19.12.03 (2of3)

Effect of Disease on Pacific Herring Population Recovery in Prince William Sound

Project Number:	03462
Restoration Category:	Oil Spill: Recovery monitoring
Proposer:	University of California, Davis
Lead Trustee Agency:	ADFG
Cooperating Agencies:	None
Alaska SeaLife Center:	no
Duration:	5th year, 5-year project (additional analysis proposed)
Cost FY03:	$73,400 (UCD) + $5,100 (ADFG) = $78,500
Cost FY04:	None
Geographic Area:	(closeout, analysis only; no field work)
Injured Resource/Service:	Pacific herring, commercial fishing, subsistence

ABSTRACT

In spring 2001, prevalence of *Ichthyophonus hoferi* (38%) in the Pacific herring population of Prince William Sound was more than 50% greater than in any year studied (1989-2000). *I. hoferi* causes severe, disseminated, chronic disease in Pacific herring that is best diagnosed using histopathology. Before 2001, *I. hoferi* was not associated with unexpected declines in population biomass, but during the last century increases in *I. hoferi* prevalence in Atlantic herring have been associated with several disease outbreaks. To understand the significance of the 2001 *I. hoferi* outbreak, we need to analyze samples already collected in fall 2001 and spring 2002 as part of project 02462. Project 03462 will fund complete histopathologic analysis of these samples.

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 1994 (94320-S, 95320-S, 96162, 97162, and 98162) revealed that viral hemorrhagic septicemia virus (VHSV), associated ulcers, and *Ichthyophonus hoferi* (previously called a fungus; now called a choanoflagellate) cause the major diseases in Pacific herring, and that VHSV and associated ulcers probably contributed most to population decline in 1993 (Meyers et al. 1994; Marty et al. 1998; Quinn et al. 2001). PWS 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 in 1997 and 1998 was associated with increased ulcer prevalence in 1998 (Figure 2).

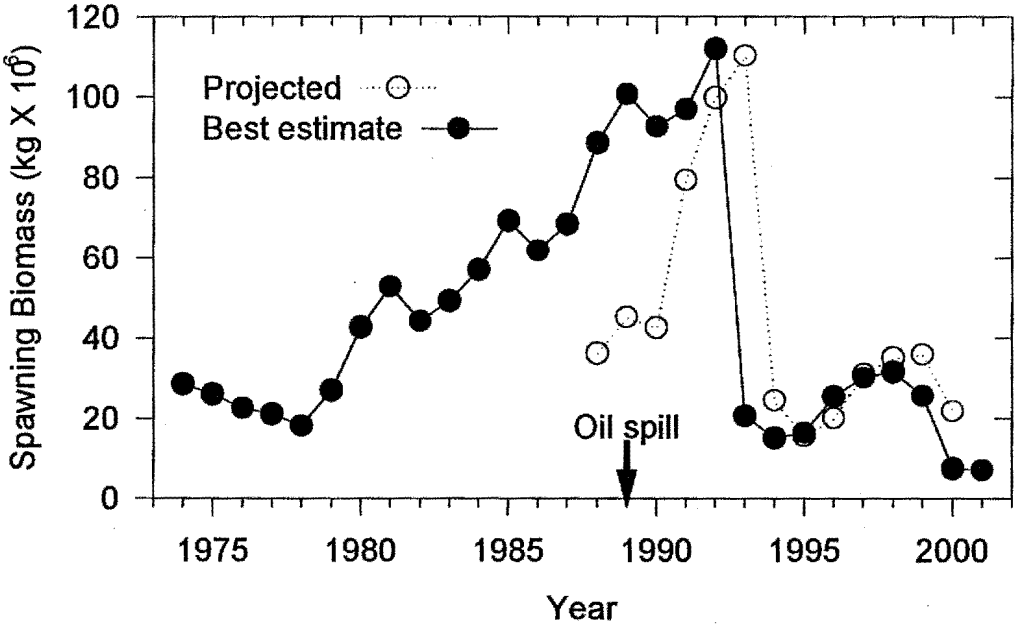

Figure 1. Spring prespawning biomass estimates of mature Pacific herring in Prince William Sound, Alaska. Unexploited spawning biomass is estimated using an age-structured assessment model (ADFG, unpublished data). Projections were not made before the 2001 or 2002 seasons, and the best estimate for 2000 and 2001 is based entirely on acoustic data.

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 funded for 3 years to continue research on the effect of disease on Pacific herring population recovery. At the same time, the U.S. National Science Foundation (Biological Oceanography) funded a 3-year project to augment continued disease research in PWS. Trustee Council Project \\462 funded sampling and virus analysis, while NSF funded complete blood analysis, histopathology, and population modeling. Population recovery had still not occurred by the 3rd year of study, so the Trustee Council extended their part of the study to a fourth year (02462).

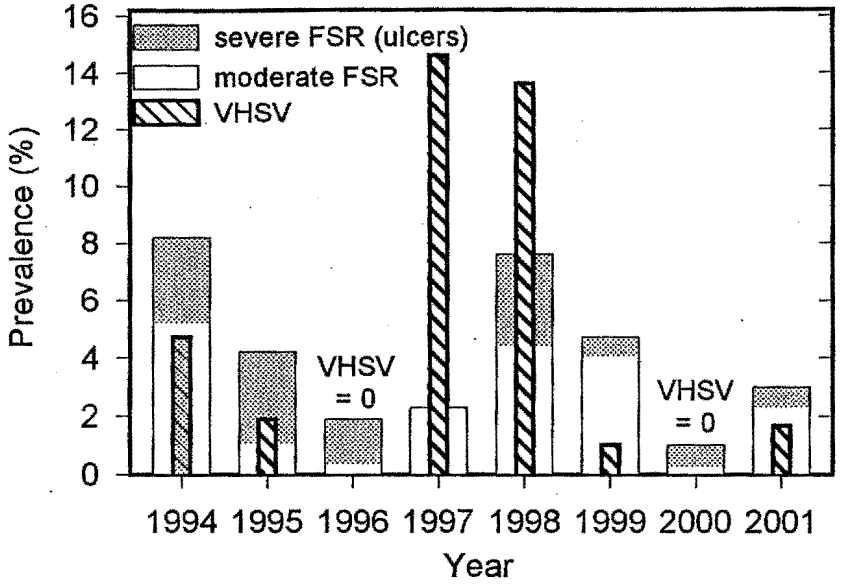

Figure 2. Spring prevalence of focal skin reddening (FSR) and viral hemorrhagic septicemia virus (VHSV) in adult Pacific herring sampled from Prince William Sound, Alaska.

During the first 7 years of this study (1994-2000), population decline was significantly associated with prevalence of viral hemorrhagic septicemia, but not with *I. hoferi* (Quinn et al. 2001). Indeed, *I. hoferi* was highly correlated with fish age, but not with unexpected population decline. Based on the age of fish in the sample in spring 2001, we predicted that prevalence of *I. hoferi* in spring 2001 would have been about the same as in 1996: 20% (Figure 3). However, in 2001 the prevalence of *I. hoferi* (38%) was more than 50% greater than in any previous year (Figure 4).

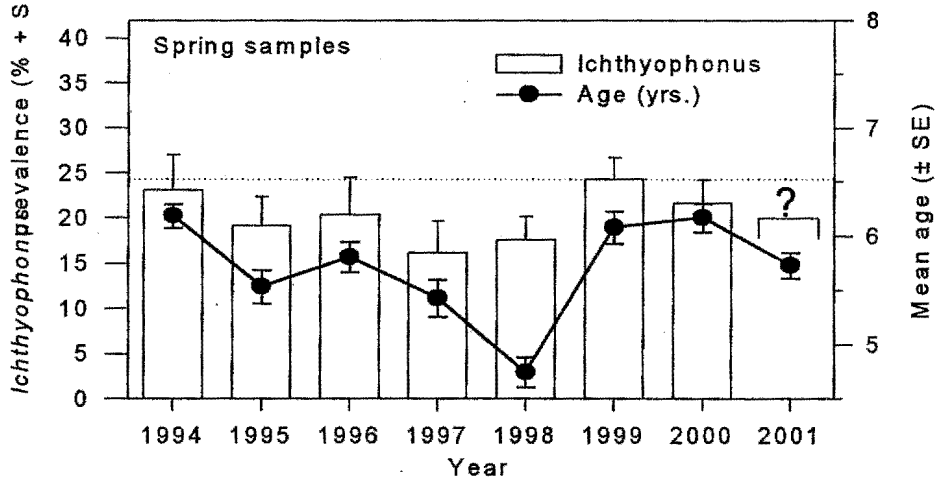

Figure 3. Mean age and prevalence of *Ichthyophonus hoferi* in Pacific herring sampled from Prince William Sound, Alaska (n = 233-300 per year). Reference line is at the maximum prevalence before 2001. "?" denotes predicted *I. hoferi* prevalence in 2001 based on fish age.

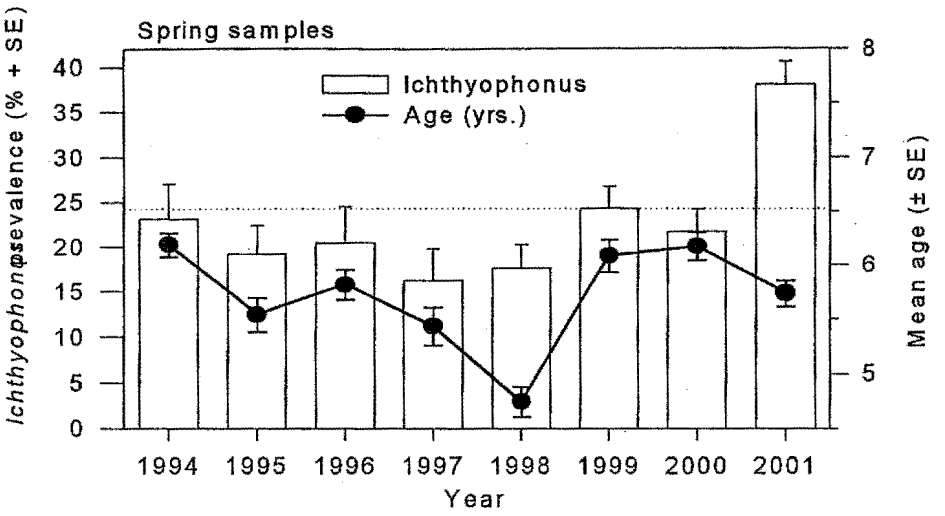

Figure 4. Mean age and prevalence of *Ichthyophonus hoferi* in Pacific herring sampled from Prince William Sound, Alaska (n = 233-300 per year). Reference line is at the maximum prevalence before 2001.

To understand the significance of the unprecedented increase in the prevalence of *I. hoferi* in 2001, this proposal (03462) asks the Trustee Council to fund complete histopathologic analysis of tissues already collected as part of project 02462. The Trustee Council has already funded collection of tissues for histopathology from fall 2000 (n = 100 fish) and spring 2001 (n = 300 fish), and histopathology is the best way to diagnose significant infections with *I. hoferi*. No additional sampling is proposed. Histopathologic analysis proposed for 03462 was included in the 8-15-02 proposal to NSF to continue their part of the research for 5 more years; however, analysis of 2001 *I. hoferi* prevalence was not yet complete when the NSF proposal was submitted, and NSF did not fund the renewal proposal.

Pacific herring are extremely important in the PWS ecosystem, and this project provides an understanding of disease and population change that is important for understanding marine fisheries worldwide. This project has benefited from project \\468 "Fundamental Estimations of Acoustic Target Strength" because acoustic estimates of population size are an important component of estimating population biomass. Better estimates of population biomass allow us to more accurately assess the relation of disease and population change.

NEED FOR THE PROJECT

A. Statement of Problem

Pacific herring are an injured biological resource in PWS classified as "recovering." However, estimates of population biomass in 2001 were the lowest on record. The population was low enough in 2001 that ADFG closed all herring fisheries in 2002 without using their age structured assessment model to calculate prespawning biomass. From ADFG's announcement Monday, April 1, 2001, "Based on last spring's estimated spawning biomass and assuming average recruitment each year, the PWS herring spawning biomass could be expected to remain below

threshold for several more years" (http://www.cf.adfg.state.ak.us/region2/finfish/herring/pws/pwsupd02.htm). Lack of recovery of the resource has resulted in lost services, particularly for commercial fisheries. Also, Pacific herring are a major part of the diet for harbor seals, an endangered species classified as "not recovering." And finally, Pacific 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. The final year of analysis is needed to determine the effect of the unprecedented increase in *I. hoferi* during 2001.

B. Rationale/Link to Restoration

This project should be done because it will provide information on what is limiting population recovery and it will monitor if fish are healthy and recovery has begun. Also, knowledge of what is limiting recovery of the Pacific herring population of PWS is important for the emotional "restoration" of people directly affected by the spill. Finally, 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 commercial fisheries until the population has truly recovered.

C. Location

Study will be done in at the University of California, Davis, on tissues previously collected in PWS, 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. We previously identified ulcer prevalence as a key indicator of population health, but managers of other Pacific herring fisheries will also need to know of the potential for *I. hoferi* to adversely affect the health of their populations.

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 FFY03. For example, contact with fishers, local residents, processors, and ADFG managers occurs through personal contact while in Anchorage and Cordova, and via regular e-mail updates. To aid in dissemination of information, Dr. Marty is available by phone for interviews (e.g., Anchorage Daily News 11-16-01) and he responds quickly to requests from the Restoration Office for general information and articles for newsletters.

PROJECT DESIGN

A. Objectives

The restoration objective states, "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. Analysis of samples already collected in the only

purpose for this proposal. Objectives include:

1. Determine the prevalence of major diseases in Pacific herring (particularly *I. hoferi*).

2. Determine the interaction of gender, age, and season on disease prevalence.

3. Determine if disease prevalence correlates with population trends.

B. Methods

Detailed methods for this project were included with the proposal for 02462. Because this proposal is limited to histopathologic analysis of tissues collected as part of 02462, only the histopathology component of the project design is repeated here. Pacific herring were or will be randomly sampled from PWS in November 2001 (at the end of the feeding season, n = 100) and in April 2002 (near the time of spawning, n = 300). Each fish will be examined for microscopic abnormalities (e.g., *I. hoferi*).

This proposal has two specific hypotheses to test:

1. Prevalence of microscopic lesions such as *I. hoferi* is different from previous years.
2. Microscopic lesions, including those resulting from *I. hoferi*, are related season, age, or gender.

To test the hypothesis that reproductive stage affects the development of disease, sampling was conducted during the spawning season (spring) and during the period of gonadal development and peak condition (fall). To provide a minimum number of fish from which at least the dominant year class can be analyzed in detail, we propose analyzing all 300 fish that were sampled in April. 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 analyzed from 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).

For Histopathology, several tissues were fixed 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. Tissues will be processed into paraffin, sectioned at 5 µm, and stained routinely with hematoxylin and eosin. Sections will be coded for blind study, combining fall and spring samples into one group. For histopathologic analysis, each lesion is semiquantitatively ranked on a four-point scale (0,1,2, or 3). To maximize comparability of results through the years, type specimens described for the 1994 data (Marty et al. 1998) provide the basis for diagnoses and scoring. For consistency, Dr. Marty will continue to perform all histopathologic analyses. A touch preparation of kidney from each fish is made on a glass slide,

stained with a Wright's stain, and examined for the myxosporean *Ortholinea orientalis*. Changes in *I. hoferi* prevalence will be followed through each major year class. *I. hoferi* prevalence is low when Pacific herring first recruit to the spawning population, but then increases.

Parasite prevalence - This study is designed to diagnose any type of disease that is causing morbidity in herring. Results will be compared with other years of study. Spring samples from PWS have several parasites that occurred at greater than 10% prevalence in at least some years; in order of decreasing prevalence, parasites in PWS spring samples included:
1) Anisakidae in the peritoneal cavity, 100% (all years);
2) intestinal coccidian *Goussia sp.* ?, 76-98%;
3) testicular coccidian *Eimeria sardinae*, 59-91%;
4) hepatic coccidian *Goussia clupearum*, 69-85%;
5) gall bladder myxosporean *Ceratomyxa auerbachi*, 16-50%;
6) renal intraductal myxosporean, *Ortholinea orientalis*, 16-32%;
7) renal intraductal myxosporean, species unclassified, 9-16%;
8) branchial *Epitheliocystis*, 11-36%;
9) gastric intraluminal trematodes, e.g., Hemiuridae, 5-16%;
10), intestinal trematodes, e.g., *Lecithaster gibbosus*, 3-34%
11) branchial monogenetic trematodes *Gyrodactylus spp.*, 1.5-13%;
12) branchial ciliated protozoans, mostly *Trichodina spp.*, 0-12%;
13) intestinal cestodes and acanthocephalans occurred at <10% in all years.

The ADFG fisheries laboratory in Cordova, Alaska, will handle logistics for shipping tissues to the University of California, Davis using funds already approved as part of 02462.

Statistical analysis in this study will focus on determining changes in disease prevalence over time. The association of selected categorical variables (e.g., *I. hoferi* 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. Multiple regression analyses will be used to determine the significance of *I. hoferi* based on fish age, gender, year, and season of capture. For all analyses, comparisons will be considered significant when $P<0.05$ and highly significant when $P<0.01$.

An alternative for saving money on this project is to analyze only some of the 10 organs normally analyzed. This is not recommended because *I. hoferi* is a disseminated disease that affects many organs, and most of the organs also contain at least one parasite that has been quantified during the other 8 years of the study. Multiple regression analysis—the most important component of statistical analysis—cannot use any fish in which even a single variable contains missing data; therefore, multiple regression cannot be used on 2002 samples unless the histopathologic analysis is consistent with all previous years. To save money, blood analysis that was part of the unfounded NSF proposal is not being included in this proposal. Blood smears and plasma chemistries were useful for identifying significant pathogens, but they did not provide as much useful information as did histopathology for determining the population-level significance of disease.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The project is being run through ADFG because Dr. Marty has worked closely with ADFG on several Trustee Council-funded projects during the past decade. ADFG has unique local knowledge on Pacific herring in PWS, and ADFG personnel have the expertise to ship hazardous materials (e.g., formalin-fixed tissues) 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.

SCHEDULE

A. Measurable Project Tasks for FY03

DATES (results due on final date)	ACTIVITY
September 2002:	Ship tissue samples from Cordova, Alaska to Davis, CA; Person in charge: Steve Moffitt, ADFG, Cordova, AK.
Oct. 1 - Dec. 31, 2002:	Prepare microscopic sections of tissues for histopathology;
Dec. 1, 2002 – May 31, 2003:	Histopathologic analysis;
January 2003 (4 days):	Attend annual restoration workshop
June 1- Aug. 1, 2003:	Statistical analysis
Aug. 1, 2003 –April 15, 2004:	Final report writing
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.
2. Determine the effect of disease on population trends.

Objectives will be met when the multi-year study is completed and the final synthesis report is submitted April 15, 2004.

D. Completion Date

Basic project objectives will be met when histopathologic analysis of samples collected during the fourth year disease study is complete. Note, however, that each additional year of disease study

in PWS provides more information on the recovery of the Pacific herring population. High prevalence of virus and ulcers among recruiting populations of both the 1994 and 1995 year-classes in 1998 severely limited the capacity of these year classes to contribute to population recovery. Recruitment of the 1996, 1997, and 1998 year classes was minimal. Preliminary evidence indicates that recruitment of the 1999 year-class is fairly good. However, even if the 1999 year class is very large, population recovery cannot be fully documented until that year class is 5 years old: in 2004 (two years after sampling for the current project ends). Therefore, termination of study in 2002 is not likely to be sufficient to document population recovery. Following the population through a full cycle—probably 7 to 10 additional years—would be needed to understand how disease and population size are linked. The 9 years of disease information that we already have constitutes 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 7-10 years through the Gulf Ecosystem Monitoring program (Phase II), with potential for cost sharing with the National Science Foundation, will greatly enhance our understanding of how and when the Pacific herring population recovers. Such an extension is not being proposed now, but a long-term extension will probably be proposed as part of phase II of the Gulf Ecosystem Monitoring program, with the focus being "Pacific herring population health as a marker of ecosystem health in Prince William Sound, Alaska."

PUBLICATIONS AND REPORTS

If we seem to have a complete picture of the *I. hoferi* outbreak after study of samples collected in spring 2002, one publications is anticipated in FY03. The publication will combine earlier work (\\162) with this project:

Marty, G. D., T.J. Quinn II, S.D. Moffitt, and N.H. Willits. Effect of *Ichthyophonus hoferi* on population biomass of Pacific herring in Prince William Sound, Alaska. Diseases of Aquatic Organisms.

If the prevalence of *I. hoferi* has not yet decreased, and additional study is funded, publication will be delayed until we have a more complete understanding of the *I. hoferi* outbreak, probably 1-3 years later (e.g., FY06). Diseases of Aquatic Organisms does not have a page charge, and costs for supplies associated with this publications is included in the supply part of the budget.

PROFESSIONAL CONFERENCES – No funds are requested. Funds to attend a professional conference each year are provided by UC Davis.

NORMAL AGENCY MANAGEMENT - Not applicable.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Project \\462 was closely coordinated with ADFG population modeling efforts as part of normal

management, and with a 3-year project funded in late 1998 by the National Science Foundation's Division of Biological Oceanography. The three-year $286.4K NSF project had no funds for sample collection, and it depended entirely on Trustee Council funds for sample collection. The NSF project included collaboration with the University of Alaska, Fairbanks (Dr. Terrance J. Quinn). Using Dr. Quinn's expertise, the NSF project included a modeling component to mathematically determine the relation of disease and changes in population biomass (Quinn et al. 2001). 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 three years of this project (99462 - 01462), NSF saved about $230K on its project. At the same time, the Trustee Council benefited from $286.4K worth of analysis funded entirely by NSF. In August 2001, Dr. Marty submitted a competitive renewal proposal to NSF to continue funding disease analysis and modeling for another 5 years (2002-2006). Although the proposal was not funded, the NSF program director noted that the funding success for similar unsolicited proposals was only about 15%. Dr. Marty's initial proposal to NSF in 1997 was not funded until after the proposal was revised and resubmitted in 1998. Resubmission of a revised renewal proposal in August 2003 is likely if this proposal (03462) is funded.

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, 01462, and 02462). 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 one more year of histopathology 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 funds for histopathologic analysis of tissues that were collected as part of project 02462 in fall 2001 and spring 2002. Funds for this analysis were included in a proposal to NSF, but the NSF proposal was not funded. However, information from histopathologic analysis of these tissues is critical for understanding 1) the effects of the *I. hoferi* outbreak of 2001, and 2) why population recovery continues to be delayed.

PROPOSED PRINCIPAL INVESTIGATOR

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Phone: 530-754-8062; FAX: 530-752-7690
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PRINCIPAL INVESTIGATOR

Gary D. Marty, DVM, Ph.D., and Diplomate, American College of Veterinary Pathologists, will

be responsible for histopathologic analysis and final report writing. Dr. Marty has been doing equivalent work on this project since 1994.

OTHER KEY PERSONNEL

none

LITERATURE CITED and RELEVANT PUBLICATIONS:

Becker, S., and T. Grieb. 1987. Guidance for Conducting Fish Liver Histopathology Studies During 301(h) Monitoring. U.S. EPA 430/09-87-004, Washington, D.C.

Carls, M.G., **G.D. Marty, T.R. Meyers**, R.E. Thomas, and S.D. Rice. 1998. Expression of viral hemorrhagic septicemia virus in pre-spawning Pacific herring (*Clupea pallasi*) exposed to weathered crude oil. Can. J. Fish. Aquat. Sci. 55:2300-2309.

Davis, C.R., **G.D. Marty**, M.A. Adkison, E.F. Freiberg, and R.P. Hedrick. 1999. Association of plasma IgM with body size, histopathologic changes, and plasma chemistries in adult Pacific herring Clupea pallasi. Dis. Aquat. Org. 38:125-133.

Holst, J. C. 1996. Estimating the prevalence of *Ichthyophonus hoferi* (Plehn and Mulsow) in a herring stock (*Clupea harengus* L.): observed effects of sampling gear, target school density and migration. Fisheries Research 28:85-97.

Kocan, R.M., P. Hershberger, T. Mehl, N. Elder, M. Bradley, D. Wildermuth, and K. Stick. 1999. Pathogenicity of *Ichthyophonus hoferi* for laboratory-reared Pacific herring *Clupea pallasi* and its early appearance in wild Puget Sound herring. Dis. Aquat. Org. 35:23-29.

Marty, G.D., E.F. Freiberg, **T.R. Meyers**, J. Wilcock, T.B. Farver, and D.E. Hinton. 1998. Viral hemorrhagic septicemia virus, *Ichthyophonus hoferi*, and other causes of morbidity in Pacific herring *Clupea pallasi* spawning in Prince William Sound, Alaska, USA. Dis. Aquat. Org. 32:15-40.

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

Meyers, T.R., J. Sullivan, E. Emmenegger, J. Follet, S. Short, W.N. Batts, and J.R. Winton; 1992. Identification of viral hemorrhagic septicemia virus isolated from Pacific cod *Gadus macrocephalus* in Prince William Sound, USA. Dis. Aquat. Org. 12:167-175.

Meyers, T.R., and J.R. Winton. 1995. Viral hemorrhagic septicemia virus in North America. Ann. Rev. Fish Dis. 5:3-24.

Quinn, T.J. II, **G.D. Marty**, J. Wilcock, and M. Willette. 2001. Disease and population assessment of Pacific herring in Prince William Sound, Alaska. Pages 363-379 in F. Funk, J. Blackburn, D. Hay, A. J. Paul, R. Stephensen, R. Toreson, and D. Witherell, editors Herring: Expectations for a new millennium. University of Alaska Sea Grant, AK-SG-01-04, Fairbanks.

Rahimian, H., and J. Thulin. 1996. Epizootiology of *Ichthyophonus hoferi* in herring populations off the Swedish west coast. Dis. Aquat. Org. 27:187-195.

Sindermann, C.J. 1958. An epizootic in Gulf of St. Lawrence fishes. Trans. N. Amer. Wildl. Conf. 23:349-360.

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

Budget Category:	Authorized FFY 2002	Proposed FFY 2003
Personnel	12.9	$0.0
Travel	0	$0.0
Contractual	50.1	$73.4
Commodities	9	$0.0
Equipment	0	$0.0
Subtotal	72	$73.4
General Administration	5.4	$5.1
Project Total	77.4	$78.5
Full-time Equivalents (FTE)	0.4	0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Dollar amounts are shown in thousands of dollars.

Comments:

This project proposal includes two components:

1. University of California, Davis: Fish organ histopathology (9-10 organs from each of 400 fish)
   a. Funds for writing the final report in FY03 were included in the FY01 budget.

2. Alaska Department of Fish and Game: administrative support .

2003

Project Number: 03462
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 4-2-02

4/10/02

2001 EXXON VALDEZ TRUSTEE 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 2003
							0.0
							0.0
		Subtotal		0.0	0	0	
Those costs associated with program management should be indicated by placement of an *.						Personnel Total	$0.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
PM		Price	Trips	Days	Per Diem	FFY 2003
	Description					
Those costs associated with program management should be indicated by placement of an *.					Travel Total	$0.0

2003

Project Number: 03462
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

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

Contractual Costs:	Proposed
Description	FFY 2003
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed
Description	FFY 2003
Commodities Total	$0.0

2003

Project Number: 03462
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
4/10/02

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

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FFY 2003
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

2003

Project Number: 03462
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 TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2002	Proposed FY 2003	LONG RANGE FUNDING REQUIREMENTS					
Personnel	$12.3	$55.1						
Travel	$5.4	$1.0						
Contractual	$2.5	$0.0						
Commodities	$2.3	$5.4						
Equipment	$0.0	$0.0						
Subtotal	$22.5	$61.5						
Indirect	$4.3	$11.9						
Project Total	$26.8	$73.4						
Full-time Equivalents (FTE)	0.2	0.8						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments: Indirect Costs include the standard overhead rates and applications for the Center for Health and the Environmental (CHE) at the University of California, Davis (19.3%).

Proposal includes funds (here, direct costs) for histopathologic analysis (3.0 month time for G. Marty), community involvement and manuscript preparation (1.0 mo time for G. Marty), and the annual workshop (travel and per diem). The proposal does not include funds for NEPA compliance (no field work is involved) or professional conferences (Dr. Marty can get funds from UC Davis to attend a professional conference).

Funds for technician time are for trimming and procesing ~4000 organs into paraffin (C. Teh, 2 months time) and preparing stained 5-μm sections from the resultant 2400 blocks (T. Harrington, 3 months time).

Costs for producing a final report have already been secured through previous year's funding.

FY03

Prepared:
GDMarty 4-2-02

Project Number: 03462
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

4/10/02

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 2003
	Marty, G.	Assistant Researcher V	4.0	7.5	0.0	30.0
	Teh, C.	Laboratory Assistant III	2.0	4.0	0.0	8.0
	Harrington, T.	Staff Research Associate III	3.0	5.7	0.0	17.1
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	9.0	17.2	0.0	
					Personnel Total	$55.1

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2003
	airfare to Anchorage for annual restoration workshop	0.6	1	4	0.1	1.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$1.0

FY03

Prepared:
GDMarty 4-2-02

Project Number: 03462
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

4/10/02

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

Contractual Costs:	Proposed
Description	FY 2003
Contractual Total	$0.0

Commodities Costs:	Proposed
Description	FY 2003
Materials and supplies (for tissue processing, sectioning, staining, and hazardous waste disposal; 2400 blocks @ $2/block)	4.8
ITEH supplies (cover costs for project administration not included with the low CHE overhead rate)	0.6
Commodities Total	$5.4

FY03

Project Number: 03462
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
4/10/02

Prepared:
GDMarty 4-2-02

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

New Equipment Purchases: Description		Number of Units	Unit Price	Proposed FY 2003
	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

FY03

Project Number: 03462
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 4-2-02

4/10/02

Effects of Oiled Incubation Substrate on Pink Salmon Reproduction

Project Number:	03476
Restoration Category:	Research
Proposer:	Ron Heintz NMFS, Auke Bay Laboratory ABL Program Manager, Dr. Stan Rice NOAA Program Manager: Bruce Wright
Lead Trustee Agency:	NOAA
Cooperating Agencies:	none
Alaska SeaLife Center:	No
Duration:	Sixth of six years.
Cost FY03:	$36.9
Geographic Area:	Little Port Walter, Baranof Island, Southeast Alaska
Injured Resource:	Pink salmon

ABSTRACT

Populations are maintained through successful reproduction; this study is designed to determine if exposure to oil impairs pink salmon reproduction. This experiment began in the fall of 1998 when pink salmon eggs were incubated in oil contaminated water. Fish that survived exposure were marked and released in the spring of 1999. They reached maturity at sea and returned to spawn in the fall of 2000. Return rates confirmed previous observations of reduced marine survival among exposed fish, but evaluations of offspring (F1) survival rates did not indicate any reproductive impact. The F1 were incubated in clean water until spring 2001 when they were marked and released. They will mature and return to the hatchery in the fall of 2002 and their reproductive ability will be evaluated by generating an F2 generation. A diminished ability to produce the F2 generation represents a genetic effect of oil transmitted to unexposed generations. Such an effect was demonstrated with for similarly treated pink salmon in 1997, but corroborating data do not exist. This project is designed to re-test that experiments; if diminished reproductive ability is corroborated, it would demonstrate a significant and unanticipated effect of oil pollution.

INTRODUCTION

This project measures the delayed effects of oil exposure on pink salmon reproduction. Low level exposures to embryos with delayed effects on growth and adult returns have been documented (Marty et al. 1997, Heintz et al. 1999), but not in reproduction. However, evidence has been accumulating that delayed effects of oil exposure extend to unexposed generations. This possibility was first revealed in 1991, when elevated egg mortalities were observed in the freshwater zone of oiled streams. The direct effects of oil exposure were not possible in this zone because of its location relative to the intertidal. However, adults returning to the oiled streams in 1991 may have been exposed when they incubated (Bue et al. 1996). This observation stimulated a series of field and laboratory studies. In 1998, Bue et al. reported adult fish returning to oil contaminated streams had reduced gamete viability. In that experiment, gametes were collected from adults returning to oil contaminated and uncontaminated streams and incubated in a hatchery before they could be they could be exposed to oil. Despite the identical incubating environments for the eggs, the gametes derived from oil contaminated streams consistently produced fewer viable embryos than gametes derived from uncontaminated streams. As in 1991, this difference was thought to result from the exposures the adults endured when they incubated as eggs, in the oiled streams. However, the exposure histories of the pink salmon used for the study could only be inferred. In addition, the underlying cause for the reduction in gamete viability was not identified.

The field evidence of reproductive impairment has some corroborating experimental evidence. Controlled laboratory exposure tests designed to measure direct and delayed effects of embryonic exposure have identified delayed effects on growth at the part per billion level of PAH exposure. These tests have provided secondary results also suggesting a reproductive effect, but the results were equivocal for the most part. Hence, the present study has been designed to specifically measure reproductive effects from adults with known exposure histories. However, a recent analysis of egg mortalities in earlier experiments by Smoker et al. (2000) indicates that exposure to crude oil can cause heritable damage to female pink salmon, and is consistent with other research on the mutagenicity of crude oil (Roy et al. 1999) and existence of heritable effects of benzo[a]pyrene after exposure during embryonic development (White et al. 1999).

Reproductive impairment described by Bue et al. may result from phenotypic effects on the parents, or genetic effects passed to the offspring. Both result in delayed impacts on the successive generations, and have significant but different implications for the recovery of the damaged populations. A phenotypic effect resulting in the failure to produce high quality gametes would be limited to those individuals that experienced sufficient exposure to oil. Consequently, the effect would diminish along with the exposure levels in the contaminated streams. However, genetic damage passed to offspring could potentially persist for a large number of generations; existing even after oil could no longer be found in contaminated streams. Phenotypic effects on the adults, or genetic effects are not mutually exclusive, and may occur at

the same time.

This project is designed to measure the effect of exposure on reproductive ability by measuring the viability of gametes taken from fish whose parents were exposed to oil. Exposures began with eggs collected from wild fish in 1998. Fish that survived incubation were marked in released in the spring of 1999 and the surviving adults returned in the fall of 2000. The surviving offspring were marked and released in the spring of 2001. When they mature the viability of their offspring will be measured, effectively repeating the work reported by Smoker et al. (2000). Incubation of the final generation in the fall of 2002 will require about 90 days to identify effects on that generation. Neither these fish nor their parents will have been exposed to oil, thus effects related to the exposure history will represent effects with a genetic basis. The final product of this project includes a life-history model with the phenotypic and genotypic impacts of exposure quantified for each life stage. This model represents an important advance in our understanding of the impacts of environmental contaminants on populations.

NEED FOR THE PROJECT

A. Statement of the Problem

Field and laboratory work conducted after the EVOS by Restoration Study 191 demonstrated that pink salmon populations in contaminated streams had reduced fitness when they were exposed to low concentrations of polynuclear aromatic hydrocarbons (PAH). The data clearly demonstrate that reductions in average fitness are the result of decreased survivorship in the exposed populations. This study is designed to verify that fitness is further reduced by the failure to produce viable offspring. This will lead to refinement of our current estimates of the reduction in average fitness. Identification of reduced fertility in the contaminated streams field will greatly strengthen the Trustee conclusions regarding EVOS impacts on pink salmon, and demonstrate the relevance of our model to real-world conditions.

Smoker et al.'s (2000) demonstration of a genetic effect suggests that the fitness model we have proposed to construct should include both genetic and phenotypic components to the total reduction in reproductive output. Fitness reductions resulting from phenotypic impacts will persist only as long as the exposures take place. However, fitness reductions resulting from genotypic impacts may persist after the exposures have ended. Elaboration of the fitness model to account for genotypic effects can potentially provide the Trustees with a time line for recovery.

We propose replicating the genetic analysis to verify the claims of Smoker et al. (2000) and to provide more information for elaborating the fitness model. Confirmation of the genetic effect is required because such claims are likely to be met with skepticism. The work reported by Smoker et al. (2000) was not corroborated by our own evaluations performed the same year. The differences in results are likely due to the high mortality rates we observed in our own studies. Thus, replication of the genotypic effects will provide a firm basis for refuting the criticism we expect from the oil industry. Replicating the genotypic effects also provides opportunity to

design experiments that will permit us to evaluate the contribution of dominance effects to the genetic component of variance. Such an evaluation provides a basis for estimating the number of generations required for the genetic load to dissipate.

B. Rationale/Link to Restoration

Identification of a genetic effect of embryonic exposure to crude oil provides EVOS Trustees with important evidence of a significant and unanticipated effect of the EVOS. This information is important to managers working to restore salmon populations in PWS. The recovery status of pink salmon in PWS remains controversial, and establishing an identifiable endpoint for recovery remains problematic. Pink salmon escapements to oiled streams were high even in the years when embryo mortality rates were elevated. Recently, embryo mortality has not differed from reference streams, but evidence for oil in stream waters can be found (Rice personal communication). Measurement of the potential genetic load acquired by incubating in oil contaminated streams coupled with the estimated persistence of such a load can provide valuable insight into the recovery status of these populations.

Pink salmon are an ideal species for identifying prolonged population effects resulting from embryonic oil exposure which makes them a premier sentinel species for detecting EVOS impacts. Consequently, a large amount of effort and money was expended towards understanding how oil affected pink salmon populations. This work has led to important advances in our understanding of the scope and mechanisms of oil toxicity and has led to developing a model describing the average reduction in reproductive fitness of exposed populations. The importance of this work transcends the immediate needs of the Trustees to evaluate recovery and can be generalized for all natal fish habitats. Thus, this work represents an important legacy of the EVOS.

C. Location

This project is underway at Little Port Walter (LPW), a research hatchery operated by NMFS in southeastern Alaska. This location is appropriate because it has been the site of these studies since their inception. The facility 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

This project began in southeastern Alaska, and maturing fish will return to their natal stream on Baranof Island. We will continue to provide information to interested public (primarily fishermen) who visit the station by displaying at the facility the posters developed for the Restoration Workshop for 97191B and 97076 as interpretative tools. In addition, we have presented our data to the RCAC in the winter of 2000.

PROJECT DESIGN

A. Objectives

The objectives of this study have been to:

1. Determine the average viability of gametes taken from adult fish exposed to uncontaminated and contaminated water during incubation.(Earlier years)

2. Determine how incubating in oiled contaminated water influences individual variation in gamete viability. (Earlier years)

3. Determine if reductions in gamete viability can be inherited in unexposed generations. (FY03)

4. Develop a fitness model that includes all observed phenotypic and genotypic impacts of oil exposure. (FY03)

Heintz (2001) reported on objectives 1 and 2 finding that while the average viability of gametes decreased with increasing oil exposure, the differences were not statistically significant. The lack of significance resulted from high levels of variation in gamete viability among individuals. This likely resulted from asynchrony in the timing of ovulation among fish chosen for spawning. Changes in procedure will be used to minimize this effect when evaluating objective 3. The F1 generation will be mature in September 2002 when they will be mated to produce the F2 generation. Objective 4 will be produced after the evaluating survival of the F2 through the eyed egg stage.

B. Methods

Overview of completed work

The exposure mechanism and fish culture procedures followed those described in previous proposals for Restoration Study 191B. Gametes were taken from an intertidally spawning pink salmon stock, transferred to our hatchery at Little Port Walter where they were incubated beginning in FY98. The eggs were exposed to effluent from either oil-coated or untreated gravel. In FY99, approximately 60,000 surviving fry from each exposure group were marked and released. Marked fish were held for a short period to recover from the marking procedure and then released. Exposures began in September of 1998; between 30 and 100 mature fish representing each treatment returned in September 2000.

All pink salmon returning to the Sashin Creek weir during the 2000 escapement period were inspected for marks. The exposure history was identified by external marks and those with similar histories were held in holding pens for spawning. On a given spawning date, fish were removed from each pen and spawned and their offspring incubated. Average offspring survival during incubation was inversely related to exposure of the parental generation, but this trend was not statistically significant (Heintz 2001). Survivors were fin marked in Spring 2001 and 48,657 fry were released representing 3 treatment groups. Examination of the survival of their offspring provides an avenue for identifying genetic effects on reproductive ability.

Previous attempts at identifying reproductive impacts have produced equivocal results. In 1995, fish that had been exposed during incubation in 1993 demonstrated a dose related effect on offspring survival (Figure 1), but as in 2000 that trend could not be verified statistically. The eggs fertilized in 1995 were incubated in clean water and the fish marked and released the following spring. When these fish returned in 1997 their offspring were incubated and a genetic effects on reproductive ability was identified (Smoker 2000). However, these data were not corroborated by impacts in the previous generation. Nor were they corroborated through a separate analysis described by Wertheimer et al. (2000).

Estimation of average offspring survival

Returning pink salmon will be collected at the Sashin Creek weir and identified by fin clips. Fish with missing fins will be floy tagged to identify the date they ascended the creek, and removed to holding tanks supplied with freshwater. Females that have recently ovulated will be removed to a separate tank and spawned the following day. Unovulated females will be monitored every other day, and those found to have ovulated will be removed to the spawning tank. Thus, no female will be held for more than 24 hours after ovulation. In addition to collecting marked fish, wild fish will also be collected as a second level of control.

Average offspring survival will be estimated following the approach employed by Smoker (2000). An aliquot of each females's eggs will be divided into three parts and each part will be fertilized by a different male representing the same exposure level as the female. Each male's sperm will be used to fertilize eggs from two females creating a block of 2 females by 3 males. As many of these blocks as practical will be developed each day, while ensuring that equal numbers of blocks are produced for each strain.

The fertilized eggs from a given family (male and female) will divided into four aliquots and each of the aliquots will be incubated separately in a randomly selected location in the incubator. After approximately 15 hours one of the aliquots will be removed and the eggs inspected to determine the fertilization rate. Only dead eggs will be removed from the remaining aliquots and the remainder will continue incubating until hatching. Reproductive output will be measured as: percentage of eggs fertilized, survival between fertilization and eyeing, and days required for 50% of the eggs to hatch. During incubation standard hatchery practices will be employed.

Statistical evaluation of survival will the following ANOVA model:

$$Y_{ijkl} = \mu + B_i + S_{j(i)} + D_{k(i)} + SD_{jk(i)} + e_{ijkl}$$

Where Y is a survival measure observed for the l^{th} replicate generated from the j^{th} sire ($S_{j(i)}$ is random) in each and the k^{th} dam ($D_{k(i)}$ is random) in each of the I mating blocks (B_i is fixed). Last-squared estimates of survival for specific blocks will be used to generate mean survivals for each strain. These will be contrasted to test the hypothesis that offspring from oiled strains are equal to that of control strains. Testing will use a quasi F-ratios formed from the mean square (MS) of the contrast divided by an expected mean square calculated as :

MS Dam(B) + MS Sire (B) -MS SD(B)

All calculations will be performed in SAS using Type III mean squares produced by the GLM procedure.

In addition, to contrasting differences between the strains, additive genetic, maternal, non-additive genetic, and phenotypic variances will be estimated. Heritability the ratio of maternal and nonadditive genetic variances to phenotypic variances will be calculated using an animal model solved by applying a derivative free technique for estimating variance components employing restricted maximum likelihood (Graser et al., 1987). The derivative-free restricted maximum likelihood (DFREML) analysis procedure of Meyer (1988) will be utilized. The technique has been utilized to analyze data from breeding experiments of fish (Crandell and Gall, 1993). Heritability estimates may be used to predict expected genetic change due to natural selection for a range of selection intensities (Van Vleck, 1987).

Estimation of fitness reduction

Average fitness for pink salmon that incubate in oiled gravel will be estimated from the fitness function

$$W_i = S_i F_i$$

where W_i is the average fitness of the population incubated at the i^{th} exposure level, with survivorship S_i from the time of exposure to maturity, and fecundity equal to F_i. Survivorship will be estimated as the product of survival during incubation and marine survival. Both of these values have been reported in previous reports where embryos were exposed to conditions similar to those used here. Estimates of fecundity will be calculated as the proportion of eggs that survive through eyeing. Thus, W will be expressed as the probability of producing a viable offspring. Assuming a genetic effect is corroborated then the fitness model then the difference in survival between exposed and unexposed lines can be used to parameterize the model proposed by Cronin and Bickham (1998).

C. Cooperating Agencies, Contracts and Other Agency Assistance

The statistical analysis of the results have been designed by the University of Alaska and the Alaska Department of Fish and Game (ADF&G) continues to play an important role in

reviewing our results.

SCHEDULE

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

Tasks for FY02

Sep. 2002: Recover mature F1, begin incubation of F2

TASKS for FY03

Oct. 2002: Evaluate F2 survival to eyeing.

Jan. 2003: Begin analysis of results and development of life history model.

Sep 2003: Final Report due

B. Project Milestones

Completed in FY98, FY99, FY00, FY01 :

Sept. 1998: Set-up exposure apparatus, collect gametes, begin exposures of P1

May 1999: Mark and release P1 generation

Sept. 2000: Examine oil effect on viability of F1 generation by recovering and spawning marked P1adults when they return to weir.

Sept. 2001: Complete analysis of gamete viability and fitness model.

May 2001: Mark and release F1 fry from oiled and control lines.

FY02 Milestones:

Sep. 2002: Recover adult F1 generation and begin incubating F2 generation

FY03 Milestones:

Dec. 2002 Complete incubation of F2 generation.

Sep . 2003 Submit final report.

C. Completion Date

Final Report will be submitted on September 15, 2003.

PUBLICATIONS AND REPORTS

FY00: Annual report describing the doses, exposure apparatus and effects on early incubation.

FY 01: Annual Report describing survival to maturity, mating procedures and fertilization rates.

FY 02: Annual report describing release numbers of F1 and preliminary evaluation of fitness model.

FY 03: Final report

Other potential reports:

Heintz, R. 2002. Incubating in oiled gravel damages the entire life-history of pink salmon. Journal Unknown.

Heintz, R. 2003. Embryonic exposure to oil causes genetic damage in pink salmon. Journal unknown.

PROFESSIONAL CONFERENCES

Travel to 2003 EVOS Oil Spill Symposium.

NORMAL AGENCY MANAGEMENT

This project will complete the work begun under Restoration 191B which has been performed cooperatively between the Trustees and NMFS from the outset. However, NMFS proposes providing most labor requirements for this project and seeks funding for primarily contractual labor and commodities. There is no charge for project support costs which include management of the LPW facility and project budget, or production of. There was no charge for setting up the experiment in FY98 and early FY99, NMFS covered costs associated with setting up the exposure apparatus, spawning pink salmon, and maintaining the incubation for 9 months and analyzing the hydrocarbon data.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project will be coordinated with continuation of NOAA research and monitoring efforts regarding pink salmon embryo survival under 01454, and integrates with a new study proposed to evaluate the effects of egg dig timing on mortality estimates. This study also coordinates the results of Restoration 191B and 076 by completing a life-history model for oil effects on pink salmon. Investigators and agencies will coordinate by sharing data. NOAA/NMFS will coordinate with the Trustees by providing labor requirements and laboratory overhead.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

No changes to the existing study have been described.

PROPOSED PRINCIPAL INVESTIGATOR

Name	Ron Heintz
Affiliation	NMFS
Address	Auke Bay Laboratory
	11305 Glacier Hwy.
	Juneau, AK 99801
Phone	907-789-6058
Fax	907-789-6094
E-mail	ron.heintz@noaa.gov

PRINCIPAL INVESTIGATOR

Ron Heintz has been involved in examining the effects of *Exxon Valdez* oil on pink salmon since 1992. He has developed the methods proposed for this project, published 4 peer-reviewed papers and has another in press on this topic. In addition, he has presented results of these studies at 15 professional meetings.

OTHER KEY PERSONNEL

Dr. S. D. Rice provides consultation.

LITERATURE CITED

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.

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Wertheimer, A. C., S. D. Rice, A. G. Celewycz, J. F. Thedinga, R. A.Heintz, R. F. Bradshaw, and J. Maselko. 1996. Effects of oiled incubation substrate on straying and survival of wild pink salmon. Restoration Project 95076 Annual Report. *Exxon Valdez* Trustee Council, Anchorage, AK.

White P.A., S. Robitaille and J. B. Rasmussen . 1999. Heritable reproductive effects of benzo[a]pyrene on the fathead minnow (*Pimephales promelas*). Environ.Toxicol. hem.18(8):1843-1847

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2002 - September 30, 2003

Budget Category:	Authorized FY 02	Proposed FY 03	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$19,200.0						
Travel		$7,050.0						
Contractual		$6,700.0						
Commodities		$1,000.0						
Equipment		$0.0						
Subtotal	$0.0	$33,950.0	Estimated FY 04					
General Administration		$3,026.5						
Project Total	$0.0	$36,976.5						
Full-time Equivalents (FTE)		0.3						
			Dollar amounts are shown in thousands of dollars.					
Other Resources								

Comments:
NOAA contributions: Principle Investigator R. Heintz, 2 mo @ 6.9K , operation costs of LPW 5K for a total contribution of 18.8K.

FY03

Prepared:4/11/02

Project Number: 03476
Project Title: Effects of Oiled Incubation Substrate on Pink Salmon
Agency: NMFS

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 03
Ron Heintz	Principle Investigator	GS12 Step 4	2.0	6900.0		13,800.0
Robert Bradshaw	Fish culturist	GS 11 Step 2	1.0	5400.0		5,400.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		3.0	12300.0	0.0	
					Personnel Total	$19,200.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 03
Trip to EVOS workshop	450.0	1	4	200.0	1,250.0
					0.0
					0.0
					0.0
Trip to SETAC	1850.0	1	5	150.0	2,600.0
					0.0
Air charters to LPW for egg collection and picking					3,200.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$7,050.0

FY03

Prepared:4/11/02

Project Number: 03476
Project Title: Effects of Oiled Incubation Substrate on Pink Salmon
Agency: NMFS

FORM 3B
Personnel
& Travel
DETAIL

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

Contractual Costs:	Proposed FY 03
Description	
Contract labor	
3 people at $17.00/ hour x 80 hours for egg picking	4,000.0
1 person at $18.00/ hr for 150 hours for monitoring incubation	2,700.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$6,700.0

Commodities Costs:	Proposed FY 03
Description	
groceries, misc field supplies	1,000.0
Commodities Total	$1,000.0

FY03

Prepared:4/11/02

Project Number: 03476
Project Title: Effects of Oiled Incubation Substrate on Pink Salmon
Agency: NMFS

FORM 3B
Contractual & Commodities DETAIL

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 03
			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
incubation facilities, incubators, egg picking machines, computers, xeroxing and library costs		

FY03

Prepared:4/11/02

Project Number: 03476
Project Title: Effects of Oiled Incubation Substrate on Pink Salmon
Agency: NMFS

FORM 3B
Equipment
DETAIL

Alaska Resources Library & Information Services (ARLIS)

Project Number: 03550

Restoration Category: Community Involvement/Public Outreach/Other

Proposer: Restoration Office

Lead Trustee Agency: All Trustee Agencies

Alaska SeaLife Center: No

Duration: Ongoing

Cost FY 03: $100,280

Cost FY 04: TBD

Geographic Area: All

Injured Resource/Service: All

ABSTRACT

Project 02550 represents the Trustee Council's contribution to Alaska Resources Library and Information Services (ARLIS). ARLIS serves as a central access point for information generated through the Trustee Council restoration process and the GEM program. In addition, ARLIS acts as the public repository for reports and other materials generated from and related to the cleanup, damage assessment and restoration efforts following the *Exxon Valdez* oil spill (EVOS). ARLIS supports the research efforts and information needs of the Restoration Office, principal investigators, natural resources professionals, and the general public.

INTRODUCTION

The Trustee Council has contributed budgetary support for ARLIS since the library was established in 1997. ARLIS is providing services that were previously provided through the Oil Spill Public Information Center (OSPIC). With the exception of Fiscal Year 1994, this activity has historically been funded under the Public Information, Science Management and Administration budget (Project /100). Funding as a separate project began in Fiscal Year 2001, as Project 01550.

In Fiscal Year 2002, the Trustee Council supported 1 FTE librarian at ARLIS. This proposal seeks a continuation of that funding for Fiscal Year 2003. Council funding in Fiscal Year 2004 and in subsequent years will be assessed on an annual basis.

NEED FOR THE PROJECT

A. Statement of the Problem

Over the years, a vast array of scientific literature has been produced as a result of the restoration program. ARLIS provides guidance to the principal investigators regarding preparation of the reports, distributes the reports to individuals and libraries as appropriate, and acts as a repository of all reports and publications generated as a result of the restoration process. ARLIS also supplies the principal investigators with research materials and reference service pertinent to their restoration and GEM projects.

All research begins with identifying and compiling existing information. This is especially true of the restoration process and GEM program, wherein a review of current knowledge is built into the research process. ARLIS's comprehensive natural and cultural resources collection provides access to current and historic information, some of which is available nowhere else. Materials not available directly from ARLIS are borrowed from other libraries, making comprehensive access to information possible for researchers.

The ARLIS collection contains 150,000 books, including agency publications, technical reports, and masters and doctoral theses, 700 journals, maps and atlases, legal reference materials, federal and state documents, public review documents, administrative records, videotapes, audiotapes, slides, photographs, electronic databases, environmental education kits, and a circulating collection of furs, skulls, and mounted birds. These materials are cataloged in a global bibliographic database making most circulating items accessible to users around the world. The library catalog is available for searching at the ARLIS website at www.arlis.org.

ARLIS provides universal access to Alaska natural and cultural resources information. Since it was established in October 1997, ARLIS annually receives 21,000 visitors, responds to 15,000 requests for information, performs over 15,000 interlibrary loans and circulates 14,000 books. Approximately 15% of the use of the library is directly related to the *Exxon Valdez* oil spill and the Trustee Council's restoration and GEM programs. In addition, 15% of the materials borrowed by other libraries from ARLIS are EVOS materials.

B. Rationale/Link to Restoration

Project 03550 provides essential support to implement the restoration program as directed by the Trustee Council and guided by the *Restoration Plan* and during the transition to the GEM program. The Trustee Council's policies, as specified in the *Restoration Plan* and the GEM program, include a strong commitment to public information. ARLIS ensures that findings and results of restoration efforts are available to the public, scientists, and agency staff to help understand the status of injured resources and services and to plan for future restoration, research and monitoring. The ARLIS staff provides reference service, literature searches, and document delivery to Restoration Office staff and principal investigators creating documents and databases for the GEM program.

C. Location

ARLIS is located at 3150 C Street, Suite 100, Anchorage, Alaska.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Project 03550 supports various aspects of community involvement. This includes public information efforts to assist the general public and spill community residents to learn about the restoration process and GEM program. ARLIS provides research support to those principal investigators conducting research in the areas of subsistence and traditional ecological knowledge.

PROJECT DESIGN

A. Objectives

The fundamental objective for ARLIS is to provide research materials to governmental agencies, researchers, the general public, and spill community residents.

Specific objectives for FY 03 include:

1. Provide access to restoration and GEM program information for local, state, national, and international users.

2. Support the research efforts and information needs of the Restoration Office staff, the principal investigators, and the general public.

B. Methods

ARLIS provides access to information through participation in library networks and a global bibliographic database. Through cooperative collection development efforts, appropriate books, technical reports, journals, gray literature, videotapes, maps, and other materials are acquired and

cataloged. A web accessible library catalog, through a partnership with the University of Alaska Anchorage Consortium Library and the Anchorage Municipal Libraries, provides worldwide access to ARLIS materials through interlibrary loan services. Thousands of fulltext publications are available through web links in the catalog record. Reference service is provided on-site and off-site via phone, mail, fax and email. The library provides in-house access to topical databases to the general public and desktop access to agency users. Additional databases are available through a partnership with the UAA Consortium Library.

In addition to print materials, ARLIS has cataloged thousands of web-based documents and publications. In the process, the staff has encountered the instability of electronic documents on the web. Documents change location; new versions replace earlier versions; documents disappear completely. Electronic documents are often comprised of multiple files, as many as fifty for large documents, and getting the complete document is not assured. ARLIS catalogers use national standards and practices to catalog electronic documents completely and accurately. Broken links are tracked to ensure the catalog records contain current URLs. In addition, housing EVOS, restoration and GEM print materials at ARLIS circumvents the unreliability of web-based documents and associated hardware/software obsolescence and incompatibility issues, and ensures permanent access to these important materials.

C. Cooperating Agencies, Contracts and Other Agency Assistance

ARLIS is a consolidation of eight libraries and information centers from state and federal agencies and a university institute:

Alaska Department of Fish and Game
Bureau of Land Management
Environment and Natural Resources Institute (UAA)
Exxon Valdez Oil Spill Trustee Council
Fish and Wildlife Service
Minerals Management Service
National Park Service
U.S. Geological Survey

The University of Alaska Anchorage is also a partner, although its library collection is not a part of ARLIS, as is the U.S. Army Fort Richardson Environmental Division.

ARLIS shares a library catalog with the Anchorage Municipal Libraries, the University of Alaska Anchorage Consortium Library, and the Anchorage Museum of History and Art Library. The holdings of all partner libraries can be searched 24 hours a day from the ARLIS web site by anyone with Internet access.

SCHEDULE

The Trustee Council operates on the Federal Fiscal Year (October 1 - September 30).

A. Measurable Project Tasks for FY 03 (October 1, 2002 - September 30, 2003)

On-going tasks throughout the fiscal year:

1. Review and approve format of final and annual reports, maintain a list of completed reports, and distribute reports to appropriate libraries. Catalog reports in a global bibliographic database for access throughout the world.
2. Maintain for public review the public record copy of the Trustee Council official record.
3. Maintain for public access a file of peer reviewed journal articles and conference papers resulting from Trustee Council funded research.
4. Provide reference service for oil spill related topics and other information needs to the Trustee Council, Restoration Office staff, science review staff, principal investigators, media, students and faculty, spill area residents, resource agency professionals, and the general public.
5. Acquire and catalog publications generated by the Trustee Council.
6. Acquire and catalog other oil spill and restoration related materials deemed appropriate for the collection and necessary to the restoration process and supporting GEM program research.
7. Maintain an annotated list of web sites relevant to EVOS, the restoration process, and the GEM program.
8. Annually update related topic bibliographies for the Trustee Council web site.

B. Milestones and Endpoints

1. Provide monthly reports to the Restoration Office on the status of the report format review and distribution process.
2. Provide quarterly reports and an annual summary of library usage statistics and staff projects.

C. Completion Date

Council funding in Fiscal Year 2004 and subsequent years will be assessed on an annual basis.

PUBLICATIONS AND REPORTS

Not applicable to this project.

NORMAL AGENCY MANAGEMENT

Funding in Project 02550 is for the sole purpose of supporting restoration program and GEM program activities and may not be used for other purposes.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Unless otherwise specified by the Restoration Office, each project funded by the Trustee Council is required to submit an annual report or a final report. As the public repository, all reports are cataloged and permanently housed at ARLIS.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

In October 1997, the Oil Spill Public Information Center (OSPIC) was consolidated with seven other state and federal agency libraries to create ARLIS. Planning for the consolidation was done by library staff, with the guidance of a Management Advisory Group consisting of participating agency heads, through the U.S. Department of Interior, under the auspices of the Reinventing Government program. Although ARLIS was established as a cost saving measure in response to federal and state budget cuts, the resulting library provides a vastly more comprehensive collection of Alaska resource information in a single location, served by highly qualified staff specializing in resource related information.

PROPOSED PRINCIPAL INVESTIGATOR

Carrie Holba, Librarian
Alaska Resources Library and Information Services (ARLIS)
3150 C Street, Suite 100
Anchorage, AK 99503
(907) 272-7547, 271-4742 fax
carrie@arlis.org

PRINCIPAL INVESTIGATOR

Carrie Holba holds a masters degree in Library and Information Science. In February 1991, she joined the staff of the Oil Spill Public Information Center, serving as public services librarian and then as director since 1992. Since OSPIC was consolidated with ARLIS in October 1997, Ms. Holba has served as reference services coordinator and a member of the ARLIS library management team, and continues to specialize in EVOS related reference service.

OTHER KEY PERSONNEL

As a founding agency of ARLIS, the Trustee Council benefits from the combined services of the library staff, including reference librarians, interlibrary loan staff, collection development staff, cataloging staff, and web development specialists, all trained to meet oil spill related information needs. ARLIS is a recipient of the 1997 National Performance Review Award and the 2001 National Award for Museum and Library Service, for innovation, partnership, and excellence in library service.

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

Budget Category:	Authorized FY 02	Proposed FY 03	LONG RANGE FUNDING REQUIREMENTS					
Personnel	$81.2	$87.2						
Travel		$0.0						
Contractual		$0.0						
Commodities		$0.0						
Equipment		$0.0						
Subtotal	$81.2	$87.2	Estimated FY 04					
General Administration	$12.2	$13.1						
Project Total	$93.4	$100.3	TBD					
Full-time Equivalents (FTE)	1.0	1.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

This budget is for the Trustee Council contribution to funding for the Alaska Resources Library and Information Services (ARLIS). With the exception of Fiscal Year 1994, this activity has historically been funded under the Public Information, Science Management and Administration Budget (Project /100). Funding as a separate project began in Fiscal Year 2001, as Project 01550.

FY03

Project Number: 03550
Project Title: ARLIS - Alaska Resources Library & Information Services
Agency: Alaska Department of Fish and Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Prepared: 4/12/2002

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 03
Holba	Librarian III	19J	12.0	7.3		87.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		12.0	7.3	0.0	
					Personnel Total	$87.2

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 03
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.0

FY03

Project Number: 03550
Project Title: ARLIS - Alaska Resources Library & Information Services
Agency: Alaska Department of Fish and Game

FORM 3B
Personnel
& Travel
DETAIL

Prepared: 4/12/2002

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

Contractual Costs:	Proposed FY 03
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0
Commodities Costs:	Proposed FY 03
Description	
Commodities Total	$0.0

FY03

Project Number: 03550
Project Title: ARLIS - Alaska Resources Library & Information Services
Agency: Alaska Department of Fish and Game

FORM 3B
Contractual & Commodities DETAIL

Prepared: 4/12/2002

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 03
Description			
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.	**New Equipment Total**		$0.0

Existing Equipment Usage:	Number of Units	Inventory Agency
Description		

FY03

Project Number: 03550
Project Title: ARLIS - Alaska Resources Library & Information Services
Agency: Alaska Department of Fish and Game

FORM 3B
Equipment
DETAIL

Prepared: 4/12/2002

Harbor Seal Recovery: Application of New Technologies for Monitoring Health

Project Number:	03558
Restoration Category:	Research
Proposer:	Shannon Atkinson, Ph.D., University of Alaska Fairbanks, School of Fisheries and Ocean Sciences, Institute of Marine Science
Lead Trustee Agency:	ADFG
Alaska SeaLife Center:	YES
Duration:	3rd of a 3-year project
Cost FY 01:	$120,128
Cost FY 02:	$128,400
Cost FY 03:	$109,210
Geographic Area:	Alaska SeaLife Center, Gulf of Alaska
Injured Resource/Service:	Harbor seals

ABSTRACT

This study is a continuation of the study to assess the potential for new technologies to monitor the endocrine and immune systems for the health of harbor seals. During year one, baseline samples were collected from both permanently captive and rehabilitation seals at the Alaska SeaLife Center (ASLC). Analysis of thyroxine (T_4), triiodothyronine (T_3), and cortisol (metabolic and gluconeogenic hormones), and measurement of immunoglobulins (IgG, IgM, and IgA) and organochlorine contaminants are currently being assessed. Cell lines to quantify immunoglobulins have been initiated, and baseline hormones have been established. The final year will compare the profiles of free-ranging seals and those failing to thrive in their environment in an effort to restore this species.

INTRODUCTION

The potential exists for several environmental factors to impact the biology of harbor seals (*Phoca vitulina*), resulting in poor survival, recruitment and reproductive rates. While the leading hypothesis is that changes in the availability of high quality prey have reduced the carrying capacity of the Gulf of Alaska, a contributing factor to poor survival and reproduction may include exposure to organochlorine contaminants (OCs), with associated endocrine and immune system impairment (Addison, 1989; De Swart *et al.*, 1994, 1996; Ross *et al.*, 1995; Reijnders, 1986). OCs and their by-products are bioaccumulated, biomagnified and transferred through lactation from mother to pup (Beckmen *et al.*, 1999; Gallenberg and Vodicnik, 1989; Vreel *et al.*, 1996; Wagemann and Muir, 1984). These contaminants and by-products may continually affect a population of animals even though no major polluting event has occurred. The adverse effects on the physiology of the animal may be subtle or subclinical, or may manifest themselves with symptoms such as, 'failure to thrive' or 'failure to reproduce'. The systems that typically respond to environmental changes, including contamination of suitable prey, are the endocrine and immune systems. This proposed study would develop technologies to examine these two systems to be used to monitor the health of individuals and the well being of subpopulations.

The endocrine system is a complex system that integrates the environment in which an animal lives with the physiology of that animal. As seasons, nutrition, and other environmental parameters change, the neuroendocrine system is the first to work toward ensuring that the body can adapt to the changes. Many compounds in the environment are known to interfere with the endocrine systems of mammals and are often referred to as 'endocrine disrupting compounds' (EDCs). The most commonly known EDCs are the organochlorines, including polychlorinated biphenyls (PCBs), DDT and it's metabolites, as well as the phthalates. Some EDCs are known to bind with estrogen receptors (Katzenellenbogen, 1995), either mimicking or blocking the effects of estrogens. Extreme examples of the effects of OCs on reproductive function are the neoplastic occlusions of the uterus resulting in infertility and the development of hermaphroditic offspring (Helle *et al.*, 1976; Baker, 1989; Reijnders, 1998). PCBs can also compete for binding sites on the transport proteins for the thyroid hormones, resulting in hypothyroid conditions that can affect early development or later reproductive performance (Brouwer, 1989). The results from these endocrine disruptions can be varied and also include suppression of the immune system (De Swart *et al.*, 1996; Ross *et al.*, 1995). To assess the baseline patterns of hormone release in harbor seals, Oki and Atkinson (Oki, 2001) measured the circadian patterns of the thyroid hormones and cortisol during winter and summer. Interestingly, the thyroid hormones were elevated in winter; however, the circadian pattern of cortisol was also abandoned in winter. Using these results for baseline pattern in captive harbor seals, we are now assessing a suite of measurements, including these hormones, with the goal of providing a good indication of the physiology of a seal and its ability to adapt to suboptimal environments.

The immune system of marine vertebrates is a rapidly advancing area of interest, both in the basic components of the immune system as well as the development of immunodiagnostic reagents. Baseline information on the immune system of pinniped species is critical to any future field assessment of immunocompetence. The lack of baseline information on the immune system of the harbor seal population in Europe hindered assessment of the role of pollution-induced

immunosuppression in the phocid distemper virus outbreak of 1988 (Dietz *et al.*, 1989a; Vos and Luster, 1989). Studies of levels of immunoglobulins and of isotypes of those immunoglobulins have been reported for a few species of pinnipeds. Cavagnolo and Vedros (1979) evaluated IgG, IgM, and IgA levels in sera and colostrums of adult and immature northern fur seals (*Callorhinus ursinus*), finding low immunoglobulin levels in the sera of pups during the first four months of life. Baker (1984) found similar results for overall gamma globulin levels in grey seal (*Halichoreus grypus*) pups. Carter *et al.* (1990) measured specific immunoglobulin isotype levels in sera and colostrums of the grey seal. Ross *et al.* (1993) evaluated IgG levels in the harbor seal, and also evaluated lymphocyte function in this species by measuring responsiveness to a T-cell mitogen. A number of reports have appeared describing enzyme-linked immunosorbent assay ELISAs or other immunoassays measuring pinniped antibody levels against canine distemper virus (e.g. Dietz, *et al.*, 1989b; Carter, *et al.*, 1990; Bengston, *et al.*, 1991; King, *et al.*, 1993). It is of note that some of the latter studies utilized antibodies specific for canine immunoglobulins to measure pinniped immunoglobulins, with which they cross-react. In assays such as the ELISAs mentioned above that require the use of anti-immunoglobulin indicator antibodies it is generally preferable to utilize species-specific antisera when available, but such antisera are not readily available for most species of pinnipeds. We are in the process of developing antisera that is specific to harbor seals. All of the samples that are being collected for the captive and rehabilitated seals will also be analyzed for immunoglobulins once the assay is developed.

This project will utilize our ability to monitor several hormones and immunoglobulins, and relate their function to the body burden of contaminants and the overall health of individual seals. During the proposed third year of this study we will assess the hormone and immunoglobulin concentrations in free-ranging harbor seals. This portion of the project will be conducted in collaboration with Dr. Robert Small, Alaska Department of Fish and Game. We will continue to develop the critical reagents and methodologies necessary for the assessment of several aspects of immunocompetence levels in the harbor seal, and to establish baseline data on these levels for the duration of the project in selected populations of harbor seals. This project will also determine critical baseline concentrations of the thyroid hormones and cortisol of captive seals, housed in a stable environment with regular and balanced diets, to compare with free-ranging seals. In doing so, we can assess whether the seals in the Gulf of Alaska are being exposed to endocrine disrupting and/or immunosuppressive agents at level that are impacting their ability to survive, grow and reproduce. If contaminants are affecting the physiology of harbor seals, then we need to incorporate this into the working hypothesis under which this species is being managed. In addition, assessing the effects of environmental contaminants should be incorporated into any long-term plans for monitoring harbor seals. Monitoring endocrine and immune levels can also be used as indicators upon which parameters needed to model the population dynamics of harbor seals can be developed. This will become increasingly important if this species continues its population decline in Prince William Sound and the Gulf of Alaska.

NEED FOR PROJECT

A. Statement of Problem

Harbor seals were one of the resources that were injured by the 1989 *Exxon Valdez* oil spill (EVOS). To date this species is listed as 'not recovering'. Several studies have focused on the

general health and metabolism of these seals as it relates to their diet, body condition, and habitat (Projects 001, 341, 371, and 441). The proposed study will complement these investigations as it will utilize new techniques to enhance our understanding of the health and physiology of the species and incorporate the possible effects of environmental organochlorine contaminants. If the techniques can be combined to develop a concise indicator of a given animal's health, then these techniques should be incorporated into the routine assessment and monitoring of harbor seals in the Gulf of Alaska.

B. Rationale/Link to Restoration

In order to recover any species whose population has experienced a major decline, it is necessary to fully understand the biology of the species. A few species of marine mammals have failed to recover with the enactment of the Marine Mammal Protection Act (e.g. Hawaiian monk seals and Steller sea lions). Other species have declined precipitously since the Marine Mammal Protection Act, with some subpopulations more affected than others (e.g. Alaskan harbor seals). The problems that these species face are multifaceted and complex. Many times a combination of factors will synergize to produce a devastating effect (such as the 1988 harbor seal epizootic in the North Sea), while either factor alone may not have had clinical effects. In understanding what the Alaskan harbor seals are experiencing, it is essential to know the degree to which they are being subjected to immunosuppressive or endocrine disrupting agents. Restoration of the species can only be successfully accomplished if the species is thoroughly understood. With this knowledge we can begin to predict the devastating effects of environmental changes and model the long-term population dynamics. In addition to predicting the impact of a given environment, we can also begin to manipulate animals and their environments to assist in their recovery.

The information gained from this study will enable us to assess two groups of animals; those that live in a stable, consistent environment (captivity), with those that experience the natural environment (rehab and free-ranging seals). Seals brought in for rehabilitation are generally young animals that are failing to thrive in their environment. They may not be able to naturally survive the weaning process due to a variety of factors, including immuno-incompetance or inadequate maternal investment (i.e., poor milk quality or shortened lactation period). Through morphometric measurements, assessment of immune and endocrine function, and measurement of body contaminant levels, we can evaluate the degree to which these animals are adapting to a changing environment. Once these techniques have been perfected at the ASLC, we plan to test their application to a long-term field monitoring program. The ability of harbor seals to adapt to a changing environment is essential to the recovery of this species. Knowing what the animals are dealing with and their ability to adapt will enable resource managers to predict the recovery or mitigate the future decline of this species.

C. Location

Years one and two of this project have been, and are still being, undertaken at the ASLC using harbor seals that are currently resident and permitted for research under the Marine Mammal Protection Act for research. It has also utilized animals that will be brought in for rehabilitation under the terms of an existing letter of authorization, and through our collaboration with the Alaska

Native Harbor Seal Commission. Year three of this work is proposed to closeout the project, including the publication of results that have been obtained in years one and two, as well as the analysis of free-ranging seals in Prince William Sound and areas near South Central Alaska.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

This project has been closely associated in a growing collaboration with the Alaska Native Harbor Seal Commission (ANHSC). To a large extent the collaboration with ANHSC has increased our awareness of traditional and local knowledge of harbor seals as well as incorporated local expertise into the project. In addition to the native communities, we propose working with Dr. Robert Small, Alaska Department of Fish and Game (ADFG) to obtain samples from free-ranging harbor seals. ADFG has had a successful program working with free-ranging seals, and has offered to collaborate to provide samples from Alaskan waters, including Prince William Sound.

This project will also coordinate with the existing volunteer and intern programs at ASLC to make opportunities available for individuals who would like to spend time volunteering at ASLC. This project is budgeted for one graduate student and one research associate who will receive training to increase their level of expertise in marine mammal physiology as well as provide the necessary time to ensure that our community involvement is successful.

PROJECT DESIGN

A. Objectives

The overall goal of this project is to develop and test new methods of monitoring the physiology of harbor seals. In doing so the project has the following five objectives:

1. Determine seasonal and circadian patterns of total and free triiodothyronine (T_3), thyroxine (T_4), and cortisol in healthy captive harbor seals (Yr 1).
2. Develop new antibodies specific to harbor seal immunoglobulin classes IgG, IgM and IgA (Yr 1).
3. Determine seasonal patterns of IgG, IgM, and IgA, in healthy captive harbor seals (Yrs 2 and 3).
4. Determine endocrine and immunoglobulin profiles and measure organochlorine concentrations for rehabilitation seals periodically throughout the rehabilitation process (Yrs 2 and 3).
5. Assess the suite of measurements as overall indicators of health in free-ranging seals (Yr 3).

The third year of this project is essential to the success of this project.

B. Methods

Objective 1. This objective has been successfully completed and resulted in a Master's thesis for Ms. Carolyn Oki at the University of Hawaii. Ms. Oki is in the process of drafting a manuscript for publication.

Objective 2. This objective is currently underway and should be completed during year two. The project has a Master's candidate at the University of Southern Mississippi working on it.

Objective 3. This objective is also underway and will be continued into year three. An ELISA protocol similar to that described by Suer *et al.* (1988) has been used to evaluate serum antibody levels in several species of marine mammals against several antigens (e.g. Patterson *et al.*, 1994). A "sandwich" ELISA protocol will be employed in an effort to determine general immunoglobulin levels in these samples. In the sandwich ELISA, a plastic solid phase matrix (polystyrene microwells) is coated with unlabeled antibodies against the antigen in question, i.e. in this case against one of the heavy chain isotypes (gamma, alpha, or mu for IgG, IgA, and IgM respectively) of immunoglobulins from the harbor seal (prepared via completion of Objective 2 above). The sandwich ELISA conducted in this manner will allow quantification of general immunoglobulin levels in samples by comparison with a standard curve generated using preparations made with known concentrations of immunoglobulins purified from the harbor seal.

Blood samples are being collected on a monthly basis from the permanently captive seals at ASLC. Aliquots of each sample (and aliquots of other samples of harbor seal sera which become available) will be quantified for isotype levels using the ELISA described above in completion of Objective 2.

Objective 4. This objective is also underway and will continue throughout year three. A Master's candidate, Ms. Danielle O'Neil is being employed and her project will run through the third year of funding. Using the previously described techniques, we have measured total and free T_3, T_4, and cortisol, in harbor seals that are brought in for rehabilitation at ASLC and The Marine Mammal Center in California. An assessment of the level of contamination by organochlorines is underway in collaboration with the University of Hawaii Department of Environmental Biochemistry on all animals that have not been successful in the rehabilitation program, and is being developed for use in blood samples.

Seals admitted for rehabilitation at the SeaLife Center are held in quarantine and placed in individual holding tanks. Currently, health data such as blood chemistry and morphometrics are collected every ten days from each harbor seal admitted for rehabilitation. Blood chemistry and hematology values are used in conjunction with body composition to detect significant changes in health status that might alter water balance, cause anemia, or compromise basic metabolic status (Castellini *et al.*, 2000, 1993). Blood urea, nitrogen (BUN) ketone bodies, and free fatty acids, as well as hematocrit, hemoglobin, and erythrocyte sedimentation rates are measured. We are currently analyzing past samples from the Castellini study to synthesize the data from both studies.

Objective 5. Year three has two primary goals. First will be to publish the data collected in years one and two, and second is to include samples collected from free-ranging seals. The sites of collection, numbers of animals, and the permits to cover the sampling of wild seals are being planned in collaboration with Dr. Robert Small, ADFG. Samples will also be collected from native harvests in collaboration with the Alaska Native Harbor Seal Commission.

C. Cooperating Agencies, Contracts and Other Agency Assistance

This project will primarily be based at ASLC, with the National Marine Fisheries Service permits for the captive seals being held by ASLC with Dr. S. Atkinson serving as the Principal Investigator of that permit. Seals needing rehabilitation will be sought with the guidance of the Alaska Native Harbor Seal Commission and The Alaska Region of National Marine Fisheries Service. The letter of authorization for these seals is also held by ASLC.

SCHEDULE

A. Measurable Project Tasks for FY 03 (October 1, 2002 – September 30, 2003)

October 2002:	Blood sampling continues on a monthly basis for captive animals. Perform endocrine assays on FY02 samples.
November 2002:	Blood samples from ADFG archive supplied. All samples will be sent for contaminant analysis.
January 2003:	Endocrine assays will be undertaken with batches of samples to assist with quality control.
March–June 2003:	Spring collections from ADFG received.
May–June 2003:	ASLC rehab season samples collected.
June–September:	Endocrine and immunology samples analyzed.
September–October:	Rehabilitation seals released.

Samples collected in 2002 will be scheduled for completion during FY 02.

B. Project Milestones and Endpoints for Year Three

1. Publish baseline levels of T_3, T_4, and cortisol levels in the serum. Publish circadian hormone concentrations from captive animals, comparing winter and summer seasons. Monthly blood samples from all years will enable us to assess the variation in values from the samples collected from healthy animals in a stable environment. The rehabilitation seals from all years will also have samples collected enabling an analysis of seals that are failing to thrive in the natural environment.

2. Development of species-specific antisera against immunoglobulins of the harbor seal will be complete and the production of antisera against immunoglobulin isotypes will be available. These antisera will be available for quantifying immunoglobulins in samples collected in year two. The immunoglobulins will be analyzed for seasonal variation, allowing the question of the variability in immune status throughout the year to be addressed for permanently captive seals in a stable environment and for free-ranging seals.

3. The quantification of organochlorines in captive and rehabilitated harbor seals will provide a baseline as to what kinds of body burdens we can expect. Collaboration with the Alaska Native Harbor Seal Commission's biosampling program will allow samples from free-ranging seals to be collected.

C. Completion Date

The anticipated completion date of the captive portion of this project is October 2003. At this point we will hope to be able to recommend that some form of these techniques be applied to a field-monitoring program. If this is accomplished the feasibility of field sampling could be determined by October 2004.

PUBLICATION AND REPORTS

It is anticipated that all of the work conducted under this proposal be published in peer-reviewed international journals. The Master's project by Ms. Carolyn Oki is completed and will be prepared for publication in either General and Comparative Endocrinology or Comparative Biochemistry and Physiology. In sum, we anticipate three Master's projects to be produced from this project. Any student projects will be presented in thesis or dissertation format as well as submitted for journal publication.

PROFESSIONAL CONFERENCES

Two presentations of work from this project have already been presented at the Society for Marine Mammalogy's 14th Biennial conference on the Biology of Marine Mammals in Vancouver, BC in November 2001. An additional poster is being presented at the International Association of Aquatic Animal Medicine in May 2002. The PI will request travel to Quebec, Canada to discuss results with harbor seal researchers. The discussion will center on comparisons of Alaskan and Atlantic harbor seal physiology and population dynamics.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The PI of this proposal also serves as the Science Director of the ASLC. Through this avenue, the PI holds regular discussions on the projects that are currently taking place at ASLC, and is making an effort to collaborate with harbor seal researchers in Alaska. This project will be using the same animals as have been used for projects 341, 371, and 441, and it is anticipated that the data obtained from FY03 will complement the data obtained from previous EVOS funded projects. It is also anticipated that the samples collected in year three will come from a shared field site, integrating existing field projects with our sample collections.

PROPOSED PRINCIPAL INVESTIGATOR

Shannon Atkinson, Ph.D.
University of Alaska Fairbanks
School of Fisheries and Ocean Sciences – Institute of Marine Science
PO Box 730, Seward, AK 99664.
Phone 907-224-6346 Fax 907-224-6360 Email shannon_atkinson@alaskasealife.org

PRINCIPAL INVESTIGATOR (qualifications)

The PI of this project has been a professor at the University of Alaska Fairbanks for 2.3 years, with half-time duties as the Science Director at ASLC. She has eighteen years experience in analyzing body fluids for hormone concentrations. She has established and worked in two other endocrinology laboratories, one at Hawaii Institute of Marine Biology, University of Hawaii, and the other at Murdoch University in Western Australia. The PI also has extensive experience working with a variety of marine mammals, including the endangered Hawaiian monk seal, California harbor seals, northern elephant seals, Risso's, rough-toothed, white-sided, and bottlenose dolphins, and, humpback, beluga, and false killer whales. The PI will be responsible for the completion of all project objectives. Her curriculum vita is attached.

OTHER KEY PERSONNEL

Dr. Bobby Middlebrooks is a Professor at the University of Southern Mississippi. He has been an active part of this project for both years one and two; year three will provide the necessary closure for his part of the project. He has an immunology laboratory that focuses on the basic components and functioning of the immune systems of marine vertebrates. He has developed immunodiagnostic assays for pinnipeds and is highly qualified to undertake the immunological aspects of this study. He is responsible for performing and analyzing the results from the immunological assays. His curriculum vita is attached.

Salaries have been included for a research associate and a graduate student. The research associate will assist with the overall coordination of the sample collection from all seals. The research associate will also work to analyze data and assist in the submission of manuscripts for publication.

The graduate student is responsible for organizing the sample collections and performs the laboratory work. With assistance from the PI, they will analyze the data and present them in graphical and tabular form. They will be responsible for the first draft of any manuscripts that arise from the work included in their thesis or dissertation.

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Curriculum Vitae (abbreviated)

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Education: Ph.D. Murdoch University, School of Veterinary Studies, 1985
M.Sc. University of Hawaii, Department of Animal Science, 1981
B.Sc. University of Hawaii, Department of Animal Science, 1978

Professional Experience
Professor, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks 2000–present
Science Director, Alaska Sealife Center, Seward, AK 2000–present
Associate Researcher, Hawaii Institute of Marine Biology, University of Hawaii 1991–present
Affiliate Researcher, Hawaii Institute of Marine Biology, University of Hawaii 1989–1991
Experimental Scientist, Commonwealth Scientific and Industrial Research Organization (CSIRO), Division of Animal Production, Western Australia 1986–1988

Recent Research Projects:
- Harbor seal recovery: Application of new technologies for monitoring health 2000–present, EVOS/Pacific Marine Life Foundation
- Assessment of endocrine and immune status in relation to organochlorine burdens in Steller sea lions, 2000–present, NMFS/PCCRC
- Reproduction and development of rough-toothed and bottlenose dolphins 1998–2002, NOAA/Sea Grant

Selected Relevant Publications:

Feinholz, D.M., and **Atkinson, S.** 2001. Possible etiologies of yellow coloration in dolphin calves. Aqua. Mamm. 26:191–195.

Robeck, T.R., **Atkinson, S.**, and Brook F. 2001. Reproduction. *In* CRC Handbook of Marine Mammal Medicine. 2nd Edition. Dierauf , LA and Gulland, FMD. Eds. CRC Press pp. 193–236.

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Pietraszek, J.R. and **Atkinson, S.** 1994. Concentration of oestrone sulfate and progesterone in plasma and saliva, vaginal cytology and bioelectric impedance during the oestrous cycle of the Hawaiian monk seal (*Monachus schauinslandi*). Mar. Mamm. Sci 10:430–441.

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Curriculum Vitae (abbreviated)

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DATE AND PLACE OF BIRTH: January 12, 1941, Greenville, Texas

SOCIAL SECURITY NUMBER: 456-68-8457

EDUCATION:

B.A. (1962) in Biology from Rice University, Houston, Texas
M.A. (1964)
Ph.D. (1966) in Microbiology from the University of Texas Southwestern Medical School, Dallas, Texas
Postdoctoral (1966-68) in Virology at Army Biological Research Laboratories, Ft. Detrick, Maryland

EXPERIENCE:

1974–present	Professor (1982–present), Associate Professor (1977–1982), Assistant Professor (1974–1977) of Microbiology; Administrative positions held: Associate Provost (1998–1999), Assistant Vice President for Academic Affairs (1997–1998), Chair of Biological Sciences (1991–1997), Interim Dean of the Graduate School (1990–1991), University of Southern Mississippi, Hattiesburg, Mississippi
1972–1974	Assistant Professor of Biology, Plymouth State College of the University of New Hampshire, Plymouth, New Hampshire
1968–1972	Assistant Professor of Microbiology, University of Texas Medical Branch, Galveston, Texas

HONORS AND AWARDS:

Recipient of Outstanding Faculty Research Award at the University of Southern Mississippi (1988)
Co-recipient of Mississippi Innovation Advocate Award, presented by the Small Business Administration (1986)
O. B. Williams Award, Texas Branch, American Society for Microbiology (1964)

PUBLICATIONS AND PRESENTATIONS (Representative):

Patterson, R.A. and B. L. Middlebrooks. 2000. Methods for purification and study of cetacean immunoglobulins, *in* Cell and Molecular Biology of Marine Mammals (in Press)

Middlebrooks, B. L., J,C, Jones, and R. A. Patterson. 2000. Application of ELISA methodology for detection of *Erysipelothrix rhusiopathiae* antibody titers in cetaceans, *in* Cell and Molecular Biology of Marine Mammals (in Press)

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Middlebrooks, B.L., N.J. Brown-Peterson, P.M. Toom, and W.L. Douglas. 1988. Evaluation of specific binding affinity and biochemical properties of fish eye-lens reagents from seven teleost species. Comp. Biochem. Physiol. 90B:721–730.

FY 03 *EXXON VALDEZ* TRU E COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

Budget Category:	Authorized FY 02	Proposed FY 03	LONG RANGE FUNDING REQUIREMENTS					
			Estimated FY 04					
Personnel		$23.9						
Travel		$2.8						
Contractual		$60.3						
Commodities		$0.5						
Equipment		$0.0						
Subtotal	$0.0	$87.5						
Indirect		$21.8						
Project Total	$128.4	$109.3						
Full-time Equivalents (FTE)		1.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY03

Prepared: 4/10/02

Project Number: 03558
Project Title: Harbor Seal Recovery: Application of New Technologies for Monitoring Health
Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 03
	Atkinson	PI	0.5	10.0		5.0
	TBA	Research Associate	2.0	4.5		9.0
	Danielle O'Neil	Master's degree student	9.0	1.1		9.9
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	11.5	15.6	0.0	
					Personnel Total	$23.9

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 03
	Seward-Anchorage (Car mileage)	0.1	1	2	0.1	0.3
	Seward-Quebec	0.7	1	6	0.3	2.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$2.8

FY03

Prepared: 4/10/02

Project Number: 03558
Project Title: Harbor Seal Recovery: Application of New Technologies for Monitoring Health
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

FY 03 *EXXON VALDEZ* TRU[illegible]E COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

Contractual Costs:	Proposed
Description	FY 03
Hormone analyses (175 samples x 4 hormones @ $13/sample)	9.1
Dr. Middlebrook (subcontract)	10.0
University of Hawaii (subcontract for contaminant analysis)	10.0
ADF&G free-ranging samples	28.0
Tuition (Danielle O'Neil)	3.2
Contractual Total	$60.3

Commodities Costs:	Proposed
Description	FY 03
Blood collecting supplies and reagents	0.5
Commodities Total	$0.5

FY03

Prepared: 4/10/02

Project Number: 03558
Project Title: Harbor Seal Recovery: Application of New Technologies for Monitoring Health
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities
DETAIL

FY 03 *EXXON VALDEZ* TRU .E COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 03
			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	

FY03

Prepared: 4/10/02

Project Number: 03558
Project Title: Harbor Seal Recovery: Application of New Technologies for Monitoring Health
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

EVALUATING THE FEASIBLITY OF DEVELOPING A COMMUNITY-BASED FORAGE FISH SAMPLING PROJECT FOR THE EVOS GEM PROGRAM

Project Number:	03561
Restoration Category:	Monitoring
Proposer:	DOI-FWS
Lead Trustee Agency:	USFWS
Cooperating Agencies:	
Duration:	0.5 years
Cost FY 03:	$17.8K (estimated close-out costs for analyzing FY 02 Project 02561 data and writing a final report)
Geographic Area:	The proposed close-out study will be conducted at the Alaska Maritime National Wildlife Refuge headquarters in Homer, Alaska
Injured Resource/Service:	Common murres and other seabirds, and marine mammals injured by the T/V *Exxon Valdez* oil spill

ABSTRACT

This proposed project is a close-out study for Project 02561, a previously approved study designed to evaluate the feasibility of developing a community-based forage fish sampling project for the upcoming EVOS-sponsored Gulf Ecosystem Monitoring (GEM) program. The work will consist of compiling and analyzing information collected during FY 02, and writing a final close-out report discussing Project 02561 results.

INTRODUCTION

This proposed project is a close-out study for Project 02561, a previously approved study that is currently in the process of collecting information on the feasibility of developing community-based forage fish sampling projects for the upcoming EVOS-sponsored Gulf Ecosystem Monitoring (GEM) program. The work will consist of compiling and analyzing information collected during FY 02, and writing a final close-out report discussing Project 02561 results.

NEED FOR THE PROJECT

A. Statement of Problem

Project 02561 is currently collecting information on the feasibility of developing community-based forage fish sampling projects for the EVOS GEM program. There will be a need to compile and analyze information collected during FY 02, and write a final close-out report discussing Project 02561 results.

B. Rationale/Link to Restoration

The proposed project is a close-out study for previously approved Project 02561. There will be a need to compile and analyze information collected during FY 02, and write a final close-out report discussing Project 02561 results. The final report will provide the information needed to help design cost-effective community-based forage fish sampling studies to monitor long-term trends in capelin and sand lance stocks in the Kachemak Bay – lower Cook Inlet, Resurrection Bay, Kodiak Island, and Prince William Sound regions for the EVOS GEM program.

C. Location

The project will be conducted at the Alaska Maritime National Wildlife Refuge (AMNWR) headquarters in Homer, Alaska.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Community involvement is the central theme of the proposed project. The study is specifically designed to explore and evaluate the feasibility of directly involving residents (e.g., subsistence and personal use fishermen, charter boat operators, students, teachers, village and IRA council natural resource specialists, and other residents) from a number of oil spill communities in long-term forage fish monitoring studies that could become valuable components of the soon-to-be implemented GEM program.

PROJECT DESIGN

A. Objectives

The objectives are to compile and analyze the information collected by previously approved Project 02561, and write a final close-out report discussing project results.

B. Methods

The proposed close-out project will be conducted at the AMNWR headquarters in Homer, Alaska.

Data Collection

Data collection is not required during the proposed close-out study. Data that will be compiled, analyzed, and discussed by the project will consist of the information collected by Project 02561 in the various oil spill communities during FY 02.

Data Analysis

Data analysis will consist of compiling and tabulating Project 02561 community visit information into several categories and summarizing and discussing these topics in a final close-out report. Topics will include, but will not be limited to (1) the general types and levels of local interest expressed by residents in participating in community-based GEM forage fish studies; (2) the number of potential initial participants; (3) the species of predatory fish typically caught by potential participants (e.g., subsistence and personal use fishermen, charter boat operators, other interested residents); and (4) the general levels and kinds of support that would be required to encourage and maintain participation in community-based long-term forage fish studies (e.g., stipends for local project coordinators and students collecting predatory fish stomachs from fishermen; other potential needs, such as supplying small freezers to store samples before shipping them to research facilities, and covering costs of shipping samples to researchers). The report will provide the information needed by Trustee Council scientists to help assess and understand the levels and types of community participation that may be available for incorporation in long-term GEM forage fish monitoring studies.

Examples of draft data collection and analysis protocols will also be developed for use during potential community-based GEM forage fish monitoring studies and appended to the final close-out report. The protocols will based on information obtained during the 1995-1999 APEX large fish as samplers studies and Project 02561 FY 02 community visits (see Roseneau and Byrd 1996, 1997, 1998, 1999, 2000).

C. Cooperating Agencies, Contracts, and Other Agency Assistance

No contracts or other agency assistance are needed for the study. The Alaska Maritime National Wildlife Refuge will donate two weeks of the project manager's time (G.V. Byrd) to the project. The refuge will also provide computers and office space for the study.

SCHEDULE

A. Measurable Project Tasks for FY 03 (1 October 2002 – 30 September 2003)

FY 03

1 Oct - 31 Dec 2002:	Compile and tabulate the FY 03 information; analyze information and organize results.
1 Jan – 15 Mar 2003:	Begin preparing draft final report of FY 03 activities.
16 March -15 Apr 2003:	Finalize and submit final report of FY 03 activities to Chief Scientist for peer-review on or before 15 April.

B. Project Milestones and Endpoints

December 2002	Finish compiling, and analyzing FY 03 data and organizing results.

March 2003	Finish preparing draft final report of FY 03 activities
April 2003	Submit final draft report of FY 03 activities to Chief Scientist for peer review.

C. Completion Date

A final report on FY 02 Project 02561 results will submitted to the Chief Scientist on or before 15 April 2003.

PUBLICATIONS AND REPORTS

A final report on FY 02 Project 02561 results will be submitted to the Chief Scientist by 15 April 2003.

PROFESSIONAL CONFERENCES

A brief summary of FY 02 Project 02561 results will be presented at the annual Trustee Council-sponsored workshop in January 2003.

NORMAL AGENCY MANAGEMENT

The proposed close-out work is not something that AMNWR or the FWS are required to do by statute or regulation, and the types of information analyzed in the study are not part of the normal AMNWR resource monitoring plan. The proposed close-out study could not be conducted without support from the EVOS Trustee Council.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The proposed close-out study will be coordinated with Paul McCollum, Chugach Regional Resources Commission Fisheries Consultant. The refuge will donate up to two weeks of the project manager's time to the project, and will also provide office space and computers for the close-out work.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

This is close-out project. No changes have been made to the analytical methods and schedules listed in the previously approved FY 02 Project 02561 DPD.

PROPOSED PRINCIPAL INVESTIGATOR

Name: David G. Roseneau
Affiliation: Alaska Maritime National Wildlife Refuge
Mailing address: 2355 Kachemak Bay Drive (Suite 101), Homer, Alaska 99603-8021
Phone number: (907) 235-6546
Fax number: (907) 235-7783
E-mail address: dave_roseneau@fws.gov

PRINCIPAL INVESTIGATOR

1. David G. Roseneau (Co-Principal Investigator)

Mr. Roseneau will be responsible for conducting the proposed study. He will compile and analyze the information collected in the communities by Project 02561 during FY 02, and write a final close-out report discussing Project 02561 results. He will also be responsible for presenting the information at scientific meetings and workshops. Mr. Roseneau received his B.S. degree in wildlife management and M.S. degree in biology from the University of Alaska - Fairbanks in 1967 and 1972, respectively. His thesis research was on the numbers and distribution of gyrfalcons, *Falco rusticolus* on the Seward Peninsula, Alaska. He joined the U.S. Fish and Wildlife Service in January 1993, and was project leader for EVOS-sponsored common murre restoration studies at the Barren Islands during 1993-1994 (Projects 93049 and 94039). Mr. Roseneau was also principal investigator of the 1995-1999 APEX Barren Islands seabird and large fish as samplers studies (Projects 95163J, 95163K, 96163J, 97163J, 97163K, 98163J, 98163K, 99163J, and 99163K), and the 1996-1997 and 1999 Barren Islands and 1998 and 2001 Chiswell Islands common murre population monitoring projects (Projects 96144, 97144, 98144, 99144 and 01144). Currently, he is principal investigator for Project 02561. Prior to 1993, Mr. Roseneau worked as a consulting biologist for over 20 years. During that time, he conducted and managed marine bird, raptor, and large mammal projects in Alaska and Canada for government agencies and private-sector clients, and he also participated in several large-scale murre (*Uria* spp.) monitoring projects. In 1976-1983, as co-principal investigator of NOAA/OCSEAP Research Unit 460, he conducted monitoring studies of murres and black-legged kittiwakes *(Rissa tridactyla)* at capes Lisburne, Lewis, and Thompson in the Chukchi Sea, and St. Lawrence, St. Matthew, and Hall islands in the Bering Sea. He also studied auklets (*Aethia* spp.) at St. Lawrence and St. Matthew islands, and participated in murre and kittiwake projects at Bluff in Norton Sound. During 1984-1986, he also participated in monitoring studies of murres and kittiwakes in the northeastern Chukchi Sea, and in 1987-1988, 1991-1992, and 1995-2000, he conducted additional murre and kittiwake monitoring work at capes Lisburne and Thompson, and Chamisso and Puffin islands. Mr. Roseneau is experienced in collecting and analyzing data on numbers, productivity, and food habits of seabirds; relating trends in numbers and productivity to changes in food webs and environmental parameters (e.g., air and sea temperatures, current patterns); and assessing potential impacts of petroleum exploration and development on nesting and foraging marine birds. He also has experience collecting and analyzing certain types of data on forage fish, and he has designed and successfully tested a new technique for sampling capelin *(Mallotus villosus)* and Pacific sand lance *(Ammodytes hexapterus)* by using stomach contents from sport-caught Pacific halibut *(Hippoglossus stenolepis)*. He has broad knowledge of rock climbing techniques and has operated inflatable rafts and other outboard-powered boats in the Bering, Chukchi, and Beaufort seas and on various Alaskan rivers in excess of 3,000 hrs. He has also accrued several hundred additional hours operating time in small boats and larger, more powerful vessels (e.g. 25 ft, 300-400 hp HydroSports and Boston Whalers) in Kachemak Bay, Prince William Sound, and Kenai Peninsula and Barren Island waters. During his career, Mr. Roseneau has authored and co-authored 100 reports and publications, including 33 on Alaskan seabirds and 5 on a new sampling technique for capelin and sand lance. He has also made over 30 public presentations on seabirds, raptors, and caribou at scientific and wildlife law enforcement conferences and meetings.

Selected Publications

Roseneau, D.G. and G.V. Byrd. 1997. Using Pacific halibut to sample the availability of forage fishes to seabirds. Pp. 231-241 *in* Forage Fishes in Marine Ecosystems, Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems, University of Alaska Sea Grant College Program Report No. 97-01, University of Alaska-Fairbanks, Fairbanks, Alaska.

Murphy, E.C., A.M. Springer, and D.G. Roseneau. 1991. High annual variability in reproductive success of kittiwakes (Rissa tridactyla L.) at a colony in western Alaska. J. Anim. Ecol. 60: 515-534.

Springer, A.M., E.C. Murphy, D.G. Roseneau, C.P. McRoy, and B.A. Cooper. 1987. Paradox of pelagic food webs in the northern Bering Sea - I. Seabird food habits. Cont. Shelf Res. 7: 895-911.

Murphy, E.C., A.M. Springer, and D.G. Roseneau. 1986. Population status of *Uria aalge* at a colony in western Alaska: results and simulations. Ibis 128: 348-363.

Springer, A.M., D.G. Roseneau, D.S. Lloyd, C.P. McRoy, and E.C. Murphy. 1986. Seabird responses to fluctuating prey availability in the eastern Bering Sea. Marine Ecol. Prog. Ser. 32: 1-12.

Springer, A.M. and D.G. Roseneau. 1985. Copepod-based food webs: auklets and oceanography in the Bering Sea. Marine Ecol. Prog. Ser. 21: 229-237.

Murphy, E.C., D.G. Roseneau, and P.J. Bente. 1984. An inland nest record for the Kittlitz's murrelet. Condor 86: 218.

Springer, A.M., D.G. Roseneau, E.C. Murphy, and M.I. Springer. 1984. Environmental controls of marine food webs: food habits of seabirds in the eastern Chukchi Sea. Can. J. Fish Aquat. Sci. 41: 1202-1215.

OTHER KEY PERSONNEL

1. G. Vernon Byrd (Project Manager)

Mr. Byrd will supply overall guidance to the project, including providing advice during data analysis and report writing, and he will also review presentations and reports as needed. Mr. Byrd received a B.S. degree in wildlife management from the University of Georgia in 1968, did post-graduate studies in wildlife biology at the University of Alaska-Fairbanks in 1975, and completed his M.S. degree in wildlife resources management at the University of Idaho in 1989. His thesis, entitled "Seabirds in the Pribilof Islands, Alaska: Trends and monitoring methods", explored statistical procedures for analyzing kittiwake (*Rissa* spp.) and murre (*Uria* spp.) population data. Mr. Byrd has worked for the U.S. Fish and Wildlife Service for over 20 years, focusing on studies of marine birds in Alaska and Hawaii. His major interests center around monitoring long-term trends in seabird populations, including numbers of birds and reproductive performance, and he has worked at murre colonies in the Aleutian Islands, the Bering and Chukchi seas, and western Gulf of Alaska. Mr. Byrd was a co-author of the final T/V *Exxon Valdez* oil spill damage assessment report for murres. Also, he was project manager of the 1993-1994 Barren Islands common murre restoration monitoring projects (Projects 93049 and 94039), the 1995-1999 APEX Barren Islands seabird and large fish as samplers studies (Projects 95163J, 95163K, 96163J, 97163J, 97163K, 98163J, 98163K, 99163J, and 99163K), the 1996-1997 and 1999 Barren Islands and 1998 and 2001 Chiswell Islands common murre population monitoring projects (Project 96144, 97144, 99144, 98144, and 01144), and EVOS-sponsored work designed to remove predators from seabird nesting habitats (Projects 94041 and 95041). Currently, Mr. Byrd is project manager for Project 02561. He has authored and co-authored over 50 scientific papers and 75 U.S. Fish and Wildlife Service reports on field studies, and has made over 35 presentations on seabirds at scientific conferences and meetings. Mr. Byrd is the supervisory wildlife biologist at the Alaska Maritime National Wildlife Refuge, the premier seabird nesting area in the national public land system.

Selected Publications

Roseneau, D.G. and G.V. Byrd. 1997. Using Pacific halibut to sample the availability of forage fishes to seabirds. Pp. 231-241 *in* Forage Fishes in Marine Ecosystems, Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems, University of Alaska Sea Grant College Program Report No. 97-01, University of Alaska-Fairbanks, Fairbanks, Alaska.

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

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

Byrd, G.V., and J.C. Williams. Red-legged Kittiwake. 1993. A chapter describing the biology of the species in The birds of North America No. 60 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia PA, and the American Ornithologists' Union, Washington, D.C. 12 pp.

Springer, A.M. and G.V. Byrd. 1989. Seabird dependence on walleye pollock in the southeastern Bering Sea. Pages 667-677 in Proceedings of the International Symposium on the Biology and Management of Walleye Pollock. Alaska Sea Grant Rep. No. 89-1, Univ. of Alaska-Fairbanks, Fairbanks, Alaska.

LITERATURE CITED

Roseneau, D.G, and G.V. Byrd. 1996. Using predatory fish to sample forage fishes, 1995. Appendix K (13 pp.) *in* APEX: Alaska Predator Ecosystem Experiment (D.C. Duffy, Compiler), *Exxon Valdez* Oil Spill Restoration Proj. Annual rept. (Restoration Proj. 95163), Alaska Natural Heritage Program, Univ. of Alaska - Anchorage, Anchorage, Alaska.

_____. 1997. Using Pacific halibut to sample the availability of forage fishes to seabirds. Pp. 231-241 *in* Forage Fishes in Marine Ecosystems, Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems, University of Alaska Sea Grant College Program Report No. 97-01, University of Alaska-Fairbanks, Fairbanks, Alaska.

_____. 1998. Using predatory fish to sample forage fishes, 1997. Appendix K *in* APEX: Alaska Predator Ecosystem Experiment (D.C. Duffy, Compiler), *Exxon Valdez* Oil Spill Restoration Proj. Annual rept. (Restoration Proj. 97163), Alaska Natural Heritage Program, Univ. of Alaska - Anchorage, Anchorage, Alaska.

_____. 1999. Using predatory fish to sample forage fishes, 1998. Appendix K *in* APEX: Alaska Predator Ecosystem Experiment (D.C. Duffy, Compiler), *Exxon Valdez* Oil Spill Restoration Proj. Annual rept. (Restoration Proj. 98163 A-T), Paumanok Solutions, 102 Aikahi Loop,Kailua, Hawaii 96734.

_____. 2000. Using predatory fish to sample forage fishes, 1995-1999. Appendix K *in* APEX: Alaska Predator Ecosystem Experiment (D.C. Duffy, Compiler), *Exxon Valdez* Oil Spill Restoration Proj. Annual rept. (Restoration Proj. 99163 A-T), Paumanok Solutions, 102 Aikahi Loop,Kailua, Hawaii 96734.

2003 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

Budget Category:	Authorized FY 02	Proposed FY 03
Personnel	$26.1	$14.8
Travel	$20.8	$0.8
Contractual	$0.0	$0.0
Commodities	$3.5	$0.0
Equipment	$0.0	$0.0
Subtotal	$50.4	$15.6
General Administration	$3.9	$2.2
Project Total	$54.3	$17.8
Full-time Equivalents (FTE)	0.4	0.2
	Dollar amounts are shown in thousands of dollars.	
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
Estimated FY 04					
$0.0					

Comments: This proposed project is a close-out study. The proposed budget covers the cost of compiling and analyzing the information collected by previously approved Project 02561 in FY 02 , and writing a final report of Project 02561 activities.

Travel costs to attend the 2003 EVOS workshop in Anchorage are included in the proposed budget.

The Alaska Maritime National Wildlife Refuge will donate two weeks of the project manager's time to the project. The refuge will also provide computers and office space for the study.

FY03

Prepared: 04/10/02

Project Number: 03561
Project Title: Evaluating the Feasibility of Developing a Community-based Forage Fish Sampling Project for the EVOS GEM Program
Agency: DOI-FWS

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2003 EXXON VALDEZ TRUS[illegible]E COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 03
David G. Roseneau	Project Leader (Principal Investigator)	GS11/6	2.5	5.9	0.0	14.8
G. Vernon Byrd	Project Manager	GS13/1	0.5	0.0	0.0	0.0
T. DeGange	Program Manager	GS14	0.1	0.0	0.0	0.0
	Subtotal		3.1	5.9	0.0	
					Personnel Total	$14.8

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 03
					0.0
Travel to Anchorage to attend the 2003 EVOS workshop	0.2	1	3	0.2	0.8
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.8

FY03

Prepared: 04/10/02

Project Number: 03561
Project Title: Evaluating the Feasibility of Developing a Community-based Forage Fish Sampling Project for the EVOS GEM Program
Agency: DOI-FWS

FORM 3B
Personnel
& Travel
DETAIL

2003 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

Contractual Costs:	Proposed FY 03
Description	
No contracts are needed for the proposed project	0.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 03
Description	
[Note: FWS will furnish office supplies for the project]	
Commodities Total	$0.0

FY03

Prepared: 04/10/02

Project Number: 03561
Project Title: Evaluating the Feasibility of Developing a Community-based Forage Fish Sampling Project for the EVOS GEM Program
Agency: DOI-FWS

FORM 3B
Contractual & Commodities DETAIL

2003 EXXON VALDEZ TRUS. .E COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 03
No equipment is needed for the project			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
Computers and printers (non oil spill equipment)	2	FWS
[Note: The FWS will also supply office space for the project]		

FY03

Prepared: 04/10/02

Project Number: 03561
Project Title: Evaluating the Feasibility of Developing a Community-based Forage Fish Sampling Project for the EVOS GEM Program
Agency: DOI-FWS

FORM 3B
Equipment
DETAIL

6/12/97

Assessment of Bivalve Recovery on Treated Mixed-Soft Beaches in Prince William Sound

Project Number:	03574-BAA
Restoration Category:	Research and General Restoration
Proposer:	Dennis C. Lees, Littoral Ecological & Environmental Services
Lead Trustee Agency:	National Oceanic & Atmospheric Agency, NMFS
Cooperating Agencies:	None
Alaska SeaLife Center:	No
Duration:	2nd year, 2-year project
Cost FY 03:	$35,300
Cost FY 04:	$0
Geographic Area:	Prince William Sound
Injured Resource Services:	Clams, Intertidal Communities, Sediments, Sea Otters, Harlequin Ducks, Subsistence

ABSTRACT

Studies from 1989 through 1997 suggest that bivalve assemblages on beaches in PWS treated with high-pressure hot-water washing remain severely damaged in terms of species composition and function. This project will assess the generality of this apparent injury to these assemblages. A finding that our conclusions are accurate will indicate that a considerable proportion of mixed-soft beaches in treated areas of the sound remains extremely disturbed and that these beaches are functionally impaired in terms of their ability to support foraging by damaged nearshore vertebrate predators such as sea otters and harlequin ducks. The study will also provide insight into the need for remediation of beaches to restore biodiversity and function in these assemblages.

INTRODUCTION

The T/V *Exxon Valdez* ran aground in the northeastern part of Prince William Sound, Alaska, on March 24, 1989. Over the next several weeks, a substantial amount of the nearly 41 million liters of spilled Alaska North Slope crude oil was deposited on beaches in the southern and western portions of the sound and on Gulf of Alaska beaches to the southwest. Shoreline cleanup activities were carried out with varying degrees of intensity throughout the summer of 1989 on about 560 km (Harrison 1991) of the 780 km of oiled shoreline in the sound. A primary method of shoreline treatment in 1989 was hydraulic flushing with water heated to moderate to high temperatures (Lees et al. 1996).

In Prince William Sound, most of the oiled beaches were "cleaned," typically using high-pressure, hot-water washing techniques. The technique involved various methods of dislodging the oil by spraying the intertidal zone with heated sea water (40-60° C) and then skimming up the oil as it flowed down the beach and refloated on the tide. Commonly, the hot water was directed at the beach using hose nozzles or a large spray-head mounted on a mechanical arm.

Recent analyses of infaunal data from the NOAA study of treatment effects and recovery in intertidal sediments in the sound have suggested that infaunal assemblages remained fundamentally impaired as late as 1997. This impairment was most evident in bivalve assemblage but was generally apparent for most major infaunal taxa. While not always apparent from the perspective of overall abundance, the impairment is quite conspicuous from the perspective of species composition and biological function or trophic structure. For bivalves, it appears that larger burrowing suspension and deposit feeders that dominate at unoiled (reference) and oiled but untreated sites have been replaced at sites exposed to high-pressure hot-water (HP-HW) washing by smaller surficial suspension feeders. This means that valuable and preferred species that typically dominate at undisturbed beaches (e.g., the littleneck clam *Protothaca staminea*, and the butter clam *Saxidomus giganteus*, which are favored by sea otters, harlequin ducks, and subsistence gatherers, and various species of *Macoma*) are replaced by a small opportunistic species (i.e., *Hiatella arctica* and a tiny nestling clam *Rochefortia* (= *Mysella*) *tumida*. that are of little or no value to nearshore vertebrate predators. In addition to bivalves, this pattern was still apparent as late as 1997 for polychaetes, echinoderms, snails, and crustaceans. In fact, whole classes or families of invertebrates that dominated at reference and oiled but untreated beaches are lacking in the infauna at treated beaches. Moreover, our studies indicate that a return to the apparent climax assemblage is occurring very slowly, apparently from lack of recruitment by the more favored bivalves, and suggest that recovery is probably delayed by the slow rate of recovery in sediments, which were also seriously disturbed by the effects of HP-HW washing. The impaired condition of intertidal bivalve assemblages may be a contributing factor in the failure of sea otters and harlequin ducks to achieve significant recovery in some areas that were oiled and may be a critical issue in the restoration of those damaged resources. .

NEED FOR THE PROJECT

The primary reason we are proposing this study is that we became concerned about the implications of differences in condition of intertidal infaunal assemblages that we have observed

between oiled and treated, oiled but untreated, and unoiled reference sites in western Prince William Sound since 1989. We observed that the assemblages at the treated sites were substantially impoverished relative to those at the reference sites and that they displayed fundamental differences in functional capabilities. Moreover, we postulated that these differences were due primarily to differences in inorganic and organic sediment characteristics rather than hydrocarbons in the sediments.

As a consequence of these differences, the treated beaches that we observed were far less able to support foraging by organisms from higher trophic levels or to serve as subsistence harvest areas for the native or tourist populations in Prince William Sound. The impoverished condition of the bivalve assemblages may, in fact, be an important contributing factor in the failure of sea otters and harlequin ducks to demonstrate recovery in many oiled parts of the sound. Moreover, the increase in harlequin duck populations in other parts of the sound may be a consequence of movement to areas with more adequate food resources.

The geographic scope of our previous studies was, unfortunately, limited and cannot our findings cannot be extrapolated to the rest of the sound. Consequently, we are proposing this study to assess if the conditions that we observed in the intertidal infaunal assemblages and sediments occur generally in sediments on beaches exposed to high-pressure hot-water wash in western Prince William Sound. Determining the answer to that question could also provide helpful information in understanding the dynamics of sea otters and harlequin ducks in areas of the sound that were oiled and treated in 1989-90.

A. Statement of Problem

A large proportion of the mixed-soft sediment habitats in Prince William Sound was exposed to the spilled oil from the *Exxon Valdez* oil spill. Most of the oiled areas, however, were subsequently subjected to either warm- or hot-water washing. This process washed a considerable amount of the oil out of the area but mixed low concentrations of oil into the sediment column. Moreover, the process also flushed the finer sediment fractions and associated organic materials out of the sediment into the water column. Most of these materials were then carried away by the currents, leaving the sediments substantially altered in terms of particle grain size distribution and organic content. This process also flushed large numbers of the infaunal organisms out of the sediments and displaced or damaged them to a point where they were killed (Lees et al. 1996), leaving the infaunal assemblages greatly impoverished (Driskell et al. 1996).

A major objective of the infaunal study was to describe the differences in the structure of the infaunal assemblages existing among these treatment categories. This analysis focuses on the bivalve assemblages. The location of the various sampling sites is shown in Figure 1. Infaunal invertebrates were identified in sediment samples collected from oiled and treated, oiled but untreated, and unoiled (reference) intertidal sediments in Prince William Sound from 1989 through 1997. Invertebrate groups most commonly observed were, in decreasing order of abundance, Mollusca, Polychaeta, and Crustacea. Snails and clams were the most abundant mollusks.

Species composition and functional characteristics of intertidal infaunal assemblages at sites in Prince William Sound exposed to crude oil from the *Exxon Valdez* oil spill appear to have been influenced more by exposure to shoreline treatment than by exposure to oil. Dominance patterns of the infaunal invertebrates, which varied according to type of treatment, appear to provide

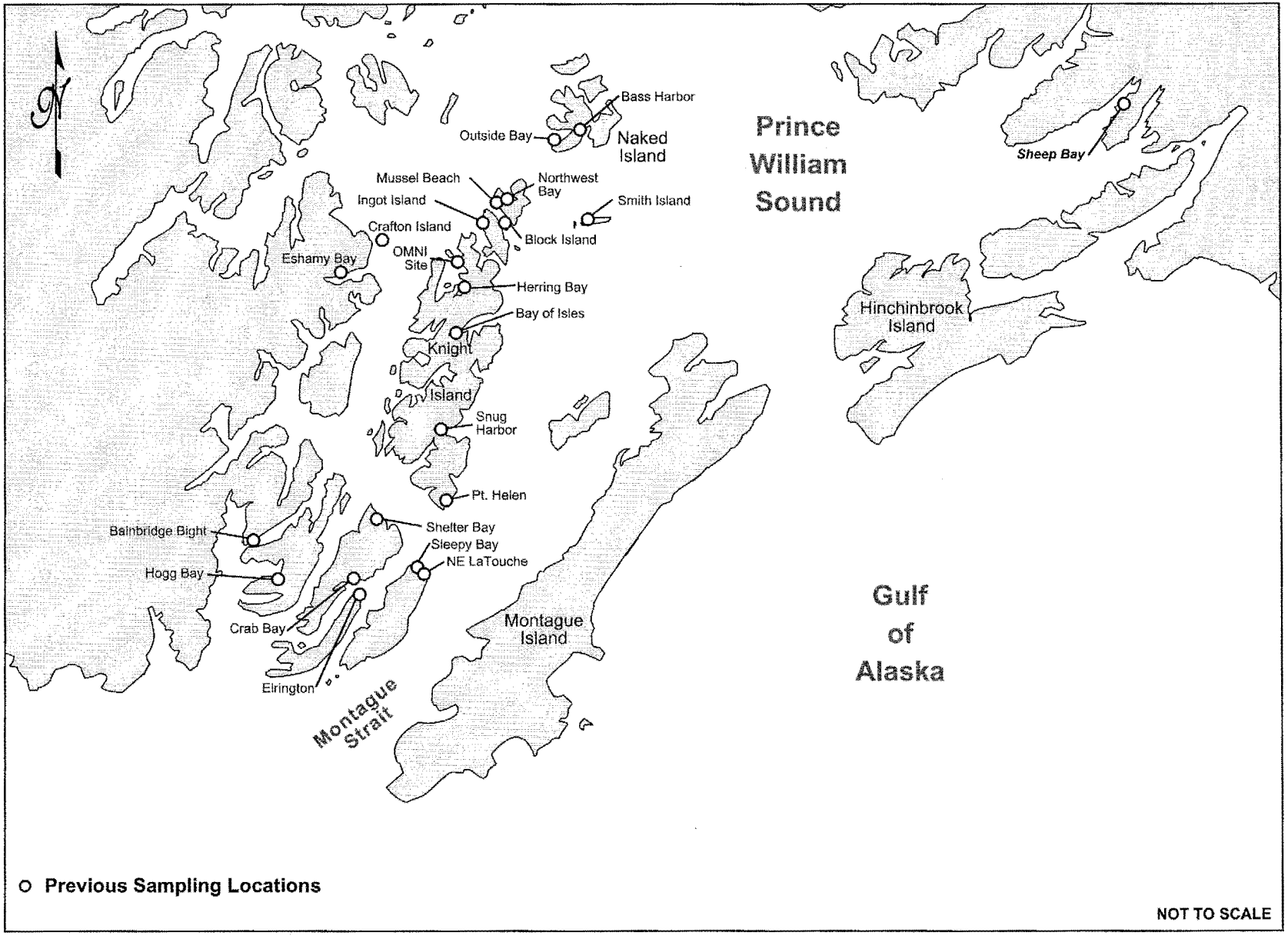


Figure 1. Prince William Sound study area and sampling locations in previous studies.

important insights into the effects of the spill, the ensuing treatment, and the recovery process. Life histories and ecological characteristics of the individual species suggest a rationale for the differences in dominance patterns seen among treatments. These patterns suggest that failure to achieve recovery is a consequence of lingering secondary effects from the spill rather than its primary effects.

These patterns are apparent in most of the major taxonomic groups that occur as infauna. For infaunal bivalves, lower values were typically observed at oiled and treated sites whereas highest numbers were observed at reference sites. Species richness, very similar at reference and oiled but untreated sites after 1990, declined slightly during the study. Abundance, also quite similar at reference and oiled but untreated sites, peaked in 1992 or 1993 and then gradually declined through the remaining years. In contrast, averages for species richness and abundance were substantially lower at oiled and treated sites and exhibited no apparent trends representing recovery (Figures 2a and 2b) . Differences in both variables were highly significant between reference and oiled but untreated sites, on one hand, and oiled and treated sites on the other. Similar patterns were observed in polychaetes, snails, and echinoderms. In contrast, these numerical characteristics were similar among the treatment categories for microcrustaceans.

Species richness and abundance of bivalves were significantly higher at reference and oiled but untreated sites than at oiled and treated sites, suggesting that community succession has reached a higher level at the former sites than at oiled and treated sites. All of the bivalve taxa observed were encountered at either reference or oiled but untreated sites whereas only eight taxa were observed at oiled and treated sites.

Dominance patterns and functional characteristics provide further important insights into the effects of the spill, shoreline treatment, and the recovery process. For bivalves, *Mysella tumida, Macoma* spp., and *Protothaca staminea* dominated at reference (unoiled) and oiled but untreated sites but they were far less common at oiled and treated sites. *Mysella* is typically commensal with larger burrowing species that were mostly absent or uncommon at oiled and treated sites. Although small, *Mysella* is relatively long-lived and reproduces slowly. In the absence of the burrowing hosts, it apparently nestles on the surface of the sediment. The other bivalve dominants generally are relatively long-lived, slowly reproducing species that bury up to several centimeters below the surface of stable sediments. In contrast, *Hiatella arctica*, the dominant bivalve at oiled and treated sites, is an opportunist that nestles on the surface of disturbed sediments or newly available substrate.

Species Composition

Bivalve assemblages observed in reference and oiled but untreated sites during this study were dominated by species of the bivalve families Montacutidae (a single species), Tellinidae, and Veneridae, both of the latter families represented by several taxa. Thus, reference and oiled but untreated sites have been dominated by relatively long-lived clams, mainly *Mysella tumida*, *Macoma* spp., and *Protothaca staminea* (Table 1). Most of these taxa characteristically burrow in stable sediments (e.g., *Macoma* and *Protothaca*; Peterson and Andre 1980; Houghton 1973; McGreer 1983). In contrast, members of the genus *Mysella* usually live in a commensal relationship in semi-permanent burrows with large burrowing infaunal organisms such as sea cucumbers, sipunculids, echiurans, or shrimp (Ockelmann and Muus 1978). In fact, abundance

Figure 2. Average Numbers of Bivalve Taxa and Individuals by Treatment Category

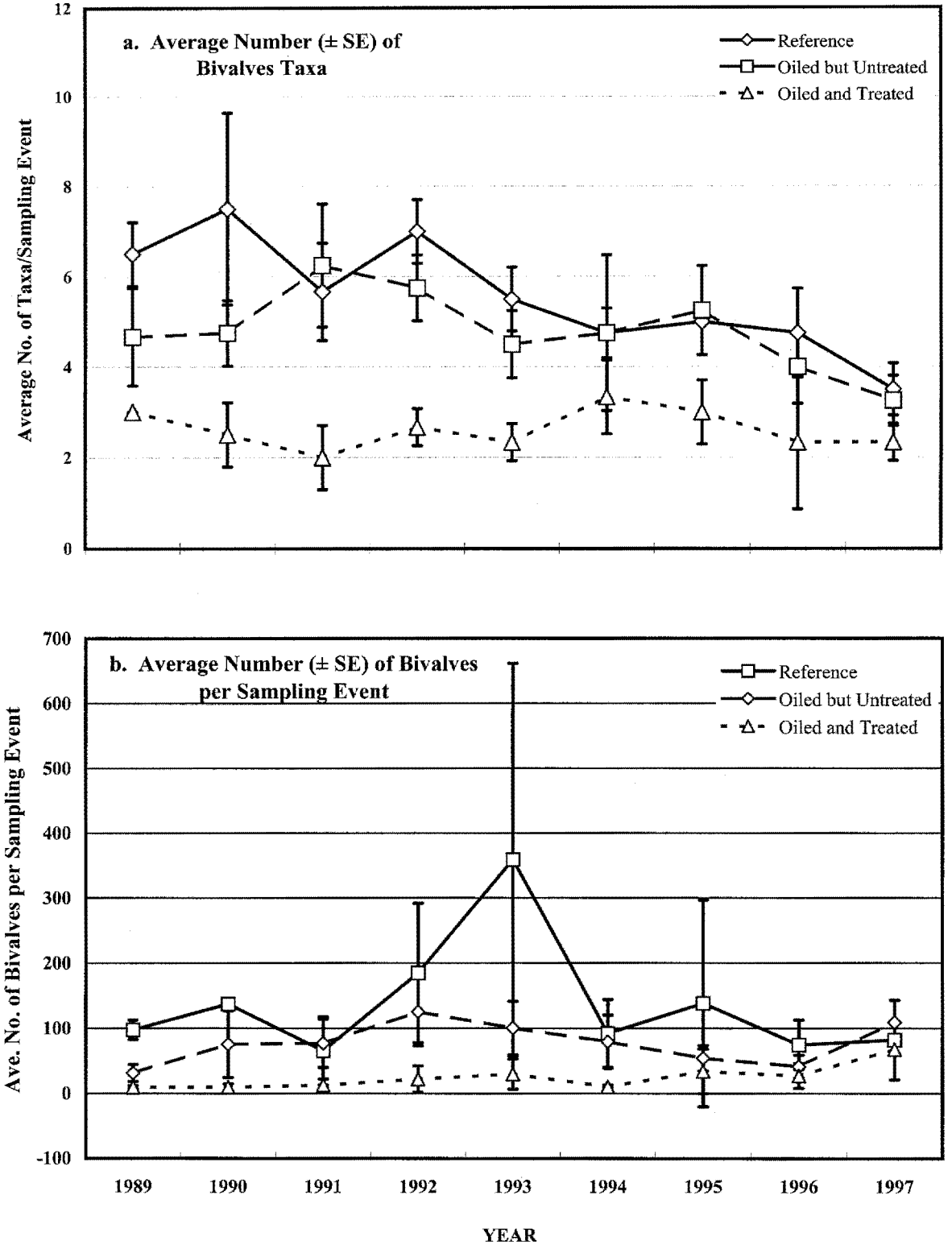


Table 1

Dominance Patterns of Infaunal Bivalves in Treatment Categories

Taxon	Reference Sites			Oiled but Untreated Sites			Oiled and Treated Sites			Totals
	Total Number of Individuals	Percent Abundance in Category	Ave. No. per Sampling Event	Total Number of Individuals	Percent Abundance in Category	Ave. No. per Sampling Event	Total Number of Individuals	Percent Abundance in Category	Ave. No. per Sampling Event	
Clinocardium ciliatum	2	0.06	0.1							2
Compsomyax subdiaphana	2	0.06	0.1	3	0.1	0.1				5
Cryptomya californica	3	0.1	0.1							3
Diplodonta aleutica				19	0.7	0.5	2	0.3	0.1	21
Hiatella arctica	90	2.8	3.5	298	10.9	8.5	**460**	**71.0**	**18.4**	848
Macoma spp.	30	0.9	1.2	80	2.9	2.3	1	0.2	0.0	111
Macoma balthica	176	5.5	6.8	148	5.4	4.2	19	2.9	0.8	343
Macoma inquinata	295	9.2	11.3	299	10.9	8.5	1	0.2	0.0	595
Macoma obliqua	6	0.2	0.2	1	0.04	0.0				7
Mactridae, unid.				2	0.07	0.1				2
Mya arenaria	4	0.1	0.2	1	0.04	0.0				5
Mysella tumida	**2139**	**66.7**	**82.3**	**1327**	**48.5**	**37.9**	129	19.9	5.2	3595
Protothaca staminea	423	13.2	16.3	493	18.0	14.1	34	5.2	1.4	950
Saxidomus giganteus	33	1.0	1.3	58	2.1	1.7	2	0.3	0.1	93
Semele rubropicta				2	0.07	0.1				2
Tellina spp.	1	0.03	0.0							1
Tellina modesta	3	0.1	0.1	1	0.04	0.0				4
Tellinidae, unid.				5	0.2	0.1				5
Veneridae, unid.				1	0.04	0.0				1
Total Taxa in Category	14			16			8			
Total Individuals	3207			2738			648			6593
Ave. No./Sampling Event			123.3			78.2			25.9	76.7

of *M. tumida* and two burrowing sea cucumbers, with which *Mysella* could have a commensal relationship, exhibited a significant positive correlation.

In contrast, oiled and treated sites were strongly dominated by a single species of the family Hiatellidae (Table 1). *Hiatella arctica*, an opportunistic, widely distributed "weed" species, nestles on the surface of disturbed sediments, on new rocks, or synthetic substrates (Morris et al. 1980; Gulliksen et al. 1980; MacGinitie 1955) and frequently dominates the biota in those habitats.

Temporal Changes of Dominant Taxa

Comparison of abundance patterns for the major species provides little evidence that dominance patterns have been changing in any of the treatment categories, especially at oiled and treated sites. In terms of raw abundance, none of the four species that dominated at reference or oiled but untreated sites showed any indication of significant increases at oiled and treated sites during the eight-year period following EVOS (Figures 3 through 6). In contrast, *Hiatella arctica* remained consistently the dominant species at oiled and treated sites (Figure 7, Table 2). When viewed in terms of relative abundance to reduce the influence of variation in overall abundance, it is still clear that dominance relationships at oiled and treated sites were not changing to any great extent (Table 2).

Mysella tumida

This small long-lived suspension-feeding clam lives near the surface of the sediment or in burrows of burrowing forms such as sea cucumbers, sipunculids, echiurids, or shrimp (Ockelmann and Muus 1978). It was by far the most abundant species at reference and oiled but untreated sites, comprising 66 and 43 percent, respectively, of the total bivalves collected in sites from these categories. Nevertheless, the average number of *Mysella* per sampling event (94.2 individuals) was nearly three times higher in reference sites than at oiled but untreated sites (35.2 individuals; Table 1). *Mysella* was particularly abundant at Outside Bay (Figure 3). The species was twice as abundant as *Protothaca staminea*, the next most abundant species in both categories. In contrast, overall abundance of *Mysella*, comprising only 28 percent of the total number of bivalves at oiled and treated sites, was an order of magnitude less abundant in this category. The average number of *Mysella* per sampling event in oiled and treated sites were an order of magnitude lower than in reference and oiled but untreated sites (Table 1).

Protothaca staminea

The little-neck clam *Protothaca staminea*, a suspension feeder (Morris et al. 1980; Peterson and Andre 1980), burrows to moderate depths. It probably lives at least 10 years. It was the second most abundant bivalve at reference and oiled but untreated sites, comprising 13 and 19 percent, respectively, of the total bivalves collected in these categories. The average number of *Protothaca* per sampling event, averaging 18.7 and 15.8 individuals per sampling event, respectively, was nearly the same in both categories (Table 1). It was relatively quite abundant at Outside and Sheep Bays, Block Island, and Mussel Beach South but an order of magnitude less abundant at the remaining reference, oiled but untreated, and oiled and treated sites (Figure 4). Although the abundance of *Protothaca* was patchy among reference and oiled but untreated sites, it was consistently sparse at oiled and treated sites, where density was about one-tenth that

Figure 3
Trends in Numbers of *Mysella tumida* at Variously Treated Sites in Prince William Sound in Years Following EVOS

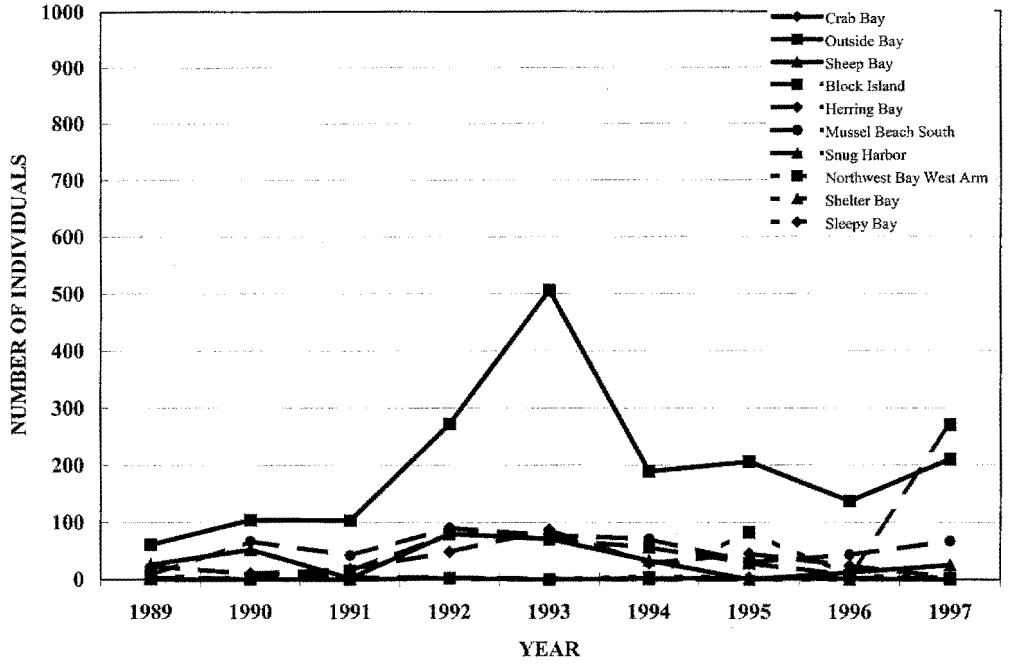


Figure 4
Trends in Numbers of *Protothaca staminea* at Variously Treated Sites in Prince William Sound in Years Following EVOS

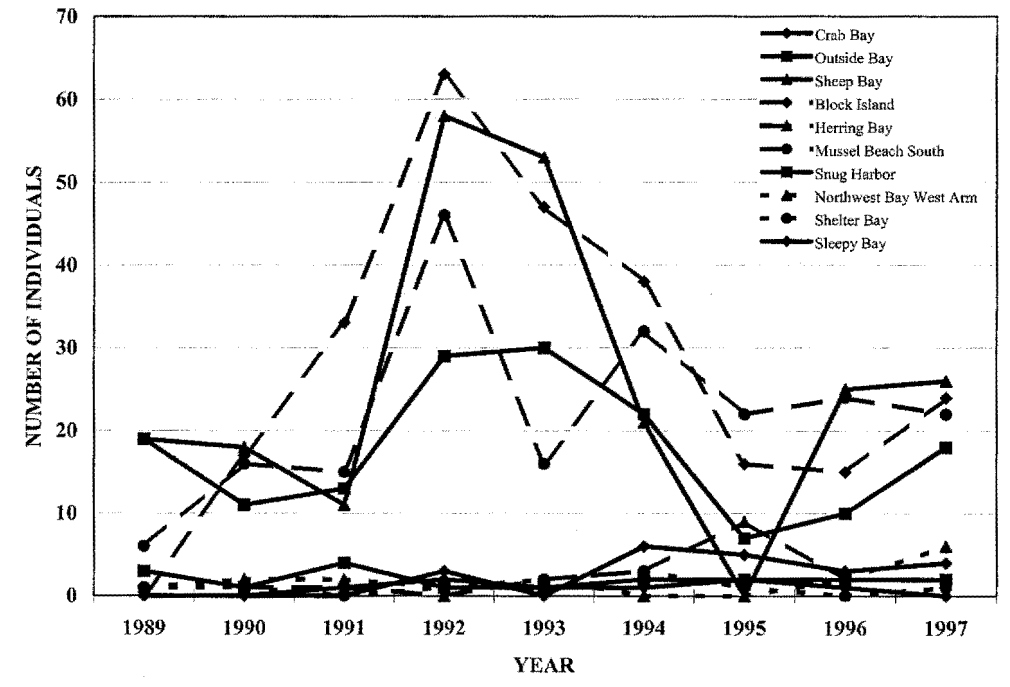


Figure 5
Trends in Average Numbers of *Macoma inquinata* at Variously Treated Sites in Prince William Sound in Years Following EVOS

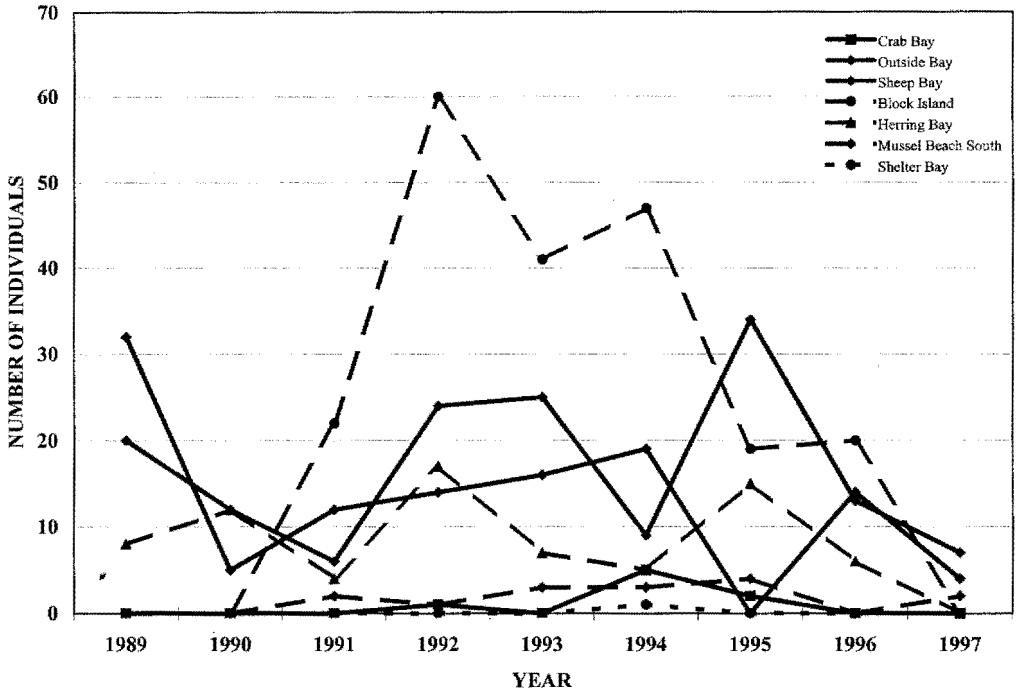


Figure 6
Trends in Numbers of *Macoma balthica* at Variously Treated Sites in Prince William Sound in Years Following EVOS

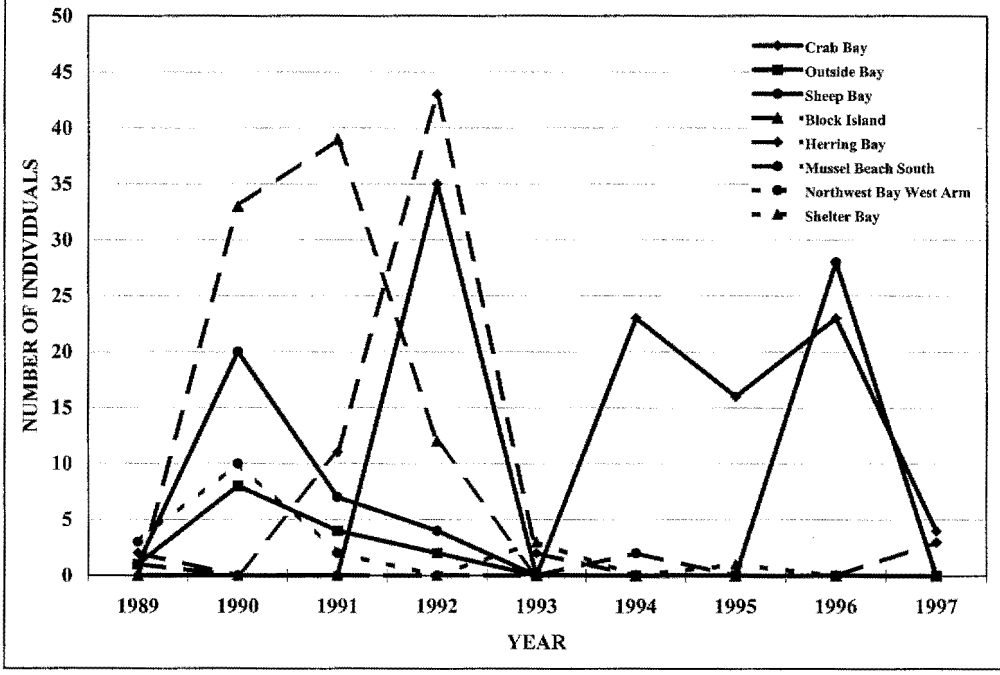


Table 2

Temporal Patterns in Relative Abundance of Infaunal Bivalves
Relative to Treatment Category

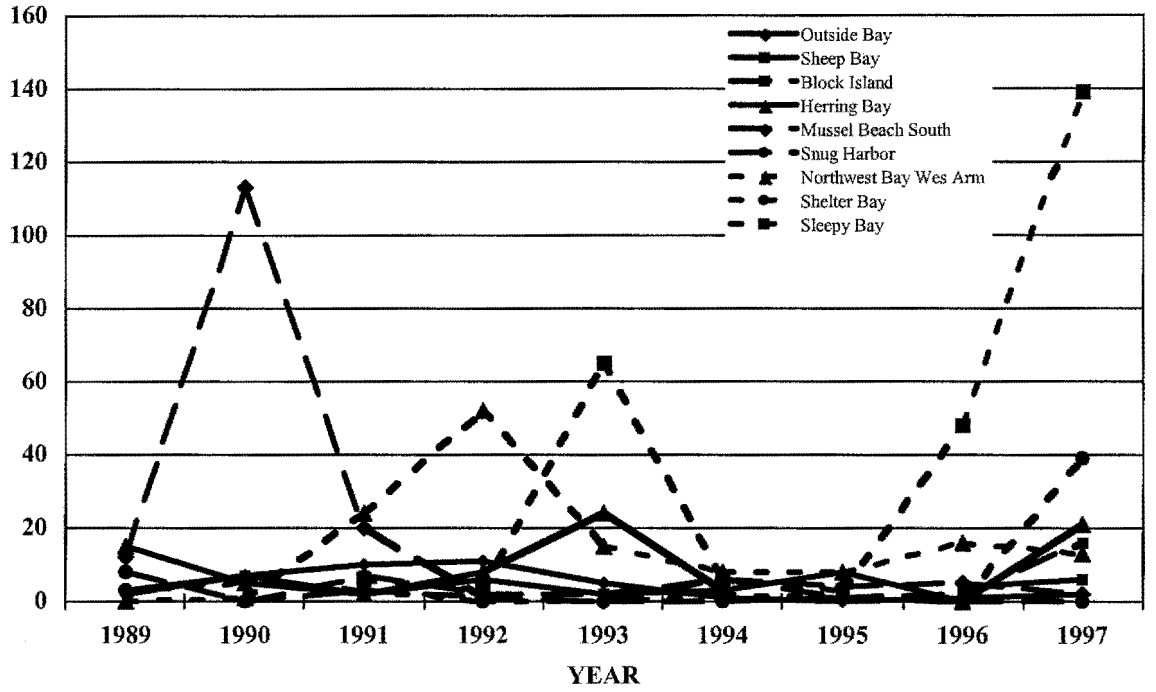
Percent of Total Abundance in Category by Year

Category/Taxon	1989	1990	1991	1992	1993	1994	1995	1996	1997	Average	Std. Error
Reference Sites											
Hiatella arctica	2.6	5.1	7.7	3.2	1.0	1.9	0.0	4.0	3.7	3.2	0.81
Macoma balthica	1.0	10.2	5.6	7.4	0.0	6.3	5.8	17.1	1.2	6.1	1.88
Macoma inquinata	26.7	6.2	11.7	7.0	5.7	10.6	13.0	10.7	4.9	10.7	2.35
Mysella tumida	44.6	56.9	58.7	63.9	80.4	65.2	75.4	52.0	75.3	63.6	4.19
Protothaca staminea	19.5	10.6	12.8	16.2	11.6	14.7	4.3	14.4	14.9	13.2	1.50
Saxidomus giganteus	5.1	1.8	1.0	0.7	0.7	1.1	0.4	0.7	0.0	1.3	0.54
Total Individuals by Year	195	274	196	554	718	368	276	298	328	356.3	61.13
Ave. No./Sampling Event*	97.5	137.0	65.3	184.7	359.0	92.0	138.0	74.5	82.0	136.7	
Oiled but Untreated Sites											
Hiatella arctica	37.2	39.2	10.4	2.4	6.5	4.7	6.5	4.2	8.9	13.3	5.06
Macoma balthica	3.2	11.0	16.2	11.0	0.5	0.6	0.0	0.0	0.7	4.8	2.20
Macoma inquinata	8.5	4.0	9.1	15.6	12.7	17.4	18.1	15.8	0.5	11.3	2.19
Mysella tumida	35.1	26.9	25.6	44.2	58.6	48.9	47.7	47.3	78.4	45.9	5.76
Protothaca staminea	12.8	11.6	17.2	22.0	16.5	23.7	22.7	26.1	11.5	18.2	1.97
Saxidomus giganteus	1.1	2.0	2.6	1.4	2.0	0.3	0.9	2.4	0.0	1.4	0.32
Total Individuals by Year	94	301	308	500	401	317	216	165	436	304.2	46.20
Ave. No./Sampling Event*	31.3	75.3	77.0	125.0	100.3	79.3	54.0	41.3	109.0	76.9	
Oiled and Treated Sites											
Hiatella arctica	15.8	31.6	86.8	83.3	89.9	51.6	11.8	79.0	94.1	60.4	11.75
Macoma balthica	15.8	52.6	5.3	0.0	3.4	0.0	1.0	0.0	0.0	8.7	6.10
Macoma inquinata	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.4	0.38
Mysella tumida	57.9	0.0	0.0	10.6	0.0	29.0	83.3	14.8	2.5	22.0	10.54
Protothaca staminea	10.5	15.8	7.9	6.1	5.6	12.9	2.9	3.7	3.4	7.7	1.60
Saxidomus giganteus	0.0	0.0	0.0	0.0	1.1	3.2	0.0	0.0	0.0	0.5	0.39
Total Individuals by Year	19	19	38	66	89	31	102	81	203	72.0	20.51
Ave. No./Sampling Event*	9.5	9.5	12.7	22.0	29.7	10.3	34.0	27.0	67.7	24.7	

* Number includes taxa not included in this summary table

of *Hiatella* (Table 1). Also, with an average of 1.4 individuals per sampling event, it was about an order of magnitude less abundant in oiled and treated than at reference and oiled but untreated sites (Table 1).

Figure 7
Trends in Numbers of *Hiatella arctica* at Variously Treated Sites in Prince William Sound in Years Following EVOS



At the four sites at which *Protothaca* was more abundant (noted above), its abundance peaked in 1992 and 1993 (Figure 4) and then appeared to decline in the following years. Nevertheless, the abundance of *Protothaca* appeared to remain at a higher level at these stations than at the other stations both before and after this period of peak abundance. It was consistently second or third most abundant at reference and oiled but untreated sites.

Macoma inquinata

This long-lived deposit-feeding clam, likely the deepest burrower of the more abundant bivalve species considered in this discussion, probably lives more than 5 years. It was the third most abundant clam at reference and oiled but untreated sites, comprising 9.5 and 12.9 percent, respectively, of the total bivalves collected in sites from these categories. The average number of individuals per sampling event was also basically the same (13.7 versus 10.6 individuals per event). *Macoma inquinata* was particularly abundant at Outside, Sheep, and Herring Bays and Block Island (Figure 5). Shelter Bay was the only oiled and treated site at which this species occurred.

Macoma balthica

This deposit-feeding clam (Newell 1965: Taghon 1982) burrows to shallow or moderate depths and can live at least five years (McGreer 1983). The average number of *Macoma balthica* per

sampling event ranged from 9.1 at reference sites to 1.0 at oiled and treated sites. This shallow-burrowing clam was most abundant at Block Island and Crab, Herring, and Sheep Bays. It was not observed at either Snug Harbor or Sleepy Bay (Figure 6). It was relatively uncommon in 1989, increased considerably at several stations in 1990 through 1992, and then declined dramatically at most stations from 1993 through 1996 (Figure 6).

Hiatella arctica

This suspension-feeding clam nestles in crevices on rocks at the surface of the substrate (Gulliksen et al. 1980). It was the third most abundant bivalve observed in the infaunal samples. It was the most abundant bivalve at oiled and treated sites, where it was twice as abundant as *Mysella tumida*, the next most abundant bivalve at oiled and treated sites (Table 1; 13.5 versus 6.2 individuals per sampling event). However, it only ranked fourth or fifth in the other categories.

Based on temporal abundance patterns observed in this study, it probably lives less than 3 years. *Hiatella* apparently failed to establish persistent populations wherever it appeared, instead exhibiting one- or two-year pulses at sites when it appeared (Figure 7). Even at oiled and treated sites, *Hiatella* only dominated the bivalve assemblage in 1991 through 1994 and in 1996.

Patterns in Sediment Characteristics

Several physical and chemical characteristics of sediments that can influence development of infaunal assemblages include particle grain size (PGS), total organic carbon (TOC), total Kjeldahl nitrogen (TKN), and polycyclic aromatic hydrocarbons (PAH) were measured.

Generally, sediments at all sampling sites were relatively coarse and most contained substantial quantities of pebbles. Average median grain size was finest at reference sites, where PGS averaged 1.9 mm, and coarsest at oiled but untreated sites, where PGS averaged >5.8 mm. Concentrations of fines in the sediments were generally low, ranging from 21.4 percent at reference sites to 5.0 percent at oiled and treated sites (Table 3).

In addition to fine particulates, sediments at reference and oiled but untreated sites were characterized by higher concentrations of total organic carbon (TOC) and total Kjeldahl nitrogen (TKN) than oiled and treated sites (Table 3). Highest concentrations of organics were measured at oiled but untreated sites and lowest at oiled and treated sites. This condition is probably partially related to whether or not the specific beaches experienced beach washing. These differences are significant except for the comparison of TOC between the reference and oiled and treated sites, percent fines between the reference and oiled but untreated sites, and PGS between reference and oiled and treated sites. The significant differences between reference and oiled but untreated sites in TOC and TKN are probably related to the oil residuals in the sediments and the bacterial flora operating to metabolize the oil.

Comparison of carbon:nitrogen (C:N) ratios provides further insight into the sediment quality at these sites. C:N ratios at reference and oiled but untreated sites are about 50 percent lower than at oiled and treated sites. This indicates that, per unit of carbon, nitrogen concentrations (largely contributed by bacteria on particulates) are lower at oiled and treated sites than elsewhere. This suggests that nutrient quality is poorer for deposit feeders (and selected suspension feeders) at oiled and treated sites than at reference or oiled but untreated sites (e.g., Newell 1965).

Table 3

Comparison of Sediment Characteristics at Infaunal Stations

Category/Site	Elevation Relative to MLLW (feet)	Median Grain Size (mm)	% Fines	PAH (ng/g)	TOC (%)	TKN (%)	C:N Ratio
Reference							
Bainbridge Bight	1.3	2.4	21.5	0.6	1.7	0.041	42.5
Crab Bay	–	1.5	18.6	5.4	2.4	0.047	49.8
Outside Bay	0.3	2.4	20.6	1.4	1.3	0.032	42.1
Sheep Bay	1.3	1.2	24.9	1.4	1.2	0.043	26.5
Average	1.0	1.9	21.4	2.7	1.6	0.041	40.2
Std. Error	0.3	0.4	1.5	0.8	0.3	0.004	5.7
Oiled but Untreated							
Block Island	3.6	2.8	14.6	2547	1.9	0.041	45.7
Herring Bay	-0.1	1.9	24.4	18	1.5	0.040	38.3
Mussel Beach South	-0.7	5.8	9.0	47	2.9	0.079	37.0
Snug Harbor	-0.4	>12.5	14.1	220	3.8	0.196	19.2
Average	0.6	>5.8	15.5	807	2.5	0.089	35.1
Std. Error	1.2	>2.8	3.7	431	0.6	0.043	6.5
Oiled and Treated							
Northwest Bay West Arm	0.5	3.9	3.4	19	0.8	0.009	88.1
Shelter Bay	0.5	3.1	7.2	67	0.8	0.013	57.9
Sleepy Bay	-0.8	3.9	4.2	77	1.9	0.025	76.0
Average	0.1	3.6	5.0	54	1.2	0.016	74.0
Std. Error	0.4	0.3	1.2	17	0.4	0.005	8.8

Because of the remoteness of these beaches from substantial sources of fine particulates, it is likely that the recovery to pre-treatment grain-size distributions could require at least several decades (pers. comm., Dr. M. O. Hayes). All of these beaches are relatively protected from wave action so the coarseness of the sediments on the beaches not exposed to washing is a strong indication that deposition rates are very slow. Although a strong relationship is frequently observed between fine particulates and organics (e.g., Newell 1965; Hartman 1965), it was not apparent is these data. However, as Cammen (1982) reported, neither TOC nor TKN exhibited an appreciable relationship to percent fines.

Average concentrations of PAH in sediments were lowest at reference sites sand highest at oiled but untreated sites and differed substantially among the three categories. Nevertheless, PAH concentrations at oiled but untreated sites (Table 3) are three to four orders of magnitude below concentrations used by Pearson et al. (1981) to assess effects of crab predation on *Protothaca* due to behavioral changes following exposure to oiled sediments. They are also below concentrations reported by Bernem (1982) as not causing mortality in *M. balthica*. The NOAA ER-L for PAH is 4022 ppb (Long et al. 1995), almost two times that of the highest average observed. Furthermore, PAH concentrations at both oiled but untreated and oiled and treated sites were declining by about 25 percent per year.

Possible Factors Influencing Composition Differences

The biological characteristics of the bivalve assemblages differed considerably among the treatment categories (Table 4). Reference and oiled but untreated sites supported relatively diverse robust populations of both suspension and deposit feeders and burrowing species appeared to thrive. In contrast, the relatively impoverished bivalve assemblages at oiled and treated sites were strongly dominated by suspension feeders, especially *Hiatella*, that live mainly at the surface of the sediments (Tables 1 and 4). Abundance of deposit feeders and burrowing species was low. Notably, *Hiatella* was substantially more abundant at oiled but untreated sites than at reference sites.

It is likely that several physicochemical and ecological factors are combining to cause the observed differences in community structure. Possibly physicochemical factors influencing larval recruitment and growth and survival of suspension- and deposit-feeding bivalves at oiled and treated sites include: 1) reduced fines, 2) nutrient concentrations, and 3) nutrient quality. Larvae for the species that dominate at the reference and oiled but untreated sites are more likely to settle out (recruit) in sediments with higher rather than lower concentrations of fine particulates or organics (TOC and/or TKN; e.g., Ockelmann and Muus 1978; Thorson 1957). In fact, except for *Hiatella*, significant recruitment events were lacking at oiled and treated sites (Figure 7). In contrast, they were commonly observed at most reference and oiled but untreated sites for all other dominant bivalve species (Figures 3 through 6).

Deposit feeders require large quantities of fines in order to survive and support growth (Lopez and Levinton 1987). Taghon (1982) reported than many deposit feeders effectively select smaller particles with a protein coating. Based on concentrations of carbon, nitrogen, and the C:N ratio (Table 3), nutrition conditions are considerably more favorable for suspension and deposit feeders at reference and oiled but untreated sites than at oiled and treated sites.

Table 4

Comparison of Relevant Biological Characteristics of Dominant Bivalve Species

Characteristic	Clam Species				
	Mysella tumida	*Protothaca staminea*	*Macoma inquinata*	*Macoma balthica*	*Hiatella arctica*
Potential Longevity (Years)	Up to 7	> 10	> 5	> 5	< 3?
Feeding Type	Suspension	Suspension	Deposit	Deposit	Suspension
Common Burrowing Depth (cm)	Surficial or nestles in host burrows	5 to 8	5 to 15	1 to 15	Nestles on surface of substrate
Dominance Pattern	All Types of Sites	Reference and Oiled but Untreated Sites	Reference and Oiled but Untreated Sites	Reference and Oiled but Untreated Sites	Oiled and Treated

Potentially relevant ecological factors include: 1) the paucity of host species to support *Mysella*, 2) paucity of adult populations to stimulate recruitment, 3) decreased predation on *Hiatella* at oiled but untreated and oiled and treated sites, and 4) predation and/or interference exclusion of the other bivalves by *Hiatella* at oiled and treated sites. The paucity of potential hosts at oiled and treated sites probably accounts in part for the failure of *Mysella* to recolonize these recently disturbed areas. Burrowing organisms such as sea cucumbers, sipunculids, echiurans, and shrimp were considerably less abundant at oiled and treated sites than at reference or oiled but untreated sites (Houghton et al. 1997). Moreover, the presence of adult infaunal organisms has been shown to facilitate recolonization of depauperate sediments (Thrush 1992), but these forms were generally lacking at these sites. Gulliksen et al. (1980) observed that *Hiatella* became dominant in areas with reduced predation. It is possible that the increased density observed for *Hiatella* at oiled but untreated and oiled and treated sites is a consequence of losses of predators following exposure to crude oil and, at oiled and treated sites, shoreline cleaning activities.

Recovery Predictions

Based on apparent patterns in community structure and sediment characteristics, habitats in greatest need of recovery are sites that were treated similarly to oiled and treated sites, i.e., washed with high pressure hot water. None of the sediment characteristics except PAH appeared to exhibit temporal patterns indicating recovery by 1996. PAH concentrations, however,

generally decreased, on average, 25 percent annually at oiled but untreated and oiled and treated sites between 1990 and 1993.

Based on the apparent lack of recruitment in the dominant bivalve species, it is likely that recovery of the bivalve assemblages at the oiled and treated sites will be delayed for a long period of time. Recovery seems to be tied more to re-establishment of initial sediment conditions and community structure disturbed by the shoreline treatment program than to reductions of PAH concentrations.

Conclusions

1. Bivalve assemblages at reference and oiled but untreated sites had significantly higher numbers of species and individuals than those at oiled and treated sites.

2. Species composition and dominance patterns at reference and oiled but untreated sites were very similar but differed markedly from those at oiled and treated sites.

3. Thus, it appears that exposure to oil, by itself, did not result in a significant long-term influence on infaunal bivalve assemblages in intertidal sediments in Prince William Sound.

4. However, it appears that exposure to shoreline treatment aimed at removing oil from the intertidal zone was accompanied by significant long-term impacts to infaunal bivalve assemblages. These impacts are partly a consequence of disruptions to the assemblages existing at the sites prior to the oil spill and to significant alterations of sediment conditions at the sites.

5. Because of the distance from these areas to regions producing substantial quantities of fine particulates, recovery of the sediment structure may take several decades.

6. Because recovery is based on, at least, re-establishment of: 1) complex interspecific interactions in the infaunal assemblages; and 2) sediment conditions, it is likely that recovery of the bivalve (and, concurrently, other components of the infaunal) assemblages in the intertidal zone at treated sites will require many generations of the invertebrate species before it is complete.

B. Rationale/Link to Restoration

What is described above is what we have found for a limited number of sites. At this point, no other studies have been continued long enough to observe the conditions that concern us and these conditions have not been reported elsewhere. Consequently, no other studies have suggested that sediment conditions such as reduced concentrations of fine particles, reduced availability of organic debris, or depressed microbial biomass, may be limiting the nature and rate of recovery of the intertidal infaunal assemblage. However, the implications of these conditions are momentous in terms of the ability of treated beaches to support foraging by higher trophic levels, especially nearshore vertebrate predators such as sea otters or harlequin ducks, and in terms of recovery rates,. We believe they are potentially significant and they need to be investigated to ensure the sound becomes whole again in less than geologic time.

This program is linked closely to the Nearshore Vertebrate Predator program. Personal observations and photographs from western Prince William Sound indicated that sea otters and sea ducks foraged intensively in intertidal areas before the spill. However, sea otters populations are not recovering in bays on northern Knight Island (pg 17, FY 02 Invitation). Harlequin ducks are also not recovering in parts of the sound that were oiled. Inadequate clam resources could be one contributing factor in these recovery failures. However, this has not been investigated satisfactorily for intertidal habitats and may be a critical issue in the restoration of these other damaged resources.

This program provides an important linkage between the basic impact study that was designed to assess the nature of impacts and the rate of recovery, on one hand, and restoration efforts, on the other. Our initial studies have suggested the potential nature of the impacts in infaunal assemblages and have suggested mechanisms that could be responsible for the observed impacts. This program will provide insight into the generality and extent of the reported impact. Moreover, it will provide a detailed examination of some of mechanisms that could be driving the observed impact and could be the key to a restoration effort.

Within the framework of the goals of the Gulf Ecosystem Monitoring (GEM) program planned by the EVOS Trustee Council, this program would address Shorter-term Focused Research (i.e., the lingering effects of EVOS discussed on pg 29 of the GEM Review Draft, March 7, 2000) and long-term monitoring. It would provide insights into whether general restoration projects should be carried out on mixed-soft substrates in order to bring about recovery of intertidal bivalve and other infaunal resources important to nearshore vertebrate predators and human subsistence fishing.

In terms of the long-term monitoring aspects of the planned GEM program, this program can be viewed as a first step for establishing long-term monitoring of intertidal bivalve resources in the region. It would establish a network of sampling sites in Prince William Sound that could be expanded into the Gulf of Alaska (Blying Sound and the Outer Kenai Peninsula), Cook Inlet, and onto Kodiak Island, as discussed on pg 79 of the draft document.

C. Location

Prince William Sound is a protected fjord system located on the southcentral coast of Alaska (Figure 1). The shoreline is heavily dissected and irregular, providing a high diversity of shoreline types and a wide range of exposure. We are proposing to conduct these studies in central, western, and southwestern portions of Prince William Sound, which lay in the path of the oil slick as it flowed through the sound. Areas where sites may be selected include: the Naked Islands, Perry Island, islands in the Knight Island archipelago (i.e., Knight, Eleanor, and Disk Islands, and the smaller islands on the west side of Knight Island), Chenega, Bainbridge, Evans, Elrington, Latouche, and Green Islands, and the mainland bordering the west side of the sound from Port Nellie Juan to Port Bainbridge.

Many beaches on the islands and mainland in this area were oiled. We propose to focus on areas that were moderately to heavily oiled and subsequently exposed to shoreline treatment involving high-pressure hot-water washing. We propose to concentrate our efforts on beaches in protected embayments and small coves that are primarily composed of a mixture of gravel, sand, and silt (mixed-soft). However, we will also sample in relatively more exposed beaches such as Sleepy

Bay. We also propose to intersperse reference (unoiled and untreated) sites throughout the sampling area to the degree possible.

The semi-diurnal tides have an extreme tidal excursion of about 5.5 m. We propose to sample the beaches between Mean Lower Low Water (MLLW = 0 meter) and 0.8 m above MLLW. While the treated sites that we examined during the NOAA study ranged from –0.25 m to +0.15 m relative to MLLW, we are aware that shoreline cleanup crews attempted to avoid washing the lower intertidal. Therefore, we are proposing to sample at a higher level to increase the likelihood of sampling at elevations that were treated. Densities of the littleneck clam and other species were common within or above this elevation range at most of the untreated or reference sites sampled during our NOAA studies. In contrast, infaunal assemblages were impoverished at sites above +1.3 m.

Prince William Sound was recently subjected to another catastrophic event when it was uplifted by the 1964 Good Friday Earthquake. The portion of the sound in which our studies will be conducted was uplifted from ~4 feet in the vicinity of the western mainland and islands to ~10 feet on Latouche Island (Hanna 1971). Heaviest oiling occurred in areas that were uplifted from 4 to 8 feet.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

We propose to include a community involvement element for the regional native villages in this program. The purposes of this element are to: 1) disseminate the findings of our previous studies to the natives; 2) describe the objectives of the proposed study; and 3) solicit traditional knowledge from the natives regarding locations of beaches traditionally used for gathering clams. To accomplish the goals of this element, we propose to involve natives from New Chenega, Tatitlek, and possibly Valdez. We propose to contact the native communities by telephone and mail initially and, subsequently, conduct informal meetings in each location if this is deemed desirable. These meetings will be organized with the assistance of Ms. Sarah Ward, the Spill Area-Wide Coordinator for the Trustee Council and Dr. Henry Huntington, the Traditional Ecological Knowledge Specialist for the Council. In mailings, we will describe the findings of our previous studies, our conclusions, and their implications for recovery and restoration of bivalve assemblages on the affected beaches in the sound. We will describe our plans for this program, i.e., where we are going, and what we are trying to achieve. In order to identify historically productive beaches, we will solicit information from the native elders to identify traditional subsistence gathering beaches in and adjacent to the region exposed to the oil spill.

If deemed desirable, we will meet with native groups during our field studies to expand on the information that we have provided. At each meeting, we will make an informal presentation with slides and maps describing our findings.

PROJECT DESIGN

A. Objectives

The purposes of this program are to determine if the impoverished condition of intertidal bivalve assemblages observed in oiled and treated areas during the NOAA 1990-97 studies is general to treated sites throughout the western sound and to examine the sediment characteristics that may be causing it. The program will address two major objectives. The first is to evaluate whether the depressed condition of bivalve assemblages at treated sites observed in our earlier work is general to treated sites throughout western Prince William Sound. The second objective is to evaluate the role that three sediment characteristics may play in the apparent depression of bivalve assemblages in treated sediments. The four major hypotheses that will be tested to compare patterns in bivalve assemblages between oiled and treated and reference sites in western Prince William Sound are listed below:

Bivalve Assemblages

1. H_o = Numerical characteristics of the bivalve assemblage (numbers of taxa and individuals) are similar at treated and reference sites.

   H_a = Numerical characteristics of the bivalve assemblage exhibit lower values at treated sites that at reference sites.

A. H_o =Species composition of the bivalve fauna is similar at treated and reference sites.

   H_a = Species composition of the bivalve fauna is more complex and productive at reference sites than at treated sites.

3. H_o = Functional characteristics of the bivalve assemblage (dominance by deposit feeders, tubicolous or burrowing forms) are statistically similar at treated and reference sites. Deposit feeders and tubicolous or burrowing forms are equally abundant at treated and reference sites.

   H_a = Functional characteristics of the bivalve assemblage are dissimilar at treated and reference sites. Deposit feeders and tubicolous or burrowing forms are more abundant at reference sites than at treated sites.

Sediment Characteristics

4. H_o = Sediment characteristics are statistically similar at treated and reference sites. Percent silt/clay, Total Organic Carbon, Total Kjeldahl Nitrogen, , and C:N ratios are similar at treated and reference sites.

   H_a = Sediment characteristics are dissimilar at treated and reference sites. Total Percent silt/clay, Organic Carbon, and Total Kjeldahl Nitrogen are lower at treated than at reference sites., and C:N ratios are higher at treated than at reference sites.

B. Methods

Approach

The approach we are proposing addresses whether the depressed condition of bivalve assemblages observed at treated sites in our earlier work is generally occurring at treated sites throughout western Prince William Sound. It examines species composition and ecological function for the intertidal bivalve assemblages. This study will involve 22 sites throughout western Prince William Sound that were oiled and subsequently treated with high-pressure hot-water wash techniques and 12 reference sites that have not been oiled or treated but are otherwise similar. For this study, we will focus on bivalves. We will also characterize several relevant sediment characteristics at all sampling sites.

Sampling Design

Based on the results of power analyses (see below), we propose to sample at 22 oiled and treated sites and 12 reference sites. We will collect five replicate samples for bivalves and sediment grain size at each of these sites. Samples for important sediment characteristics such as particle grain size, total organic carbon, and total Kjeldahl nitrogen will be collected for each replicate and composited for each site.

Random Selection of Sites

A large proportion of the sites will be selected in a stratified random manner in order to reduce the potential variability that could be experienced if all beaches were considered together. The region will be stratified geographically into northern and southern strata. The east-west oriented portion of Knight Island Passage will act as the dividing line between the southern and northern strata. Each of these strata will be further stratified on the basis of oiling and treatment history. These histories will be reconstructed to the degree practical based on two databases as described below in the section Assessment of Treatment History.

This study is focusing on intertidal mixed-soft sediments[1]. Because most beaches with this sediment type are located in relatively protected areas, the shoreline will be stratified to include embayments and protected passages. Selection of areas with potentially suitable substrate types will be facilitated using both the PDF and GIS versions of NOAA's ESI Atlas for Prince William Sound. The GIS version of the atlas will be queried using the appropriate Shoreline Habitat Rankings employed in the database to identify areas within each stratum that have potentially suitable substrate. These will be further screened to eliminate exposed sites.

Within each of the strata, the potentially suitable sites will be cross-referenced with the shoreline segments in embayments and protected passages identified as having suitable oiling and treatment histories. Segments with favorable characteristics for substrate and oiling and treatment history within each stratum will be assigned an incremental number. The NOAA Shoreline Segment Summary and Department of Natural Resources GIS databases will be used to assist in this process. Finally, these

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[1] Sites with predominantly sandy or silty sediments, such as the northern end of Crab Bay, will be eliminated from further consideration because they typically support a substantially different bivalve fauna.

beach segments will also be stratified on the basis of beach elevation. Only beaches on which the appropriate sediment type is found between 0 and 0.8 m above MLLW will be considered. Because tidal elevation data are not available in the GIS databases, this determination will be finalized during the reconnaissance/site selection survey.

Six sites will be carried over into the sampling design from previous programs due to their historic value. These historic sites will include two reference sites (Outside Bay and Bainbridge Bight) and four oiled and treated sites (Northwest Bay West Arm, Shelter Bay, and Sleepy Bay) from the NOAA recovery and treatment effects program; and a high-pressure hot-water washed site from an Exxon beach cleaner study (Disk Island).

The proposed allocation of sites among strata is shown in Table 5. The number of sampling sites allocated to each cell is based roughly on the amount of shoreline available within each specific stratum. Allocation has also been tempered by the potential for finding suitable sites within a cell and the need to have at least three sites to provide reasonable estimate of variability.

Table 5

Allocation of Potential Sampling Sites Among Geographic and Spill Exposure Strata

Strata	Oiled and Treated	Unoiled Reference
Northern Insular	8 sites Northwest Bay West Arm, Disk Island + 6 random sites	3 sites Outside Bay + 2 random sites
Northern Mainland	3 random sites	3 random sites
Southern Insular	8 sites Shelter and Sleepy Bays + 6 random sites	3 random sites
Southern Mainland	3 random sites	3 sites Bainbridge Bight + 2 random sites
Total Sampling Sites	22	12
Number of Historic Sites	4	2
Number or New Random Sites	18	10

Assessment of Treatment History

Determining the treatment history for any particular stretch of shoreline is a somewhat difficult and complex task. However, it has been demonstrated by Mearns (1996) for several areas in the sound that it can be accomplished to a reasonable degree. For his analysis, he employed NOAA's Shoreline Segment Summary database. Based on that database, he was able to assign substrate type, relative degree of oiling (no-, light-, moderate-, or heavy oiling), types of treatment (e.g., moderate to high pressure or warm or hot water), number of types of treatment, and number of treatment days on a segment. He did this for 37 shoreline segments in Herring Bay and 31 segments on Eleanor and Ingot Island. He concluded that, although "... treatment varied greatly among shorelines,...treatment effort was generally proportional to the amount of oil present." According to his data for Eleanor and Ingot Islands, 81 percent of the heavily oiled sites were exposed to warm or hot water and 71 percent were exposed to both. In addition, 80 percent of the moderately oiled sites were exposed to warm or hot water. Only about 10 percent of the moderately or heavily oiled segments were not treated or did not have accompanying treatment characterization. From these data, one can conclude that most heavily or moderately oiled sites were washed with hot or warm water. Furthermore, it appears this data set provides relatively good insight into the oiling and treatment history of many shoreline segments.

In addition, an ArcView map set showing many of these same types of data provides similar information. This map set, a 1997 product of the EVOS Trustee Council prepared by Alaska Department of Natural Resources, is included on a compact disk entitled "EVOS Research and Restoration Information Project". This data set will be used in combination with the NOAA data to fill in gaps where possible.

Suitability Criteria for Site Selection

At least 50 sites will be visited and evaluated during the reconnaissance survey to evaluate their suitability as potential candidate sites. As described above, these sites will have been previously screened to assure, to the degree possible, they were moderately or heavily oiled and subsequently treated with high-pressure, hot- or warm-water treatment techniques. This screening will be based on applicable Shoreline Segment Summary databases.

During the visit, the suitability of the sites will be evaluated on the basis of the criteria described below. Unsuitable sites will be omitted from further consideration. Final selection of the random sites will be made by randomly selecting the appropriate number of sites from among the remaining pool of acceptable sites for each stratum.

The following criteria will be evaluated for each site in order to determine its suitability for inclusion in this study.

- Does the site have mixed-soft sediment (mixed fines, sand, pebbles, and boulders) between 0 and +0.8 m (+2.6 feet) above MLLW?
- Is there a 30-m long expanse of suitable sediment available for sampling at the appropriate elevation?
- Is the site located suitability far from any stream, river, or glacier that could expose it to depressed temperatures or a strong or sustained freshwater influence?

- Is the site subject to strong anthropogenic influences other than the effects of the oil spill and shoreline treatment (e.g., mine tailings, log dumps, or marina activities)?

Note that the species composition and abundance of bivalves are not included as suitability criteria. Because two major hypotheses involve species composition and abundance, using these variables as site selection criteria would bias the results, especially for the reference sites.

Bivalve Sampling

Sample Collection and Handling

Samples for the bivalve assemblage will be collected with core samplers 10.7-cm in diameter (0.009 m^2) by 15-cm deep. Five of these cores will be collected at randomly selected locations along a 30-m horizontal transect placed at the appropriate elevation at each site. To the degree possible, the elevation sampled will be standardized among sites.

Each sample will field sieved through a 1.0-mm screen, washed into a double-labeled Ziploc bag, and fixed with buffered 10% formalin-seawater solution. After several days, we will replace the formalin-seawater solution with isopropyl alcohol. The preserved samples will be stored in water-tight plastic buckets and shipped to the taxonomic laboratory at the completion of the field work.

Lab Analysis

Following receipt of the samples in the laboratory, they will be washed by elutriation and the bivalves will be preserved in isopropyl alcohol. The remainder of each sample will be discarded. The bivalves subsequently will be sorted, identified to the lowest appropriate taxon, and enumerated.

A representative sample of each bivalve taxon will also be measured to provide insight into the size structure and biomass of the populations living at each site. Length measurements will be made with vernier calipers or ocular micrometers, as appropriate.

Sediment Characteristics

Whole sediment samples will be collected at all sites for analysis of particle grain size, total organic carbon (TOC), and total Kjeldahl nitrogen (TKN). These samples will be composited from surficial sediments scooped approximately 2 cm deep at points immediately adjacent to the randomly selected sampling locations for collection of the bivalve cores. Thus, the single composite sample will not provide a measure of within-site variance for the sediment variables but this measure is not viewed as necessary for the purposes of this study. Each composited sample will be preserved by freezing.

These will be analyzed to provide information on a suite of pertinent sediment property covariates that appeared important to the development of infaunal assemblages in our previous studies.

Particle Grain Size

Particle grain size distributions will be determined using a pipette method (Plumb 1981) modified to correct for dissolved solids (i.e., salinity and the dispersant added to keep silt/clay particles from clumping).

Organic Nutrients (Total Organic Carbon and Total Kjeldahl Nitrogen

The samples used for analysis of organic nutrients in the sediments will be purged of inorganic carbon, dried at 70°C, ground, and sieved through a 120-mesh screen. TOC will be measured on a Dohrman DC-180 Carbon Analyzer using EPA method 415.1/5310B. TKN will be measured using EPA Method 351.4.

Statistical Analysis

Two types of statistical analyses will be used in this study, namely inferential and exploratory analyses. The inferential statistics will test, for example, specific values or indices (e.g., species richness or density of an indicator bivalve species) to measure the significance of the difference between the controls and treated sites. Where possible, an exact probability and the power of the statistic will be stated. Typically, we prefer to use randomization or permutation statistics (Edington 1987; Manly 1997) in contrast to the classical parametric techniques. These computer-intensive methods require none of the assumptions of equality of variance or normal distribution of data as do the parametric techniques. They rely solely on a truly random sample and the empirical distribution of the data to calculate the exact significance of the statistic.

Most of the inferential statistics will be either two-sample t-tests or simple ANOVAs although the procedures can be modified for more novel designs. The tests will be either one- or two-tailed, depending on our ability to predict the impacts from prior data. While acknowledging the inherent dangers of multi-comparison testing (i.e., you are likely to find some positive results based solely on probability rather than a real effect; also termed losing control of the alpha error), we will be looking for overall trends of significant effects and supporting evidence from the exploratory analyses rather than relying on any "critical" inferential decision result. Thus, Bonferroni corrections to experiment-wise alpha will not be used.

Exploratory analyses would include some appropriate combination of multivariate analyses. It might be as simple as graphically looking at various stratum- or species-specific histograms for the bivalve species or as complex as a full-blown ordination and clustering exercise using multi-species biological and physical data (Clarke 1993). This form of analysis can be quite useful to discern and interpret common or correlated patterns in the data but is difficult to quantify with probability values. However, exploratory analyses are invaluable for providing an understanding of the natural processes that is sufficient to interpret the inferential findings and to formulate testable hypotheses.

Statistical Power

Power analyses are useful to this project for two purposes: to estimate the number of replicates appropriate to study's statistical goals, and after data are collected, to understand the sensitivity of the inferential tests.

First, using as pilot data the latest available set of infauna data (NOAA, 1996), the sampling variances can be used to calculate the sampling intensity (number of replicates) required to detect an appropriate size of effect. The statistic of concern is the difference in individual species abundance (or species richness, total abundance, sediment fraction, TPAH, etc.) between reference and oiled and treated sites. The infauna pilot data set contains 3 sites (replicate means) in each category, n= 3, 3. Power analyses projected combinations of replication up to n = 25, 25 using the reported sampling variances. The species with the best power to detect an effect (i.e., highest power for lowest practical effect) are suggested as primary indicator species for discriminating the reference from the oiled and treated sites (Table 6).

Table 6

Power to detect proportional differences in species abundance between reference and oiled and treated sites. Calculations are based on 1996 data (n = 3,3), for a 2-sample t-test for the difference of means using alpha = 0.10, pooled variance and sampling intensity of n = 10 and 20 replicates, respectively, for reference and oiled and treated sites. Values with power exceeding 50% and potential indicator species are bold formatted.

	Reference		**Oiled and Treated**		**Proportionate Detectable Effect (percent)**				
Taxon	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**100**	**75**	**50**	**25**	**10**
Diplodonta aleutica	0.0	0.0	0.7	1.2	**81**	**60**	35	17	11
Mysella tumida	50.0	75.5	4.0	3.6	**83**	**62**	37	17	11
Macoma spp.	9.0	7.8	0.0	0.0	**100**	**98**	**81**	35	14
Macoma balthica	17.0	14.9	0.0	0.0	**100**	**98**	**81**	35	14
Saxidomus gigantea	0.7	1.2	0.0	0.0	**81**	**60**	35	17	11
Protothaca staminea	12.7	11.2	1.0	1.0	**100**	**100**	**97**	**54**	18
Mya arenaria	1.0	1.0	0.0	0.0	**100**	**97**	**76**	32	14
Hiatella arctica	1.7	2.1	21.3	24.4	**91**	**72**	44	19	11

The second utility of power analyses comes during *post-hoc* calculations wherein the actual power of the significant results is reported. For example, a difference in the abundance of a single species between two treatment categories may be statistically significant ($p < 0.05$); however, the ability to detect a meaningful change may not be very powerful. If the power analysis reported a power of 0.50 for a 100% change in a species abundance, it means that although you have only a 5% chance of wrongly proclaiming the change was real, you also have a 50% chance of missing a real change that was less than a 100% difference.

A concern arises in estimating power for randomization statistics; currently no formula are available s to use for the calculations. However, based on the knowledge that a randomization test produces precisely the same result as a comparable parametric test when applied to normally distributed data, the power of randomization tests is inferred to be equal to parametric tests in that ideal case. As a data distribution deviates from normality, the assumptions for the parametric test are violated and power is compromised. However, under these circumstances, the randomization test results are unaffected and power is assumed to remain roughly the same. For our purposes, we must rely on calculations of parametric power to estimate the power of the randomization tests.

Bivalve Variables

Inferential testing for comparing bivalve variables between reference and oiled and treated sites will be accomplished using 2-sample t-tests for the selected indicator species and population indexes. If needed, size frequencies will be tested using either a Kolmogorov-Smirnov test or the alternative weighted Anderson-Darling test. Two-way ANOVAs will be used to test for stratified category effects. Multivariate analyses will likely follow the combined NMDS and clustering techniques described in Clarke (1993).

Sediment Characteristics

Physicochemical sediment characteristics will be tested for category effects using 2-sample t-tests. The data will also be examined for correlations with various species and as covariates to the multivariate ordinations.

Comparison Between Site Categories

The following categories will be compared , using 2-sample t-tests or stratified 2-way ANOVAs:

- All oiled and treated vs all reference sites
- New oiled and treated vs new reference sites
- New oiled and treated and NOAA Category 3 (oiled & treated sites carried over from previous studies)

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Not Applicable

SCHEDULE

The first year of this project will focus on three major items. These include: 1) selection of appropriate sampling locations, 2) conduct of the field sampling program, and 3) laboratory analysis of bivalve and sediment samples. The field work (reconnaissance survey and field sampling program) will be conducted during the two spring tide series in June 2002.

The samples will be received by the laboratories in July 2001 so it is unlikely that results will be available until October 2002. Consequently, we do not anticipate completion of data entry and database development until December 2002.

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

December 1 –15, 2001 Arrange and finalize contracts with subcontractors

December 16 Commence sampling site selection process by review of appropriate SCAT and shoreline treatment records

January 14 - 23 (2 days) Attend Annual Restoration Workshop; initiate dialog with knowledgeable native regarding location of historical subsistence clam harvest sites

March/April Arrange air/vessel support logistics and contracts

April 13 Submit progress report; no data available for FY 02 at this point.

May 15 Finalize list of candidate sampling sites

July 20 – 28 Conduct reconnaissance survey to finalize selection of sampling sites

August 8 - 15 Conduct field sampling program

August 16 Ship bivalve and sediment samples to respective labs for analysis

September – October Analysis of bivalve and sediment samples

Most of the data analysis, report and manuscript preparation, and presentation of the results at the annual restoration workshop and at a national conference, will occur during the second year of the project (FY 03).

B. Project Milestones and Endpoints

The objectives for this program are to evaluate: 1) whether or not the depressed condition of bivalve assemblages at treated sites observed in our earlier work is general to treated sites throughout western Prince William Sound; and 2). the role that several sediment characteristics in may play in the apparent depression of bivalve assemblages in treated sediments. The objectives for this program will be addressed concurrently starting in June 2001 by collecting bivalve and sediment samples at numerous oiled and treated and unoiled reference sites in western Prince William Sound.

FY 02

January 14 - 23 (2 days) Attend Annual Restoration Workshop

April 15 Arrange air/vessel support logistics and contracts

May 15 Finalize list of candidate sampling sites

July 28 Complete reconnaissance survey.

August 5 Finalize selection of sampling sites

August 15 Complete detailed field sampling program

August 16 Ship bivalve and sediment samples to laboratories

October 30 Complete analysis of bivalve and sediment samples

FY 03

November 1 Commence data entry and analysis

December 31 Complete analyses of bivalve and sediment data

January 15, 2003 Commence preparation of annual report describing findings of the FY 02 field survey

February 15 Commence preparation of presentation describing the findings of the bivalve studies

April 13 Submit annual report (FY 02 findings)

May 1 Commence preparation of manuscript for peer-reviewed journal describing the findings of the bivalve studies

Laboratory analysis of those samples will require at least 3 months, following which we evaluate the data to address the questions posed by the objectives.

C. Completion Date

The program described in this proposal will be completed in the 3rd quarter of FY 03, in time for presenting final results and conclusions in the annual report describing FY 02 findings. The findings will be submitted as a manuscript to a national peer-reviewed journal and at a national conference during FY 03.

PUBLICATIONS AND REPORTS

At least two deliverables will be produced from the proposed research. The first will be the April 2003 annual report to EVOS Trustee Council for project activities in FY 2002. This annual report will be the final report for this program.

Moreover, assuming this research is funded, we will prepare a publication for a peer-reviewed journal. This paper, combining the findings of this work with those of the NOAA studies, will be submitted in Fall 2003 to Marine Ecology Progress Series or Ecological Applications. The title of this paper will be "Long-term Recovery Patterns in Prince William Sound Intertidal Bivalves Following *Exxon Valdez* Oiling and Shoreline Treatments, 1989 through 2002," If this

proposal is not funded, a paper entitles "Response and Recovery of Intertidal Infaunal Bivalves Exposed to the *Exxon Valdez* Oil Spill and Related Shoreline Treatment at Selected Sites in Prince William Sound," based solely on the NOAA studies, will be submitted in Summer 2002 to one of the same journals.

Concerns that the results from this research might not be published were summarized in the initial review of this proposal. Reviewers should be aware that the team that participated in NOAA's initial studies on the effect of shoreline treatment in Prince William Sound has recently published the first of a series of papers on our studies of the *Exxon Valdez* Oil Spill. This paper (Driskell, W. B., J. L. Ruesink, D. C. Lees, J. P. Houghton, and S. C. Lindstrom. 2001. Long-term signal of disturbance: *Fucus gardneri* after the *Exxon Valdez* oil spill. Ecological Applications 11:815-827) examines synchronized senility in individual plants forming a population. Synchronized senility led to population crashes about 4-5 years following the cleanup. We demonstrated that these crashes were a consequence of reduced diversity in age structure resulting from obliteration of pre-cleanup populations of rockweed. Continued surveys in the region observed similar but weaker declines in 2000 (Dr. Alan Mearns, pers. comm.)

Regarding other publications of the NOAA studies, Mr. Lees currently has a manuscript about 80-percent complete on the response and recovery of intertidal infaunal bivalves exposed to the *Exxon Valdez* Oil Spill and related shoreline treatment (indicated as a manuscript above). We have delayed completing this paper until we know the decision on this proposal. The conclusions of that paper, reflected in both the presentations that we have made at national conferences and in this proposal, are that shoreline treatment has caused considerable disturbance to the intertidal bivalve assemblages at treated sites, and that these assemblages are recovering only at a very slow rate, in contrast to assemblages at oiled but untreated sites. Because the objective of this proposal is to determine if this pattern is, in fact, general to the treated areas in Prince William Sound, it seems that the best approach for publishing the results would be to combine both data sets into a single paper. This strategy has benefits whether the results of the effort proposed herein either confirm or refute the findings of the NOAA studies. Either alternative can be addressed and integrated in the same paper and we would avoid placing potentially erroneous conclusions into the oil-spill literature by premature publication of the NOAA conclusions. If the findings of this research are ultimately supportive, publication of the results of the EVOS-funded work in a separate and subsequent paper would seem more like an afterthought to the original paper.

Finally, rather than allowing this concern to deny funding for the proposed study, we would suggest specifying in the contract a hold on payment of a reasonable proportion of the second year's funding until the proposed integrated manuscript is submitted for review by a peer-reviewed journal.

PROFESSIONAL CONFERENCES

No funds requested at this time. Probable attendance at the 2003 International Oil Spill Conference and the 2003 SETAC Conference to present papers on findings of this program.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

We have coordinated with Dr. Henry Huntington to develop a Community Involvement program and gain access to traditional knowledge that we intend to use in selection of sample sites. Those aspects are described above in this proposal.

We anticipate sharing information with Steven Jewett, Univ. of Alaska, Fairbanks, James L. Bodkin, USGS, and Thomas Dean, Coastal Resources Associated, Inc. Furthermore, we will discuss our findings with Glenn VanBlaricom and Allan Fukuyama to exchange with information with their subtidal programs.

PROPOSED PRINCIPAL INVESTIGATOR

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PRINCIPAL INVESTIGATOR

Dennis C. Lees

With over 30 years of national and international experience, Mr. Lees has extensive capabilities in the study and evaluation of nearshore and intertidal benthic systems ranging from the Beaufort Sea and Chukchi Sea in Alaska to California, Micronesia, and the Arabian Gulf. He has been a pioneer in the research of intertidal and shallow subtidal ecology in Cook Inlet and Prince William Sound and has performed intertidal or subtidal surveys at numerous other locations in the state including Prudhoe Bay, the eastern Chukchi Sea, the Bering Sea, Unalaska, Akutan, Shelikof Strait, and the Outer Kenai Peninsula. He has participated in a variety of field, analytical, and reporting activities as a principal investigator or project manager. He has assessed or predicted impacts for a wide spectrum of industrial development activities on coastal marine habitats around the world. He has strong experience in evaluation of impacts from oil-and-gas and mining exploration and development, oil and ore spills and related clean-up and treatment activities, especially in Alaska, construction and operation of petrochemical, power, desalination, and wastewater treatment facilities, and port and airport construction and operation.

Specific experience related to oil spills and Alaskan marine systems includes:

- Recent experience in oil spill assessment and evaluation of treatment methodologies on the *Exxon Valdez* Oil Spill in Prince William Sound, the outer Kenai Peninsula, and Cook Inlet for NOAA and Exxon.
- Baseline studies of intertidal biota in Prince William Sound, Outer Kenai Peninsula, and upper and lower Cook Inlet.
- Completion of an important reconnaissance survey and comprehensive analysis of factors controlling infaunal assemblages in upper Cook Inlet.
- Completion of an Ecological Risk Assessment evaluating risks to the water column and intertidal habitats of coal-water fuel spills in upper Cook Inlet.
- Recent and continuing experience in pre- and post-abandonment (decommissioning) projects in the Santa Barbara Channel with special emphasis on surveying and restoration efforts for kelp, eelgrass, and surfgrass resources.
- Extensive experience in sampling and analysis of sediment contamination and benthic and demersal fish communities associated with rocky and soft substrates and kelp beds along the west coast of the United States and Alaska.
- Extensive experience with environmental assessments for the development phase of offshore and coastal oil and gas development and refinery operations in California, Alaska, and the Arabian Gulf

Mr. Lees obtained his B.A. in Zoology from UCSB, an M.S. in Biology from San Diego State University (SDSU), and completed all but the dissertation requirements for a Ph.D. in a joint doctoral program for SDSU and University of California, Riverside.

Mr. Lees participates in and manages a variety of marine science and environmental activities focusing on marine ecological risk assessment, habitat restoration, sediment and effluent toxicity testing, as well as traditional marine ecological assessment of benthic and nearshore fish communities. His research experience has been concentrated in evaluation of contaminant impacts in intertidal and nearshore biological systems in bays, estuaries, and coastal regions ranging from Alaska and California to the Arabian Gulf. From 1989 to 1996, he served as a project manager and principal investigator on a series of multi-year marine biological studies of intertidal and shallow subtidal habitats in Prince William Sound to study: 1) the initial impacts of the *Exxon Valdez* oil spill; 2) biological costs and effects of shoreline treatment following the oil spill; and 3) long-term effects and recovery of the biota. He participated in a major ecotoxicological study to determine the effects of spilled copper ore on the biota in marine sediments in San Diego Bay. Other sediment quality studies in which he has participated include dredging feasibility studies at the Sub Base, 32nd Street, and Continental Maritime of San Diego, and PCB evaluations at Convair Lagoon. Recently, he has been involved in eelgrass and kelp resource assessments and subsequent restoration and mitigation programs. He has assessed or predicted impacts on nearshore marine habitats from a wide variety of industrial development activities, including construction and operation of port facilities, power, desalination, petrochemical, and wastewater treatment facilities, oil development, oil spills and related clean-up and treatment activities. He participated in development of ecological risk assessment programs for Pearl Harbor and Guam as part of Ogden's Navy CLEAN program for PACDIV. He was project manager and principal investigator on major biological studies of the demersal fishes, zooplankton, benthic assemblages, wetlands, and coral reefs in two regions in the Arabian Gulf to monitor the development of a major petrochemical industrial complex, associated large power and desalination plants, and operation of a major supertanker port.

OTHER KEY PERSONNEL

All of the key personnel worked together in Alaska on major projects reaching back to 1975. We have well established working relationships.

A. William B. Driskell – Sampling Design and Statistical Approach

Mr. William Driskell will design the sampling program for this study. Moreover, he will be in charge of the various databases required for the various kinds of data and statistical analyses. In 1988, Mr. Driskell began a computer and marine biological consulting business in Seattle dealing primarily with scientific databases and statistical analyses ranging from sampling designs to multivariate statistics. He has worked as a marine biologist for the past 25 years, principally in the south-central Alaska and the Puget Sound regions but interrupted by a three-year sojourn in the Middle East where he participated in major baseline and effluent effects studies. He has been working in Prince William Sound since 1977 and on the *Exxon Valdez* oil spill since March 1989. His specialties applicable to this program are statistics, data management and computer programming. His expertise also includes: taxonomy of North Pacific and Arabian Gulf marine invertebrates and fish; biological survey techniques including trawl, seine, diving, benthic grab, dredge and box core, underwater television and still photography; and bird identification.

B. Laboratories

Bivalve Assemblages – Littoral Ecological & Environmental Services

Sorting, identification, and measurement of the bivalves in the samples obtained in July 2002 will be conducted in the laboratory of Littoral Ecological & Environmental Services, under the direct supervision of Mr. Dennis Lees.

Sediment Characteristics – To Be Determined

The laboratories in which these routine analyses (particle grain size, total organic carbon, and total Kjeldahl nitrogen), will be conducted will be determined after contract award.

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FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2002	Proposed FY 2003
Personnel	$42.2	$17.8
Travel	$6.6	$2.1
Contractual	$37.5	$12.5
Commodities	$2.3	$0.6
Equipment	$0.0	$0.0
Subtotal	$88.6	$33.0
Indirect		
Project Total	$88.6	$33.0
Full-time Equivalents (FTE)		0.1
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2004					
$0.0	-				

Dollar amounts are shown in thousands of dollars.

Comments:

FY03

Prepared: 4/16/02

Project Number: 03574
Project Title: Assessment of Bivalve Recovery on Treated Mixed-Soft Beaches in Prince William Sound
Name: Dennis C. Lees

FORM 4A
Non-Trustee
SUMMARY

Personnel Costs:				Months	Monthly		Proposed
	Name	Position Description		Budgeted	Costs	Overtime	FY 2003
	D. Lees	Principal Investigator, Infaunal Analyses		1.3875	12.8		17.8

						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.4	12.8	0.0	
					Personnel Total	$17.8

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2003
	D. Lees, San Diego to Anchorage, annual Restoration mtng	0.8	1			0.8
	W. Driskell, Seattle to Anchorage, Travel to point of departure for field s	0.7	1			0.7
	Per diem	0.12	4			0.5
	Cab fare	0.1	1			0.1
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$2.1

FY03

Prepared: 4/16/02

Project Number: 02574
Project Title: Assessment of Bivalve Recovery on Treated Mixed-Soft Beaches in Prince William Sound
Name: Dennis C. Lees

FORM 4B
Personnel
& Travel
DETAIL

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Contractual Costs:				Proposed
Description		Budgeted	Costs	FY 2003
W. [W. Driskell	Sampling Design and Statistics	1.3000	9.6	12.5
			Contractual Total	$12.5

Commodities Costs:	Proposed
Description	FY 2003
Printing, xerox, and phone	0.5
Film & Processing	0.1
Commodities Total	$0.6

FY03

Prepared: 4/16/02

Project Number: 02574
Project Title: Assessment of Bivalve Recovery on Treated Mixed-Soft Beaches in Prince William Sound
Name: Dennis C. Lees

FORM 4B
Contractual & Commodities DETAIL

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 2003
Description			
Not Applilcable			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		
Not Applilcable		

FY03

Prepared: 4/16/02

Project Number: 02574
Project Title: Assessment of Bivalve Recovery on Treated Mixed-Soft Beaches in Prince William Sound
Name: Dennis C. Lees

FORM 4B
Equipment
DETAIL

DESIGNING A COMMUNITY INVOLVEMENT/COMMUNITY-BASED MONITORING PLAN FOR GEM Submitted Under the BAA

Project Number:	03575-BAA
Restoration Category:	Monitoring
Proposer:	Center for Alaskan Coastal Studies, Chugach Regional Resource Council, Prince William Sound Science Center
Lead Trustee Agency:	
Cooperating Agencies:	
Alaska SeaLife Center:	No
Duration:	1st year, 1-year project
Cost FY03:	Quarter 1 (October-December, 2003): $39.2 Quarters 2-4: $53.0
Cost FY04:	
Geographic Area:	Prince William Sound, Kenai Peninsula
Injured Resource/Service:	N/A

ABSTRACT
This project will design and produce a draft GEM community involvement and community-based monitoring plan to address the needs of diverse communities in the region. This initiative be informed by 1) a case history review of working models of community-based monitoring efforts relevant to the GEM conceptual foundation 2) a regional capacity assessment to identify potential partnerships, 3) issues and indicators as identified by CRRC's Tribal Natural Resource Management Planning Process and other community planning processes. Recommendations will include identifying new approaches to melding Western science and local and traditional knowledge and pilot community-based monitoring projects.

INTRODUCTION

The Exxon Valdez Oil Spill Trustees Councils (EVOSTC) has provided numerous opportunities for significant community involvement in all aspects of the EVOS restoration program. A recent EVOSTC report (March 4, 2002) summarizes the extensive efforts and actions undertaken to date to involve tribes, communities, stakeholders, and the general public. The report highlights a continuing commitment to public and community involvement and expresses the Council's hope for expansion of these efforts as the GEM program develops. This "clear desire" to incorporate community involvement and Traditional Ecological Knowledge into the overall GEM program is recognized in the National Research Council review of the draft GEM programmatic document. The NRC review included a conclusion that the involvement of local Native, fishing, and other communities was an appropriate and necessary component of GEM.

In 2000, Dr. Ted Cooney was contracted by the Chugach Regional Resource Council (CRRC) to review issues and considerations for a long-term citizen's monitoring program for the Northern Gulf of Alaska. He reviewed issues of program structure and their relationships to the broader goals of GEM, of measurement standardization and quality control, and of data archival and access. He concluded that a citizen's coastal monitoring program (CCMP) would be ideally suited for describing important spatial and temporal differences in coastal marine micro-habitats using the infrastructure of Native corporations and corporation villages, towns, salmon hatcheries at remote locations, marine stations, and private eco-businesses scattered throughout the region. His report (Cooney 2000) states that "Properly coordinated, observations from this matrix of sites could capture the complex responses of near-shore waters to larger-scale changes occurring in the open Gulf of Alaska associated with shifts in global climate or other events – a primary goal of GEM." He recommended that the planning process for the CCMP must (at least initially) be an inclusive activity.

A number of efforts to develop and support citizen monitoring are underway in the region. The Center for Alaskan Coastal Studies has organized a beach monitoring program, Kachemak Bay Coastwalk, for 17 of the last 20 years. Other efforts include the Cook Inlet Keeper Citizen Environmental Monitoring Program for water quality monitoring and the University of Alaska Fairbanks Sea-Air-Land Monitoring and Observation Network (SALMON) Project.

During the period 1995 to the present, the Trustee Council has provided funding to the CRRC to respond to the interest in community involvement in EVOS restoration planning and research. From 1995 to 2001, CRRC employed a region-wide community involvement coordinator and employed and coordinated the activities of community facilitators in ten spill area communities. These community facilitators served as the link between EVOS and these communities for the purposes of providing outreach from EVOS, provided a primary contact for the EVOSTC and staff and facilitating communications, and promoted community-based restoration projects. More recently, the facilitators have provided tribal input into the development of GEM. CRRC is also working with each Tribe and several pilot villages to integrate restoration activities and planning for GEM involvement into Tribal Natural Resource Management (TNRM) Plans and implementing programs as well as a Chugach Region Integrated Tribal Natural Resource Management Plan and program. CRRC is submitting a FY03 EVOS proposal (Project Number 03052) to develop common areas of interest between TNRM programs, their Management and Action Plans, and the GEM program. In particular, they propose to develop research and monitoring plans in five pilot communities,

including project identification and training needs for Eyak, Nanwalek, Ouzinkie, Port Graham, and Tatitlek in FY03.

NEED FOR THE PROJECT:

A. Statement of the Problem:

The EVOSTC commitment to tribal and community involvement in GEM is clear. "The challenge then", according to the NRC review comments of the GEM Draft Programmatic document, "is not whether community involvement is warranted but how to build such involvement in a meaningful way." The review comments continue: "Community involvement needs a foundation (simple, robust, and adaptable) that permits the local issues to be addressed in a meaningful way from the very beginning of the program. . . . Communities must have a role in helping define what will be done and where it will be done." The Committee explicitly recognized the importance of direct involvement in research and monitoring: "They must also be involved in actively conducting the research, analyzing data, and disseminating the results to members of the community." The committee further recommended that power and opportunity be shared between scientific and local communities and explicitly recommended against autonomous community GEM programs or required community involvement components for every GEM project.

The EVOSTC has designed and implemented successful projects and processes for community involvement in restoration efforts. Although GEM transition planning has been on-going for several years, however, a transition plan for a GEM community involvement program has not yet been developed. A transitional process is needed to switch from the promotion of community activities and projects allied with restoration objectives to a structured and comprehensive suite of opportunities to become meaningfully and directly involved in activities and projects relevant to the long-term monitoring and research activities associated with the GEM program.

Community involvement in GEM will have a broader geographic scope and additional regional stakeholders compared to community involvement initiatives under EVOS restoration program. CRRC has had a primary focus on the seven tribal governments in the Chugach Region that make up the Resource Council and EVOS Community Involvement Facilitators have typically been employees of the tribal government in each community. This proposal addresses the need to design and pilot GEM community involvement planning and development of community-based research and monitoring in both Native and non-Native communities by integrating on-going CRRC planning efforts into a broader GEM framework and with an expanded partnership with community-based science/environmental education organizations in Prince William Sound (Prince William Sound Science Center) and Lower Cook Inlet (Center for Alaskan Coastal Studies) . The project will also identify strategies to link GEM community-based efforts and GEM scientist-directed activities and to link community-based research and monitoring efforts with education/outreach efforts to increase understanding about the Gulf Ecosystem, the dynamics of environmental change, and stewardship of natural resources.

Cooney (2000) focused on issues and aspects of monitoring by citizens related to the collection of data that was both valid and relevant the scientific priorities of the GEM Program. He primarily looked at citizen monitoring from the perspective that scientific priorities and efficiencies of data

collection would drive the priorities. The table on the next page compares the approach taken by scientists and a community-based approach. From the standpoint of the public and local communities, the relevancy and saliency of issues and concerns will drive the interest and commitment of citizens to become involved in the GEM program in general and to participate in GEM monitoring or research. This table does not suggest that these approaches are oppositional or polarized. Rather its aim is to depict the ways that differently positioned GEM monitoring partners have somewhat different approaches to understanding the same environments.

Table 1.

Scientific Approach to Monitoring	**Community- Based Approach**
	What are the issues of concern at the local scale that would be affected by regional and global-scale environmental changes?
What is the conceptual framework for understanding change at the scale of an "ecosystem" or region?	What is the conceptual framework for understanding how these changes will affect resources of concern?
What are the key and significant indicators of environmental change at that scale?	What are the appropriate environmental indicators of change relative to the issues of concern?
How and where can these indicators best be detected? - Scientifically-valid sampling - Cost Effective sampling	How can these indicators best be detected? - Scientifically-valid sampling - Collection of meaningful local observations and TEK
How will date be stored, retrieved and interpreted?	How can community-derived data be stored, retrieved, interpreted and shared with scientists?
How will data interpretation and the synthesis of results be accomplished to determine what they mean in the context of conceptual framework?	How will the synthesized results of local and regional –scale monitoring be communicated in the context of the issues of concern?

The inherent challenge of the community involvement and monitoring planning process is the identification of the overlap between community issues of concerns and goals and priorities of GEM. As noted by the NRC Review Committee, this must be accomplished at the outset of the program. In the long-term, an "adaptive management" process will be required to sustain relevancy.

Institutional and cultural barriers exist in the scientific community that thwart the acceptance and perceived validity of community-based monitoring / citizen science data by scientists and natural resource agencies. Incentives for scientist partnerships with communities and students or citizens are generally lacking. The EVOSTC and the NRC Committee both recognize the overriding need for public and community "buy in" to long-term environmental monitoring and the potential for direct participation in monitoring to translate to improved understanding and stewardship of natural

resources. To address this overriding need, design of a community involvement and monitoring component which is integrated with the framework and goals of GEM is needed

B. Rationale/Link to Restoration

This project would extend the community involvement that has occurred throughout the EVOS restoration phase under the leadership of CRRC and develop the framework and components of monitoring activities that will be included in GEM.

C. Location

Project partners are based in Cordova, Homer, and Anchorage. Pilot communities for the planning process will be Eyak, Nanwalek, Ouzinkie, Port Graham, Tatitlek Homer, and Cordova

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

The focus of this project is the design of effective mechanisms for incorporation of community involvement and traditional knowledge into the GEM Program.

PROJECT DESIGN

A. Objectives

1. To design and draft a proposed GEM framework for community involvement and community-based monitoring and research.

2. To assess the regional capacity and issues of concern for community-based monitoring.

3. Research effective existing community involvement / community-based monitoring case studies and develop a searchable "case history" database for the model projects.

4. To identify potential community-based monitoring pilot projects relevant to the GEM conceptual framework for FY04.

5. To develop review criteria for community-based GEM project proposals and community involvement components of scientific project proposals.

B. Methods

The project will be conducted by a Project Team that includes:

- Chugach Regional Resources Commission
    - Patty Brown-Schwalenberg, Executive Director
    - Paul McCollum, Fisheries and Natural Resource Consultant
    - Henry Huntington, consultant in Traditional Ecological Knowledge
    - Ted Cooney, consultant in citizen monitoring

- Center for Alaska Coastal Studies
  - Marilyn Sigman, Executive Director
  - Joe Spaeder, Traditional Ecological Knowledge and Community Natural Resource Planning consultant
- Prince William Sound Science Center
  - Gary Thomas, Executive Director
- Tribal Natural Resource Professionals
  - Gary Kompkoff, Tatitlek Natural Resource Coordinator
  - Jim Miller, Port Graham Natural Resource Specialist

There are a number of potential dimensions to community involvement in GEM. The initial framework will include design work addressing several community involvement components including:

1) Recommendations for an integrated community-based monitoring component of GEM with special attention to recommendations about how to link local ecological knowledge with information collected by agencies and external scientists. Sub-components may include:
   a) Scientist-directed projects for which data collection by that is critical to the project objectives,
   b) Scientist-directed projects that include data collection by citizens and K-12 students to replicate or extend sampling beyond that which is critical to the project objectives,
   c) Community or school-based data collection projects working cooperatively with scientists or employing scientist-validated data collection protocols, and
   d) A regional citizen observer and information network with centralized database and support system

2) Community involvement in planning and implementation of GEM scientist-directed projects

3) Community involvement in development of future GEM goals and priorities.

Additional components will be developed in consultation with EVOS staff.

Quarter 1 (October 1- December 31, 2002):

1. **Community Monitoring Capacity Assessment:** The CACS and PWSCC education/outreach specialists will begin development of a comprehensive list of potential partners, regionally or by community, for community-based monitoring relevant to the GEM Program and research potential funding sources. The review will incorporate the results of a statewide inventory of organizations providing training for adult audiences related to coastal management issues and technologies that will be completed by the Kachemak Bay Research Reserve in summer, 2002, and an inventory of Southcentral Alaska environmental education programs compiled by the Alaska Natural Resources and Outdoor Education Association for a meeting in August, 2001. CRRC staff and consultants will work to develop descriptions of technical capacity, training needs, and responsible parties for implementing monitoring and research components of Action Plans for communities involved in the development of Tribal Natural Resource Management Plans. To be completed by forth quarter.

2. **Survey / Literature Review of existing Community Involvement / Community-based Monitoring cases studies:** The CACS and PWSSC education/outreach specialists begin the review of projects and project components against criteria developed by the Project Team. They will begin with an initial list (Table 2), as well as case studies identified by EVOS staff and conduct a literature, WEB, and listserve search and review for other relevant community-based monitoring and research projects, including past and on-going EVOS projects that involve a community involvement, citizen data collection or TEK or local knowledge component.

   Information on each of these working models will be entered into a searchable database with emphasis on identifying the indicator or parameter that was measured with citizen participation and community issues or concerns addressed by the project or program. Project leaders will be contacted by telephone or email to obtain additional information if needed. Based on their review and the screening criteria developed by the Project Team, they will work with the CACS and PWSSC Executive Directors to develop recommendations to the Project Team for the selection of model projects or project elements to be developed as case histories.

3. **Initial Community Involvement and Monitoring Planning Session:** The Project Team will meet for a strategic planning session with EVOS staff in Homer to:

a) Perform an initial review of on-going efforts by the project partners and other efforts within the region in community involvement and community-based monitoring and research
b) Plan an expanded regional and community capacity assessment for community-based monitoring.
c) Review sources of information about the "priority issues" or concerns of specific communities including the status of identifying these issues through Tribal Natural Resource Management planning process.
d) Design a community involvement process and develop an initial framework for the GEM Community Involvement/Community-based Monitoring and Research Plan including an Alaska Coastal Community Ecological Knowledge and Information Network (Alaska CCEKIN).

Table 2.

Example of Issue/*Indicators*	**Model Citizen-based Project (s)**	**Relevant EVOS Project(s) or Data Collection Method(s)**
Reduced Productivity of Intertidal Species Harvested for Subsistence/*Intertidal Biodiversity Index*	Island County/Washington State University Beach Watchers Replicate larval settlement study, Nanwalek and Port Graham GLOBE (Coastal Protocols)	Shoreline Mapping & Intertidal Transect/Quadrant Sampling (protocols under development)
Shoreline Erosion/*Beach Profile*	Island County/Washington State University Beach Watchers	
Reduced Productivity of Subtidal Species Harvested for Subsistence/*Abundance in Index Areas, Predator Diet Items*	Recreational Diver Surveys	USFWS Halibut Stomach Contents Sampling
Water Pollution/*Water Quality Parameters*	Keeper Projects (e.g., Cook Inlet Keeper CEMP) GLOBE (Hydrology Protocols) UAA/ENRI Stream Bio-Assessment Project	
Climate Change Effects/*Ocean Water Temperature Patterns*	GLOBE data-loggers (continuous water temp. sampling)	Remote sensing Ships-of-opportunity plankton sampling
Population declines in marine birds/*winterning populations*	Audubon Christmas Bird Count B.C. Waterbird Survey Program COASST beached bird surveys (University of Washington) Beach COMBERS (Monterey Bay)	Youth Area Watch seabird surveys, Seabird colony monitoring (USFWS)
Population declines in marine mammals/*stomach contents, nutritional status*	Beached marine mammal surveys Strandings Networks	Sea Otter Boat Surveys Harbor Seal Tissue Bio-assays
Contaminants in Subsistence Food Items/*Contaminant Levels*	Native American Fish and Wildlife Foundation "off the plate" sampling Mussel Watch Program	Youth Area Watch pristine sampling of mussels Food Safety sampling projects
Loss of shoreline and nearshore habitat to development/*effects of shoreline development projects*	CACS Kachemak Bay Coastwalk Citizen GIS projects	Shoreline mapping
Putting climate change into a long-term perspective/*long-term climate observations*	GLOBE Native elder survey protocol	Hind-casting with isotope ratios (e.g, bowhead whale baleen)

Quarters 2-4:
The Project Team will hold two more meetings to:
1) Draft and edit a proposed framework document.
2) Develop plans or strategies for partnerships or networks based on the results of the assessment of regional and community capacity for community-based monitoring and research.
3) Develop review criteria and recommendations for multi-partner pilot projects for FY04.
4) Work with EVOS to develop a public review process and inclusion of review comments.

Project Team members Henry Huntington, Joe Spaeder and Paul McCollum will work with P.I. Marilyn Sigman to write the final draft Community Involvement/Community-based Monitoring and Research Plan. Henry Huntington will serve as document editor. They will circulate the draft document to other Project Team members and to potential participants (scientists and community groups and members) in GEM community involvement/community-based monitoring and research for review prior to the second and final Project Team meeting.

The final project report will include a recommended GEM Community Involvement Plan, case histories, and recommended GEM pilot projects in terms of suitable indicators, feasible monitoring methods, and potential scientist partnerships related to priority issues for communities as identified in Tribal Natural Resource and Management Plans and other community planning efforts.

C. Cooperators and Contracts

Cooperators:
Center for Alaskan Coastal Studies
Chugach Regional Resource Council
Prince William Sound Science Center

Contractors:
Joseph Spaeder
Henry Huntington
Ted Cooney

SCHEDULE

A. Measurable Project Tasks for FY03 (October 1, 2002 – September 30, 2003)

Date:	**Task:**
By October 31:	Searchable database developed and literature review underway
By November 20:	Preliminary Community Monitoring Capacity Assessment completed and circulated to Project Team Recommendations for candidate case histories circulated to the Project Team
By December 1:	Project Team Meeting
By December 15:	Project Status Report provided to EVOS

B. Project Milestones and Endpoints

September 2003: Review criteria and identification of pilot potential projects for FY04.
Community Involvement/Community-based Monitoring Plan submitted to EVOS
Searchable database of community-based monitoring programs and case histories completed
Final report submitted to EVOS.

Completion Date

September 30, 2003

PUBLICATIONS AND REPORTS

Framework for Community-based Gulf Ecosystem Monitoring and Research and an Alaska Coastal Community Ecological Knowledge and Information Network (Alaska CCEKIN), Draft and final project report to EVOSTC
Case Histories and Searchable Database of Community-based Monitoring and Research Projects

PROFESSIONAL CONFERENCES

Alaska Statewide Environmental Education Conference, November, 2002. Presentation of project goals and discussion about effective community involvement and citizen science projects.

NORMAL AGENCY MANAGEMENT

This section N/A. Cooperators are non-profit organizations.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This community outreach effort is in fact a novel effort to coordinate the Restoration Program with the Tribal Natural Resource Management Programs and builds on the established relationship between CRRC and the communities in Cook Inlet and Prince William Sound. CRRC is partnering in this proposal with the Center for Alaska Coastal Studies and the Prince William Sound Science Center. Other organizations that have been involved in EVOS outreach and community involvement projects during the restoration phase will be invited to participate in the review of the framework and identification of priority issues and potential partnerships and pilot projects.

PROPOSED PRINCIPAL INVESTIGATOR, IF KNOWN

Marilyn Sigman
Center for Alaskan Coastal Studies

P.O. Box 2225, Homer, Alaska 99603
(907) 235-6667
(907) 235-6668 (FAX)
cacs@xyz.net

Qualifications:

Ms. Sigman is the Executive Director of the Center for Alaskan Coastal Studies. She has directed their school and community education and been the organization's administrator since 1998. She is experienced in the administration of educational program budgets, contracts, and grants; management of field facilities and field travel, supervision of employees, and recruitment and training of large numbers of volunteers. Ms. Sigman has an in-depth knowledge of Alaska's coastal ecosystems and resource management issues and experience in program and project management that focuses on coastal ecosystems and facilitating linkages among the scientific, education, and local communities. She was Project Director of the EPA-sponsored Tillamook Bay National Estuary Project from 1993-96 where she developed and facilitated the integration of community involvement and scientific research in the context of developing solutions to watershed management issues. She also served as the regional coordinator for the Alaska Department of Fish and Game Conservation Education and Watchable Wildlife Program in Southeast Alaska from 1990-93, and statewide coordinator for the ADFG Wildlife Curriculum Program from 1988-92 for which she was primary writer/editor of a "Wetlands and Wildlife" curriculum that won national recognition from the Department of Interior. She was also the Regional Habitat Biologist for Southeast Alaska from 1982-88 and participated in state and federal land use planning teams for management of tidal and submerged lands and forests and also served on the inter-agency committee that developed regulations to implement the Alaska Coastal Management Program.

OTHER KEY PERSONNEL

Patty Brown-Schwalenberg:
Ms. Brown is the Executive Director of the Chugach Regional Resources Commission (CRRC) since 1994. She assists the Chugach Region Tribes in developing their Tribal natural resource programs, developing projects that stimulate the local community economy, and addressing issues and concerns directly related to subsistence and natural resources. She has worked for the past 19 years in such positions as Tribal Administrator for her Tribe, the Lac du Flambeau Band of Lake Superior Chippewa Indians, Society Administrator for the Native American Fish & Wildlife Society, Office Manager of the Bering Sea Fisheries Development Fund, and as a private consultant, assisting Alaska Native Tribes in obtaining funding for natural resource management programs, and setting up their natural resource program administrative systems. CRRC and the previous organizations that Ms. Brown has operated have consistently met all standards of proper management, including annual program and financial audits.

Paul McCollum:
Mr. McCollum is the owner and chief biologist of Sound Fisheries and will serve as the project consultant for CRRC. He is a fisheries biologist with 30 years of experience in Alaskan fisheries research, enhancement and management projects. He is contractually employed by CRRC as the

Natural Resource and Fisheries Consultant and also contracted by the Port Graham Village Council working on Fisheries, Natural Resources and Environmental projects. He works closely with the Port Graham Hatchery staff, providing training, education, and consulting advice for all aspects of the project. He also works directly with the Nanwalek Tribal I.R.A. council providing consultation and technical assistance with their fisheries, natural resources and environmental projects and programs. He works with the Port Graham and Nanwalek Schools from time to time, helping to bring fisheries and natural resource issues into the classroom.

Dr. Henry Huntington:

CRRC has contracted with Dr. Huntington to serve as the TEK Specialist. Dr. Huntington received his Ph.D. at the University of Cambridge (U.K.), Scott Polar Research Institute in Polar Studies. He has served as the Environmental Coordinator for the Inuit Circumpolar Conference (ICC), coordinating ICC policy regarding the Arctic Environmental Protection Strategy (AEPS), in cooperation with indigenous organizations in Russia and Scandinavia. He was also responsible for traditional ecological knowledge and other research projects under the auspices of the AEPS.

Dr. Joseph Spaeder:

Dr. Spaeder is a consultant and researcher based in Homer, Alaska. His research examines the role of local knowledge systems in resource management; the design of wildlife and fisheries co-management regimes and most recently, building broad-based coalitions between state, federal and native institutions to support improved conservation and management of subsistence fisheries. In Western Alaska's Yukon-Kuskokwim region he has conducted research on the evolution and performance of co-management regimes for managing caribou, waterfowl and brown bear. He is currently involved with traditional ecological projects in two Bering Sea coastal villages and serves as a fisheries consultant for the Association of Village Council Presidents. He holds a Ph.D. in Ecology from the University of California-Davis.

Dr. R. Ted Cooney:

Dr. Cooney has recently retired from the University of Alaska-Fairbanks where he served on the faculty as a biological oceanographer for 29 years. Dr. Cooney has been involved with many studies of Alaska oceanic, shelf and coastal zooplankton stocks. He has worked on, and published extensively in the area of salmon oceanography. Most recently, Dr. Cooney was designated by the EVOS Trustee Council as the Lead Scientist for the Sound Ecosystem Assessment (SEA) Program in Prince William Sound, 1994-1999. His work with the juvenile salmon ecosystem over a 20-year period helped to create the spring-time plankton watch at hatcheries operated by the Prince William Sound Aquaculture Corporation.

Dr. Gary Thomas:

Dr. Gary Thomas is the President of the Prince William Sound Science Center in Cordova, Alaska, the Executive Director of the Prince William Oil Spill Recovery Institute and a principal investigator on plankton and nekton acoustics research projects. He has been responsible for developing an ecosystem research and education program, implementing a granting program to fund technology, ecology and educational grants. He has presented more than 20 invited papers at international, national and regional professional meetings and contributed many more, chaired a number of scientific fisheries symposia. Dr. Thomas received a PhD in Fisheries Science from the College of Fisheries, University of Washington, Seattle, WA.

LITERATURE CITED

Cooney, R. Ted. On the development of a long-term citizen monitoring program for the coastal Northern Gulf of Alaska. Report to the Chugach Regional Resource Council. September 29, 2000. 13 pp. Mimeo.

EVOS tribal and community involvement. EVOS Staff Report. March 4, 2002. 4 pp. Mimeo.

National Research Council. The Gulf Ecosystem Monitoring Program: first steps toward a long-term research and monitoring plan. Interim Report. February 2001. National Academy Press, Washington, D.C.

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2002 - September 30, 2003

Budget Category:	Authorized FY 02	Proposed FY 03
Personnel		$16.2
Travel		$5.1
Contractual		$10.0
Commodities		$0.8
Equipment		$2.0
Subtotal	$0.0	$34.1
Indirect		$5.1
Project Total	$0.0	$39.2
Full-time Equivalents (FTE)		0.4
Other Resources (CRRC in-kind)		$5.0

LONG RANGE FUNDING REQUIREMENTS					
Estimated FY 04					

Dollar amounts are shown in thousands of dollars.

Comments:
Indirect: CACS's indirect amount is 15%. This includes costs of general office operation.
NEPA Compliance Not applicable to this project.
Professional Conferences: Statewide Environmental Education Conference -RT travel, Homer-Anchorage, and per diem incldded in travel
Community Involvement - 100% of this project.

This detailed budget is for FY03, Quarter 1
Estimated budget for Quarters 2-4: $53.0
(Includes Annual EVOS Conference Attendance, Report Writing, Pubilcations)

FY03

Prepared: 4/14/02

Project Number: 03575
Project Title: Designing a Community Involvement/Community-based Monitoring Project for GEM
Name: Center for Alaskan Coastal Studies

FORM 4A
Non-Trustee
SUMMARY

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 03
M. Sigman	CACS Executive Director		1.0	5.0		5.0
	CACS Education/Outreach Asst.		2.0	2.3		4.6
G. Thomas	PWSSC Educ./Outreach Prog. Coord.		0.2	14.0		4.2
	PWSSC Educ./Outreach Prog. Coord.		2.0	4.8		9.6
P. Brown-Schawelberg	CRRC Executive Director (in-kind)					0.0
P. McCollum	CRRC Fisheries & Nat. Res. Consultant (in-kind)					0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		5.2	26.1	0.0	
					Personnel Total	$23.4

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 03
G. Thomas, Cordova-Homer, attend Project Team meeting		0.5	1	3	0.1	0.8
G. Kompkoff, Tatitlek-Homer, attend Project Team meeting		0.6	1	3	0.1	0.9
J. Miller, Port Graham-Homer, attend Project Team meeting		0.1	1	2	0.1	0.3
T. Cooney, Anchorage-Homer, attend Project Team meeting		0.2	1	2	0.0	0.2
H. Huntington, Anchorage-Homer, attend Project Team meeting		0.2	1	2	0.1	0.4
P. Brown-Schwalenberg, Anchorage-Homer, attend Project Team mee		0.2	1	2	0.1	0.4
M. Sigman, Homer-Anchorage, presentation at statewide Env. Ed. mee		0.2	1	3	0.1	0.5
PWSSC Education/Outreach Program Coord., Cordova-Homer, coordi		0.5	1	3	0.1	0.8
M.Sigman, Homer-Anchorage, meet with consultants to plan work		0.2	2	2	0.1	0.6
J. Spaeder, Homer-Anchorage, meet with other consultants to plan and		0.2	1			0.2
						0.0
						0.0
					Travel Total	$5.1

FY03

Prep 4/14/02

Project Number: 03___
Project Title: Designing a Community Involvement/Community-based Monitoring Project for GEM
Name: Center for Alaskan Coastal Studies

FORM 4B
Personnel
& Travel
DETAIL

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2002 - September 30, 2003

Contractual Costs:	Proposed
Description	FY 03
Joe Spaeder, consultation on community involvement, case histories, and integration of TEK	3.5
Henry Huntington, consultation on community involvement and integration of TEK	3.0
Ted Cooney, consultation on design of community-based monitoring	3.0
Gary Komkoff consultation on local community planning	0.3
Jim Miller, consultation on local community planning	0.2
Contractual Total	$10.0

Commodities Costs:	Proposed
Description	FY 03
Teleconference & telecommunication expenses	0.8
Commodities Total	$0.8

FY03

Prepared: 4/1/402

Project Number: 03___
Project Title: Designing a Community Involvement/Community-based Monitoring Project for GEM
Name: Center for Alaskan Coastal Studies

FORM 4B
Contractual & Commodities DETAIL

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2002 - September 30, 2003

New Equipment Purchases:		Number	Unit	Proposed
Description		of Units	Price	FY 03
1	Laptop Computer & ACCESS software	1	2.0	2.0
				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**	$2.0

Existing Equipment Usage:	Number
Description	of Units

FY03

Prepared: 4/1/402

Project Number: O3_____
Project Title: Designing a Community Involvement/Community-based Monitoring Project for GEM
Name: Center for Alaskan Coastal Studies

FORM 4B
Equipment
DETAIL

Title: Evaluation of Airborne Remote Sensing Tools for Gulf Ecosystem Monitoring and Research (GEM) Monitoring

Originally submitted under: Innovative Tools and Strategies to Improve Monitoring; page 31 FY02 Invitation

Project Number:	03584
Restoration Category:	Monitoring; GEM Transition
Proposer:	P.I., Evelyn D. Brown, University of Alaska Fairbanks (UAF) School of Fisheries and Ocean Sciences Co-P.I. James H. Churnside, National Oceanic and Atmospheric Administration (NOAA) Environmental Technology Laboratory (ETL), Boulder, CO
Lead Trustee Agency:	Alaska Department of Fish & Game (ADF&G)
Cooperating Agency:	NOAA
Alaska Sea Life Center:	No
Duration:	2nd year of proposed 3-year project; reduced to 2 years total
Cost FY02:	$41.5 K ($8.2K to NOAA, the remainder to UAF and ADF&G overhead)
Cost FY04:	$0K
Geographic Area:	Prince William Sound and Northern Gulf of Alaska
Injured Resources:	Potential survey species include sea birds (common murre, marbled murrelet, pigeon guillemot) and fish (Pacific herring, pink salmon, sockeye salmon)

ABSTRACT

This is the year-two completion phase for a project initiated in FY02 with data collection from July 2002. The main objective is an evaluation of airborne remote sensing tools for GEM ecological interpretation of the data collected. The instrument package consists of: 1) a pulsed lidar to map subsurface features to a maximum of 50 m; 2) an infrared radiometer to map Sea Surface Temperature (SST) day; 3) two 3-chip digital video systems to map ocean color (chlorophyll), birds, mammals, surface fish schools, and ocean frontal structure; and 4) an infrared digital video to map birds and mammals at night. We will use shipboard and buoy data for validation and interpretation of remotely sensed data.

INTRODUCTION (duplication of FY02 proposal)

Biological assessment and ecological study of marine pelagic resources poses severe challenges from high cost and logistical difficulty to an inability to adequately address issues of spatial and temporal scale. Ship surveys in Alaska are severely limited by storm activity, high cost, overbooking, and year-in-advance scheduling. In addition, ships and acoustics have depth limitations that miss shallow, nearshore regions and the near surface. Ship avoidance behavior, by fish and their predators, affects results and sampling nets disturb biological features from their natural orientations. Finally, the slow speed of ship travel precludes the understanding of short term or ephemeral events and cannot provide a synoptic view of the study region over short time scales. Biological relationships shift diurnally and with the tides, storm events restructure ocean fronts along with the biological structure that attracts fish and their predators, and predator-prey associations are often spatially patchy and short-lived. Data from satellites shows promise in helping to solve some of these problems, but frequent cloud cover is a problem in Alaska. All of these issues can be addressed by using increasingly high-speed, cost-effective data collection tools that can document structure in real time, without disturbance, and that can be used to supplement satellite data on cloudy days; i.e. airborne remote sensing and visual survey methods.

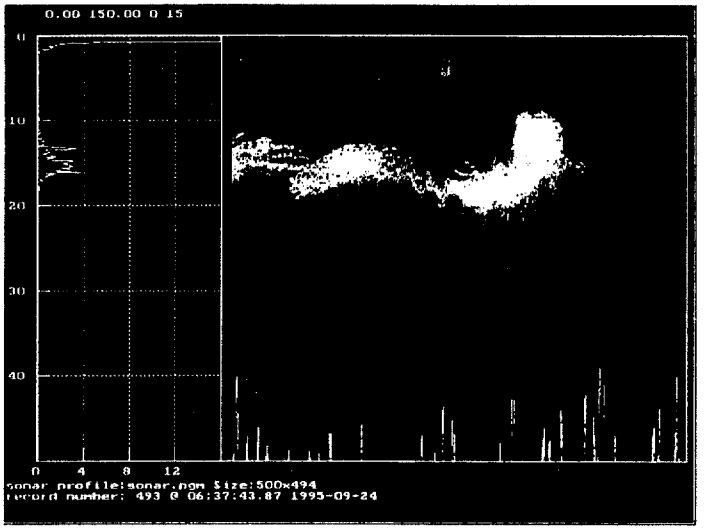
Airborne remote sensing and visual survey methods cost less than 10% of a ship survey per survey kilometer and depth penetration has been improved to more than three times the visual range with the use of lidar (described here). The synoptic views that aerial surveys provide are more appropriately coupled with satellite images in temporal scale than ship board results and data from airborne remote sensing instruments can be used to interpret and expand missing or low resolution images from satellite data. Biological features are observed in real space and time without complications from ship avoidance behavior and disturbance of biological structure (as with net sampling). Airborne remote sensing shows particular promise for the field of marine ecology in determining predator-prey relationships, capturing ephemeral biological events, and defining spatial and temporal scale. The accuracy of remotely sensed data is improved by adaptive or "response-type" ship sampling. Using adaptive ship sampling and new technology in underwater digital video and plankton recorders, the overall cost of obtaining the information required could dramatically decrease.

Airborne lidar (light detecting and ranging) is a tool that shows promise for marine research. One form of lidar produces short pulses of green laser light, which pass through the water surface, reflects off fish and particles in the water, and returns to a receiver on the instrument. The strength of the returning pulse separates fish targets from small particles and the elapsed time indicates the range or depth of the object. When coupled with other instruments on a single platform, such as multi-spectral imagers, infrared and/or microwave radiometers, and infrared cameras, physical and biological parameters can be collected simultaneously. Surface and subsurface features, such as zooplankton layers, fish schools, large individual fish, marine mammals, sea birds, oceanic fronts, sea surface temperature and salinity, and chlorophyll blooms are recorded to depths where light signals are attenuated.

The use of lidar and multi-spectral imagers are not new to ocean science. Squire and Krumboltz (1981) were among the first to experiment with optical lasers and other remote sensing devices for the purposes of fish surveys. Gauldie (1996) provided a review of lidar applications to fisheries management, mainly concerned with obtaining fish abundance and distribution information. Krekova et al. (1994) provided a numerical evaluation of remotely sensing fish schools with lasers; however, lidar applications are not limited to schooling fishes. Development

of airborne lidar fisheries applications was greatly enhanced by Dr. James Churnside and his research team from the National Oceanic and Atmospheric Administration (NOAA) Environmental Technology Laboratory (ETL). They constructed and tested the Fish Lidar Oceanic Experimental (FLOE) system from off-the-shelf components and developed several signal processing techniques to discriminate between returns from fish and from small particles in the water (Churnside et al., in press). The FLOE system has been used off the coast of California to survey anchovies, sardines (Churnside et al., 1997; Hunter and Churnside, 1998; Lo et al., 1999) and more recently squid as well as sardines off the coast of Spain (Churnside et al., in press) and Pacific herring off the coast of Washington State. Comparisons of lidar to acoustic data have been very encouraging (Figure 1).

A.



B.

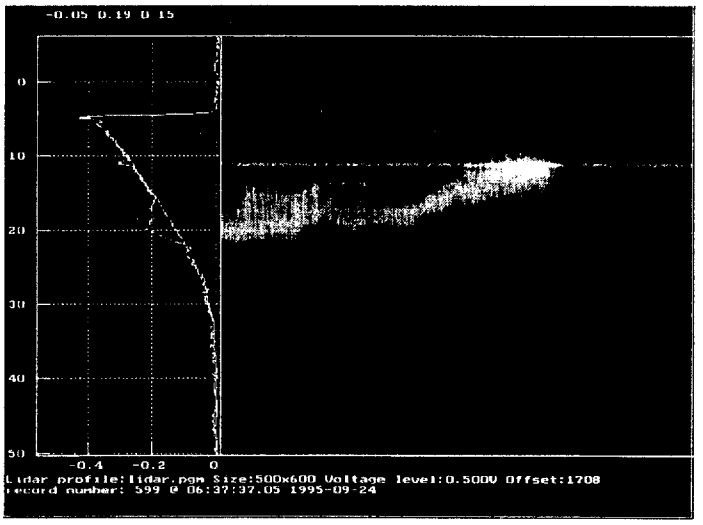
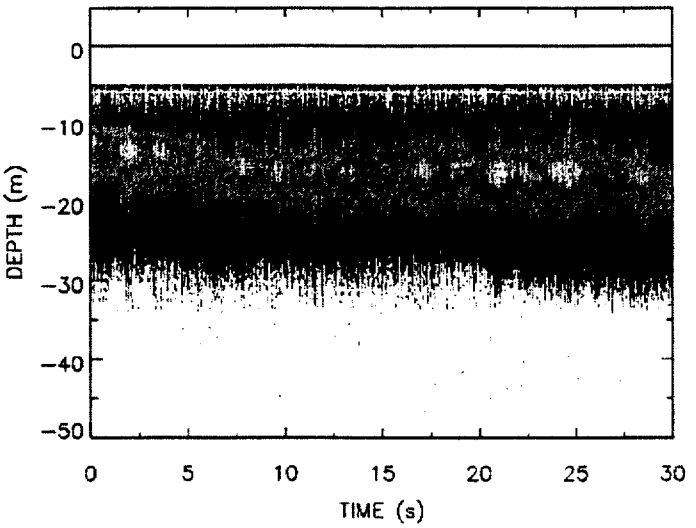
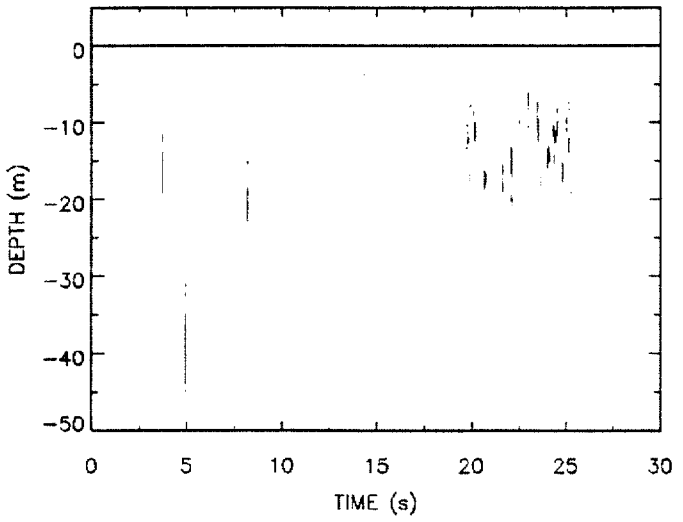


Figure 1. A comparison of signal reflection from a school of anchovy by shipboard acoustics (A) and by lidar (B; post-processed image). The images were collected synoptically (Churnside et al. 1997; http://www1.etl.noaa.gov/lidar/index.html).

Airborne lidar has also been used to detect subsurface oceanic scattering layers (Hoge et al., 1988) as well as zooplankton layers and marine mammals (Figure 2).



A.



B.

Figure 2. Examples of plotted lidar output taken at approximately 200 m in altitude at 225 knots airspeed where time here represents linear space; zooplankton imbedded with scattered fish targets (A) and dolphins (B) are shown. Each image is 30 s of data and about 900 shots from the laser; traveling at 75 m/s, this is about 2.5 km.

In the summer of 2000 the FLOE system was coupled with a digital imager and field tested in the North Pacific. Flown at 1000-ft altitude, the measured swath was about 5 m during the day and 7 m at night. The imager was a high-resolution video camera equipped with a tunable spectral filter

capable of capturing ten different bandwidths within the visual range and an adjustable focal length as well as frame-capture rate. The swath width of the imager is altitude and focal length dependent but ranged from 150–200 m at 1000 ft altitude. Both instruments were mounted side-by-side and angled down looking at about a ten-degree angle from a camera port and window port in a twin-engine aircraft (Figures 3 and 4). Data from each instrument was stored electronically and processed later with custom software. The lidar data signal processing and output is similar to acoustic data. Flights were coordinated with three ongoing marine research programs with varying objectives. Surveys were flown in British Columbia, northern southeast Alaska, in Prince William Sound, Alaska, and over the continental shelf in the Gulf of Alaska. Surveying at 120 knots, 222 km was surveyed per hour. Features captured using the lidar included plankton and euphasid/amphipod layers, fish schools (Figure 5), larger individual predators, and fine detail of biological structural changes at ocean fronts. The penetration depth was 15–30 m in inside waters (non-silty) and up to 50 m in outside waters over the continental shelf. Penetration was much better at night due to an increased field of view with no background light interference. The imager captured sea bird and mammal configurations, fish schools (Figure 6), and changes in ocean color/front structure (Figure 7). Both data types are binned in cells with a 2-D array of image data underlain with a 3-D array of lidar data. A 3-D geo-referenced visualization is produced that can be analyzed using spatial statistical methods with linked Geographical Information System (GIS) and spatial statistics software. We are in the process of completing analysis of the data from this study. However, the processing steps are listed here in methods since we propose to follow similar steps.

Figure 3. Aircraft used for the lidar/imager surveys in the North Pacific.

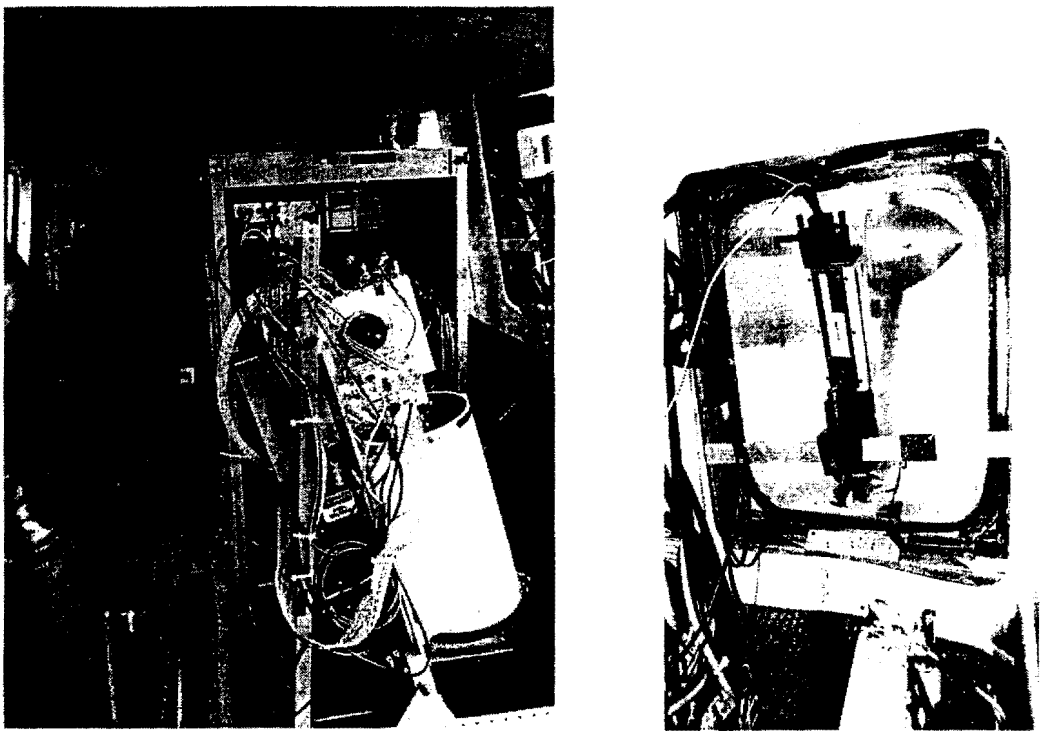


Figure 4. The photograph on the left is the NOAA-ETL fish lidar (telescope in the fore view with the hardware rack behind) mounted in the survey aircraft used in the summer of 2000. The photograph on the right shows the digital imager mounted in the window.

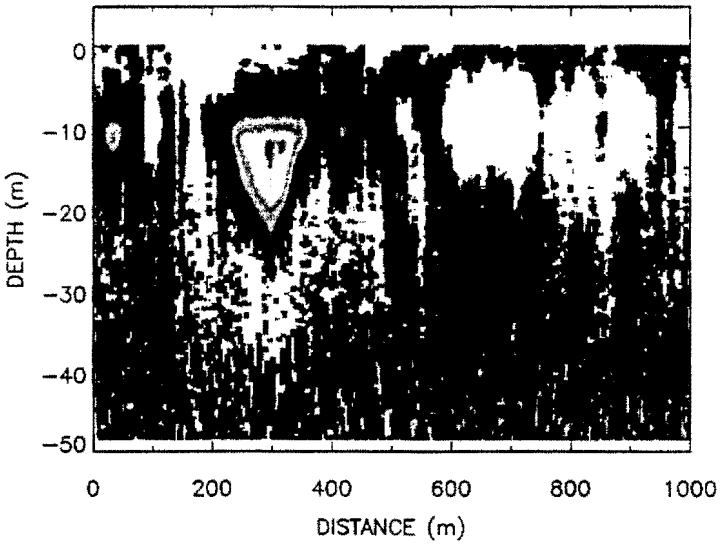


Figure 5. A raw data file output (displayed by shot number or distance with the background signal removed) of a school of fish in the Gulf of Alaska (attenuation depth here was approximately 40 m).

Figure 6. Near-surface fish schools (sand lance) captured by the digital imager (Airborne Technologies)

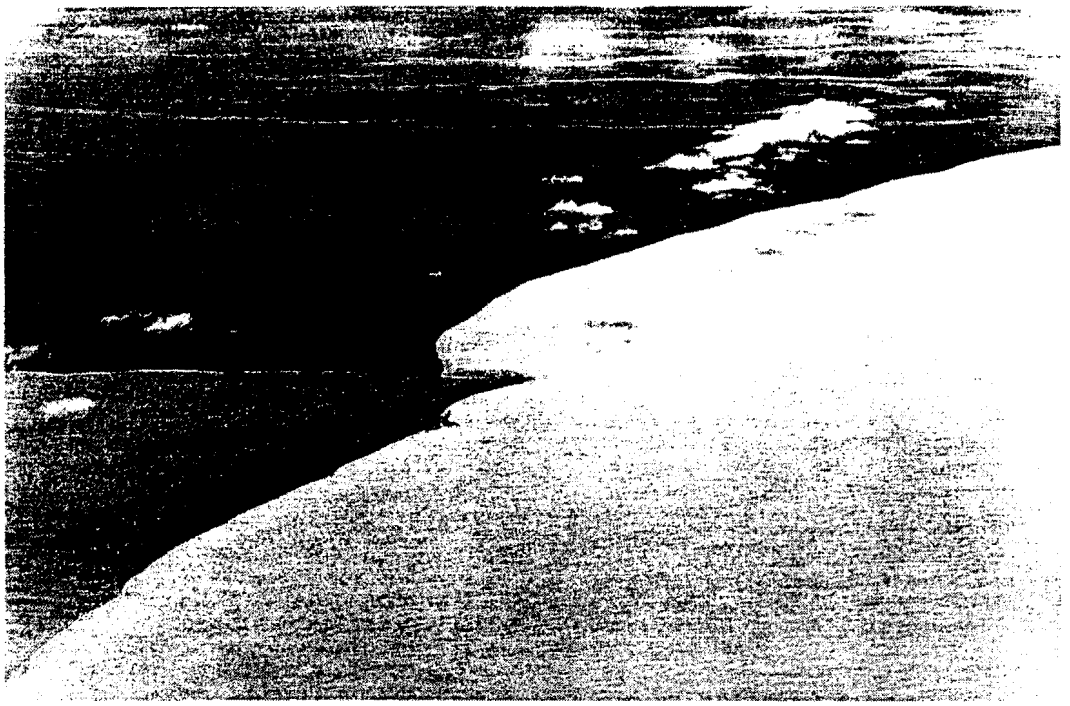


Figure 7. Image of oceanic regions captured with the imager; the binned lidar data is imbedded within this structure for analysis (Airborne Technologies, Inc.).

Following the encouraging results of the North Pacific Marine Research program (NPMR) pilot study, we now propose to evaluate the potential use of these tools for GEM monitoring. The

evaluation for this project will require cooperation with other researchers. Working with an ongoing, and separately funded shipboard research program, (GLOBEC), we will survey onshore to offshore transects overlapping and expanding the GLOBEC ship tracks. We may also exchange information with other EVOS and non-EVOS researchers working in the same area (see list below) for validation, interpretation, and assessment of the usefulness of our data to their respective programs. For this project, we propose to work with a single cruise, most likely in mid- to late-July. However, if the evaluation is positive, we propose to increase the temporal strata and survey other critical time periods in future years. In the case that future surveys are not funded and due to the late start-up data proposed, we will require close-out funds to complete analysis and report-writing in FY03. However, the reporting costs will be significantly reduced from the estimate originally provided for FY03.

As part of the evaluation, we will fuse the data from the various instruments, add shipboard data from GLOBEC (monitoring and process studies), and perform an ecological interpretation of the biological structure spatial structure (e.g. size and interrelationships of features such as zooplankton patches and fish schools, proximity to fronts, short-term scale of predator-prey events or frontal structures). We will also evaluate how the data suite (instrument data only or combination instrument/ship/buoy) addresses the complex research hypotheses and questions posed in preliminary drafts of GEM. A publication will be produced concerning the evaluation and interpretation.

NEED FOR THE PROJECT

A. Statement of Problem (duplication from FY02 proposal)

There is a need to identify cost-effective research tools for monitoring marine ecology in the EVOS spill region as a part of the GEM program. The data required to address the complex ecological questions posed by GEM are diverse. The settlement monies are finite and the GEM effort should include tools that are efficient, have adequate spatial coverage, and provide information for multiple research questions and objectives. Distributions and ecological relationships of several of the injured species will likely be captured by the instruments, including those of common murres, marbled and Kittlitz's murrelets, Pacific herring, pink salmon (high seas juveniles), sea otters, sockeye salmon (high seas juveniles), harbor seals, killer whales. Human activities in the areas also will be surveyed.

B. Rationale/Link to Restoration (duplication from FY02 proposal)

Prior to the formal initiation of the GEM plan, a full evaluation of potential monitoring tools would facilitate informed decision-making and planning. This proof of concept project enhances readiness to implement GEM by providing an evaluation of a potential suite of tools. Given the list of potential cooperating researchers and diversity of data delivered, there are likely several links to other restoration efforts that have not been identified at this point.

C. Location (revised from FY02 proposal)

In 2002 at the EVOS Workshop, we developed a cooperative working agreement with the Sea Life Center and the GLOBEC program, both conducting research in the Northern Gulf of Alaska. We decided to perform the aerial evaluation within the Chiswell Island sea lion foraging region

south of Resurrection Bay and over the GLOBEC Long-Term Ecological Research (LTER) monitoring stations overlapping and east of the Chiswell area. This survey will take place in July 2002 and will complement similar surveys that we are conducting in S.E. Alaska, Kodiak, and the Aleutian Chain funded from other sources. Therefore, the results from this study can be combined with those from the other areas for a comparison of ecological features over a broad range in the Gulf of Alaska. The choice of survey location was based on this potential for a broad scale comparison of areas. In addition, we have the opportunity to compare between years since we collected data in 2000 over the same GLOBEC sites.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE (duplication of FY02 proposal)

There will be very little physical or direct interaction with spill community residents because we will operate out of Anchorage (to keep field costs down). However, we are interested in posting interpreted visualizations on a web site easily accessed by residents. We are interested in providing the information to local schools for educational purposes and can provide simplified verbal interpretations with the visualizations. As our program (airborne remote sensing instrumentation and marine ecological research) is expanding (from other funding), we would like to encourage potential graduate students from the spill region to participate in proposed studies on both Masters and PhD levels. We will be offering opportunities to obtain multi-disciplinary degrees in a combination of two or three of the following disciplines: engineering, computer science, physics (optics), marine ecology, oceanography, wildlife biology, and fisheries. We feel that participation by local students is an optimal vehicle for information transfer to rural areas.

PROJECT DESIGN

A. Objectives (revised from FY02 proposal)

The objectives for this project, established in 2002, are:

1. Using remote sensing instrumentation, sample waters in the Gulf of Alaska and Prince William Sound to obtain a single synoptic view of the marine system in the upper 50 m of the water column.
2. Collect information on biological distributions of zooplankton, fish, and other large invertebrates synoptic with surface information on ocean color, ocean fronts, and seabird and mammal configurations.
3. Describe general distribution patterns using shipboard data for interpretation.
4. Determine spatial relationships of the biological features to one another and to ocean structure observed.
5. Evaluate the extent of data collected and cost-effectiveness per unit area.
6. Evaluate the limitations and usefulness of the interpretation in relation to GEM questions.

An additional objective, not covered by this study but included in complementary studies being conducted over the same time period, will be:

7. Compare indices of production, including ocean color, relative density, and size of patches of zooplankton and fish aggregations, sea bird and mammal occurrence, scale of foraging patches, and SST, at four areas in the Gulf of Alaska (Northern S.E. Alaska, Prince William Sound-Northern Gulf of Alaska, Kodiak, and the Aleutians) over two time periods (May and July).

8. Compare the information collected in 2002 in the Northern Gulf of Alaska with that collected in 2000 in the same region (GLOBEC LTER sites) and the same time period (late summer).

B. Methods (revised from FY02 proposal)

The hypothesis for this project is:

Data from airborne remote sensing instrumentation can be used to define spatial and temporal variability of zooplankton, fish, and predator distributions; interrelationships between the three; ocean structure; and relationships between biological distribution and ocean structure.

The instrument package consists of: 1) a lidar using pulsed green laser light to map subsurface biological features to a maximum of 50 m, 2) a gated, high resolution, high speed B/W video to image features illuminated by the lidar at specified depths, 3) an infrared radiometer to map SST day (analogous to AVHRR satellite data), 4) a high resolution RGB imager to map ocean color (chlorophyll), ocean fronts, near-surface fish schools, and seabird or mammal aggregations, 5) a thermal Infrared high resolution imager for mapping sea surface thermal patterns and locations of birds and mammals at night. The instruments are deployed to maximum overlap of captured area on the surface. Instrument settings and use vary from day to night. During the day, all five instruments are deployed. During the night, only the Red-Green-Blue (RGB) imager is shut off.

The components and settings of the FLOE lidar system are described in detail by Churnside *et al.* (2001a) and summarized here. The FLOE system is a non-scanning, radiometric lidar with three major components: 1) the laser and beam-control optics, 2) the receiver optics and detector, and 3) the data collection and display computer. The laser is linearly polarized and the beam diverged, using a lens in front of the laser, to meet eye safety standards established for marine mammals (Zorn, *et al.*, 2000). During the day, a narrow divergence filter is used compared to the nighttime filter, which is three times wider. The narrow filter minimizes the amount of background light entering the receiver but effectively limits the penetration depth of laser light. (Gordon, 1982). A polarizer in front of the telescope selects the cross-polarized component of the reflected light thus maximizing contrast between fish and smaller light-scattering particles (Churnside, et al., 1997; Lewis, et al., 1999). The telescope collects the light onto an interference filter to reject background light. As with the divergence filter, a narrow interference filter is used during the day and a wider one at night. An aperture at the focus of the primary lens also limits background light by limiting the field of view of the telescope to match the divergence of the transmitted laser beam. The resulting light is incident on a photomultiplier tube (pmt), which converts the light into an electrical current. For the nighttime receiver, the active area of the pmt is the field-stop aperture. During the day, separate aperture is used, and the light is transferred to the pmt by a second lens. The combination of divergence lens size, field of view setting, interference filter width, and altitude flown in 2000 determined the spot diameter or sampling swath at 5 m during the day and 15 m at night. The pmt output is passed through a

logarithmic amplifier to increase the dynamic range of the signal. A 50-Ohm load resistor converts the current into a voltage, which can be digitized in the computer.

A new feature in the lidar system will be a gated video camera. This camera allows snap-shots of lidar returns at specified depth levels in 0.1 m increments. This will allow a more detailed examination of optical targets within a given data bin (5–7 m by 0.1 m). Military applications of airborne lidar have used this technology, along with shape recognition software, to locate sub-surface mines as small as a dinner plate. For our purposes, images from this video will allow us to allocate signal data between large and small objects (e.g. fish within a zooplankton layer or predators within a fish school). Processing of this data is intensive and we will, therefore, selectively sample desired mixed species layers.

We will also use the NOAA ETL infrared radiometer. Radiometers are passive instruments that receive energy signals that are naturally emitted from objects within the instrument's viewing angle. A radiometer antenna pointed downward receives infrared emissions from the ocean surface. It monitors thermal emissions near the wavelength of 11 microns and the Infrared brightness temperature is approximately equal to the physical temperature of the ocean surface. The Infrared brightness temperature is calibrated in the laboratory prior to and following field data collection.

A high resolution, RGB imager will be used for capturing images used to produce ocean color data as well as sea bird and marine mammal counts and spatial configurations. The image swath width was altitude- and focal length-dependent ranging from 150–200 m at 305 m in altitude with a pixel resolution of approximately 6 cm. The imager is set up to capture the blue, green, red, and near infrared bands. Both an analog output and digital output are recorded. The analog output is recorded onto digital tape at 7.5 fps during the course of the flight. Global Positioning System (GPS) information was recorded onto one of the available sound tracks and later retrieved through post-process to create a dbf file of GPS points along the flight track. The digital signal is captured via a frame grabber at a pre-determined distance along the flight track. In this case, we captured an image every 1000 meters. These images were then batch processed to create a database file of RGB color values for each image at its given location. From this database file the following algorithm was run that gave us a value of green for each image:

$$V_n = G_{(An)}/G_{(An)}+R_{(An)}+B_{(An)}$$

Where: V_n is calculated green value for n^{th} image in the set of images
G is the mean green value of the histogram of A_n
B is the mean blue value of the histogram of A_n
R is the mean red value of the histogram of A_n
A_n is an area of interest centered on the n^{th} image in order to mask the outer pixels to keep them from being included in the calculation. This was done in order to eliminate a vignetting effect from the lens and camera port.

The thermal imager captures images of features emitting heat in the mid-Infrared range. This camera is linked to the same control system as the RGB imager but records to a separate digital tape. Intricate thermal patterns on the ocean surface as well as heat emitted from sea bird beaks, whale exhalations, and other marine mammals are captured in the images. We are building a

validation and identification index of thermal signatures during separately funded work in Kodiak in cooperation with our research partners there.

We will base our flight plan around the July GLOBEC LTER survey in the Northern Gulf of Alaska and the acoustic forage fish target strength survey conducted within the Chiswell Island sea lion colony foraging region (about 20 n mi radius around the Island). We will coordinate flights to overlap ship transecting in the same regions. We will fly a total of approximately 25 hrs; flying at approximately 140 knots, we will cover approximately 6500 km of ocean transects. The day-to-day schedule is relatively flexible due to weather, altered ship courses (due to weather), and other logistical concerns. Our goal will be to maximize synoptic observations with ground survey programs. We will overfly at least one, continuously recording oceanographic buoy for each flight. The ship survey or buoy provides: 1) a temperature array used to compare temperature profile to surface temperature, 2) light attenuation from PAR or Photosynthetically Active Radiation used to check background correction estimated for lidar data, and 3) chlorophyll concentrations from a fluormeter (for ocean color calibration measurements). We will also derive biological validation measurements from the ground programs from interpreted acoustic data, zooplankton tows, net captures of fish, and visual sightings of birds and mammals. Finally, we will use shipboard data to obtain sub-surface oceanographic structure (especially salinity, pycnoclines, location/size of fronts, and information of stratification) used to ecologically frame our spatial observations.

The majority of personnel time allocated within this project is for signal processing and analysis. The ratio, summed over all the instruments data produced, is well over 3:1 processing to collection time (a standard for acoustic data). However, processing algorithms are well established for the radiometer and ocean color video. The imaging video and lidar data is significantly more time-intensive.

Lidar files are large, representing an array with 1000 depth bins of 0.1m extent multiplied by 2000 shot returns. The laser pulsed light 30 times s^{-1} and a file contains 66 s of data representing about 4.5–5 km explored distance (airspeed dependent). A typical flight can acquire several hours of data yielding approximately 150–200 data files. Files are first corrected by the surface echo and then the median return per bin; slope of background backscatter was estimated in order to calculate signal over noise. The backscatter signals are normalized to the background backscatter or median backscatter for comparison with other bins. The background signal, the total received averaged signal (root-mean-square averaged; RMS), and the median signal were often plotted geographically to aid in batch processing using geo-referenced notes or auxiliary data collected during a survey.

A threshold depth below which meaningful signals cannot be discriminated from noise determines penetration depth. Because light attenuates in the water column, the return signal is weaker with increasing depths and, therefore, a threshold is selected to be above the signal produced by noise alone. Using the plotted median of the lidar return over several hundred shots of the data, threshold noise can be easily identified and the depth at which this curve crosses the threshold is the penetration depth. This is illustrated in Figure 3b where the return signal becomes noisy, corresponding to a penetration depth of about 30m. This depth occurs at a signal current of 1×10^{-9} A, which is the threshold signal, used to filter the data from shots associated with the estimated median.

A general treatment of remotely sensed and other aerial data is provided in Hunter and Churnside (1995). However, detailed statistical modeling of lidar results was explored by Lo et al. (2000) in relation to an aerial census of anchovy off the coast of California. They provided methods: 1) to estimate the number of transects needed to minimize abundance estimates, 2) to determine the effects of signal to noise ratio (SNR) with attenuation (or depth) on the probability of detection, 3) to estimate the maximum detection depth (z_{max}) based on threshold to noise ratio (TNR) and SNR, 4) to predict the probability of detection based on water mass characteristics, and 5) comparisons of estimates to other methods. The maximum detection depth is a function of the size of the organism or aggregation (i.e. school). For organisms residing partly below the maximum detection depth, acoustic data is combined with lidar data to produce a subsurface correction factor. Lo et al. (2000) suggest the application of line transect theory applied in the vertical along transect plane (rather than horizontal) to estimate abundance, estimation, and detection error. For organisms above the maximum detection depth, we can assume 100% detection along the survey track. Finally, Lo et al. recommend the further development of signal processing algorithms to automate the SNR, TNR, and z_{max}. Several of these algorithms have been developed under the NPMR pilot study and will be applied to this study. We will use the models developed by Lo et al. to interpret the data collected for this project.

Once we have identified and quantified (normalized signal strength; Figure 9d), we will rely mainly on spatial statistics to describe distributions and interrelational parameters. Potential stochastic descriptions of the data include comparison of spatial variability via variograms, indices of spatial association between distributions (e.g. Moran's or Geary's index; Cliff and Ord 1981; Geary 1954), kridging to smooth and expand estimated distribution patterns, and nearest neighbor or distance statistics to quantify interrelationships. This statistical interpretation will be included in the publication produced as part of this project.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The work for this project is part of a larger array of related tasks that are being performed by a remote sensing team that was established in 2000. Members of this team include personnel from the Institute of Marine Science (IMS) and Geophysical Institute (GI) at UAF, the NOAA Environmental Technology Laboratory at Boulder Colorado, Airborne Technologies, Inc (ATI)., and Scientific Fisheries, Inc. See "Personnel" under the Principal Investigator Section for a complete list of responsibilities. Instruments are provided by IMS, ETL, and via a contract with ATI; the aircraft is chartered by ATI. In the field, we will coordinate with Chuck Baker (SeaLife Center) and Ken Coyle (UAF IMS) who will be conducting acoustic surveys in the Northern Gulf of Alaska aboard the R/V *Pandalus* and R/V *Alpha Helix*.

SCHEDULE

A. Measurable Project Tasks for FY03

Nov 15, 02	Completed compilation of processed instrument data Evaluate need for possible rebinning/rescaling of LIDAR data
Dec 15, 02	Compile shipboard and satellite data needed for interpretation Begin qualitative and quantitative comparisons or aircraft-ship-satellite data

Jan 03:	Attend EVOS workshop and present preliminary findings
Mar 15, 03	Begin spatial analysis of mapped biological and physical features (from airborne, ship, and satellite data)
Apr 15, 03	Complete spatial analysis and begin evaluation of methods
May 1, 03	Begin report and publication preparation

B. Project Milestones and Endpoints

FY03

Jul 2002:	Objective 1–2 completed during FY02 phase
Mar 15, 2003	Objective 3; distribution descriptions completed
Apr 15, 2003:	Objective 4; spatial analysis completed
Apr 30, 2003:	Objective 5; evaluation of cost-effectiveness of information Objective 6; evaluate usefulness and limitations for GEM
May 31, 2003:	Manuscript draft submitted; final report completed
Aug 31, 2003:	Manuscript revised and finalized

C. Completion Date

August 31, 2003, FY03, is the estimated completion date for this project.

PUBLICATIONS AND REPORTS

For the NPMR pilot study, the following publication was produced:

Brown, E.D., J.H. Churnside, R.L. Collins, T. Veenstra, J.J. Wilson, and K. Abnett 2002. Remote sensing of capelin and other biological features in the North Pacific using lidar and video technology. ICES Journal of Marine Science, XXX:000–000.

For this study, we will included a more in-depth analysis of target identification, instrument calibration, relative abundance or density indices, and spatial scale of features to complement our earlier publication. We will include some of the data collected in 2000 (during the NPMR study) for an interannual comparison in the Northern Gulf of Alaska region. This publication will be submitted to either Ecological Applications or Fisheries Research.

PROFESSIONAL CONFERENCES

Other than the EVOS workshop and scientific planning meeting, we have no plans to present the results formally in FY03. However, we may present some of the results from this study, combined with similar results from other studies, at scientific meetings covered by other funded projects.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

In 2002, we are conducting studies in other areas in the Gulf of Alaska, some within the spill region. Although these studies focus on sea lion issues, the data collected includes broad-based

physical and biological parameters in near shore areas as well as the continental shelf. Data collected in Northern S.E. Alaska, Kodiak, and the Aleutian Chain will be directly comparable to the data collected under this project in the Northern Gulf of Alaska and Prince William Sound region. We are well connected and actively cooperating with researchers in Kodiak (UAF Fisheries Industrial Technology Center, National Marine Fisheries Service (NMFS)), Juneau (NMFS Auke Bay Lab), Seattle (NMFS Alaska Fisheries Science Center and National Marine Mammal Laboratory), University of California, Irvine (George Hunt), and Anchorage (United States Fish & Wildlife Service, University of Alaska Anchorage). Using funds from other studies, we are establishing a web-based browser that will enable other researchers to view, download, or order (in the case of very large data sets) useful data from our surveys. Databases compiled from aerial surveys (funded by EVOS and NMPR) since 1995 will also be available on-line.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

None

PROPOSED PRINCIPAL INVESTIGATORS

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PERSONNEL RESPONSIBILITIES

The list of responsibilities for the PIs and associated personnel in our research team is as follows:

UAF-IMS
PI – Evelyn Brown, Ph.D. candidate (defending 2002)
Background: Fisheries Biology and Marine Ecology, Airborne Surveys, Statistical Analyses
Duties: Chief Scientist during airborne surveys, instrument operation, oversee UAF signal processing tasks, signal validation, biological interpretation, spatial analysis, and reporting

Martin Montes, Ph.D.
Background: Ocean Productivity, Oceanography, and Remote Sensing
Duties: Research Analyst, signal processing and target identification, assistance with development of processing software, integration of airborne and satellite imagery, assistance with analysis and reporting

UAF-GI
Richard Collins, Ph.D.
Background: Electrical Engineer, Optics and Research Lidar, Atmospheric Science
Duties: (not funded by this project) signal analysis, instrument design and improvement, assist with software, and analytical algorithm development

Kevin Abnett, MS
Background: Software Engineer, Signal Processing
Duties: (not funded by this project); software development, web-based browser tools

NOAA-ETL
PI – James Churnside, Ph.D.
Background: Physicist, Optics, and Electrical Engineering
Duties: provide, operate, and calibrate LIDAR and Infrared Radiometer; assist with calibration and interpretation of other physical and biological measurements (e.g. ocean color from video), assist with signal processing algorithm development, analysis and reporting.

James Wilson, BS
Background: Electrical Engineer, Ocean Instrument Specialist
Duties: (funded by this project in FY02) install and maintain instruments, assist with field data collection, install and synchronize gated video (provided by UAF) with LIDAR.

Private Industry:
Tim Veenstra, President Airborne Technologies, Inc.
Background: Aircraft Charter and Configuration, Imaging Services
Duties: Provide, install, maintain, and operate imaging equipment; perform all image processing and data delivery tasks, assist with image interpretation, validation, and reporting

Pat Simpson, President, Scientific Fisheries, Inc.
Background: Scientific and industry acoustic instrumentation development and design and software development including neural networks.
Duties: (not funded by this project) development of acoustic-lidar integration and fusion software, instrument development and support of acoustic system used by coordinating project for target validation.

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FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2002 - September 30, 2003

Budget Category:	Authorized FY 02	Proposed FY 03
Personnel		$18.8
Travel		$2.2
Contractual		$0.2
Commodities		$0.6
Equipment		$5.0
Subtotal	$0.0	$26.8
Indirect		$6.7
Project Total	$47.5	$33.5
Full-time Equivalents (FTE)		0.3
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
Estimated FY 04					
None					

Dollar amounts are shown in thousands of dollars.

Comments:
NOAA component ($7.3 direct, $.9 indirect) - $8.2
ADF&G overhead - $2.0

Grand Total - $43.7

FY03

Prepared: 4/2/02

Project Number: 03584
Project Title: Evaluation of Airborne Remote Sensing Tools for Gulf Ecosystem Monitoring and Research (GEM) Monitoring
Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

FY 03 *EXXON VALDEZ* TRUS[illegible]E COUNCIL PROJECT BUDGET
October 1, 2002 - September 30, 2003

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 03
	Brown, E.	PI, Chief Scientist	1.5	6.8		10.2
	Montes, M.	Research Analyst	1.5	5.7		8.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	3.0	12.5	0.0	
					Personnel Total	$18.8

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 03
	Brown to EVOS workshop (air and per diem)	0.3	1	4	0.2	1.1
	Montes to EVOS workshop (air and per diem)	0.3	1	4	0.2	1.1
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$2.2

FY03

Prepared: 4/2/02

Project Number: 03584
Project Title: Evaluation of Airborne Remote Sensing Tools for Gulf Ecosystem Monitoring and Research (GEM) Monitoring
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2002 - September 30, 2003

Contractual Costs:	Proposed
Description	FY 03
Communications	0.2
Contractual Total	$0.2

Commodities Costs:	Proposed
Description	FY 03
Software upgrade	0.3
Copy/reproduction	0.1
Data storage	0.1
Hardware/Printer Supplies-repair	0.1
Commodities Total	$0.6

FY03

Prepared: 4/2/02

Project Number: 03584
Project Title: Evaluation of Airborne Remote Sensing Tools for Gulf Ecosystem Monitoring and Research (GEM) Monitoring
Name:University of Alaska Fairbanks

FORM 4B
Contractual & Commodities DETAIL

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2002 - September 30, 2003

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 03
Description			
Computer (Cost estimated from Internet site)	1	5.0	5.0
			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**		$5.0

Existing Equipment Usage:	Number of Units	
Description		

FY03

Prepared: 4/2/02

Project Number: 03584
Project Title:Evaluation of Airborne Remote Sensing Tools for Gulf Ecosystem Monitoring and Research (GEM) Monitoring
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

Lingering Oil: Bioavailability and Effects to Prey and Predators

Project Number:	03585
Restoration Category:	Research and Monitoring
Proposers:	
Part I: NOAA- ABL	Stanley Rice, Jeff W. Short, Mandy Lindeberg; NMFS, Auke Bay Laboratory; Program Manager: Dr. Stan Rice
Part II: DOI-USGS:	Jim Bodkin, Brenda Ballachey, Paul Snyder, Dan Esler; DOI Program Manager: Dede Bohn
Lead Trustee Agency:	NOAA
Cooperating Agencies:	DOI-USGS
Alaska Sea Life Center:	Yes
Duration:	Closeout
FY03	52.1K Project total Part I (NOAA-ABL): 35.5K Part II (DOI-USGS): 16.6K
Geographic Area:	Prince William Sound, Gulf of Alaska
Injured Resource/Service:	Intertidal, Sediments, Sea Otters, Harlequin Ducks

ABSTRACT

About 20 acres of contaminated beach were found in 2001 surveys of western PWS conducted by Auke Bay Laboratories (ABL). In these areas, sea otters and harlequin ducks have not recovered, raising concerns that continued oil exposure may be affecting their survival. This study was an outgrowth of ABL surveys in 2001 and USGS studies of impacts to sea otters and harlequin ducks. Biochemical assays and mortality patterns are consistent with continuing oil exposures, but prior to this study, linkages between oil persistence and impacts at higher trophic levels had not been attempted. In this study, shoreline contamination, exposure and effects were examined simultaneously by choosing a common set of sites at which to assess oil persistence and biological impacts on sea otters and harlequin ducks. Fieldwork was conducted in 2002, and closeout activities, including data analyses and writing of reports and publications, will be done in 2003. During field operations, prey living in oil patches were encountered in larger numbers than anticipated. These have been sampled (primarily clams) and archived. Additional closeout funds have been requested to analyze these samples. NOAA-ABL has been leading the studies of oil bioavailability and impacts to prey species; DOI-USGS has been directing the studies on sea otters and harlequin ducks.

GENERAL INTRODUCTION

In summer 2001, the shoreline assessment project found about 20 acres of beach in Prince William Sound that were still contaminated with oil. This 20 acre estimate was more than twice the estimate coming from surveys in 1993 (1993 surveys covered more beaches, but dug far fewer holes) (Gibeaut and Piper, 1998a and b). Most of the oil found in 2001 was classified as "light", but was still readily located, and easily observed. Some of the subsurface pits (20) were classified as heavily oiled. In these, oil saturated all the interstitial spaces, and was extremely repugnant. These "worst case" pits exhibited an oil mixture that resembled the oil a few weeks after the spill- highly odiferous, lightly weathered, very fluid. Most of the subsurface oil was found at a lower tide height than expected (between zero and 6 ft), in contrast to the surface oil which was found mostly at the highest levels of the beach. This is significant, because the pits with the most oil were found low in the intertidal zone, closest to the zone of biological production.

Recovery of sea otters and harlequin ducks in the Knight Island area has not occurred (Bodkin et al. in press, Esler et al. in press). Oil exposure has been suspected as a factor constraining recovery, particularly in consideration of elevated levels of cytochrome P4501A (P450), a biomarker of aromatic hydrocarbon exposure, in otters and ducks from oiled areas (Ballachey et al. 2001b, Trust et al. 2000). Higher mortality rates have been demonstrated for sea otters (Monson et al. 2000) and harlequin ducks (Esler et al. 2000) residing in oiled areas of western PWS, but without confirming bioavailability and identifying exposure pathways, it has not been clear that lingering oil was responsible. Presence of oil was not a measure of bioavailability. Earlier studies showing significant oil concentrations in contaminated mussel beds were suggestive, but there was never an exhaustive survey of mussel beds to determine their distribution and significance, and assumptions were made that they were not widespread and likely did not present a large risk to predator species. The survey in 2001 indicates relatively more oil lower down on the beach, near the biological zone, and raises the possibility that oil deposits at high impact sites may be limiting recovery of sea otters and harlequin ducks.

Field studies in 2002 focused on two questions: (1) Is the lingering oil bioavailable? And, (2) is it still causing impacts? Auke Bay Laboratory (ABL) led studies on oil bioavailability, with surveys designed to overlap with impact sites relevant to sea otters and harlequin ducks (and control areas). DOI-USGS focused their impact studies on sea otters and harlequin ducks at the same sites. Bioavailability studies looked at the mobilization of oil out of oil patches, into the water and into prey species. Together, these studies will allow interpretation of the data by having answers to questions of bioavailability within a site, within a bay, within a region, and impacts at a very site specific level (within an oil patch, within a bay, within a region), including information on both prey and predators.

In 2002, the two research groups submitted a joint proposal to investigate bioavailability and impacts. The site selection process was coordinated so that the oil persistence/bioavailability data can be compared to the exposure and impact data gathered on the two predator species. For

2003, funds are requested for closeout activities, primarily data analysis and write-up. Additional funds are requested for analyses of clam samples collected at oiled sites. The following project proposal has been divided into two sections: Part I, led by ABL, with focus on bioavailability of oil from oil patches and transport to prey species; and Part II, led by DOI-USGS, with focus on the impacts to sea otters and harlequin ducks. During the closeout process, researchers from the two groups will work together to interpret results and prepare a final report and publications.

PART I: Bioavailability of PAH from oil patches and impacts to prey species (NOAA-ABL)

ABSTRACT

Presence of oil indicates but does not prove that the oil is potentially bioavailable. The extensive beach surveys conducted in western PWS in 2001 estimate that about 20 acres of upper intertidal beach remain contaminated, and lend support to the hypothesis that lingering oil can still cause injury to invertebrates near the oil patch as well as to the predators feeding in the area. This half of the project, led by ABL, focused on the bioavailability of oil within an oil patch, within a bay, and possibly within a region of the spill. Further, prey species (mussels, other invertebrates, and crescent gunnels living in the oil patches) were assessed for contamination (bioavailability of PAH) and also for impacts. Fieldwork was conducted in 2002, and closeout activities, including data analyses and writing of reports and publications, will be done in 2003. During field operations, prey living in oil patches were encountered in larger numbers than anticipated. These have been sampled (primarily clams) and archived. Additional closeout funds have been requested to analyze these samples. This half of the project complements the impact studies on sea otters and harlequin ducks conducted by DOI-USGS.

INTRODUCTION

In summer 2001, the shoreline assessment project identified about 20 acres of beach in Prince William Sound that were still contaminated with oil, and changed our perception of how much oil remains and where on the beach it is located.Further, it has elevated the possibility that the lingering oil may be causing continuing injury in some species, including sea otters and harlequin ducks. Oil was found at 58% of the 91 sites assessed; 6775 randomly stratified sampling pits were assessed to have the linear equivalent of 7.8 km of oil contaminated beach. This 20 acre estimate of oil contaminated beaches was more than twice the estimate coming from surveys in 1993 (1993 surveys covered more beaches, but dug far fewer holes) (Gibeaut, and Piper, 1998a, b). Most of the oil found in 2001 was classified as "light", but was still readily located and observed. All the pits used in the assessment were dug by hand, and all the initial classifications were made from visual observations. Over a period of about 100 days, 91 sites were visited, each site picked randomly from a population of sites judged to be heavily or moderately oiled in one of the surveys from 1989-1993.

In addition to the area estimated to remain contaminated, several other important points are evident. (1) Surface oil was not a good indicator of subsurface oil at that specific pit. In other words, surface oil, which was found predominantly high in the intertidal beach areas, was not a good predictor of subsurface oil, which was found predominantly much lower in the intertidal zone. (2) Some of the subsurface pits (n = 20) were classified as heavily oiled. In these pits, oil saturated all of the interstitial spaces, and was extremely repugnant. These "worst case" pits exhibited an oil mixture that resembled the oil a few weeks after the spill- highly odiferous, lightly weathered, very fluid. (3) Subsurface oil was also found at a lower tide height than

expected (between zero and 6 ft), in contrast to the surface oil which was found mostly at the highest levels of the beach. This is significant, because the pits with the most oil were found low in the intertidal zone, closest to the zone of biological production, and indicate that our estimates are conservative at best.

The lingering oil has survived two summers of intense clean-up by Exxon (1989,1990), 12 winters of storms, and 12 years of tides (Brodersen et al., 1999; O'Clair et al., 1996). Oiling levels have certainly declined during this time period, but the remaining oil would appear to be relatively stable and not very vulnerable to further degradation and weathering (Hayes and Michel, 1998 and 1999). This begs the question- is it bioavailable, and is it still causing impacts? In the mid 1990's, similar concerns grew out of some studies on oiled mussel beds (Babcock et al., 1998; Carls et al., 2000). A few oiled mussel beds had been located, and were thought to remain oiled because they were not cleaned in 1989 or 1990, but their impacts were presumed to be relatively insignificant because their total areas were not large (less than an acre). It was curious that oil remained and that it was not heavily weathered, but the volumes from the specific sites were thought to be too small to be damaging on a wide scale. The surveys in 2001, which were not exhaustive surveys of the lower intertidal zones, raise the question that there may be more mussel beds that remain contaminated, and that possible entry into the food chain may not be restricted to the lingering oil targeted in the 2001 surveys. The distribution, quantity and significance of oiled mussel beds remains unknown, and probably deserves further attention in outlying years.

Sea otter and harlequin duck studies in 1996-98 continued to show long term effects: elevated P450s (Ballachey et al. 2001, Trust et al. 2000), and abnormal mortality patterns Monson et al. 2000, Bodkin et al. in press, Esler et al. 2000)). In the heavily oiled area of northern Knight Island (including Herring Bay and Bay of Isles), sea otter abundance remains well below pre-spill levels (Dean et al. 2000). The population size of harlequin ducks before the spill was not accurately known, but the winter mortality rates in oiled areas are significantly higher than in non-oiled areas of the sound. Studies of both sea otters in 2001 found further evidence of continued exposure, based on blood chemistries and liver examinations (sea otters) and P450 levels (harlequin ducks). This generates concern that the lingering oil is indeed bioavailable and at concentrations sufficient to have impacts on predator species.

This half of the project is attempting to determine if oil is bioavailable in areas where sea otters and harlequin ducks are doing poorly, and compare results from oiled areas to nonoiled areas where they are doing well. Bioavailability of PAH in prey species, and their damage, are being assessed at very specific oil patch sites, and at control sites within the impacted bays as well as regional control sites. These data should permit a better evaluation of lingering oil as a potential cause of the continuing injury in sea otters and harlequin ducks. There has been a high degree of overlap, geographically and chronologically, between the study sites looking at PAH bioavailability/prey damage and assessment of effects on the predators.

NEED FOR THE PROJECT

A. Statement of Problem

After 12 years, significant oil remains in and on the beaches of Prince William Sound, but its presence is not proof that the oil is bioavailable to prey and predators. The amount of oil found in 2001 was surprising (more than twice the estimate coming from 1993 surveys), as was the location on the beach (lower intertidal zone). Significant impacts to sea otters and harlequin ducks in the oiled area persist, including lower survival rates in oiled areas than in unoiled areas, for both species. We do not know if the persistent oil is bioavailable to otters and harlequin ducks, and if it is, if it has toxic impacts as the data suggest.

B. Rationale

Studies of persistence/ bioavailability will be coordinated with further studies of impacts to sea otters and harlequin ducks. The study sites will be modified from the existing studies so that there is greater overlap- bioavailability studies and impact studies will be compared at the same sites where otters and ducks have adequate numbers for study (Montague Island as a control site; Green Island, Bay of Isles, Herring Bay, Northwest Bay as impact sites). The bioavailability studies will be led by the Auke Bay Laboratory, and the impact studies on sea otters and harlequin ducks will be led by USGS.

C. Location

All study sites and sampling will be conducted within Prince William Sound. For some of the "effects" studies, Cordova harbor will be used as a "positive" oil control and samples of mussels or fish will be collected there. All other sites will range from Montague Island (control area) to Green Island and northern Knight Island.

COMMUNITY INVOLVEMENT

Charters to support the research will be solicited from the spill impacted area. Further, some labor support for some of the field operations may be solicited from the Native villages.

A. Objectives

1. Determine if the oil remaining is bioavailable:
    a. From beach sites judged to be heavily oiled from the 2001 surveys

2. Determine if the oil remaining is still causing impacts:
    a. To mussels, as determined by DNA damage to hemolymph cells

b. To intertertidal fish (crescent gunnels) living in or near subsurface oil deposits

B. Methods

General sampling strategy for bioavailability and prey impacts:

Bioavailability of PAH and prey impacts will be assessed at a suite of sites that overlap with the harlequin duck and sea otter studies. There are several sampling components to the study:

Bioavailability of PAH: The key question of bioavailability will be assessed in several different ways and scales. Plastic strips (sensitive, cheap to analyze) will be the primary sample medium for assessment, and will be supplemented by mussel and prey samples. Plastic strips will be placed above and below the beach surface at several points in a beach relative to an oil patch. See the sampling diagram with a beach layout.

Bioavailability to mussels and mussel beds: Mussels and strips sample slightly differently; mussels can pick up more PAH in droplets than strips. Using combinations of mussels and strips, we will have better capabilities of interpreting the data. Mussels are not ubiquitous in oil patches; for this reason, there will be some use of caged mussels to supplement collections from resident mussels. Mussel beds within the sample sites will also be targeted if they are oiled, to see if bioavailability and impacts are the same as oil patches without mussels. Mussel beds from the earlier mussel bed studies will not be targeted in this study (for budget reasons) because we need the present sample sites to have overlap with the 2001 surveys and the otter/duck studies. The probability of detecting released oil is not great after 12 years of tides and weathering. For this reason, we have adopted the general strategy of targeting beaches with high quantities of oil remaining, and have put many sampling devices in a spread of locations and depths to increase our probabilities for capturing minimal releases of oil. The strips are the most sensitive sampling device we know of.

Design and structure:
Regional Controls: Montague island area will serve as a regional control. Two independent sites on Montague may be used for some of the sampling.

Within Bay Control sites: Several bays will be sampled in an oil patch, but also at some distance within the bay away from the sampled patch. This will allow interpretation on the scope of some of the signals (PAH in resident mussels; P450 in crescent gunnels) to determine how site specific the signal is.

Positive Control: Some analyses require a "positive" control for the methods and field collections. If there were no measurement of DNA damage in mussels or P450 impacts in crescent gunnels, the methods would be in question; positive controls (Cordova harbor)

will prevent this interpretation glitch. Table 1 lays out the sampling design by site, sample type, sub-location, and sample quantities.

Statistics: In addition to the complement of retrieved samples for analyses, an additional 10% will be added as duplicates. This will be spread across the sample sites and strata, and will permit accuracy measurements.

Sampling Periods (Seasonal): Two seasons will be sampled where practical; winter when storm violence may be more likely to cause the release of subsurface oil, and impacts may be the greatest; plus summer when extensive sampling is more favorable and practical. There is risk of loss of the sampling devices, so about twice as many will be deployed as will be analyzed. This extra deployment has little impact on costs, but ensures a sampling scheme without holes. These extra deployment numbers are not shown in table 1. There will be "over-sampling", particularly of strips and prey, and some analyses will be contingent on primary analyses, to be run later in the current year, or possibly into next year under a different proposal.

Sampling Locations: The following sites will be used

Montague Island	a control site; two different areas may be sampled
Green Island	otter impact site with known oil; otters are present in numbers
Bay of Isles	impacted site with marginal numbers of recovering otters
Northwest Bay	impacted site; worst case site for bioavailability studies
Herring Bay	impacted sites; worst case site for bioavailability studies
Cordova harbor	impacted "positive" control site

*Oiled mussel beds will also be sampled from a subset of these.

Specific Methods: Sampling strategy for bioavailability and prey impacts:

A. Determine bioavailability of PAH at heavily oiled 2001 survey sites.

1. To determine if PAHs are available, plastic strips (low density polyethylene devices or LDPEs) will be deployed at each of the sites in a sampling pattern designed to capture any flow dynamic that is possible. Strips will be deployed above and below the beach surface in protective perforated containers. Some strips will be deployed higher on the beach from an oil patch, some within the oil patch, and some below the oil patch. At some distance away from the oil patch, a similar sampling scheme will be deployed to determine if PAH are available on a broader scale than just in the immediate vicinity of a specific oil patch. Likewise, regional controls will determine if there is more PAH available at even a larger scale. These deployments will be made in both the winter and in the summer. Oiled patches discovered and mapped during the 2001 survey will be relocated (patches found in lower zones near the biological active zones will be targeted) and LDPEs placed in close proximity. This array of LDPEs will be replicated to ensure retrieval of sufficient numbers 30 days later, and to allow for the 10% replicate analyses required for statistical evaluation of accuracy. See table 1 for numbers analyzed by site, compared to other measurements.

2. Mussels will also be sampled for bioavailability of PAH. Mussels will be used in addition to strips because they tend to sample oil droplets more efficiently than strips, and comparative analyses will allow for greater interpretation of the results. Mussels are often not available at some of the oiled sites, and caged mussels may be used for that sampling. See table 1 for numbers analyzed by site, compared to other measurements

3. Some prey animals will be sampled in addition to resident mussels to see if PAH are bioavailable in these species. Over-sampling will be the strategy; selected samples for analyses will be based on results from strips, and collections from other sites. Only the high impact areas will be analyzed initially; other samples will be archived and further analyses will be proposed if PAH are found in the mussels from the high impact sites. A minimum of 20 samples will be analyzed by GC-MS (Short et al., 1996).

4. A limited number of sediment samples will be collected during both sampling periods within the oiled patches to determine the condition of the oil and whether PAH composition matches weathered *Exxon Valdez* oil (EVO) (Short and Heintz, 1997). These samples will be analyzed by GC-MS (Short et al., 1996). These samples will be needed for interpretation and only a few need to be analyzed.

B. Determine DNA damage to resident mussels from oiled and unoiled patches via single cell gel electrophoresis (comet analysis).

DNA damage in mussels, measured by the comet analysis, has evolved as a monitoring tool for

PAH and other contaminants in polluted harbors (Steinert et al., 1998). It is a very sensitive technique, is relatively inexpensive, and requires relatively few cells. DNA damage is repairable, hence sample collection and preservation at the site is a requirement.

Specific methods:
20 mussels will be sampled from each specific sampling location; hemolymph samples will be taken on site, cryopreserved in liquid nitrogen, and returned to the lab for storage (-70 C) and assay of DNA damage. A "positive" control will be used (Cordova harbor) to verify that the sample collection and methods are working. A minimum of twenty five cells will be utilized to determine the extent of damage at the individual level. Impacted sites will be compared to control sites within the bay (e.g., bed rock mussels with no underlying oil bed), and to regional controls (Montague Island). Samples will be analyzed blind. 200 mussels will be analyzed from winter, and 200 from summer collections. Comet analyses will be contracted out to Dr. Robert Thomas of California State University at Chico. See table 1 for numbers and sites compared to other measurements.

C. Determine if crescent gunnels living in oil patches are exposed to oil (P450) and compare to collected specimens from other sites that are either nearby (same bay) or distant (regional controls)

Crescent gunnels live under rocks in the intertidal zone at low tide and are the only vertebrate that resides within an oil patch (Peden and Hughes, 1984). If a vertebrate can show exposure and damage, crescent gunnels would appear to be the species with the highest probability. Earlier work has shown that gunnels collected from the spill zone had higher P450 values (Woodin and Stegeman, 1993), but interpretations were hampered by the lack of collections from known oil patches. This project would collect animals from within oiled patches, from nearby unoiled patches within the same bay, and from regional controls. Damage to organs evaluated histopathologically would not be conducted this fiscal year (because of costs), but the tissue blocks would be retained and would be proposed for future funding if there are significant differences in P450 responses from the different sites.

Specific methods:
20 crescent gunnels will be sampled, dissected, and preserved appropriately on site. Gunnels collected from impacted sites will be compared to control sites within the bay system of the impact site, and to regional controls (Montague Island, and also a "positive" control from Cordova Harbor). Organs (including liver, kidney and gills) will be dissected out, preserved, and subsequently processed into blocks and slides for P450 antibody staining. A total of 200 fish will be analyzed. Samples will be analyzed blind. All analyses will be contracted to Dr. Gary Marty of University of California Davis. This study will be done only in the summer. . Sampling sites for gunnels will be the same as they are for the mussels.

Interpretive model for bioavailability studies

The following rationale outlines how we will interpret the bioavailability of lingering EVO :

PAH are bioavialable if:
- The LDPE tested positive for PAHs in the surface deployments.
- The LDPE strips are positive in subsurface deployments outside the oil patches.
- The bioavailability is more significant if the control sites within a bay test positive.
- The bioavailability is more questionable if the regional control sites have significant positive PAH results.
- The deployments are suspect if lab and field blanks test positive.
- The methods are suspect if the positive control of Cordova Harbor is NOT positive.

Further analyses to strengthen case:
- The multiple impact sites test positive.
- PAHs are present in mussels and/or prey.
- P450 present in Crescent Gunnels; comets are above normal in oiled areas.
- P450 and comet assays are suspect if the samples from Cordova Harbor are not positive.

SCHEDULE for Bioavailability and prey impact studies

A. Measurable Project Tasks for FY03 (October 1, 2002 – September 30, 2003)

This is a closeout year for the project:

October 2002:	Complete Comet tests
November 2002:	Complete P450 analyses
December 2002:	Complete hydrocarbon analyses
January 2003:	Attend Annual Workshop
September 2003:	Complete final report

B. Project Milestones and Endpoints

Complete Final Report by September 30, 2003.

C. Completion Date

September 30, 2003.

PUBLICATIONS AND REPORTS

Several specific papers on bioavailability, and impacts are expected. We anticipate a joint publication incorporating bioavailability and impact data but this synthesis may not be completed

within the FY03.

PROFESSIONAL CONFERENCES

The EVOS Trustee meetings will be attended by the principle investigators.

NORMAL AGENCY MANAGEMENT

None of these projects are part of normal agency management activities.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project is related to the close-out of the Shoreline assessment project, and will use the information generated from that study for specific site selections. Likewise, the sea otter and harlequin duck work is an outgrowth of projects funded in FY 01 or FY 02, and will utilize information from those projects. Further, there has been coordination between the two agency component parts in development of the proposal, to ensure geographical overlap and relationship.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

N/A

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PRINCIPAL INVESTIGATORS

Stanley D. Rice
GM-14 Physiologist

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 115 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. Quality assurance of all studies, particularly the biological impacts research has been the continuing focus through the restoration years. Principle investigator in subtidal sediment studies, pink salmon effects studies, and in the SCAT surveys of 2001. In addition, Rice has lead the effort on use of LDPE research by the Auke Bay Lab.

Jeffrey W. Short
Research Chemist

Education: M.S. (Physical Chemistry). 1989- Present: Established and managed the hydrocarbon analysis facility at ABL to analyze hydrocarbon samples generated by the *Exxon Valdez* NRDA effort. Responsible for quality control and data interpretation of all data hydrocarbon data produced by ABL labs. Principle investigator of several EVOS projects through the damage assessment and restoration years, paarticularly those studies involved in tracking oil (subtidal sediments), tracking the Hydrocarbon Data Base, several specific projects (Pristane; Coal as a background source), and most importanly, principle investigator of the large shoreline

assessment project (SCAT) in FY 2001. Many publications.

Mandy R. Lindeberg
Fisheries Research Biologist

B.S. Marine Biology. 1990- present: Mandy has been involved in *Exxon Valdez* oil spill research for the last 11 years. Her research includes studies on intertidal invertebrates and seaweeds, mussel populations, and a co-principal investigator of spot shrimp populations in Prince William Sound. She was the field chief of the intensive PWS oiled shoreline survey during 2001. Her responsibilities include quality control of field and laboratory sample processing, data analysis, graphics, and proposal/report preparation.

OTHER KEY PERSONNEL

Chemists Marie Larsen, Larry Holland, Josefina Lunasin will participate in the chemical analyses of the samples. Contractors Dr. Robert E. Thomas and Dr. Gary Marty will participate at the principle investigator level on analyses for DNA damage in mussels and P450 response in crescent gunnels.

LITERATURE CITED

See combined "Literature Cited" section for Parts I & II.

PART II: Impacts to Sea Otters and Harlequin Ducks (DOI - USGS)

ABSTRACT

Sea otters and harlequin ducks have not fully recovered from the EVOS, based on demographic, physiological and biochemical differences between populations in oiled and unoiled areas. To explore links between residual oil and the lack of population recovery, we captured sea otters in areas known to have relatively high quantities of residual oil, and collected blood and liver samples. These areas overlapped with the study sites described in Part I of this DPD, sampled by ABL for bioavailability of lingering oil in intertidal areas. Exposure of sea otters to hydrocarbons is being measured by the cytochrome P450 biomarker (in blood and liver), and liver alterations are being assessed by gross and histologic examination, and by serum enzymes. Harlequin ducks have also been captured in oiled areas as part of another project (02423). However, in this proposal, we included components for (1) histopathology of sea duck liver biopsies, collected from Barrow's goldeneyes in 1996 and from harlequin ducks in 2001 and 2002. In 2003, we request funds for closeout of the sea otters and harlequin duck components of this study. Results of 2002 field studies will be interpreted in conjunction with data collected by NOAA-ABL scientists, on the bioavailability of oil in shoreline areas of western PWS. Activities for the closeout year will include data analyses and preparation of the final report and publications.

INTRODUCTION

Through 2001, studies have shown a lack of recovery for sea otters (*Enhydra lutris*) and harlequin ducks (*Histrionicus histrionicus*) in oiled areas of western PWS, and several lines of evidence strongly implicate continuing exposure to oil as a primary factor limiting recovery (Bodkin et al. in press; Esler et al. in press). Both species feed on invertebrates in the nearshore ecosystem, and potentially could be exposed to oil either through their prey or directly, in sediments or in the water column. Major research findings in 1995-2001 include: (1) lower survival rates for sea otters and harlequin ducks in oiled areas (Monson et al. 2000, Esler et al. 2000), (2) elevated levels of cytochrome P450 1A (CYP1A), a biomarker of hydrocarbon exposure (Ballachey et al. 2001b, Trust et al. 2000, Esler, pers. comm.), and (3) diseased livers in sea otters from the oiled area in 2001 (USGS unpub. data). The discovery in summer 2001 of greater amounts of residual EVOS oil on beaches (NOAA-ABL, unpubl. data) substantiates concerns that exposure in nearshore areas persists, and that residual hydrocarbons are constraining recovery of sea otters and harlequin ducks in areas of PWS that were heavily oiled in 1989.

Sea otters and harlequin ducks were subject to continuing study in 2002, as part of Projects 02423 and 02585. For harlequin ducks, work consisted of (1) capture of wild birds for survival rate studies (radiotelemetry) and tissue sampling for CYP1A assays, and (2) controlled studies of oil exposure on physiology and behavior of harlequin ducks held at the SeaLife Center in

Seward. For sea otters, studies included (1) collection of carcass remains off beaches, to estimate ages and survival rates, and (2) surveys of abundance, and (3) capture of sea otters to examine livers and collect blood and liver for biomarker assays. In 2001, the incidence and severity of liver lesions were higher in sea otters caught at northern Knight Island, as were the P450 values. Thus, there is continuing concern about the effect of residual oil on health of both sea otters and harlequin ducks residing in areas of western PWS where beach sediments are known to retain oil.

In 2002, we captured additional sea otters, in waters adjacent to known areas of residual oil, to assess oil exposure (using the P450 biomarker) and liver condition (by gross examination, biopsies for histopathological examination, and serum chemistries). For harlequin ducks, similar work is ongoing as part of Project 02423; however, the harlequin duck studies were expanded with histopathological examinations of liver biopsies from wild-caught and captive birds. Additionally, histology was done on archived liver biopsies collected in 1996 from Barrow's goldeneyes in oiled and unoiled areas of western PWS. Capture locations for sea otters and harlequins were coordinated with NOAA-ABL researchers, who are examining bioavailability of lingering oil (see Part I of this DPD).

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. Previous restoration projects (95025-99025; 99423-02423) have examined the status of recovery of sea otters and harlequin ducks. Results to date clearly suggest that complete recovery has not occurred for sea otters or harlequin ducks, and implicate continuing exposure to oil as a limiting factor.

The lack of recovery of sea otters is based on an aggregate of findings. The sea otter population in western PWS (WPWS) suffered heavy losses in 1989, with estimates of sea otter mortality due to the spill ranging from 750 to 2,650 individuals (Garshelis 1997, Garrott et al. 1993). Surveys of abundance, conducted 1993-2000, have shown a significant increasing trend in the overall WPWS sea otter population. In contrast to the western Sound, sea otter numbers at northern Knight Island (where oiling of beaches was heavy) remain below pre-spill estimates and through 2001, do not show any increasing trend (Bodkin et al. in press; Dean et al. 2000; USGS unpubl. data). Survey results are consistent with other observations which suggest that the population in the most heavily oiled areas has not yet recovered. Carcass collections and modeling efforts based on age-at-death data through 1998 (Monson et al. 2000) indicate post-spill survival rates of sea otters in WPWS have been lower than pre-spill rates, even for animals born after 1989. From 1996-98 and again in 2001, measurement of the P450 biomarker in sea otters showed elevated levels at Knight Island (Fig. 2), indicating recent exposure to aromatic hydrocarbons (Ballachey et al. 2001b, Bodkin et al. in press). Serum chemistries of sea otters in the western Sound show elevations of enzymes indicative of liver disease, most notably gamma-glutamyl transferase

(GGT) (Ballachey et al. 2001a, USGS unpubl. data). In July 2001, livers of sea otters in oiled and unoiled areas of WPWS were examined directly, by endoscopy, and biopsied for histopathology. Observations of the livers, and histology results, confirm that there is a higher incidence of microscopic and biochemical abnormalities in sea otters from the oiled area (USGS unpubl. data). In some cases, damage to the liver appears sufficient to impair survival of those individual otters.

To further investigate links between continuing oil exposure and toxic effects on sea otters, we captured sea otters in summer 2002 in areas of western PWS which are known to have relatively high concentrations of residual EVOS oil, and which were concurrently monitored to determine the bioavailability of that oil. We are measuring induction of P450 and liver function in these otters, and relating our findings to results on bioavailability of oil along adjacent shorelines. The results will provide unique and valuable information on long-term chronic effects of the oil spill on sea otters and aid in projecting recovery time for the sea otter population in PWS.

Recent studies (/025, /427, and /423) suggest that harlequin duck populations also continue to suffer deleterious effects from the oil spill. In 1996-98, sea ducks (harlequins and goldeneyes) had higher CYP1A levels in oiled areas than in unoiled (Trust et al. 2000), and in 2000, harlequin duck samples continued to show elevated CYP1A (D. Esler, pers. comm.) indicating continuing hydrocarbon exposure. In addition, harlequins in oiled areas have lower survival than their counterparts in the unoiled area. This difference was demonstrated over the course of 3 winters (1995-98) and again in the winter of 2000-2001 (Esler et al. 2000, Esler et al. in press, D. Esler pers. comm.). Continued study of harlequin ducks is underway as part of Project 02423, and thus additional capture of harlequins was not part of this project. However, given the liver pathologies observed in sea otters in summer 2001, histopathology on (1) archived liver biopsies collected from Barrow's goldeneyes in oiled and unoiled areas in 1996 (Trust et al. 2000), (2) liver biopsies collected from wild-caught harlequins in oiled and unoiled areas in the fall of 2001, and (3) liver biopsies collected in spring 2002 from harlequin ducks held in captivity at the SLC and exposed to oil (the latter two groups are part of studies under 02423) was conducted as part of this study.

B. Rationale/Link to Restoration

Sea otter and harlequin duck restoration requires assessments of population recovery status and definition of impediments to recovery. The study complements a related study of continuing injury to sea otter and harlequin duck populations (Project //423), by identifying the extent to which residual oil is bioavailable and examining individual animals from those same areas for evidence of exposure and toxic effects of hydrocarbons on the liver.

C. Location

Studies were conducted in PWS. Specific study sites for the sea otter components were northern Knight Island, Green Island, and the Port Chalmers/Stockdale area at Montague Island. Harlequin duck study sites, as described in Project 02423, were Montague Island, Green Island, Knight Island, Crafton Island, Main Bay, and Foul Bay. Captive harlequin duck studies (02423) were at the Alaska SeaLife Center in Seward. Communities affected by the project include Chenega, Whittier, Cordova and Seward.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Charters to support the research were solicited from the spill impacted area.

PROJECT DESIGN

A. Objectives

1. Assess liver function and incidence of liver abnormalities in sea otters from oiled and unoiled areas (FY02).

2. Monitor P450 induction in sea otters in oiled and unoiled areas, as an indicator of ongoing aromatic hydrocarbon exposure (FY02).

3. Assess incidence of liver abnormalities in harlequin ducks from oiled and unoiled areas (FY02).

4. Relate P450 and liver findings to residual oil concentrations in capture areas (FY02).

5. Closeout: data analyses, writing and submission of final report and publications (FY03).

B. Methods

Sea Otters. In summer 2002, we captured sea otters (up to 50 total) in oiled and unoiled areas of PWS, using capture and handling methods will be similar to those employed previously (Bodkin et al. 1999).

The RT-PCR assay (quantitative reverse transcriptase PCR assay; Snyder et al. 2000, Vanden Heuvel et al. 1993, 1994) was used to measure P450 levels in sea otters. This assay quantifies the messenger RNA (m-RNA) that codes for the cytochrome P4501A protein. We conducted the

assay on both peripheral blood mononuclear cells and a liver biopsy. Analyses were done at Purdue University. Blood samples were also sent to a clinical laboratory for hematology and chemistry assays. Histopathology on the liver samples was done at the School of Veterinary Medicine, Purdue University.

Harlequin Ducks

An extensive study of harlequin ducks is ongoing under Project //423. Liver biopsies were collected from individual birds at the time of surgeries to implant radiotransmitters for survival studies. In addition, liver biopsies were collected from Barrow's goldeneyes in 1996 and archived. Histopathology on the liver samples will be done using standard procedures by Alaska Pathology Services or at the School of Veterinary Medicine, Purdue University.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The overall project is a joint effort with NOAA-ABL. USGS-BRD personnel were responsible for directing and conducting sea otter and harlequin duck studies. A contract was established with Purdue University for histopathology of liver samples and for P450 assays on sea otter tissues. ABL personnel conducted studies on oil bioavailability as described in Part I of this DPD.

SCHEDULE

A. Measurable Project Tasks for FY03

October-December	Histopathology of liver samples collected in 2002 P450 & Blood chemistry assays Data entry & analyses
January 2003	Attend annual EVOS Workshop
January-Sept.	Coordination of data interpretation with ABL personnel Writing of reports and publications
Sept. 30, 2003:	Submission of Final Report

B. Project Milestones and Endpoints

Sept. 30, 2003:	Submission of Final Report

C. Completion Date

All sample collection was completed in FY02; laboratory analyses will be completed by December 2002, and project closeout will occur in FY03. A final report will be submitted by Sept. 30, 2003.

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.

PROPOSED PRINCIPAL INVESTIGATORS

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PRINCIPAL INVESTIGATOR QUALIFICATIONS

Jim Bodkin, Research Wildlife Biologist, and team leader for coastal ecosystem in Alaska for the Alaska Science Center of USGS. 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.

Brenda Ballachey is a Research Physiologist at the Alaska Science Center of USGS. 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.

Dr. Paul Snyder is an Associate Professor of Pathology and Immunotoxicology and Director of the Clinical Immunology Laboratory of the Department of Veterinary Pathobiology, Purdue University. He is also a Diplomate of the American College of Veterinary Pathologists. His research interests are in the area of mechanism-based studies on the pathology and immunology of xenobiotics on biological systems. He has been a PI on the Nearshore Vertebrate Predator project since 1995.

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.

OTHER KEY PERSONNEL

George Esslinger, Kim Kloecker and Daniel Monson of the USGS Alaska Biological Science Center will assist with data input and analyses.

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2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2002	Proposed FY 2003	PROPOSED FY 2002 TRUSTEE AGENCIES TOTALS ADEC	ADF&G	ADNR	USFS	DOI	NOAA
							$94.8	$201.6
Personnel	$28.7	$33.4						
Travel	$17.4	$1.2						
Contractual	$139.2	$7.0						
Commodities	$97.0	$5.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$282.3	$46.6			Estimated FY 2004	Estimated FY 2005		
General Administration	$14.1	$5.5						
Project Total	$296.4	$52.1			$0.0	$0.0		
Full-time Equivalents (FTE)	0.5	0.5						
Other Resources	$0.0	$0.0			$0.0	$0.0		

Comments:

Part I of this budget is being submitted at a higher cost than predicted in the FY02 DPD. Part I was estimated to cost **15K** but is now being submitted at **35.5K**. As stated in the proposal, some additional chemical analyses may spill into FY03 due to unexpected primary analyses. There are no changes to Part II (USGS) of this budget.

FY03

Prepared: 4/12/2002

Project Number: 03585
Project Title: Lingering Oil: Bioavailability and Effects
Lead Agency: NOAA- Auke Bay Laboratory

FORM 2A
MULTI-TRUSTEE
AGENCY
SUMMARY

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2002	Proposed FY 2003	LONG RANGE FUNDING REQUIREMENTS					
Personnel	$12.5	$19.0						
Travel	$12.6	$1.2						
Contractual	$77.2	$7.0						
Commodities	$92.0	$5.0						
Equipment	$0.0	$0.0						
Subtotal	$194.3	$32.2			Estimated FY 2004	Estimated FY 2005		
General Administration	$7.3	$3.3						
Project Total	$201.6	$35.5			$0.0	$0.0		
Full-time Equivalents (FTE)	0.2	0.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

Supervision and participation by J. Rice and J. Short contributed. **This budget is being submitted at a higher cost than predicted in the FY02 DPD.** Part I was estimated to cost 15K but is now being submitted at 35.5K. As stated in the proposal, some additional chemical analyses may spill into FY03 due to unexpected primary analyses.

FY03

Prepared: 4/12/2002

Project Number: 03585
Project Title: Lingering Oil: Bioavailability and Effects
Agency: NOAA - Auke Bay Laboratory

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2002
						0.0
						0.0
Mandy Lindeberg	Fisheries Research Biologist	GS-11	2.0	6.0		12.0
						0.0
						0.0
Larry Holland	Chemist	GS-11	1.0	7.0		7.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		3.0	13.0	0.0	
					Personnel Total	$19.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2002
EVOS Workshop - Jan. 2003	0.4	2	2	0.2	1.2
					0.0
				Travel Total	$1.2

FY03

Prepared: 4/12/2002

Project Number: 03585
Project Title: Lingering Oil: Bioavailability and Effects
Agency: NOAA- Auke Bay Laboratory

FORM 3B
Personnel
& Travel
DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Contractual Costs:	Proposed FY 2002
Description	
Temporary labor (NOAA) - chemical analysis support	7.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$7.0

Commodities Costs:	Proposed FY 2002
Description	
Laboratory Supplies	5.0
Commodities Total	$5.0

FY03

Prepared: 4/12/2002

Project Number: 03585
Project Title: Lingering Oil: Bioavailability and Effects
Agency: NOAA- Auke Bay Laboratory

FORM 3B
Contractual & Commodities DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2002
			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
NOAA/NMFS- Auke Bay Laboratory		
Computer/Software		
HPLC		
GCMS		

FY03

Project Number: 03585
Project Title: Lingering Oil: Bioavailability and Effects
Agency: NOAA- Auke Bay Laboratory

FORM 3B
Equipment
DETAIL

Prepared: 4/12/2002

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2002	Proposed FY 2003						
Personnel	$16.2	$14.4						
Travel	$4.8	$0.0						
Contractual	$62.0	$0.0						
Commodities	$5.0	$0.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$88.0	$14.4			Estimated FY 2004	Estimated FY 2005		
General Administration	$6.8	$2.2						
Project Total	$94.8	$16.6			$0.0	$0.0		
Full-time Equivalents (FTE)	0.3	0.2						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

No changes to estimated closeout costs.

FY03

Prepared: 4/12/2002

Project Number: 03585
Project Title: Lingering Oil: Bioavailability and Effects
Agency: DOI/USGS - Sea Otters and Harlequin Ducks

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2002
Research scientist	Wildlife Biologist	GS 12/04	2.0	7.2		14.4
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		2.0	7.2	0.0	
					Personnel Total	$14.4

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2002
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.0

FY03

Prepared: 4/12/2002

Project Number: 03585
Project Title: Lingering Oil: Bioavailability and Effects
Agency: DOI/USGS - Sea Otters and Harlequin Ducks

FORM 3B
Personnel
& Travel
DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

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

Existing Equipment Usage:	Number of Units	Inventory Agency
Description		

FY03

Project Number: 03585
Project Title: Lingering Oil: Bioavailability and Effects
Agency: DOI/USGS - Sea Otters and Harlequin Ducks

FORM 3B
Equipment
DETAIL

Prepared: 4/12/2002

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

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

Commodities Costs:	Proposed
Description	FY 2002
Commodities Total	$0.0

FY03

Prepared: 4/12/2002

Project Number: 03585
Project Title: Lingering Oil: Bioavailability and Effects
Agency: DOI/USGS - Sea Otters and Harlequin Ducks

FORM 3B
Contractual &
Commodities
DETAIL