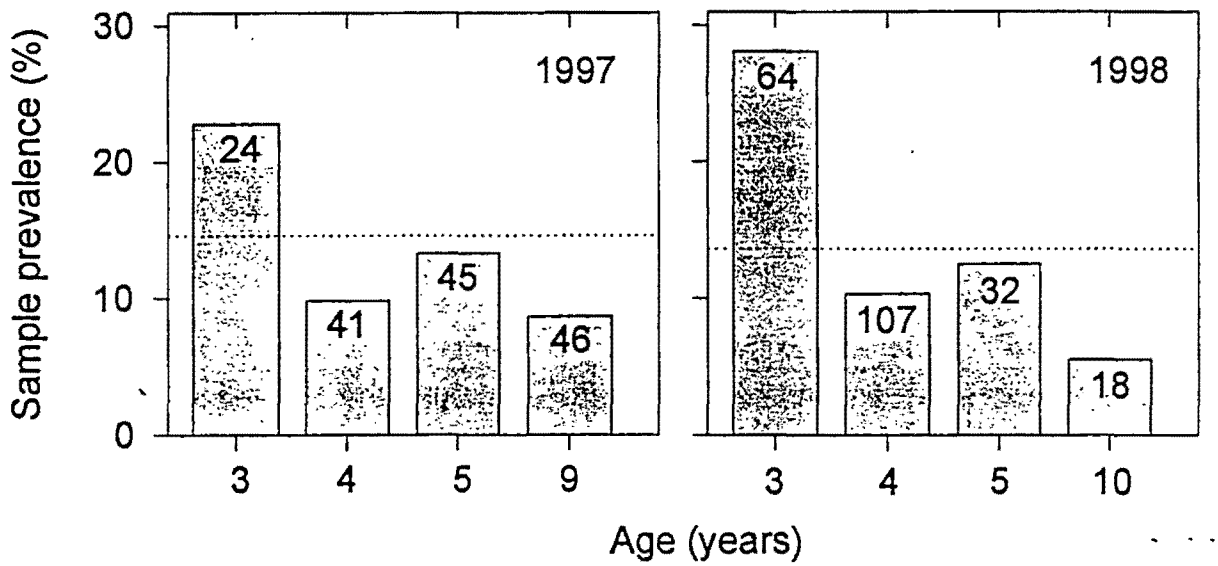


Figure 3. VHSV prevalence in Prince William Sound Pacific herring.
Reference line = overall sample VHSV prevalence.
Numbers within bars = sample size for each age.

NEED FOR THE PROJECT

A. Statement of Problem

Pacific herring are an injured biological resource in Prince William Sound (PWS) officially classified as recovering. Viral prevalence dropped to 1% in 1999, but recruitment of the 1996 year class into the fishery in 1999 was less than any other year class in the 30 years that ADFG has estimated herring biomass in Prince William Sound. Preliminary estimates for 2000 provide no evidence that recruitment of the 1997 year-class is any more than average, and recovery of the population will not occur in the foreseeable future. Lack of recovery of the resource has resulted in lost services, particularly for commercial fisheries. Also, several thousand pounds of herring and herring spawn on kelp are harvested annually for subsistence purposes and form an important part of the local native culture of Chenega and Tatitlek. Delay in recovery of the herring population results in lost resources for subsistence use. Continued study is needed to examine how disease may be limiting recovery and to document when recovery has occurred.

B. Rationale/Link to Restoration

This project should be done because it will provide information on what might be limiting population recovery and it will monitor when fish are healthy and recovery has occurred. Also, ADFG now uses disease information as part of it mathematical model to estimate population biomass. If disease prevalence again increases, ADFG can use this information to delay opening of any commercial fisheries until the population has truly recovered. Continued sampling of fish twice a year is needed to determine the dynamics of disease in the population. During the first 7 years of disease research already funded by the Trustee Council, we established that VHSV and *Ichthyophonus hoferi* were the most significant causes of disease. Prevalence of VHSV can be determined by virus isolation and prevalence of *Ichthyophonus hoferi* can now be estimated fairly closely by gross examination.

C. Location

Study will be done in Prince William Sound, Alaska. Information will benefit fisheries managers as they consider alternatives for managing Pacific herring fisheries. As the resource is enhanced, users throughout PWS could potentially benefit.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Dr. Marty has a solid record of local contact and dissemination of information, and continued collaboration with local users is proposed for FFY01. For example, Dr. Marty led a herring dissection and necropsy demonstration for the Youth Area Watch in Cordova on April 19, 1999. Contact with fishers, processors, and ADFG managers occurs through participation in conference telephone calls, personal contact while in Anchorage and Cordova, and via e-mail.

To aid in dissemination of information, Dr. Marty is available by phone for interviews and will respond quickly to requests from the Restoration Office for general information and articles for newsletters. Dr. Marty is based in California, but Dr. Kathy Burek of Alaska Veterinary Pathology Services (one of only two board-certified veterinary pathologists residing in Alaska) has been contracted as a necropsy pathologist in 1995, and 1996, and 1999, and she has indicated

her interest to serve as the second pathologist in April 2001. Alaska residents will be hired by ADFG for sampling logistics and recording data, and ADFG will charter vessels from local residents for collecting and processing fish.

PROJECT DESIGN

A. Objectives

The restoration objective states that "Pacific herring will have recovered when the next highly successful year class is recruited into the fishery and when other indicators of population health are sustained within normal bounds in PWS." The population cannot be classified as healthy until individuals within that population are healthy. Continued high prevalence of VHSV in spring 1998 samples was consistent with a population at risk, and this was confirmed by poor returns in 1999. Field sampling to determine the ongoing disease status is a high priority of this project. Objectives include:

1. Determine the prevalence of major diseases in Pacific herring.

2. Determine the interaction of gender, age, and season on disease prevalence.

3. Determine if disease prevalence correlates with population trends.

B. Methods

Pacific herring will be randomly sampled from PWS in November (at the end of the feeding season, n = 100) and in April (near the time of spawning, n = 300). Each fish will be examined for abnormalities (e.g., *Ichthyophonus hoferi*), and tissues from each fish will be assayed for VHSV.

This proposal has two specific hypotheses to test:

1. Prevalence of external lesions, VHSV, or *Ichthyophonus hoferi* is different from previous years.
2. Gross lesions, VHSV, or *Ichthyophonus hoferi* are related season, age, or gender.

To test the hypothesis that reproductive stage affects the development of disease, sampling is needed during the spawning season (spring) and during the period of gonadal development and peak condition (fall). Nearly 70% of the PWS Pacific herring biomass schools in the waters on the northern and western edge of Montague Island during November, and the fish remain in this area until after they spawn in April. Most fish will be sampled from this region. During the summer, fish disperse throughout the Sound. The other 30% of the PWS Pacific herring biomass overwinter and spawn in the Northeast region of PWS. Our primary goal is to get a representative sample of disease in PWS herring, and we reserve the option to sample fish in the Northeast region if warranted by changes in biomass trends. During the spawn-on-kelp investigations among fish from Northeast PWS in 1997 and 1998, trends in viral prevalence were

similar to fish in the Montague area (Hershberger et al. 1999).

To provide a minimum number of fish from which at least the dominant year class can be analyzed in detail, we propose sampling 300 fish in April. Fish are easier to capture in the spring, and the age distribution in the spring is most consistent with data used in the historical age-structured assessment model. With a sample size of 300, diseases with a prevalence as low as 1% can be detected with 95% confidence, and a 6% difference in sample prevalence (e.g., 10 vs. 16%) can be detected with a statistical power of 0.80 (Becker and Grieb 1987). To test hypotheses of age differences, the dominant year class-often >40% of the sampled population-will be compared with combined groups of smaller year classes. To detect seasonal differences, and minimize costs, 100 fish will be sampled in the fall. A sample size of 100 is sufficient to have 95% confidence that disease with a prevalence of 3% will be detected in at least one fish sampled (Becker and Grieb 1987).

Proposed study is designed to minimize bias associated with gear type, capture, and holding (Holst 1996). All fish will be sampled using commercial purse seines. In the event that large numbers of fish begin to spawn in areas too shallow for commercial seines, fish will be captured using cast nets. All necropsies will be completed < 5 hours after the seine is pursed around the fish.

To best characterize the condition of herring in Prince William Sound, herring will be subjected to complete necropsy using the following sampling schedule (as field conditions allow) during the final two years of proposed study:

Dates	Reproductive Stage	Number of Fish
FY01: Oct./Nov., 2000 (4 nights)	peak condition/ gonadal development	100
mid-April, 2001 (7 days)	Spawning/post-spawning	300
	Total Fish, FY01:	400
FY02: Oct./Nov., 2001 (4 nights)	peak condition/ gonadal development	100
mid-April, 2002 (7 days)	spawning/post-spawning	300
	Total Fish, FY02:	400

Fish for necropsy will be anesthetized in tricaine methane sulfonate (Finquel®) and visually screened for external lesions (Marty et al. 1998), which are ranked as none (0), mild (1), moderate (2), or severe (3). Prevalence of *Ichthyophonus* will be estimated by gross examination of internal organs, especially the heart. With funding from NSF, histopathological analysis will be done on 10 organs to determine *Ichthyophonus* prevalence.

Measurements on each fish include body weight, standard length, age (from scales), liver weight, and gonad weight. Otoliths are archived for later use if information on annual growth rates is desired. This study is designed to diagnose gross lesions and the two major diseases: VHSV and

Ichthyophonus hoferi. Results will be compared with previous years of study. Several samples will be collected, but only selected samples will be analyzed:

a. Virus isolation - To assay fish for virus, anterior kidney, spleen, and any severe skin lesions will be put into individually labeled plastic bags and stored on ice (for each fish, one bag will hold kidney and spleen, and a separate bag will be used for skin lesions). Every 48 to 72 hours, samples will be shipped by air to the ADFG fish pathology laboratory in Juneau (under the direction of Dr. Ted Meyers) for analysis. Isolation using EPC cell lines will be as previously described (Meyers et al. 1994). The application of polymerase chain reaction (PCR) techniques for primary diagnosis of VHSV has been explored (R.M. Kocan and J.R. Winton, personal communication); to date, PCR has not proved more useful than virus isolation, but work is still underway.

b. Bacteriology - for each fish with severe gross lesions, a sterile loop is stabbed into the anterior kidney and then streaked on Trypticase Soy Agar (TSA) and Marine agar for bacterial isolation. Ulcers will be preserved for histopathology or virology, but they will not be cultured for bacteria (superficial bacteria can be diagnosed on histopathology).

Other samples will be collected and analysis will be done using funding from NSF:

a. Histopathology (fix in 10% neutral buffered formalin) - gill, spleen, liver, gonad, heart, stomach, intestinal tract, exocrine pancreas, trunk kidney, skeletal muscle, skin, brain, and other gross lesions. Also, a touch prep of kidney from each fish is made on a glass slide.

b. Hematology - blood will be drawn from the caudal vein into a Lithium-heparinized syringe and stored on ice. Packed cell volume (PCV) is determined on site. A blood smear is made on a glass slide, dried, and archived. Plasma is separated by centrifugation (3,000 *g* for 7 min) and frozen within 3 h of collection.

c. Immunology - plasma for IgM determination and a blood smear for leukocyte differential counts will be collected.

In previous study, spring samples from PWS had several other parasites, but these did not seem to be significant on the population level. Gross lesions and other observations will be scored as in previous years. All lesions are described in a "comments" section on a data sheet, but only the most common gross findings are scored for statistical analysis: caudal fin fraying, caudal fin reddening, fin base reddening, focal skin reddening, diffuse skin reddening, iris reddening, branchial copepods, number of 0.5-mm-diameter white foci on gills, number of peritoneal Anisakidae, and gonadal fullness. Parasites requiring histopathology for diagnosis will be scored using NSF funds.

The ADFG fisheries laboratory in Cordova, Alaska, will handle logistics for sampling fish for necropsy, collecting age and length data, preparing formalin and containers for tissue fixation, providing a data recorder for one pathologist on site, and ship all samples. Results from virus isolation will be reported as a VHSV titer.

Quality control and quality assurance is part of all examinations. For necropsy examination, the senior pathologist (Dr. Marty) is on site at all times; when questionable or difficult lesions are encountered, the second pathologist can consult with Dr. Marty. In the event that Dr. Marty is unavailable for necropsy, five other pathologists have experience on the herring necropsy team, and services of these pathologists would be secured.

Statistical analysis in this study will focus on determining changes in disease prevalence over time. The association of selected categorical variables (e.g., VHSV status versus external lesion scores) will be evaluated using chi-square methods for categorical data analysis; comparisons will be considered valid only if individual expected cell frequencies are >1 and no more than 20% of the cells have expected cell frequency <5. Odds ratios will be calculated only for standard (2x2) two-way contingency tables. Significance of changes in disease prevalence will be tested using chi-square or Fisher's Exact test. For all analyses, comparisons will be considered significant when $P<0.05$ and highly significant when $P<0.01$.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

This proposal includes significant contributions from ADFG as the lead agency. The project is being run through ADFG because Dr. Marty has worked closely with ADFG on several Trustee Council-funded projects during this decade. ADFG has unique local knowledge on Pacific herring in PWS, including the necessary experience and expertise to secure all necessary charters and ship hazardous materials from Cordova to Davis. Close collaboration with ADFG allows for seamless transfer of disease information to fishery managers, and rapid transfer of disease information to commercial and subsistence fishers. No other agencies are requesting funds for this section of the project, and no other agencies or universities will be contracted for this work. Dr. Marty has provided information to Dr. Brenda Norcross on ways in which disease information can be used as part of overall Pacific herring studies in PWS during the next century. Results of this effort will not be realized until the Gulf Ecosystem Monitoring plan in initiated.

SCHEDULE

A. Measurable Project Tasks for FY01

DATES (results due on final date)	ACTIVITY
Fall Samples:	
Oct. 1 - Nov. 30, 2000:	Collect samples; Person in charge: Gary D. Marty, UC Davis
Nov. 1 - Dec. 31, 2000:	Scale analysis (age); Person in charge: Greg Carpenter, ADFG, Cordova, AK
Nov. 1, 2000 – Feb. 28, 2001:	Virology and bacteriology; Person in charge: Ted Meyers, ADFG, Juneau, AK
March 1- Aug. 1, 2001:	Statistical analysis; Person in charge: Gary D. Marty

DATES (results due on final date)	ACTIVITY
January, 2001 (5 days):	Attend Restoration Science Workshop (Gary D. Marty)
Spring Samples	
April 1 - April 30, 2001:	Collect samples; Person in charge: Gary D. Marty
April - July 31, 2001:	Scale analysis (age); Person in charge: Greg Carpenter, ADFG, Cordova, AK
April - Sept. 30, 2001:	Virology and bacteriology; Person in charge: Ted Meyers, ADFG, Juneau, AK
Oct. 2001 - Feb. 1, 2001:	Statistical analysis; Person in charge: Gary D. Marty
Jan. 11, 2001 –April 15, 2001:	Annual report writing; Person in charge: Gary D. Marty
open:	Opportunities for public comment

B. Project Milestones and Endpoints

Review of Objectives:

1. Determine the prevalence of major diseases in Pacific herring.
2. Determine the interaction of gender, age, and season on disease prevalence.
3. Determine the effect of disease on population trends.

Objectives will be met when each year of results is reported in the annual report, but the most complete information will be available when the multi-year study is completed and the final synthesis report is submitted April 15, 2003.

D. Completion Date

Basic project objectives will be met at the end of the fourth year of proposed study. Note, however, that each additional year of disease study in Prince William Sound provides more information on the recovery of the Pacific herring population. The first year of this project . . . (99462) was critical for documenting relatively low disease prevalence in the population in 1999, providing evidence that most of the mortality that resulted in poor returns in 1999 probably happened in 1998 during and after the unusually early sac roe fisheries. High viral prevalence among recruiting populations of both the 1994 and 1995 year-classes in 1998 has severely limited the capacity of these year classes to contribute to population recovery. Preliminary evidence indicates that the 1997 year-class is no more than average. Even if the 1998 year class is as large as the last major year class (1988), recovery cannot be fully documented until that year class is 5 years old: in 2003 (a year after the current project ends). Therefore, termination of study in 2002 is not likely to be sufficient to document population recovery. Comments from reviewers of my NSF proposal were favorable, but most reviewers agreed that following the population through a full cycle—probably 16 to 20 years—would be needed to understand how disease and population

size are linked. Currently proposed study through 2002 will provide us with 9 years of disease information, and this is already the most comprehensive study ever conducted on disease in a wild fish population. However, 9 years of study will provide information on only about ½ of a population cycle. Extending this project another 5 years through the Gulf Ecosystem Monitoring and cost sharing with NSF will greatly enhance our understanding of how and when the Pacific herring population recovers. Such an extension is not being proposed now, but the possibility of a long-term extension will be considered as more details of the Gulf Ecosystem Monitoring plan become known.

PUBLICATIONS AND REPORTS

Several publications are anticipated in FY01 that will combine earlier work (\\162) with this project:

Marty, G. D., C. J. Kennedy, C. R. Davis, and N. H. Willits. In preparation. Effect of age, gender, size, season, and lesions on plasma of free-ranging Pacific herring. I. Total protein, albumin, IgM, cholesterol, and PCV. Diseases of Aquatic Organisms

Marty, G. D., C. J. Kennedy, and N. H. Willits. In preparation. Effect of age, gender, size, season, and lesions on plasma of free-ranging Pacific herring. II. Glucose, bilirubin, ALP, ALT, AST, and CPK. Diseases of Aquatic Organisms

Marty, G. D., C. J. Kennedy, and N. H. Willits. In preparation. Effect of age, gender, size, season, and lesions on plasma of free-ranging Pacific herring. III. Osmolarity, sodium, potassium, chloride, phosphate, calcium, and lactate. Diseases of Aquatic Organisms

Marty, G. D., T. F. Quinn, G. Carpenter, T. R. Meyers, and N. H. Willits. In preparation. The role of disease in population abundance of adult Pacific herring. Science

Quinn, T. F., G. D. Marty, J. Wilcock, and M. Willette. In preparation. Disease and assessment of Prince William Sound Pacific herring. Pages *in* Lowell Wakefield Fisheries Symposium: Proceedings of Herring 2000: Expectations for a New Millennium, February 22-26, 2000. Alaska Sea Grant

Funds needed for these publications have already been appropriated through \\162 and NSF.

PROFESSIONAL CONFERENCES – No funds are requested. Funds to attend a professional conference each year are provided by the NSF component of the project.

NORMAL AGENCY MANAGEMENT - Not applicable.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Continuation of proposed disease research in PWS is critical for obtaining other funding. In late 1998, the National Science Foundation's Division of Biological Oceanography funded an unsolicited proposal to continue complete analysis of the samples collected as part of project

\\462. The three-year $286.4K NSF project has no funds for sample collection, and depends entirely on Trustee Council funds for sample collection. The NSF project includes collaboration with ADFG (through Mark Willette) and the University of Alaska, Fairbanks (Dr. Terrance J. Quinn). Using Dr. Quinn's expertise, the NSF project includes a modeling component to mathematically determine the relation of disease and changes in population biomass. Trustee Council-funded studies of herring disease since 1994 were highlighted in the NSF proposal as a significant source of matching funds (about $2.2 million over the life of the project). NSF normally does not fund unsolicited proposals for more than $150K per year. Because the Trustee Council funded the first two years of this project (99462 and 00462), and committed to an additional year of funding, NSF saved about $207K on its project. At the same time, the Trustee Council benefits from $286.4K worth of analysis funded entirely by NSF. In February 2001. Dr. Marty plans to submit a proposal to NSF continue funding disease analysis and modeling for another 5 years (2002-2006). The extension to a fourth year of funding included as part of this proposal will provide funds for sample collection during the first year of the 5-year NSF extension. NSF likes matching funds arrangements, and commitment to a fourth year of funding will go far towards convincing NSF to fund additional Pacific herring disease study.

This project is designed to provide the same types of data that were generated during detailed disease study since 1994 (94320S, 95320S, 96162, 97162, 98162, 99462, 00462). Each year of research produces some new findings, but with each year the significance of the project becomes greater than its individual parts. The addition of two more years of data to our knowledge about the most important diseases will only add to the significance of this work.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS – This proposal requests extension of this project from 3 years to 4 years. An extra year of study is needed because Pacific herring fisheries were again closed in 1999, and there are no prospects for population recovery in the foreseeable future. Also, an extra year of funding is needed as part of cost sharing to increase the chances that NSF will extend Pacific herring disease research in PWS another 5 years (2002-2006). Methods and budget have no other substantial changes.

PROPOSED PRINCIPAL INVESTIGATOR

Gary D. Marty
Department of Anatomy, Physiology, and Cell Biology
School of Veterinary Medicine
University of California
1 Shields Ave.
Davis, CA 95616
Phone: 530-754-8062
FAX: 530-752-7690
e-mail: gdmarty@ucdavis.edu

Revision 7-7-00
Approved 8-3-00

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

Budget Category:	Authorized FFY 2000	Proposed FFY 2001	LONG RANGE FUNDING REQUIREMENTS					
Personnel	12.9	$12.9						
Travel	0	$0.0						
Contractual	47.4	$58.1						
Commodities	9	$9.0						
Equipment	0	$0.0						
Subtotal	69.3	$80.0	Estimated FFY 2002	Estimated FFY 2003				
General Administration	5.3	$6.0						
Project Total	74.6	$86.0						
Full-time Equivalents (FTE)	0.4	0.4						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

This project proposal includes two components:

1. University of California, Davis: Fish necrospsy
   a. Funds for writing the final report in FY02 are included in the FY01 request.

2. Alaska Department of Fish and Game: Logistical and analytical support . (Contractual amount is slightly higher than last year because of low population size; we need another day of boat charter for finding fish in the fall.)

2001

Project Number: 01462
Project Title: **Effect of Disease on Pacific Herring Population Recovery in Prince William Sound**
Agency: AK Dept. of Fish & Game

FORM 3A
AGENCY
PROJECT
DETAIL

Prepared:
GDMarty 3-30-00

7/19/00

2001 EXXON VALDEZ TRI E COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:			GS/Range/	Months	Monthly		Proposed
PM	Name	Position Description	Step	Budgeted	Costs	Overtime	FFY 2001
	G. Carpenter	Fishery Biologist II	16D	1.5	5,817		8.7
	Vacant	Fish & Wildlife Technician II	9A	0.5	3,229	2,614	4.2
			Subtotal	2.0	9,046	2,614	
Those costs associated with program management should be indicated by placement of an *.						**Personnel Total**	$12.9

Travel Costs:		Ticket	Round	Total	Daily	Proposed
PM		Price	Trips	Days	Per Diem	FFY 2001
	Description					
Those costs associated with program management should be indicated by placement of an *.					**Travel Total**	$0.0

2001

Project Number: 01462
Project Title: **Effect of Disease on Pacific Herring Population Recovery in Prince William Sound**
Agency: AK Dept. of Fish & Game

FORM 3B
Personnel
& Travel
DETAIL

Contractual Costs:		Proposed
Description		FFY 2001
PWS Fall Sampling	Vessel Charter (hotel boat/sampling platform 5d @ 900/d)	4.5
	Vessel Charter (seiner to locate fish, 5d @ 1100/d)	5.5
	Shipping	0.2
PWS Spring Sampling	Vessel Charter (hotel boat/sampling platform, 7d @ 900/d)	6.3
	Vessel Charter (seiner to locate fish, 7d @ 1100/d)	7.7
	Shipping	0.3
Contract with UC Davis for sampling,data analyses and report writing		33.6
When a non-trustee organization is used, the form 4A is required.	**Contractual Total**	$58.1

Commodities Costs:	Proposed
Description	FFY 2001
Misc. sampling supplies (tubes, jars, preservative, coolers, totes etc.) (approximately $500/sample event - 2 events)	1.0
Pathology Laboratory - Virology/Bacteriology Supplies (400 samples @ $20/sample)	8.0
Commodities Total	$9.0

2001

Project Number: 01462
Project Title: **Effect of Disease on Pacific Herring Population Recovery in Prince William Sound**
Agency: AK Dept. of Fish & Game

FORM 3B
Contractual & Commodities DETAIL
7/19/00

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 2001
Those purchases assoc. with replacement equipment should be indicated an "R."		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

2001

Project Number: 01462
Project Title: Effect of Disease on Pacific Herring Population Recovery in Prince William Sound
Agency: AK Dept. of Fish & Game

FORM 3B
Equipment
DETAIL

2001 EXXON VALDEZ TRI E COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001						
Personnel	$10.4	$18.6						
Travel	$5.8	$4.9						
Contractual	$2.4	$2.5						
Commodities	$2.3	$2.3						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$20.9	$28.3				Estimated FY 2002		
Indirect	$4.0	$5.3						
Project Total	$24.9	$33.6						
Full-time Equivalents (FTE)	0.2	0.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: Indirect Costs include the standard overhead rates and applications for the Institute of Toxicology and Environmental Health (ITEH) at the University of California, Davis (18.9%).

Other funds - A 3-year $286.4K grant was funded by the National Science Foundation (NSF), 2-1-99 through 1-31-02, with Dr. Gary D. Marty as principal investigator. The NSF grant includes complete blood analysis, histopathology, and population modeling not included in this proposal. This proposal (01462) can stand on its own, but completion of the NSF grant is entirely dependent on access to samples collected as part of this project. The Trustee Council benefits by getting complete analysis of all samples collected, including population modeling, at no additional cost.

Proposal includes funds (here, direct costs) for sample collection (0.5 month time for G. Marty, $400 of the supply budget), final report writing (1.8 month), community involvement (0.2 month time for G. Marty, $50 for long distance phone calls), and the annual workshop (travel and per diem). The proposal does **not** include funds for NEPA compliance, publications, or professional conferences (the NSF grant provides funds for publication and for Dr. Marty to attend one professional meeting per year).

FY01

Prepared:
GDMarty 3-30-00

Project Number: 01462
Project Title: Effect of Disease on Pacific Herring Population Recovery in Prince William Sound
Name: University of California, Davis
Agency: ADFG

FORM 4A
Non-Trustee
SUMMARY

7/19/00

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 2000
	Marty, G.	Assistant Researcher IV	2.5	6.7	0.0	16.8
	Teh, C.	Laboratory Assistant III	0.5	3.5	0.0	1.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	3.0	10.2	0.0	
					Personnel Total	$18.6

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2000
	RT airfare to Cordova for sample collection (1 fall, 3 spring)*	0.6	4	16	0.1	4.0
	airfare to Anchorage for annual restoration workshop	0.5	1	4	0.1	0.9
						0.0
	*There are actually 32 days per diem rather than 16 on these trips,					0.0
	but the field rate is $45/day which these formulas will not					0.0
	accommodate. Thus the number of days were halved and the					0.0
	rate doubled.					0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$4.9

FY01

Prepared:
GDMarty 6-26-00

Project Number: 01462
Project Title: Effect of Disease on Pacific Herring Population Recovery in Prince William Sound
Name: University of California, Davis
Agency: ADFG

FORM 4B
Personnel
& Travel
DETAIL

7/19/00

2001 EXXON VALDEZ TRI E COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed
Description	FY 2000
150 fish necropsies @ $16.50/fish (professional services of consulting pathologist)	2.5
Contractual Total	$2.5

Commodities Costs:	Proposed
Description	FY 2000
Materials and supplies (for sampling supplies, report writing, long distance phone, film, computer disks)	1.7
statistical analysis	0.4
ITEH supplies	0.2
Commodities Total	$2.3

FY01

Prepared:
GDMarty 6-26-00

Project Number: 01462
Project Title: Effect of Disease on Pacific Herring Population Recovery in Prince William Sound
Name: University of California, Davis
Agency: ADFG

FORM 4B
Contractual & Commodities DETAIL

7/19/00

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2000
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 an "R."		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units
IEC clinical centrifuge equipped with rotors for on site plasma separation and packed cell vol. determination	1
Revco -80° freezer for archiving plasma	1
YSI Model 55 hand-held dissolved oxygen meter for checking fish holding conditions before necropsy	1
For report writing and correspondence:	
Pentium III 866 DELL-PC desktop computer with 256 Mb RAM, Ethernet card, and internal 56,600 baud modem	1
HP4L LaserJet printer	1
Codonics NP-1600 Color Photographic Network Printer, for publication grade printing of digital images	1
	1

FY01

Project Number: 01462
Project Title: Effect of Disease on Pacific Herring Population Recovery in Prince William Sound
Name: University of California, Davis
Agency: ADFG

FORM 4B
Equipment
DETAIL

Prepared:
GDMarty 6-26-00

7/19/00