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Sound Ecosystem Assessment (SEA)/Prince William Sound System Investigation -Planning and Communication (SEA PLAN)

Project Number: 95320-P

Name of project leader(s): Dr. David Scheel, Ecology, Prince William Sound Science Center

Lead organization: Prince William Sound Science Center

Cooperating agencies: University of Alaska Fairbanks (UAF)
Alaska Department of Fish & Game (ADF&G)

Cost of project/FY 95: $176.5 K
Cost of Project/FY 96 and beyond: $169.6 K

Project Start-up/Completion Dates: FY95: October 1, 1994-September 30, 1995
FY96: October 1, 1995-September 30, 1996

Geographic area of project: Prince William Sound and North Gulf of Alaska

Name of lead agency project manager: Dr. Jerome Montague, Alaska Dept. of Fish & Game

Contact: Dr. David Scheel
PWS Science Center
P.O. Box 705
Cordova, AK 99574
Tel: (907) 424-5800

B. INTRODUCTION

Planning and Communication assists coordination between projects, and builds community interaction with ongoing science. Planning activities allow the SEA program to pursue integration with other Trustee-funded research projects and to evaluate possible future directions as the program evolves. Communication activities are designed to keep individual researchers aware of SEA activity outside their own projects, to facilitate coordination among SEA researchers, between SEA and other Trustee research, and to actively maintain community involvement in setting direction for SEA research in the future.

Focus on an ecosystem approach to managing the recovery from the Exxon Valdez oil spill of damaged resources is leading to a cooperative, integrated design for research. In 1994, scientists studying oceanography, zooplankton, fish, birds and mammals jointly developed an integrated research program focused around the damaged pink salmon and herring populations of Prince William Sound (Sound Ecosystem Assessment, project 94320). Similar collaborations are now developing focused on pelagic predators of forage fish, and on nearshore organisms for implementation in 1995. Within each program, obtaining public input to the integration of

research ideas, methodologies and protocols requires careful attention. Between programs, similar attention is needed to ensure that research results are complimentary rather than duplicative, and are fiscally efficient. This project addresses the needs of the SEA program for continued scientific planning, public involvement, and the use of community knowledge through the continuation of SEA Planning and Communication (94320-P).

Planning needs to be done in coordination with research programs focused in each area; e.g., forage fish studies focused on tests of the food limitation hypothesis for marine birds and mammals, or studies on intertidal and subtidal systems. In 1994, SEA researchers developed cooperative sampling designs with Alaska Department of Fish and Game on sockeye salmon, pacific herring, and harbor seals, and with the Copper River Delta Institute/U.S. Forest Service on gulls, sea ducks, and shorebirds. For 1995, additional interaction with both the Pelagic Predators of Forage Fish group and with Nearshore/Intertidal Trophic studies are developing, particularly in the areas of physical oceanography, herring biology, and foraging biology. Cooperative work on humpback whales is also proposed. Planning and communication within the SEA program needs to continue to ensure that developing interaction and integration between research efforts continues to be focused and well organized.

Planning, as well as scientific understanding, will also benefit from exchange of knowledge with long term resident resource users, developed in coordination with the proposed program for community knowledge transfer. SEA plan has been developed with an exceptional reliance on community and public involvement, facilitated through the PWS Fisheries Ecosystem Research Planning Group (FERPG). The experience provided by long-term users of the resources under study (often spanning several decades and including knowledge passed down through generations) has been an invaluable source of insight into the ecosystem. In addition, the mutual exchange of information between scientists and the public directly benefits the communities by providing increased and reliable information about species they regularly depend on. The facilitation of public participation in scientific research thereby provides community members the satisfaction of having a role in the overall effort to restore PWS (particularly through community based projects), develops a greater community knowledge for decision-making, and relieves frustration over lack of information.

The involvement of communities in the research will lead to greater confidence in the results among users, as well as facilitate the incorporation of community knowledge in study programs. Public participation in the research process will facilitate management response to public concerns, and lead to increased sense of public ownership of and satisfaction with resource research and management. This involvement of community interests and expertise does not happen without careful preparation, however. Continued coordination of communication and public involvement is needed between FERPG constituent organizations, the communities of PWS, SEA scientists, agencies, and the Trustee process.

C. NEED FOR THE PROJECT

Resources addressed by SEA include pink salmon, herring, and the principal species interacting with these fishes. These pelagic organisms support a host of birds and mammals, some of which are listed as injured species of the EVOS. Services addressed include subsistence, commercial fishing, recreation and tourism, and passive use. All resources and services benefiting from SEA stand to gain from careful planning, communication and community involvement in active research programs.

D. PROJECT DESIGN

1. Objectives:

(1) Continue Scientific Planning: This work will provide an avenue for SEA integration with other EVOS research on sea birds, mammals, and other fishes, as well as direction for future SEA science. Nearly all pelagic-nearshore, apex predator populations are subject to the same ocean state conditions and dependent upon the dominant species, and/or the prey and predator populations studied in SEA. The importance of Pacific herring and pink salmon in Prince William Sound means that the integration of apex predator studies with SEA is an efficient and meaningful approach to improving ecological studies in the region.

The pelagic-nearshore, intertidal systems and the marine and terrestrial systems are linked by the transfer of carbon and nutrients via the migrations of animal populations that feed on marine production. There are exciting areas of future cooperation, and provide a conceptual framework for the proposed study program 'Trophics and community structure in the intertidal and shallow subtidal'. The SEA 'Planning and Communication' project will continue contact with EVOS project leaders in these areas to maintain SEA program involvement with pelagic predators, nearshore/intertidal, and terrestrial system studies. Long term residents of PWS are familiar with these populations and systems. Their direct input and participation in this research will be solicited and facilitated.

(2) Communications and public participation: This project will maintain open communications regarding the progress and development of SEA with PWS communities and regional organizations (e.g. fishermans' unions, PWSCORS, native corporations). The continued input of communities in the design and implementation of SEA will be solicited.

(3) Community knowledge transfer: We will work with the proposed EVOS community knowledge transfer project and facilitate its implementation within the SEA program. This may include proactive involvement of local residents of Cordova, Chenega Bay, Whittier, Tatitlek, Valdez and Seward, and other residents of PWS in research projects through existing channels: continuation of the existing FERPG policy of promoting local hire, providing adequate notice of opportunities to bid on support service contracts, and developing volunteer research participation programs serving both an educational and a research support role.

2. Methods:
First, strategic plan development will continue to develop, refine and evaluate scientific direction for SEA research and assist coordination with other research efforts. This work will be coordinated by the Scientific Planner, but will be the product of the entire SEA Scientific Committee.

Second, meetings, memos, maps, and reports will be used as needed to distribute information both among SEA scientists and to the regional community. This will include a periodic newsletter to report on the progress and status of SEA programs, the location and duration of projects, and opportunities for participation. Travel to Anchorage, Juneau and Fairbanks will allow SEA, EVOS and University programs to remain appraised about each other's planned research, thereby minimizing overlap and promoting integration. Travel between Cordova and PWS will provide opportunity for community involvement in the SEA plan and local research efforts, to solicit input to the plan, and for interested community members to participate as members of the SEA research team where appropriate. While all projects will have responsibilities for reporting their progress, the Communication Coordinator will ensure that all involved parties are apprised of developments in all areas, and will coordinate communication between SEA scientists, FERPG constituent organizations, the communities, agencies, and the Trustees.

Third, the Communication Coordinator will work with the developing EVOS community knowledge transfer project to promote community knowledge transfer as part of the SEA program. Within SEA, several mechanisms are envisioned, including the establishment of a community-designated liaison to coordinate interaction with SEA, assisting communities to arrange workshops, teleconferences and meetings between long term resident resource users and SEA scientists, and providing timely information regarding ongoing research through verbal, written, and formal communications.

3. Schedule
Open meetings and scientific workshops will be attended as scheduled by the EVOS Restoration Office or other research programs.

Open FERPG meetings will be held monthly through out the year, and more frequently except during the field season. The Communications Coordinator will be available for public contact, by telephone or drop-in office visits at least 4 hours per week. These opportunities for public involvement are the minimum that will be provided. Many individual project leaders have active involvement of local resources and expertise in their programs. FERPG has an open-office policy and welcomes public input at any time.

4. Technical Support:
The Planning and Communication portion of SEA requires the support of all SEA projects and the continued involvement of the SEA Project Leaders and scientists. Computer services, including GIS, will be provided through the Prince William Sound Science Center. Involvement of Project Leaders will be accommodated by coordination with the Chief Scientist (Dr. T.

Cooney) and with SEA DATA program under Dr. V. Patrick. Communication with local communities will be achieved as in the past, through interaction with regional organizations such as fisherman's unions and the PWS Communities Organized to Restore the Sound, as well as through community knowledge transfer programs.

5. Location:
Prince William Sound, the North Gulf of Alaska, and the EVOS-impacted region, where appropriate.

E. PROJECT IMPLEMENTATION

The SEA program is implemented cooperatively by Alaska Department of Fish & Game, PWS Science Center, University of Alaska Fairbanks, PWS Aquaculture, as well as U.S. Forest Service, National Biological Survey, U.S. Fish & Wildlife Service, and National Oceanic and Atmospheric Administration. The interaction of scientists in these organizations to conduct SEA research occurs within the PWS Fisheries Ecosystem Planning Group (FERPG), an ad hoc organization with a mission to develop and advocate the best ecosystem science for the restoration and management of pink salmon and herring in Prince William Sound. The FERPG has formally accepted the PWS Science Center as the organization to conduct the Planning and Communications project. Major components of SEA are located at the Science Center, including SEA computer systems for data base and modeling needs, and the SEA acoustics and oceanography program.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

The purpose of SEA PLAN is to establish clear communications between SEA projects and related FY95 work plans; and to update plans to keep SEA an integrated part of the total EVOS-related research effort. Scientific planning for SEA PLAN will utilize initial SEA results collated by SEA DATA. Planning will involve the active participation of SEA lead scientists, long term residents, local resource users, and open communication with the public and the Trustee-process to ensure that planned developments and project direction are well-integrated with other EVOS-related research.

G. PUBLIC PROCESS

There has been a tremendous amount of public input into the formulation of this project. In addition to the input of agency, University, and private scientists, input has been received from Prince William Sound Communities Organized to Restore the Sound (PWSCORS), Cordova District Fisherman United, Cordova Aquatic Marketing Association and numerous Prince William Sound fisherman. It is now time to develop a process for integrating community knowledge into current research and ecosystem models. The purpose of SEA PLAN is to continue to encourage substantial involvement of the public, and to develop streamlined communication pathways between SEA programs and the public in the EVOS-impacted region.

H. PERSONNEL QUALIFICATIONS

Principle Investigator:

David Scheel, Associate Scientist, Prince William Sound Science Center. Education: Ph.D. (Ecology, 1992, University of Minnesota), MS (Ecology, 1986, Univ. of MN), BS (Biology, 1980, Renesselaer Polytechnic Institute). Professional experience: 1993-present, Associate scientist, PWSSC; 1992-93, Postdoctoral associate, University of Houston; 1986-1992, Research scientist, Serengeti Wildlife Research Institute, Serengeti, Tanzania; 1984-1992, student/post-doc/consultant, Univ. of Minnesota. Selected publications: Scheel, D. 1993. Profitability, encounter rates and the prey choice of African lions. *Behav. Ecol.* 4(1):90-97. Cameron, G. N., & D. Scheel. 1993. A GIS model of the effects of global climate change on mammals. *Geocarto International* 4:19-32. Research projects: Predator-prey dynamics of Serengeti lions and their prey, habitat selection models of Texas mammals, frequency- and density-dependence in models of community evolution, social behavior and resource/habitat use of primates in Gombe.

Communications & Community Involvement:

Jody Seitz, Communications Coordinator, Prince William Sound Science Center. Education: M.S. (1989, Rural Sociology, University of Wisconsin-Madison), B.A. (Anthropology, 1980, Beloit College). Professional experience: 1989 - June 1994, Subsistence Resource Specialist II, Alaska Department of Fish and Game; 1991 - June 94, lead researcher for Prince William Sound and the Copper River Basin; 1989 - 1990, projects in Nushagak Commercial District, Aleknagik, Clark's Point, and Unalakleet. Selected publications: Seitz, J. 1990. Subsistence Fishing in the Nushagak Commercial District. AK Dept. of Fish and Game, Juneau. Seitz, J., in prep. The Use of Wild Resources in Clark's Point, Alaska. AK Dept. of Fish and Game, Juneau. Seitz, J., L. Tomrdle, & J. Fall. in prep. The Use of Wild Resources in Hope, Whittier, and Cooper Landing. AK Dept. of Fish and Game. Ongoing projects: documentation of resource uses in Tatitlek, Chenega Bay, and Cordova from 1991 through 1993; and documentation of traditional knowledge of marine mammal uses in Prince William Sound communities.

I. FY95 BUDGET($K)

	FY95	FY96
Personnel	$89.2	$89.2
Travel	$30.4	$30.4
Contractual	$19.3	$19.3
Commodities	$2.4	$2.4
Equipment	$5.8	$0.0
Total direct costs	$147.1	$141.3
Indirect costs (20%)	$29.4	$28.3
Project Total	$176.5	$169.6

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Sound Ecosystem Assessment (SEA), An Ecosystem Research Plan for Prince William Sound--Avian Predation on Herring Spawn

Project Number: 95320-Q

Project type: Research/Monitoring

Name of project leader(s): Dr. Mary Anne Bishop, Copper River Delta Institute, US Forest Service & University of Washington Center for Streamside Studies

Lead agency: USDA, U.S. Forest Service, Pacific Northwest Research Station

Cooperating agencies:
Alaska Department of Fish & Game
National Biological Survey
National Oceanic and Atmospheric Administration
North Gulf Oceanic Society
Prince William Sound Science Center
Prince William Sound Aquaculture Corporation
University of Alaska Fairbanks

Cost of project/FY 95: $124.8K

Cost of Project/FY 96 to FY99: $427.1K

Project Start-up/Completion Dates: Ongoing; for FY95 Oct 1 1994-Sep 31 1995

Geographic area : Herring Spawning Grounds Throughout Prince William Sound

Contact:
Dr. Mary Anne Bishop
Copper River Delta Institute
U.S. Forest Service
P.O. Box 1460
Cordova, AK 99574
Tel: (907) 424-7212

B. INTRODUCTION

Pacific herring (Clupea pallasi) has been identified as a resource injured by the Exxon Valdez oil spill. Studies conducted from 1989-1994 have documented a significant decline of spawning biomass. In 1993 and 1994, the total observed spawning populations were less than one-third and two-thirds of pre-season prediction, with the 1994 commercial herring fisheries season totally cancelled.

The SEA Plan hypothesizes that the recruitment success of herring populations in Prince William Sound (PWS) is related to losses due to physical processes (e.g. wave action and

currents) and to predation during the embryo and larval stages. This study is a continuation of research begun in FY94 by the U.S. Forest Service aimed at determining herring egg loss to avian predators. In spring 1994, avian predation on herring spawn was intensively studied on northern Montague Island. A preliminary analysis of the 1994 data is underway and initial results will be available for presentation at a Fall 1994 program review.

Understanding the factors affecting herring egg loss is necessary to accurately model herring recruitment for fisheries management. Currently Alaska Department of Fish and Game (ADF&G) estimates the adult spawner biomass from total egg deposition, average fish size and sex ratio, and average fecundity at size measured. Losses to predation and physical processes before and after ADF&G spawn deposition surveys are needed to accurately calculate spawning biomass and to assess the impact on recruitment to the larval stage.

Throughout incubation, egg loss can be significant. During a 2-year study in 1990 and 1991 in PWS, rates of egg loss as high as 91.2% have been measured, with an overall estimated egg loss rate of 50.4% throughout the incubation period. Predators of herring spawn include invertebrates, marine mammals, fish, and birds. Epibenthic invertebrates (crabs, snails, and starfish) and birds (primarily Glaucous-winged gulls (Larus glaucescens), herring gulls (Larus argentatus), and surf scoters (Melanitta perspicillata)) have been identified as the greatest sources of egg loss on spawning areas in Washington and British Columbia. Until this study began in spring 1994, only potential sources of predation were identified in PWS.

Prince William Sound has a large resident population of herring spawn avian predators including glaucous-winged gulls and surf scoters. Surf scoters are abundant in the region and the most numerous sea duck. Migrant surf scoters are numerous in April and May. Glaucous-winged gulls are also an abundant resident. Although they are present in numbers throughout the year, an influx does occur in spring, mainly between mid-april and mid-May . Historically, large numbers of glaucous-winged gulls (30-50,000) have been observed in areas with herring spawn at northern Montague Island.

Northern Montague Island is also an important spring migratory stopover for two species of shorebirds that prey on herring spawn: surfbirds (Aphriza virgata) and black turnstones (Arenaria melanocephala). In May 1992 a single day count of almost 56,000 surfbirds and 25,000 black turnstones was recorded.

Spatially and/or temporally then, herring spawn deposition in PWS coincides with breeding for a large resident population of glaucous-winged gulls, and with spring stopover areas for seaducks and shorebirds. Until this study began, however, we had no information on numbers and distribution, and how predictable or variable the use of herring spawn is by resident and migrant birds. Nor has the importance of herring spawn in providing a super-abundant food resource for egg laying and migration been determined. From a fisheries management standpoint information on avian predation is important because if the avian predator population remains relatively constant or increases, then the lower herring stock levels that PWS is currently experiencing could experience higher rates of predation.

C. NEED FOR THE PROJECT

As an injured species, Pacific herring is currently not recovering. The herring fishery is crucial to the economy and well-being of PWS communities. Our study, SEA Project No. 95320-Q will continue to investigate the effects of avian predation on herring spawn survival. As part of the SEA plan, it is designed to complement ADF&G's SEA Project No. 95320-S, an ongoing long-term study on herring natal habitats. The goal of Project No. 95320-S is to improve herring fisheries management in PWS by determining accurate and precise estimates of herring abundance. A better understanding of the loss of herring spawn to avian predators will improve estimates of egg loss used in current stock assessment models. These models are used by fishery managers to set herring harvest quotas. As part of the SEA Plan, this project will also provide further information on the regulating effect that bird predation has on recruitment into the herring population.

D. PROJECT DESCRIPTION

1. Objectives

The goal of this project is to assess and document the impact of avian predation on herring spawn in Prince William Sound. Results will be integrated into a model relating Sound-wide herring embryo survival to predation, habitat type, egg density, and meteorological conditions. Specific hypotheses that will be tested include:

1) Distribution, timing, and abundance of gulls, seaducks and shorebirds is positively correlated with dispersion, timing, and abundance of herring spawn.

2) Avian predation on herring spawn is a function of egg density.

3) Egg loss resulting from avian predation occurs at higher rates in years when eggs are scarce.

4) Herring spawn is a major component in the diet of bird species foraging in herring spawn areas.

5) Viable herring spawn are preferred prey compared to dead and decaying spawn.

2. Methods

The impact of avian predation on herring spawn will be documented by observing the distribution, relative abundance and behavior of birds foraging in herring spawn areas and by analyzing their diets. Herring spawn deposition density and subsequent egg loss will be documented by the concurrent ADF&G SEA Project No. 95320-S. The extent and distribution

of herring spawn will be documented from daily aerial flights conducted as a regular part of ADF&G commercial fisheries management.

The phenology, relative abundance and species composition of birds foraging in herring spawn areas will be documented using boat and aerial shoreline surveys. Avian near-shore boat surveys will be conducted at low tide along a 15-km length of shoreline containing herring spawn. Transects will include an equal amount of shoreline with and without spawn. Transect width will extend from the shoreline seaward to 120m. Data collected will include: location, number and species (or genus), shoreline type, activity, and habitat (land, water, or air).

Aerial surveys will cover nearshore areas at northern Montague Island from just south of Port Chalmers to Zaikof Bay (approximately 100km of shoreline). Surveys will be flown during low tide, at an altitude of 250-360m. A hi-band video camcorder mounted in the bulkhead of a fixed wing aircraft will be used to record numbers and distribution of gulls and scoters. VHS output will be georeferenced with the aircraft's Global Positioning System (GPS). To identify and count birds in the lab, Super-VHS images will be analyzed using image analysis software.

Foraging ecology in herring spawn areas will be determined from: scan and focal animal samples, prey availability and removal, and diet analysis. Randomly located plots including both intertidal and subtidal zones will be scanned for birds every 30 minutes over a tidal cycle. For each species, information recorded will include activity, location, and habitat (substrate and meters above or below the tideline). To document activity budgets of avian predators, a series of 10 minute focal-animal samples will be collected.

Prey availability in the intertidal zone will be determined using random transects within the boat survey area. Transect locations will be stratified between spawn and no spawn areas. Quadrats ($0.01m^2$) will be used to sample prey items at intervals along the transect. All prey items within the plot will be quantified. Availability of prey items suspended in the water $<1m$ below the tideline will be sampled with mesh frames.

Egg loss to avian predators will be determined using $1\text{-}m^2$ plots containing a known egg density. Using photography, initial egg density and subsequent removal will be determined for each plot. During a 3 to 6-hr observation period, bird activity within the plot will be recorded.

Bird diets will be documented by collecting esophagus and proventriculus contents from 30 glaucous-winged gulls and 30 surf scoters. Sampling effort will be proportional to the spatial distribution of each species across the intensive study area.

3. Schedule

Oct 94	Formal review of FY94 season.
Nov 94	Preliminary tests of new experimental protocol.
Jan 95	Logistical planning. Order equipment and supplies.
Feb 95	Personnel selection.

Mar 95	Begin field season.
Jun-Aug 95	Field season completed, data entry and data analysis, submit 96 work plan
Sep-Nov 95	Data analysis, draft report writing and internal review
Oct 95	Formal review of the FY95 season.
Mar 96	Peer review of 95 report completed, final report submitted.

4. Technical Support:

Herring egg densities and egg loss samples from ADF&G diver surveys will be processed by ADF&G. Aerial surveys on extent of herring spawn will be conducted by ADF&G. Results from both of these efforts will be made available to this study for further analysis. Laboratory processing of esophageal and proventricular contents as well as biometric support will be contracted. Data will be archived by project staff in accordance with standardized procedures set up for handling the SEA Plan database.

5. Location:

Field research will be conducted in Prince William Sound at northern Montague Island from Port Chalmers to Zaikof Bay. High densities of herring spawn have occurred in this area nine of the last ten years. Northern Montague Island also hosts the highest numbers of migrant surfbirds and black turnstones from late April through May.

E. PROJECT IMPLEMENTATION

This ongoing project is being implemented by the Copper River Delta Institute, a research institute of the U.S. Forest Service. This project is part of the 95320 SEA program, a cooperative effort by Alaska Department of Fish & Game, PWS Science Center, U.S. Forest Service, University of Alaska Fairbanks, PWS Aquaculture, as well as National Biological Survey, U.S. Fish & Wildlife Service, and National Oceanic and Atmospheric Administration. Ongoing Copper River Delta Institute spring shorebird migration studies on the Copper River Delta will provide additional information on the phenology and habitat use of surfbirds and black turnstones.

H. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project is organized and coordinated under three of SEA's major programs: Natal Habitat, Predator-Prey, and the Database and Modeling. All aspects of field work for this study are coordinated with the Alaska Department of Fish and Game Herring Natal Habitats Study 95320-S. ADF&G will provide herring egg densities and egg loss results from ADF&G diver surveys and information on the timing and extent of spawn documented from ADF&G aerial spawn surveys.

All data from this study will be archived by the project staff in accordance with standardized procedures set up for handling the SEA Plan database. The field results from the avian

predation study will be integrated into the SEA plan's numerical and analytical models of the PWS ecosystem that include predation parameters and animal distributions.

I. PUBLIC PROCESS

Sound Ecosystem Assessment (SEA) was originally designed and implemented with extensive public involvement through the PWS Fisheries Ecosystem Planning Group (FERPG), and this group remains an important avenue for SEA scientists to interact with the public. SEA was reviewed at the December 1993 Cordova workshop. Additionally, the SEA project for Planning and Communication actively seeks public input and involvement in research from PWS communities.

J. PERSONNEL QUALIFICATIONS

Mary Anne Bishop, Ph.D., Principal Investigator. Research Avian Ecologist for Copper River Delta Institute, U.S. Forest Service and University of Washington Center for Streamside Studies. Since 1990, Bishop has been principal investigator for research projects on shorebird and trumpeter swan migration ecology, and avian predation on herring spawn on the Copper River Delta and in Prince William Sound.

S. Patrick Green, Assistant Project Leader & Field Supervisor. Copper River Delta Institute, Pacific Northwest Research Station, U.S. Forest Service. Since 1991, Green has assisted with studies on shorebird and trumpeter swan migration ecology, and was field supervisor for the avian predation on herring spawn study in FY94.

Fred Everest, Program Manager. Program Manager for the Aquatic/Land Interaction program of the Pacific Northwest Research Station, U.S. Forest Service. The Copper River Delta Institute and its research program is a major component of the Aquatic/Land Interaction program.

Disease Impacts on Prince William Sound Herring Populations

Project Number: 95320-S

Project Leader: TBD

Lead Agency: Alaska Department of Fish and Game

Cost of Project (FY95): Estimated Range of $150,000 to $400,000

Project Start-Up: February 1995 **Completion Date:** September 1995

Project Duration: TBD, estimated 2-3 years (including 1994)

Geographic Area: Prince William Sound

Contact Person: Dr. Joseph R. Sullivan
Alaska Dept. of Fish and Game
333 Raspberry Rd.
Anchorage, AK 99518-1599
Phone: 907-267-2213

B. Introduction: Prior to the 1993 herring spawning season, 134,000 tons of herring were forecast to arrive on the spawning grounds of Prince William Sound. Significantly less than half that amount appeared. Skin lesions, typically ulcerated, were seen on one-sixth to almost one half the fish in almost every school (except northeastern PWS). Viral hemorrhagic septicemia (VHS) was isolated from these fish but it was not determined whether this virus was the cause of the poor returns and apparent disease or simply a secondary infection in fish which were already in poor health for another unknown reason. Nevertheless, the virus which causes VHS was the only pathogen isolated from these fish. In 1994, it appears that only 20,000 tons of herring have arrived at the spawning grounds, little spawning has occurred, many ovaries are degenerate and the lesions, never a reported feature of the spawning population prior to 1993, are also abundant this year. Though human induced large mortalities of fish commonly occur in many places, natural epizootics of this magnitude are very rare. Herring are very long lived fish (to 15 years), and, in the absence of catastrophic events, dramatic population declines should not be expected.

VHS is a very poorly understood disease. It has the potential to infect many, perhaps most, species of bony fishes (fish other than sharks and rays), but its ability to produce disease varies from species to species. Salmon may be carriers for example while rainbow trout in European hatcheries suffer severe mortalities. Attempts to produce the disease in cod with cultures isolated from other cod have met with mixed success.

In 1994, the Trustee Council sponsored investigation of herring disease in Prince William Sound. VHSV was again isolated from spawning Prince William Sound herring, but it remains

unknown whether this pathogen is a significant cause of the decline in the size of the PWS herring population. Diseased animals have been observed during spawning, but it is unknown whether this epizootic is in progress prior to spawning or continues after spawning. Though large interannual mortalities are apparent, it is unknown whether these are concentrated during any particular part of the year nor what other factors besides VHSV may be associated with them.

C. Need for the Project: Prince William Sound Pacific herring (*Clupea pallasi*). Pacific herring support five commercial fisheries in PWS with an annual average ex-vessel value of $8.3 million. In addition, several thousand pounds of herring and herring spawn on kelp are harvested annually for subsistence purposes and form an important part of the local native culture of Chenega and Tatitlek Pacific herring provide important forage for many species including some species severely injured by the Exxon Valdez oil spill. Predator species include humpbacked whales, seals, sea lions, gulls, sea ducks, shore birds, halibut, salmon, rockfish and other fish. Significant declines in marine birds and mammals which eat forage fish have been reported from Prince William Sound. Decline in the prey base, of which herring constitute a major portion, has been implicated in decline in bird and mammal numbers. Thus a major reduction in herring numbers in Prince William Sound has the potential for significant impacts throughout the ecosystem. It is incumbent upon the Trustee Council to investigate circumstances which could seriously limit the recovery of species injured by the Exxon Valdez oil spill. Collapse of the herring population has that potential.

D. Project Design: The design for this project is yet to be determined because requests for proposals are being solicited through the State of Alaska Multi-Step procurement process. Nevertheless, some general statements may be made at this time.

1. **Objectives:** Determine the epizootiology of disease-associated decline in the size of the Prince William Sound Pacific herring population including microbial, anthropogenic and environmental causes.

2. **Methods:** To be determined by successful bidder.

3. **Schedule:** To be determined by successful bidder.

4. **Technical Support:** To be determined by successful bidder.

5. **Location:** Prince William Sound.

E. Project Implementation: This project is to be implemented through the State of Alaska Multi-Step Procurement Process. Some logistics and pathogen diagnostic testing may be

provided by the Alaska Department of Fish and Game if this is determined to be necessary for the successful completion of this project.

F. Coordination of Integrated Research Effort: This subproject was added to 94320 (Prince William Sound System Investigations) in 1994 and is expected to be part of this project in 1995. This subproject is closely allied with many of the other subprojects of 94320, with Project 94166 (Herring Spawn Deposition and Reproductive Impairment), and with Project 94163 (Forage Fish Influence on Injured Species). If VHSV is a primary pathogen, a catastrophic decline in herring abundance will occur despite other environmental parameters which might be favorable and which are being investigated by other 94320 subprojects. Conversely, VHSV may also be a sign of environmental stress and merely a secondary invader. In that case it would be much less responsible for the decline in the herring population than possibly adverse environmental conditions (cf. 94320-G, Phytoplankton and Nutrients; 94320-H, Zooplankton in the Ecosystem, and 94320-M, Physical Oceanography). Demonstrating the cause of the population decline may ultimately require information from these other subprojects. The health of the herring population in Prince William Sound will impact those animals with which it competes (cf. 94163, Forage Fishes and 94320-N, Nearshore Fish) and those resources which prey upon it (cf. 94320-F, Harbor Seals-Trophic Interactions; and 94320-Q, Avian Predation on Herring Spawn). Integrated information from the herring health subproject and the spawn deposition and reproductive impairment project may be able to predict the course of recovery for Prince William Sound Herring.

G. Public Process: The 1994 herring spawning season was the second year of herring spawning run failures apparently associated with disease. Commercial fishers believe the disease and spawning failure are a result of the Exxon Valdez Oil Spill though there is no evidence to date that this is the case. Nevertheless, commercial fishing for herring in Prince William has collapsed for the past two years. This coupled with poor returns of pink salmon in 1993 and predicted poor returns in 1994 are driving many commercial fishers to bankruptcy. The public looks to the Trustee agencies to investigate this collapse. This subproject did not follow the normal course of project development and public review because it was created to respond to an emergency situation. This is allowed in project 94320 under the Adaptive Management Process which was approved at a public meeting of the Trustee Council on April 11, 1994, a few days before the need for this herring disease subproject was apparent. Nevertheless, a representative of the Cordova District Fishermen United was present at the hastily gathered planning sessions which created this subproject and CDFU fully supports this investigation. It is expected that public fishermen will support this project in 1995.

Though this project was fielded in 1994 on an emergency basis using the authority noted above and used contractors obtained through emergency procurement procedures, it will be advertised for implementation in 1995 through the State of Alaska Multi-Step Procurement procedures. This will allow qualified offerers an opportunity to submit expressions of interest for addressing the herring disease problem. From these ideas a request for proposals will be fashioned and the qualified offerers who responded to the request for expressions of interest will be allowed

to submit a proposal for specific methods and budgets. It is for this reason that there appears a range of potential costs on the title page of this document.

H. Personnel Qualifications: Offerers qualifications will be evaluated on the basis of experience with projects of this type and magnitude, referred publications in the subject areas, advanced degrees in the fields of fisheries, microbiology or veterinary medicine with emphasis on herring life history and fish diseases, and Fish Pathologist certification by the Fish Health Section of the American Fisheries Society.

I. Budget: To be determined.

Juvenile Herring Growth and Habitat Partitioning

Project Number: 95320-T

Name of project leader(s): Evelyn Brown, CFMDD, ADFG and
Brenda Norcross, PhD, IMS-SFOS, UAF

Lead agency: ADFG

Cost of project/FY 95: $456.8 K

Cost of Project/FY 96 and beyond: $500.0 K in FY96, $500.0 K in FY97

Project Start-up/Completion Dates: November 1,1994. Completion of data analysis, model integration and reporting by September 30, 1999.

Geographic area of project: Prince William Sound

Contact Person: Evelyn Brown, CFMDD, ADFG, Box 669, Cordova AK, 99574-0669, 424-3213, FAX 424-3235 or
Brenda L. Norcross, PhD, IMS-SFOS, UAF, Fairbanks AK, 99775-7220, 474-7990, FAX 474-7204

INTRODUCTION

Prior to the *Exxon Valdez* oil spill, there had been no baseline studies conducted to document distribution or abundance of larval or juvenile forage fishes including herring in Prince William Sound (PWS). Because little was known about the early life history stages of herring in PWS, estimates of oil exposure and documented effects on specific processes such as growth and mortality was difficult. We documented injury to the embryos and newly hatched larvae in 1989 and the precipitous decline in the spawning population in 1993 (Brown et al. submitted). However, the gap in our understanding of what happened to the exposed larval and juvenile herring between 1989 and 1993 resulted in an inability to link cause and effects. We could not entirely separate the effects of oil exposure from those due to changes in oceanographic conditions, zooplankton abundance or density dependent predation. As we now take an ecosystem approach to answering questions about herring, we can fill in this gap in our understanding of the early life history stages. Through Prince William Sound Systems Investigation, Sound Ecosystem Assessment (SEA), we will address predator/prey relationships, physical processes affecting natal habitat, environmental factors controlling juvenile growth, mortality, and ultimate recruitment as adults, the relationship between transport of larvae and surface and subsurface currents in the sound, and location and condition of juvenile and adult herring in the winter. The proposed study will address the broader issue of what is causing the demise of herring in PWS by investigating dynamics of larval and juvenile herring.

An ecosystem approach is needed now because lack of such an approach immediately following the oil spill is causing interpretation of larval abnormality indices and the cause of the herring disease to be questioned. In 1993 and 1994 the adult spawning biomass was greatly reduced over previous years and showed a high incidence of skin lesions and occurrence of VHS virus (Meyers, et al., 1994; Brown et al., submitted). It is well known that exposure to oil can weaken the immune system in fish. This population is composed largely of fish that were one year old during the spill of which we knew very little. However, because historic information available indicated that the area covered by the oil trajectory overlapped the distribution of juvenile herring to a large degree, we suggested that the potential for exposure through ingestion of oiled particles and prey was great. Although the 1989 year class contributes under 5% of the affected population, the overlap between the oil trajectory and the drifting larvae was over 80% in 1989 (Norcross et al. submitted) resulting in a great exposure risk and potential for succumbing to disease. Abnormalities in free-swimming larvae were documented, but without a baseline index of occurrence, we could not estimate the oil induced perturbance. Whether or not this year class, once infected, could have exposed the rest of the adult population when it fully recruited as four-year-olds in 1993 is speculative.

Many researchers now feel that understanding the early life history stages is crucial to understanding the variability and cyclic behavior of herring recruitment. The factors affecting the abundance of recruits are believed to include changes in predator abundance, zooplankton biomass, and oceanic conditions (Ware 1990). Recent studies have also pointed to the importance of available habitat providing spatial refuge from predators and a nearby food supply. In addition, predator abundance and food availability affect foraging behavior (evidence of optimal foraging) and density dependent mortality of juveniles (Walters and Juanes 1993). Survival of larvae is probably less deterministic of ultimate recruitment than survival of juveniles; however, some years advective processes probably do impact herring recruitment. Because larval and juvenile stages lack density dependent growth mechanisms (Blaxter and Hunter 1982; Cushing 1981; McGurk et al. 1993), density dependent predation is probably more important (Stocker 1993). Through the findings of this study and related SEA programs, we hope to describe the relative importance of zooplankton or food abundance, oceanic conditions, habitat requirements, and density dependent predation in determining the large fluctuations in abundance observed. In addition, we will continue to document those variations induced by the *Exxon Valdez* oil spill by defining baseline levels of morphologic and cytogenetic abnormalities (which were believed to be elevated in 1989) occurring in PWS larvae. The larval data collected in 1995 will build upon data collected by Norcross et al. (submitted) in 1989. In future years, the development of the ocean state model will enable us to describe advective processes of larval herring, its relative importance in determining recruitment, and its importance in determining distribution of juvenile herring inside and outside of the Sound.

NEED FOR THE PROJECT

The target species of this study is Pacific herring, one of the species listed by the EVOS Trustee Council as damaged and not recovering. This species experienced poor recruitment in 1993, when the 1989 year class would have been expected to enter into the fishery a disease

(VHS) plagued the returning adult population. The resulting population crash which continued into 1994 resulted in reduction of the herring fishery in 1993, closures of all fisheries in 1994, exacerbating the already depressed economic state of the region. In addition, the herring population decline has countless effects on the ecosystem including oil spill injured apex predators. Understanding and monitoring the recovery of this important species will be crucial to understanding the restoration of the species that feed upon them.

PROJECT DESIGN

This 3-5 year study will address several core hypotheses of the SEA including: 1) oceanographic and meteorological effects on plankton dynamics and fish distribution, 2) predator/prey relationships, 3) herring condition and overwinter survival. It will also address the related hypotheses regarding ecotoxicity, specifically on herring larvae.

Objectives

The overall objective of this multi-year project is to understand interannual variability in successful year classes of herring in PWS. This can be accomplished by examining the fish in the context of their total environment including their general distribution, the meteorology and oceanography driving the system, and the biology of the lower trophic levels which act as food for fish larvae. During the first year, we will collect basic biological and baseline information needed to refine study design. During the second year and beyond, we will examine finer scale processes and habitat characteristics affecting juvenile herring growth and survival. The larval and juvenile fish aspect of the ecosystem study will achieve the following objectives this year:

1. To determine the general distribution and habitat characteristics of juvenile herring in the nearshore and offshore waters of western and southwestern portions of PWS.

2. To identify bays that are utilized by juvenile and adult herring during summer rearing.

3. To subsample these bays, and determine the relative distributions of juvenile herring and co-existing species in both bays and passes in PWS.

4. To determine the diet composition and relative food abundance compared to the relative juvenile herring abundance sampled in both bays and passes.

5. To compare age composition and growth of herring (using length frequency and size-at-age analyses) between areas and between bays and passes.

6. To determine levels of predation and relationships between juvenile herring predation rates, juvenile herring abundance, and macro-zooplankton abundance observed in bays and passes.

7. To determine the temporal and spatial differences in oceanic conditions in rearing areas in

both bays and passes.

8. To determine baseline levels of morphologic and cytogenetic condition of herring larvae.

9. To identify and count co-existing larval fishes collected simultaneously.

10. To monitor the age composition, growth, condition factor, food availability, and predation rates on a subsample of overwintering juvenile herring populations in PWS.

Methods

We will be collecting information on larval and juvenile herring from three main locations: 1) passes, bay mouths and offshore waters of western and southwestern PWS, 2) inside 6-8 bays typically utilized by juvenile herring during the spring and summer stratified by eastern, western and southwestern PWS, and 3) offshore of spawning areas on northern Montague Island. In the passes, juveniles and their predators will be collected by trawl (offshore) and seines (nearshore) by the Juvenile Salmon and Herring Integration project of SEA. Physical oceanography and zooplankton data are collected simultaneously by the Zooplankton in the Ecosystem and oceanography components of SEA that share the research platform. General distribution in the passes will be determined acoustically by the Nearshore Fish/Acoustics project of SEA. Signal processing and analysis of acoutstic data collected in bays will be contracted. In the passes, sites will be visited every two weeks. In the bays, juveniles will be sampled using bait seines from a seine vessel and physical data, zooplankton, and hydroacoustics will be collected from a smaller companion vessel. Sampling will be more intensive in bays with collection of at least three sets of continuous data through tidal cycles stratified by month and location. These data, together with information on the structure of the area (e.g. depth, distance offshore) will be used to classify the nursery habitat utilized by juvenile herring. Sampling for larval fish will be done from a small trawler using a 1 m^2 Tucker trawl with 505 mm mesh nets. We will sample offshore of the Montague spawning areas during a narrow window of time (3-5 days) immediately following hatch.

Objectives will be met through analyzing data collected by the various platforms. The Juvenile Salmon and Herring Integration study will provide data to meet objectives 1 in full and 3, 4, 5, 6, and 7 in part. Refer to the methods of that project description on collection techniques. Data collected and processed by the integration study to be analyzed by this study include juvenile herring distribution, relative densities, diet composition (stomach contents already processed), co-existing species, length frequency, weight and age to satisfy objectives 1-7. Although larvae will be collected by the zooplankton project of SEA, this study will be responsible for all sample processing and analysis in order to meet objectives 8. and 9. The majority of the larval and bay-caught juvenile herring sample processing and data analysis will be accomplished through reciprocal service agreements (RSA) with the University of Alaska, Fairbanks The acoustics project of SEA will provide some of the broad-scale distribution and relative abundance information needed to complete objective 1. The remainder of the data needed to satisfy objective 1 will come from the Physical Oceanography project of SEA as well

as physical data collected by this study. This study will in turn provide samples to the bioenergetics of PWS herring and related species study which will provide information of somatic energy cycles, condition factors, sexual maturity and ovarian energy indices relative to the other indices of juvenile herring. With the help of the SEA communications person and the community transfer coordinator for the Trustee Council, we will work with the high schools in the region to develop a volunteer data collection scheme to sample winter aggregations of juvenile herring occurring near the municipalities.

Aggregations of juvenile herring in bays throughout PWS will be identified by ADF&G overflights conducted by the regularly conducted salmon escapement surveys (general funds) and by our project. Aerial surveys will be conducted weekly over a six-week period. A high resolution 8 mm video camera, that is directly linked to a GPS and downloadable to GIS, may be used during aerial surveys to track aggregations. There will be a separate contract for GIS data processing. Potential sample locations, derived from the historic literature, include bays in eastern PWS (Port Fidalgo including Fish Bay and Irish Cove, Port Gravina including Beartrap Bay, Jack Bay off of Valdez Arm), western PWS (Pt. Chalmers, MacLeod Harbor, Hanning Bay on Montague Island; Snug Harbor and Herring Bay on Knight Island; Naked Island; Port San Juan on Evans Island; and McClure, Main, Eshamy, and Whale Bays) and the southwestern exit (Puget Bay).

A variety of statistical methods and fisheries models will be used to analyze the data. As in the integration study, multiple regression analysis will be used to examine the relationship between feeding rates (dependent variable), predator feeding rates (dependent), and macro-zooplankton abundance (independent variable) to assess density-dependent mortality due to predation in order to meet objective 6. Growth rates between sites and among years will be compared using an ANOVA. Because aging of daily growth rings in otoliths of juvenile herring is time consuming it will only be employed on a small subsample of herring collected using methods outlined by McGurk (1984, 1990). For a larger percentage of herring juveniles, we will use a time sequence of length frequency histograms to reveal growth of the fish over the study period. Stomach contents analysis will be used to estimate the diet composition of juvenile herring, with prey identified to the lowest taxonomic level. An ANOVA will conducted to test differences temporally and spatially. Using the zooplankton abundance data and growth rate analysis, a simple bioenergetics model will be applied to evaluate whether the growth of juvenile herring was likely limited by low prey density. Relative fish abundance data (CPUE) will be related to several parameters of physical conditions including habitat characteristics using linear discriminant function analysis. A stepwise multiple regression is used to further refine the relative importance of the factors.

A subsample of herring larvae will be examined for morphological deformities and assigned a Graded Severity Index analogous to that performed on the 1989 samples. A subsample of that will be sent to JoEllen Hose (Occidental College, Los Angeles, CA) for cytogenetic analysis. We expect the data obtained in herring larvae in 1995 to be within the morphologic and cytogenetic baseline range for normal larvae as newly hatched larvae in 1990 and 1991 fell within this range. However, older larvae have not been examined subsequent to

1989. It is expected that these samples will provide a baseline with which to compare 1989 and will validate the results obtained from 1989 samples.

Schedules

October 1994 - January 1995
Finalize detailed study plan, coordinate with all companion projects and investigators based on results of 1994 sampling.

January - March 1995
Stage for FY95 field season.

Mid-May - July 1995
Field work in Prince William Sound, begin sorting and identification of larvae, stomach contents analysis and other lab work.

August - September 1995
Preliminary analysis of data.

Technical Support

This project requires strong supporting projects from other SEA projects including Physical Oceanography (PWSSC), Nearshore Fish/Acoustics (PWSSC), Pink Salmon and Herring Integration (ADFG/UAF), and Bioenergetics of Herring and Related Species (UAF). Work on morphologic and cytogenetic indices will be contracted to Dr. Jo Ellen Hose who has previously conducted 3 years related work on PWS herring larvae. The bulk of the data processing, analysis and report preparation will be conducted by staff at UAF.

Location

We will concentrate on the PWS herring population. Although there is evidence that adult herring utilize offshore feeding grounds on the continental shelf adjacent to their spring spawning areas (Stocker 1993), the data available suggest that juveniles remain in nearshore areas to feed year around. Therefore, we will concentrate in the nearshore bays and passes within and immediately bordering Prince William Sound. We will collect larval samples offshore of spawning beaches on northern Montague Island.

References

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PROJECT IMPLEMENTATION

Alaska Department of Fish and Game will take the lead with the majority of the data processing and analysis conducted through RSA with the University of Alaska, Fairbanks with Brenda L. Norcross as the Co-Principal Investigator supervising all work. Dr. Norcross conducted a larval fish study in PWS in 1989, is a fisheries oceanographer, and is the logical choice for this position. Involving a new individual would involve additional costs in bringing

them up to speed.

A subcontract to Dr. JoEllen Hose, Occidental College, Los Angeles, CA for cytogenetic analysis of herring larvae. Dr. Hose developed the techniques and conducted the analyses on the 1989 herring larvae and subsequently studied PWS larvae for two additional years. Dr. Hose will be the logical choice for this contract due to her past expertise, in order to maintain consistency in the data-set, and because a new individual would require additional costs for familiarization with the data and techniques.

COORDINATION OF INTEGRATED RESEARCH EFFORT

The proposed study is a new part of the integrated Prince William Sound Ecosystem Assessment (SEA) which was initiated in 1994. This project is designed as an interdisciplinary study which focuses on transport of herring larvae but is dependent upon results of the concurrent Physical Oceanography and Nearshore Fish/Acoustic projects through shared data and resources and integrated sampling plans. This study will use results generated by Zooplankton in the Ecosystem, Phytoplankton and Nutrients, Bio-energetics of Herring in PWS, and the VHS study which was initiated in April 1994 on an emergency basis. It will also be coordinated and conduct data-sharing with FY95 studies on forage fish, pelagic seabirds, and marine mammals. The information gained from this proposed study will contribute to the PWS herring recruitment model that is part of the Herring Natal Habitat study.

PUBLIC PROCESS

As a part of SEA, this program has received significant public involvement and support to date. Recognizing that the early life stage dynamics will govern the restoration of the future herring population in PWS, there is considerable local support for this study. PWSFERG meetings, during which the SEA plan and its program elements are discussed, are open to the public and advertised at other PWS localities.

Additionally, we will participate in a community transfer program that involves potentially four PWS communities (Cordova, Valdez, Tatitlek, and Chenega) and their high schools. We will invite students to become involved in a winter data collection scheme providing data forms and assistance in study design of aggregations of overwintering herring that are adjacent to these communities.

PERSONNEL QUALIFICATIONS

Evelyn D. Brown, M.S., has been a herring research biologist with ADFG since 1988 and a crew leader for a sonar project for three years prior to that. She participated as the Principal Investigator for the herring damage assessment studies in PWS from 1989 to 1993. Currently, she is the project leader for the spawn deposition program and herring representative on the science committee for PWSFERG and the SEA plan. She recently submitted a paper for the EVOS symposium proceedings entitled "The Exxon Valdez Oil Spill and Pacific herring in

Prince William Sound: a summary of injury from 1989 - 1994" co-authored by the damage assessment research team to be published in 1995. She has also submitted as primary or co-author several papers for the Canadian Journal of Fisheries and Aquatic Science, also to be published as a special herring oil spill supplement in 1995. Former projects include a hydroacoustics study on Mullet in Florida, environmental impart studies and fisheries management plans for the Metlakatla Indian Community on Annette Island, and an oyster culture feasibility project also on Annette Island. She is currently a member of the American Fisheries Society.

Brenda L. Norcross, PhD. is a professor of fisheries oceanography, with expertise in larval and juvenile fishes, at the Institute of Marine Science, School of Fisheries and Ocean Science at the University of Alaska, Fairbanks. Brenda has conducted work on larval herring in PWS in 1989 and has worked on flatfishes and other juvenile fishes in Alaska. Since 1989, she has submitted paper, with three other co-authors, to the Canadian Journal of Fisheries and Aquatic Science entitled "larval herring distribution, abundance and sublethal assessment in Prince William Sound, Alaska during 1989 following the *Exxon Valdez* oil spill" and one for the EVOS Symposium Proceedings with one other co-author entitled "analysis of larval fishes collected in Prince William Sound, Alaska during 1989". Concurrent work includes modelling habitat for juvenile flatfishes in the central Gulf of Alaska. Previous work at the Virginian Institute of Marine Science includes the transport of larval croaker on the mid-Atlantic Bight and Chesapeake Bay, overwinter survival of croaker, and interannual variation in abundance of summer flounder. Publications include:

Norcorss, B.L. and D. Hata. 1990. Seasonal composition of finfish in waters behind the Virginia barrier islands. Virginian Journal of Science, 41, No. 4A: 441-461.

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FY95 BUDGET

Line Item	Cost	Comment
Personnel	**$62,988**	Fish and Game Staffing
Travel	**$ 4,000**	Anchorage/Fairbanks
Contractual		
RSA-Norcross	$172,800	Includes 20% overhead
Hydroacoustics	$ 36,000	Collection and Signal Proc.
GIS Mapping and Processing	$ 18,000	
Vessel Charter	$100,000	Two platforms
TOTAL	**$326,800**	
Supplies	**$ 4,000**	
Equipment	**$ 30,500**	Includes seine and CTD
Capital Outlay	$ 00	
Total	**$428,288**	
General Administration	**$ 28,484**	
Grand Total	**$456,772**	

Somatic and Spawning Energetics of Herring and Pollock

Project Number: 95320-U

Project Leader: Dr. A. J. Paul

Lead Agency: University of Alaska Fairbanks

Project Cost:

FY95	$97,176
FY96	$102,294
FY97	$125,086

Duration: Three years

Project Start Date: October 1, 1994

End Date: September 30, 1997

Geographic Area: EVOS REGION

Contact Person:

Dr. A. J. Paul
University of Alaska
Institute of Marine Science
Seward Marine Center
Phone 907 224 5261

INTRODUCTION

This project will focus on the seasonal somatic energy cycles of two important forage species in the EVOS region: the Pacific herring and the walleye pollock. It will also explore over winter survival of juvenile herring and herring reproductive biology. Historically herring and pollock have been among the most abundant pelagic forage fishes in southcentral Alaska. After the Exxon Valdez oil spill the herring population of Prince William Sound has been exhibiting reduced abundance, disease, and spawning anomalies that may be related to pollution. This research effort will focus on energetics and spawning biology of herring from Prince William Sound.

Based on larval surveys pollock are known to be abundant in the EVOS region. Little is known about *in situ* pollock energetics but, like herring, they are heavily preyed upon by commercially important fish species, sea birds and harbor seals. This project will provide the energetic information necessary to quantify trophic interactions involving pollock.

Forage fishes are key components of the pelagic food web. They are both predators and prey and their energy cycles reflect the overall production process. This energetic work will provide the basic information needed to quantify trophic interactions for two of the most common forage species in the EVOS region. A long term monitoring program of energy flow in both herring (*Clupea harrengus pallasi* Valenciennes 1847) and pollock (*Theragra chalcogramma*

Pallas) may also provide some insight into how these two key forage species interact. The study of herring reproductive biology will be useful in managing the roe fishery.

Typically high latitude fishes store energy during summer and fall feeding and throughout the winter reallocate energy to reproduction (Smith *et al.*, 1990). Thus, seasonal tissue samples must be taken to account for the temporal variation in energy content.

NEED FOR THE PROJECT

The invitation to submit restoration projects identifies food web studies as having a high priority. Basic to all food web studies are energy flow models which are used to quantify how species interact, energy transfer rates, food web changes, energy balances and reproductive success in the injured species. The primary information needed for these interaction models are population estimates and measurements of energy content of the food web species. This proposed study would provide seasonal somatic energy for two key forage species, herring and pollock, which are known be important in the EVOS area food web.

There are no previous reports on energy allocation, or over winter mortality, in Alaskan herring. Historical measurements of length, weight, age and roe yields are available in a variety of ADF&G, and other agency reports. Work by the authors on Pacific cod demonstrated that energy storage in liver varied by 116% in the two years that it was measured (Smith *et al.*, 1990). In cod 46% of the energy channeled to gonads comes from liver and soma, thus reproductive output is directly related to these energy pools. It is reasonable to assume that similar variations, or perhaps even larger fluctuations, exist in energy cycles of herring, but only quantitative sampling will validate this theory.

A considerable amount of laboratory work on growth related bioenergetics of juvenile pollock have been accomplished (Harris *et al.*, 1985; Paul, 1986; Paul *et al.*, 1990; Smith *et al*, 1988). For juveniles somatic energy content has been related to condition factor (Harris *et al.* 1985). However, there is no information on intraannual and interannual variation in somatic energy content.

PROJECT DESIGN

OBJECTIVES

The objectives of this proposal are:

1. Describe the seasonal somatic energy cycle of juvenile and adult herring and juvenile pollock.

2. Describe the spawning energetics and reproductive biology of herring.

3. Examine winter mortality of juvenile herring and critical condition factor.

This project will measure ovulation and reabsorption rates for EVOS Pacific herring and ovarian energy indices relative to condition factor index, disease, somatic energy, and liver energy indices. The seasonal energy content of juveniles will be measured and critical

condition factor determined in the laboratory so that estimates of *in situ* winter mortality can be made. For walleye pollock seasonal somatic energy cycles will be described. Collections will include all age classes of pollock commonly preyed upon by bird and mammal species injured by the oil spill.

METHODS

The methods applied to both pollock and herring will be similar to those used by the investigator in previous bioenergetic studies (Harris *et al.*, 1985; Paul *et al.*, 1993, Smith *et al*, 1988; Smith *et al*, 1990). Adult herring will be collected every other month and just prior to and after spawning by ADF&G and frozen. In the laboratory they will be divided into groups based on sex, length (or age) and condition factor where CF = g wet wt x 100/(cm fork length)^3 as well as disease status. There will be a minimum of 100 fish in each sample. Wet weight will be measured to the nearest tenth of a gram. Fish will be dissected and gonad and liver weight measured. Small subsamples of axial muscle, gonad and liver will be removed for energy measurement. Each fish will be individually tagged, and freeze dried. After freeze drying they will be placed in a convection oven at 60°C until they reach a constant weight. Individual wet and dry weight values will be used to calculate the moisture content. Dried individuals will be ground in a mill and measurements of ash and caloric content made. The percentage of ash will be determined by weighing a subsample, placing it in a crucible with a loose fitting top, and heating gradually over 3 h to 600°C and maintaining the temperature for 1 h. The muffle furnace will be allowed to cool to room temperature before opening. Sample energy content will be determined by bomb calorimetry. For juvenile herring and pollock from every sample whole body energy will be measured, but individual organs will not be examined.

Fecundity measurements will be made for 100 herring from each of the study areas based on weight of the ovaries, taking a sample equal to 10% of the ovary weight from each ovary and counting the number of eggs to measure the weight of one egg. Ovary weight times the weight of one egg will provide the estimate of total fecundity. Samples will be taken prior to any observed spawning and after spawning. Estimates of eggs not spawned will be obtained from the post spawning samples.

Herring samples will be taken from two different geographical areas in Prince William Sound. Specific sampling sites will be coordinated with bird and mammal projects. This type of information will provide insight into the extent of geographical variations in somatic energy storage. Critical condition factor for juvenile herring will be measured in the laboratory (Harris *et al.*, 1986; Smith *et al.*, 1986). The same basic methods outlined for herring will be used for measuring pollock somatic energy content. Samples will be taken from four different geographical areas. Specimens will be captured using small trawls and additional samples will be solicited from researchers who obtain specimens from birds. Specific sampling sites will be coordinated with bird and mammal projects.

Proximate analysis will be carried out on tissue samples using the facilities of a commercial or university service laboratory. Live juvenile herring will be held in the laboratory and measures of conversion efficiency relative to condition factor of fish will be made using modified methods of Paul *et al.*, in press and Harris *et al.*, 1986). Fish will be captured periodically throughout the over winter period to obtain fish with different condition factors.

Herring will be fed commercial fish pellets to determine at what condition factor they have reached the point of no return.

SCHEDULE

Samples of both species will be taken over a three year period. A study of this duration is necessary to provide some estimate of what normal values would be for these previously unmeasured parameters. A minimum of three years is needed to observe interannual variations in energy cycles and provide enough data to model condition factor and liver energy storage relative to prespawning ovarian energy.

The milestone chart below outlines the proposed schedule events for the first year of study.

1. Bimonthly field sampling for pollock and herring October 1, 1994 to August 31, 1995 for somatic energy measures.
2. Sample processing for pollock and herring October 1, 1994 to August 31, 1995.
3. Progress report June 1, 1995.
4. Renewal proposal June 15, 1995.
5. Annual report September 30, 1995

Years two and three would have similar schedules with the addition of objective 6 in year two.

6. Begin laboratory studies of critical condition factor for juvenile herring, complete in year three.
7. The final report would be completed by January 1, 1998.

Modifications in due dates dictated by revisions in the proposal process will be incorporated as required by the funding agency.

TECHNICAL SUPPORT

It is assumed that all collections of herring will be done by the Alaska Department of Fish and Game and that pollock will be collected by the FORAGE FISH project so no funding for vessel time is requested. If it proves unfeasible to get samples from the FORAGE FISH project then a supplemental request for vessel time will be submitted. All laboratory facilities and equipment needed for this project are available at the Seward Marine Center laboratory.

The data will be fitted to linear, logarithmic, power and exponential curves and the r^2 goodness of fit value used to determine which curve is the best model to describe the interrelationships between size and energy content, season and energy content, condition factor and whole body energy, liver energy and ovarian energy content, or length fecundity relations using SIGMASTAT and SIGMAPLOT software and existing computers. ASCII files will be used to archive the data.

LOCATION

Herring samples will be taken in Prince William Sound in conjunction with ADF&G sampling. Pollock will be collected around EVOS rookeries and seal feeding areas in conjunction with the FORAGE FISH project.

PROJECT IMPLEMENTATION

Virtually all the bioenergetics work on Alaskan marine fish and invertebrates completed to date has been done by the author of this proposal and his colleagues (Harris *et al.*, 1986; Paul, 1986; Paul *et al.*, 1988, 1990a, 1990b, 1990c, 1992, 1993a, 1993b, Paul in press, Paul and Fuji, 1989; Smith *et al.*, 1986, 1988, 1989, 1990, 1991) and all this work has been done at the Seward laboratory. This combination of experience and facility makes IMS Seward a logical place to do fish and invertebrate energetics.

PUBLIC PROCESS

The concept of studying forage species energetics has been discussed in Trustee sponsored gatherings of scientists that preceded the invitation to submit restoration projects for fiscal year 1995. It was also discussed at the "Friends of forage fish meeting" in Anchorage and in SEA meetings in Cordova.

PERSONNEL QUALIFICATIONS

Dr. Paul has been involved in marine ecosystems research since 1980 and has worked on the PROBES, APPRISE, and FOCI projects. In these projects he explored food web interactions, trophic phasing cycles and secondary production. In addition to his biological oceanographic research he leads a group that specializes in the study of fish and invertebrate bioenergetics.

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FY95 BUDGET($K)	FY95	FY96	FY97
Personnel	67.2	70.5	88.4
Travel	8.8	9.5	10.2
Contractual	4.0	4.1	4.4
Supplies	1.0	1.1	1.2
Equipment	0.0	0.0	0.0
Sub-total	81.0	85.2	104.2
General Administrative	16.2	17.1	20.8
TOTAL	97.2	102.3	125.1

Herring Predation by Humpback Whales in Prince William Sound

Project Number: 95320V

Name of project leader(s): Craig O. Matkin, B.S., M.S.
David Scheel, PWS Science Center

Lead Organization North Gulf Oceanic Society

Cooperating agencies: Prince William Sound Science Center/SEA
Alaska Department of Fish & Game (ADF&G)

Cost of Project: **FY95:** $181.6 K

Start-up/Completion Dates: October 1994 April 1996

Duration: 1-2 years

Geographic area of project: Prince William Sound

Contact: Craig O. Matkin
North Gulf Oceanic Society
P.O. Box 15244 Homer, Alaska 99603
tel: (907) 235-6590

B. Introduction

In Southeastern Alaska and Prince William Sound, herring (Clupea harengus pallasi) and krill (Euphausia pacifica, Thysanoessa spinifera, T. raschii) are considered important prey items of humpback whales (Baker et al 1985, Krieger and Wing 1984, Dolphin 1987). Photo-identification and enumeration studies of humpback whales in Prince William Sound have been conducted every year from 1980 to 1994 (von Ziegesar 1984, von Ziegesar and Matkin, 1986,von Ziegesar et al. 1994). Observations during these studies suggest herring as a food item of humpback whales. In Sitka Sound (southeastern Alaska) herring are an important fall/winter food item for humpback whales (J. Straley, pers. comm.). Humpback whales were closely associated with the herring schools in western Prince William Sound during acoustic surveys completed by the Alaska Department of Fish and Game and Prince William Sound Science Center in 1993 (J. Wilcock pers. comm.). There is concern that humpback whale predation may limit the recovery of the diminished herring biomass in the Sound. Additionally, the reduced herring resource may restrict the feeding opportunities for the whales and eventually reduce the population of whales that feed in Prince William Sound. This project will test the hypothesis that herring are a seasonally important food item of humpback whales in Prince William Sound and that the whales have a significant impact on the recovery of the EVOS damaged herring resource.

C. Need for the project.
Because of the recent precipitous decline of the herring population in Prince William Sound, it is important to understand which factors are limiting the herring population and may effect or delay its recovery. Predation by humpback whales may be one of these factors.

Adult humpback whales may weigh as much as 43.9 metric tons (Nishiwaki 1959), although, their average weight may be somewhat less. It has been estimated by Sargent (1969) that the feeding rate for adult rorquals is about 4% of body weight per day. Von Ziegesar et al. 1994 identified 59 humpback whales in 1989 and 65 whales in 1990 in Prince William Sound. If approximately half these whales (30 individuals) were to feed exclusively on herring during the September/October period (60 days), it is conceivable that they would consume as much as 3000 metric tons of herring. Aerial surveys in April of 1994 suggest that the current herring biomass in the Sound is in the range of 20,000 metric tons. Humpback whales could consume a substantial proportion of this biomass. During the October 1993 herring hydroacoustic surveys, humpback whales were repeatedly observed in the same area as both large aggregations and scattered schools of herring. On one instance, an estimated 15 or more whales were associated with a very large herring school between Green Island and Applegate Rocks (J. Wilcock, pers. comm.). Whales were often associated with scattered schools of herring in the waters between Seal Rocks and Bay of Isles. Most of the herring were observed at depths of 10 to 60 meters. These shallow schools are well within the diving range of humpback whales, estimated to be 0-120 meters by Dolphin (1987).
If herring are a critical prey item for the endangered humpback whales in the Sound, the diminished herring population may reduce the population of whales. In turn, the currently developing whale watching segment of the tourist industry will be negatively impacted.

D . Project Design
Objectives. Investigators will examine the impact of humpback whales on EVOS damaged herring stocks in Prince William Sound. In addition, they will assess the importance of herring as a food of Prince William Sound humpback whales. The seasonal importance of herring in the whales diet will be examined using acoustic and photographic techniques and whales enumerated using photo-identification techniques. Estimates of herring consumption by whales will be developed and a model of whale predation will be constructed.

Methods. Humpback whales will be located by search of historically important feeding areas or by using reports from other vessels. Whales feeding in the areas of operation of the SEA herring biomass surveys and other SEA hydroacoustic surveys will receive primary attention. Once located, feeding whales will be tracked on sonar as they descend to feed. Layers or patches of feed will also be visible on the sonar scan. The whales movement through these patches can be observed and charted with sonar. This technique was established by Dolphin (1987) and has been used subsequently by J.Straley (pers. comm.) in southeast Alaska. Specially outfitted still cameras with video monitor will be lowered into the feed patches being used by the whales. Photographs of prey will be taken to determine species composition and density (Dolphin 1987). Detailed hydroacoustic assessment of identified humpback whale prey biomass will be made by other SEA hydroacoustic survey vessels when possible. Concurrently,

a skiff working from the survey vessel will conduct photo-identification operations in the area, enumerating individual humpback whales. Numbers of whales using specific feeding locations will be determined as well as estimates of numbers using the entire region. Estimates of prey consumption will be constructed based on metabolic requirements of the whales, prey composition, and the numbers of whales in the feeding population.

Schedule. Primary survey effort (25 days) will occur in October 1995 in conjunction with the proposed SEA herring biomass surveys. Additional surveys will be conducted in June/July 1995 (10 days) and September 1995 (10 days) to provide a more complete picture of whale seasonal feeding habits. These surveys will be coordinated with other SEA hydroacoustic assessment surveys. A summary of field activities will be provided in early November. Data analysis will occur in November and December 1995 and January 1996. Draft annual report will be submitted in March 1996.

Technical Support. Computer modeling and biometric support will be provided by project personnel at the Prince William Sound Science Center.

Project Location. Work will occur in southwestern Prince William Sound. Location of fieldwork will be dependent on humpback whale distribution. Distribution varies from year to year (von Ziegesar et al 1994). However, in late fall (October), distribution is expected to coincide with the location of herring in the Montague Strait and waters east of Knight Island. Earlier surveys (June/July and September) will be located in Montague Strait or Lower Knight Island Passage.

E. Project Implementation.

This study will be conducted by the North Gulf Oceanic Society in conjunction with the Prince William Sound Science Center, University of Alaska, and Alaska Department of Fish and Game as a core project in the SEA program. NGOS personnel have over 14 years of experience studying humpback whales using photo-identification techniques. NGOS maintains an annually updated photographic catalogue of individual humpback whales (von Ziegesar 1992). NGOS has conducted preliminary hydroacoustic studies of humpback whale prey in cooperation with the National Marine Fisheries Service.

F. Coordination of Integrated Research Effort.

The success of this project will rely on coordination with other herring oriented projects in the SEA package. Fieldwork will be closely coordinated with 320-H The role of Zooplankton in the Prince William Sound Ecosystem and 320-N Nearshore fish/ Acoustics project.

G. Public Process.

Information from this project will be presented at conferences, in the published literature, and in popular accounts. As a non-profit research and education group, NGOS frequently presents results of its research in communities and schools in the spill area. Regular visits will be made to Port San Juan and Chenega Village to inform local residents of the continuing work.

H. Personnel Qualifications.

Craig Matkin has conducted research on marine mammals in Prince William Sound and adjacent areas since 1977. He has undertaken extensive research on killer whales and humpback whales in the Sound since becoming a director of the NGOS in 1982. He pioneered the use of photo-identification in studying the population dynamics of cetaceans in Prince William Sound. He directed the damage assessment of killer whales in Prince William Sound following the EVOS and recently published that work (see T.R. Loughlin, The Effects of the Exxon Valdez Oil Spill on Marine Mammals). He has substantial experience with the use of acoustics to study cetacean populations and to locate fish populations. He has participated in biopsy sampling of cetaceans in Canada and is establishing a biopsy/genetics program for killer whales in Prince William Sound. Mr. Matkin has published results of his work in scientific literature and as popular accounts.

Olga von Ziegesar has conducted research on humpback whales in Prince William Sound since 1980. She has maintained a photographic catalogue of individual humpback whales (flukes) since 1984. She directed the humpback whale damage assessment program in Prince William Sound following the EVOS and recently published those results in T.R. Loughlin, The Effects of the Exxon Valdez Oil Spill on Marine Mammals.

David Scheel, Associate Scientist, Prince William Sound Science Center. Education: Ph.D. (Ecology, 1992, University of Minnesota), MS (Ecology, 1986, Univ. of MN), BS (Biology, 1980, Renesselaer Polytechnic Institute). Professional experience: 1993-present, Associate scientist, PWSSC; 1992-93, Postdoctoral associate, University of Houston; 1986-1992, Research scientist, Serengeti Wildlife Research Institute, Serengeti, Tanzania; 1984-1992, student/post-doc/consultant, Univ. of Minnesota. Selected publications: Scheel, D. 1993. Profitability, encounter rates and the prey choice of African lions. *Behav. Ecol.* 4(1):90-97. Cameron, G. N., & D. Scheel. 1993. A GIS model of the effects of global climate change on mammals. *Geocarto International* 4:19-32. Research projects: Predator-prey dynamics of Serengeti lions and their prey, habitat selection models of Texas mammals, frequency- and density-dependence in models of community evolution, social behavior and resource/habitat use of primates in Gombe.

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Personal Communications
Jan Straley, Straley Investigations, Sitka, Alaska
John Wilcock, Alaska Department of Fish and Game, Cordova, Alaska.

I. BUDGET (Amounts shown in thousands).

	FY95 NGOS	PWSSC	FY96 NGOS	PWSSC
Personnel	$50.2	$19.7	$50.2	$19.7
Travel	$5.3	$0.9	$5.3	$0.9
Contractual	$69.2	$4.3	$69.2	$4.3
Commodities	$12.1	$1.0	$12.1	$1.0
Equipment	$0.0	$0.0	$0.0	$0.0
Total direct costs	$136.8	$25.9	$136.8	$25.9
Indirect costs	$13.7	$5.2	$13.7	$5.2
sub-totals	$150.5	$31.1	$150.5	$31.1
Project Total		$181.6		$181.6

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Sound Ecosystem Assessment (SEA)/Prince William Sound System Investigation--Variation in Local Predation Rates on Hatchery-released Fry

Project Number: 95320-Y

Project type: Research/Monitoring

Name of project leader(s): Dr. David Scheel, Prince William Sound Science Center

Lead agency: Prince William Sound Science Center

Cooperating agencies: University of Alaska Fairbanks (UAF)
Alaska Department of Fish & Game (ADF&G)
Prince William Sound Aquaculture Corporation (PWSAC)

Cost of Project: **FY95:** $118.9K

Start-up/Completion Dates: FY95 October 1, 1994 - September 30, 1995

Duration: Two or more years

Geographic area of project: Prince William Sound

Contact: Dr. David Scheel
PWS Science Center
P.O. Box 705
Cordova, AK 99574
Tel: (907) 424-5800

VARIATION IN LOCAL PREDATION RATES ON HATCHERY-RELEASED FRY

B: INTRODUCTION

The Sound Ecosystem Assessment (SEA) program relies upon testing a set of core hypotheses to achieve its goals of understanding marine production in Prince William Sound. The 'predator-prey relationship' hypothesis of SEA suggests that predation on early life stages of pink salmon and herring is an important modulator of survival, and that the intensity of this predation depends on the availability of alternative prey such as macrozooplankton. Initial carbon budget models suggest that the primary predators on 0-age class fish may be pollock, but there are not sufficient data to state this with certainty. The Pink Salmon & Herring Predation project (94320-E) is designed to evaluate the significance of fish predation on 0-age class fishes, focusing on the pink salmon out-migration pathway from fry emergence into the marine environment until the juveniles leave the Sound.

During May 1994 at the Esther Island hatchery (WNH, Lake Bay), SEA researchers noted hundreds of birds, including primarily terns, gulls, and mergansers, feeding near hatchery

release sites. The acoustic and net sampling at the same time did not reveal correspondingly high predation by fishes. In contrast, however, the same observations at Evans Island hatchery (AFK) found evidence of juvenile pollock aggregating around fry schools, but did not note substantial bird aggregations (T. Cooney, pers. comm.). These field observations suggest that in some cases, predation on young fish by birds may be as important as predation by larger fishes. This is a reasonable supposition in light of data from other areas, documenting the importance of avian predation on schools of small fish at both local (Piatt 1990) and regional scales (Hatch 1992, Springer 1993).

This proposal is for funds to record the size, composition, behavior and duration of foraging aggregations (including mammals, if appropriate) at salmon hatchery release sites. These data will be interpreted in conjunction with results of other projects (that will provide data on prey abundance and distribution) to evaluate the intensity and spatial variation in tetrapod (i.e. bird and mammal) predation on hatchery fry schools, and to test a series of hypotheses explaining that variation. Examination of predation on these hatchery schools of small fish will also provide insight into bird and mammal foraging aggregations on other schooling fish, such as herring or forage fish.

C. NEED FOR THE PROJECT

Pink salmon are an important resource in Prince William Sound that is not recovering from damage by the *Exxon Valdez* oil spill. Hatchery production of pink salmon fry is an important and economically valuable tool that has been successfully applied to enhance pink salmon populations and fisheries in the Sound. However, variation in the success of pink salmon releases are not currently understood.

Results of SEA and preceding investigations suggest that predation is an important moderator of pink salmon survival, and that bird predation on hatchery-released fry may be at least as important as predation by larger fish. This study is needed to evaluate the localized intensity of predation rates on hatchery-released fry, and to understand the mechanisms generating spatial, seasonal, and year-to-year variation in predation intensity. Results of this study will be useful in designing optimal fry-release strategies to minimize losses to predation. Results may also be generally applicable to understanding the efficiencies of birds and mammals foraging on small, schooling fish, and thus to testing the food limitation hypothesis as an explanation of declines in pelagically foraging bird and mammals.

This project is a component of SEA essential to evaluating the predator-prey relationships hypothesis that predation regulates pink salmon survival and is moderated by the availability of alternative prey. Techniques, equipment, and support structure (e.g. a volunteer program) used in this project may also be applicable to the herring overwintering program under SEA, as understanding localized predation on juvenile herring is one goal of that program. However, no data collection on herring are proposed under this budget.

D. PROJECT DESIGN

1.1. General Objectives

The primary goal of this proposal is to estimate the relative intensity of localized predation on hatchery-released salmon fry for one to two weeks after release, to describe variation in local predation intensity, and to provide tests of hypotheses accounting for this variation. The short period following release is when predation on fry is likely most intense, because 1) fry have not dispersed yet and hence are a locally dense food source, 2) fry are still small, and 3) fry may be unusually vulnerable because they are naive. It is also the period when fry can be most reliably located by researchers, because their location and abundance is known at the time of release.

Field observations and other studies suggest that predation by birds may be substantial relative to predation by fish, and that predation intensity is locally variable. I propose four hypotheses to account for spatial, seasonal, and year-to-year variation in local predation intensity on fry:

1) Variation in local predation intensity on fry are determined by the distribution and abundance of alternative prey, including macrozooplankton and other small fish (Prey-switching hypothesis).

2) Variation in local predation intensity on fry is determined by the energetic cost of foraging. I will assume that distance to forager breeding colonies is one measures of energetic costs, since birds must return from foraging trips to this central location. (Energetic costs hypothesis).

3) Variation in local predation intensity on fry is determined by prey vulnerability. Hatchery fry are naive and hence unusually vulnerable (Vulnerable prey hypothesis).

4) Variation in local predation intensity on fry is determined by risk to foragers of feeding. For example, high bald eagle activity in some areas may make foraging there more risky than feeding elsewhere (Risk hypothesis).

These hypotheses address the four variables known to influence feeding rates of predators (Brown 1988, 1992): missed-opportunity-costs (of foraging elsewhere), energetic costs, success rate, and the risk of foraging.

1.2. Objectives for 1995

Sampling will be conducted near hatchery release sites in the one to two weeks immediately following release. Sampling will therefore occur between mid-April and mid-May of 1995. Five to ten days of additional sampling will be done in June if a late-release is conducted. Objectives for this project are:

1) Record size and composition of foraging aggregations near hatchery-release sites following releases.

2) Sample behavior at foraging aggregations to measure dive and capture rate for foragers that bring prey to the surface before consuming them (e.g. gulls and terns).

3) Organize volunteer observers at each hatchery release site in PWS to record the qualitative abundance and composition of foraging aggregations near hatcheries during release and post-release periods. This will provide wider geographic coverage at minimal cost to estimate the extent of variation in foraging aggregations.

4) Opportunistically repeat size/composition and behavior sampling of foraging aggregations located on schools of wild fry. This data will form part of the test of the Vulnerable prey hypothesis

5) Using data from this proposal and from salmon growth, salmon predation, and nearshore acoustic projects, estimate the extent of local predation on hatchery-released fry in the 7-14 days following release.

2.1 Methods

Data will be collected at two hatcheries (Esther Island and Evans Island), on an alternating schedule designed to include the 7 days following as many releases at each hatchery as possible.

1) Size and composition of foraging aggregations: Foraging aggregations will be observed from a small boat and from shore. Sampling will start at the time of release or slightly before, as foragers are not expected to aggregate at release sites until prey becomes available. All foragers present (including potential predators on foraging birds) will be counted and identified to species if possible, or to species group, and foraging behaviors noted. Aggregations will also be photographed for later counting. Repeated counts throughout the release period will be used to measure variation in the aggregations over time. Data from other SEA and hatchery projects will be used to track the fry schools for up to 14 days post-release.
2) Behavior: Focal-animal sampling will be conducted on-site if possible, and from video tapes otherwise to estimate dive rates for each prominent species (or species-group) of forager and to estimate capture rates for each species that brings food to the surface before consumption (e.g. gulls and terns). Response to and interactions with potential predators (e.g. eagles) will be recorded to estimate impact of predation risk on foraging.
3) Volunteer organization: Each hatchery in PWS will be contacted to recruit volunteers to keep notes and the size and composition of bird aggregations near release sites. Data forms, instructions, binoculars and bird identification guides will be loaned to volunteers as necessary. Volunteers will be asked to daily record foraging aggregations near the hatchery.
4) Opportunistic sampling of aggregations on wild fry: SEA sampling boats are attempting to locate and track wild and hatchery schools of fry. If wild fry schools are located during the field sampling period and are logistically accessible, the same sampling techniques will be used on wild fry schools to estimate predation intensity on wild schools.

5) Analysis: Estimated local predation rates will be calculated from flock size, and dive success rates recorded from focal-animal samples. Variation in predation intensity will be obtained from comparison of the two focal sites, and from the volunteer data set. Hypotheses will be re-examined and evaluated in light of this data.

2.2 References

Brown, J. S. 1988. Patch use as an indicator of habitat preference, predation risk, and competition. Behavioral Ecology and Sociobiology 22:37-47.

Brown, J. S. 1992. Patch use under predation risk: I. Models and predictions. Ann. Zool. Fennici 29:301-309.

Hatch, S. A., and G. A. Sanger. 1992. Puffins as samplers of juvenile pollock and other forage fish in the Gulf of Alaska. Marine Ecology Progress Series 80:1-14.

Piatt, J. F. 1990. The aggregative response of common murres and Atlantic puffins to schools of capelin. Avian Biology 14:36-51.

Springer, A. M. 1993. Report of the seabird working group. Is it food? Addressing marine mammal and seabird declines: workshop summary. Alaska Sea Grant College Program, AK-SG-93-01. (Pages 14-29)

2.3. Schedule

Jan- 14 Apr:	Organize logistics, purchase equipment and organize volunteers
17 Apr - 19 May:	Field work at hatcheries.
22 May - 30 Sep:	Analysis and report writing.

2.4. Technical Support

This project will require normal hatchery operations to provide fry releases, and is provided logistical support through hatchery operations (equipment and personnel transport, volunteers, lodging). This project benefits from the availability of acoustic and net sampling data from SEA programs including Pink salmon growth and mortality, Salmon predation, and Nearshore fish and acoustics.

2.5. Location

This research will be conducted in Prince William Sound. Field work will be located at or near hatchery release sites and analysis will occur at the PWS Science Center.

E. PROJECT IMPLEMENTATION

This research is proposed by and should be conducted by the Prince William Sound Science Center. This work is an integral part of the SEA program and relies on close interaction and access to SEA researchers and data. It is also designed to complement other proposed research involving Science Center collaboration, including components of the SEA Herring program, SEA Predator-prey program, the Science Center proposal to conduct a Forage Fish assessment, and a proposal for sampling foraging efficiencies at food patches.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

As part of the SEA program, this project is coordinated with the SEA integrated research effort. SEA coordinating efforts include the SEA Planning and Communication project, SEA Information Systems Modeling. The proposed research contributes to SEA programs on predator-prey relationships, herring overwintering, and modeling. This project is also designed with input from the Pelagic Predators and Nearshore work groups and complements research proposed within those groups. The PI of the proposed work has been and will continue to be an active participant in SEA program and EVOS Trustee meetings to integrate research.

G. PUBLIC PROCESS

This proposal results from discussions of the SEA Scientific Committee and PWS FERPG, as well as input during the December 1993 Cordova Workshop, which requested greater attention in SEA to the role that birds and mammals may play as foragers in the ecosystem. Continued public involvement in all aspects of SEA is solicited through the activities of the PWS FERPG, as well as supported under the objectives of SEA PLAN in both 1994 and 1995.

H. PERSONNEL QUALIFICATIONS

Principle Investigator:

David Scheel, Associate Scientist, Prince William Sound Science Center. Education: Ph.D. (Ecology, 1992, University of Minnesota), MS (Ecology, 1986, Univ. of MN), BS (Biology, 1980, Renesselaer Polytechnic Institute). Professional experience: 1993-present, Associate scientist, PWSSC; 1992-93, Postdoctoral associate, University of Houston; 1986-1992, Research scientist, Serengeti Wildlife Research Institute, Serengeti, Tanzania; 1984-1992, student/post-doc/consultant, Univ. of Minnesota. Selected publications: Scheel, D. 1993. Profitability, encounter rates and the prey choice of African lions. *Behav. Ecol.* 4(1):90-97. Cameron, G. N., & D. Scheel. 1993. A GIS model of the effects of global climate change on mammals. *Geocarto International* 4:19-32. Research projects: Predator-prey dynamics of Serengeti lions and their prey, habitat selection models of Texas mammals, frequency- and density-dependence in models of community evolution, social behavior and resource/habitat use of primates in Gombe.

I. FY95 BUDGET($K).

	FY95	FY96
Personnel	$52.7	$52.7
Travel	$5.2	$5.2
Contractual	$7.9	$7.9
Commodities	$5.2	$5.2
Equipment	$28.1	$0
Total direct costs	$99.1	$71.0
Indirect costs (20%)	$19.8	$14.2
Project Total	$118.9	$85.2

Request for Supporting Data and Logistics for:
Variation in local predation rates on hatchery-released fry, D. Scheel, PI.

Please let me know which of the following will be available through your organization or SEA research project. Work will likely be primarily at Esther and Evens Islands. Thanks!

Hatchery Plankton Watch Program: Twice weekly collection of plankton settle volume at hatchery release sites for period from start to two weeks after end of fry release.

Zooplankton in the Ecosystem (T. Cooney): Analysis of samples from Hatchery Plankton Watch Program including species composition, abundance and size distribution of organisms.

Nearshore fish/Acoustics (G. Thomas): Acoustic surveys of release sites following hatchery release at Esther Island and Evans hatcheries (one or more surveys per release); to the extent possible, location and acoustic surveys of released schools for up to two weeks following release (one or more surveys per week); to the extent possible, location and acoustic surveys of wild fry schools near natal streams (one or more surveys per school found).

*** NEEDED REAL-TIME, IN-FIELD: Location of fry schools ***

Post-field information: Location of schools, within-patch density and size distribution.

Salmon growth and mortality (M. Willette): Species composition and size distribution in schools surveyed in acoustic surveys.

Salmon Predation (M. Willette): Comparative incidence of salmon fry in stomach contents of fish predators captured near fry school at release sites or identified in acoustic surveys.

Food webs - Fish (T. Kline): Isotope analysis of 5-10 bird feathers of one species.

SEA boats
Transportation of equipment to hatcheries; transportation between hatcheries (once per week)

Hatcheries (J. Olson), Can any of the following be provided, and at what cost?
Accommodations for 2
Fuel
Transport of skiff/fuel to hatchery
A skiff

Volunteer bird recorders (~ 1 hr/day)
Binoculars, etc for volunteers
Transportation between hatcheries (once per week)
Radio contact with SEA boats

Info: Date and location of scheduled releases between now and end 1995.
At time of release, number and size of fish released.

Carry-over of 1994 funds for Project 94417, Waste Oil Disposal Facilities

Project Number: 95417

Name of Project Leader or Principle Investigator: Unknown

Lead Agency: Alaska Department of Environmental Conservation

Cost of Project: $0. This project was funded for $232,000 in FY 1994; it is not yet complete. Authorization to spend FY 1994 funds ends on October 31, 1994. The Council is asked to reauthorize use of unspent funds to complete the project. No new funds are requested. The amount of spending for both 1994 and 1995 fiscal years will not total more than $232,000.

Project Start-up/Completion Dates (month/year): June 1994 through Sept. 1995.

Project Duration (number of years): One year (parts of FY 1994 and FY 1995). Additional funds may be requested in 1996 depending upon the results in 1995.

Geographic Area (locations where field work will be conducted): Communities in the oil spill area.

Contact Person (name, address, phone):

Mark Brodersen, Restoration Chief
Alaska Department of Environmental Conservation
Exxon Valdez Oil Spill Restoration Office
645 "G" Street, Suite 401
Anchorage, Alaska 99501
(907) 278-8012

B. Introduction — What You Propose as a Project

Project 94417, Waste Oil Disposal Facilities, was approved by the Trustee Council on January 31, 1994 for $232,200. As of June 1994, this project was awaiting conclusion of NEPA compliance activities. The project is expected to begin during late June or early July 1994, and it will not be completed before October 31, 1994. This project description requests that the Trustee Council allow funds not spent in fiscal year 1994 be used to complete the project in fiscal year 1995. Total expenditures for the two fiscal years will not exceed the $232,200 previously authorized by the Council.

C. Need for the Project — Why the Project Will Help Restoration

(From the 1994 Project Description):

Vessels in Prince William Sound and the Gulf of Alaska, especially in the zone affected by the *Exxon Valdez* oil spill, generate large quantities of used motor oil and other lubricants. In spite

of regulations and enforcement actions to the contrary, a substantial (but unknown) amount of this waste oil finds its way into the marine environment. During the recovery phase of the spill it is desirable to eliminate additional sources of hydrocarbon contamination to the marine environment. The ports of Whittler, Homer, Seaward, and Valdez all support increasingly large fleets of pleasure and recreational craft in addition to the resident and transient commercial fishing fleets. Cordova and Kodiak are seasonally among the busiest fishing ports on the West Coast. Villages such as Tatitlek, Chenega Bay, Port Graham, English Bay, and the Kodiak Island villages are home port for small-scale commercial fishing and subsistence-use vessels.

Proper disposal of used oil has long been viewed as a problem throughout the area. Handling, storage, and transportation of used oil has carried considerable cost and potential liability, especially under now-outdated federal regulations that routinely placed almost all waste oil under hazardous waste handling regulations. While some communities have waste oil collection facilities, others do not. Even at these few sites with collection facilities what to do with the waste oil once it is collected remains a major problem.

Nationwide, regulatory and financial issues have discouraged people from properly disposing of waste oil; more often than not, waste oil was illegally dumped in landfills, sewer systems, or other open sites. In 1992, the U.S. Environmental Protection Agency estimated that 170 million of the 190 million gallons of waste oil generated in the nation found its way into the environment due to improper disposal; this represents approximately 16 times the amount of oil spilled by the *Exxon Valdez*. On August 12, 1992, USEPA changed its classifications regarding waste oil recycling and disposal, eliminating many of the regulatory disincentives frustrating the development of good waste oil handling and disposal in the nation.

The change in federal rules offers the Trustee Council an opportunity to support a project that would reduce the amount of waste oil entering the marine environment in the area affected by the *Exxon Valdez* oil spill. Reducing or eliminating other sources of hydrocarbon contamination in the spill area is desirable as it will help resources injured by the spill recover quickly.

Resources and Services Addressed: The entire restoration effort would be enhanced by the successful implementation of this project. By providing an environmentally acceptable method of waste oil disposal the continuing introduction of hydrocarbons into the marine environment would be reduced thus permitting natural recovery to continue as quickly as possible.

D. Project Design — Objectives, Methods, Schedule and Location

1. **Objectives:** To reduce the incidental introduction of oil into the spill area ecosystem by providing alternative methods of disposal of waste oil products.

2. **Methods:** This project would create a waste oil recycling and/or disposal pilot program in a few communities that wish to participate. Depending on the success of the program this year, it will be proposed for expansion in future years. Communities could propose to use marine pollution control grants from the Trustee Council to purchase equipment for recycling and/or disposing of waste oil depending on what method(s) the community felt most appropriate to the local conditions. Volume of waste oil, distance from recycling centers, the need or opportunity for re-use of oil, and the costs (in terms of both money and mechanical complexity) of continuing operation would be among the criteria used to evaluate proposals from the communities.

   Communities wishing to participate in this program would submit proposals. An evaluation committee would review the applications for technical and regulatory feasibility. Awards would be made and the communities would begin installation.

   These facilities would be wholly owned by the local organization or government that applied for the funding. Maintenance and operation would be paid by the communities through user fees, assessments, or cost-recovery plans (e.g., reuse of waste oil for heating municipal facilities) depending on the wishes and resources of the communities. The facilities would be monitored, information collected, and a report prepared detailing the success or failure of the project.

3. **Schedule:**

August - July 1994	Meet with communities to get assistance in developing proposal packets and scoring criteria
September 1994	Send out proposal packets to communities and advertise
Nov - Feb 1995	Receive submittals, convene proposal evaluation committee, review and rank proposals, notify recipients, negotiate grant/contract awards
March - May 1995	Communities proceed with equipment purchases and development
Jan. - Feb. 1995	Project manager visit communities
June 1995	Receive first project reports from communities
Sept. 1995	Receive second operations report from communities

4. **Technical Support:** A small amount of computer support would be required in collecting the data reported by the grantees and storing it in a data base. The information would be utilized in preparing a report for the Trustees as to the relative success of the project.

5. **Location:** Communities within the spill affected area.

E. Project Implementation — Who Should Implement the Project

This project was approved for Fiscal Year 1994 and is being implemented by DEC.

F. Coordination of Integrated Research Effort

This project is a different type from other projects in the spill in terms of logistics, and community contacts. Thus, no specific coordination is needed.

G. Public Process.

The project is entirely geared toward working with local communities in the spill area. (See description of methodology).

H. Personnel Qualifications.

Not applicable.

I. Budget. Below is the FY 1994 budget. At this date it is not possible to project the amount that will be actually spent in FY 1994 or the amount that will remain for FY 1995.

FY94 BUDGET ($K)

	ADEC
Personnel	49.6
Travel	19.9
Contractual	142.9
Commodities	2.4
Equipment	0.0
Capital Outlay	0.0
Subtotal	214.8
General Administration	17.4
Project Total	**232.2**

Restoration Plan Environmental Impact Statement/Record of Decision

Project Number: 95422 (closeout)

Lead Agency: USDA Forest Service

Cooperating Agencies: Trustee Agencies

Cost of Project, FY95: $20.0K

Project Startup Date: October 1, 1994

Duration: Two months

Geographic Area: Prince William Sound, Gulf of Alaska, Kenai Peninsula, Kodiak Archipelago, Alaska Peninsula

INTRODUCTION

This project will analyze the environmental effects of implementing the Draft Restoration Plan developed over the past two years, develop alternative Restoration Plans and disclose the effects in an Environmental Impact Statement. Federal law requires an Environmental Impact Statement for major federal actions significantly affecting the quality of the human environment. The Trustee Council have agreed that the Restoration Plan constitutes a major federal action and an Environmental Impact Statement is required before adopting a Final Restoration Plan. The following description is for the Restoration Plan EIS which is being completed in FY95 by the publishing and distribution of the Record of Decision.

PROJECT DESCRIPTION

On October 8, 1991, a federal court approved settlement between the State and Federal governments and Exxon under which Exxon will pay $1 billion in criminal restitution and civil damages to the governments. The State and Federal Trustees will receive $900 million in civil damages from Exxon over the 10 years. The funds are to be used to restore to their pre-spill condition the natural resources and the services they provide, that were injured by the Exxon Valdez oil spill. This includes the restoration of any natural resource injured, lost or destroyed and the services provided by that resource or which replaces or substitutes for the injured, lost or destroyed resource and affected services. Restoration includes all phases of injury assessment, restoration, replacement, and enhancement of natural resources, and acquisition of equivalent resources and services.

All decisions about restoration and uses of restoration funds are determined by six natural resources Trustees, three Federal and three State. The three Federal Trustees are: The Administrator for the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, and the Secretaries of the Department of Agriculture and of the Interior. The three State Trustees are: The Commissioners of Fish and Game and Environmental Conservation, and the Attorney General. A Trustee Council, located in Alaska, which is
made up of designees of the Federal Trustees and the three State Trustees, is responsible for all decisions relating to the assessment of injuries, uses of the restoration funds, and all restoration activities including the preparation of a Restoration Plan.

On April 10, 1992 (57 FR 12473-12475) the Forest Service published a Notice of Intent to prepare an EIS on the Restoration Plan. Since then the Trustee Council has developed a draft Restoration Plan which has become the proposed action for the analysis to be conducted in the EIS. The proposed action (Draft Restoration Plan) consists of nine policy statements, a discussion of categories of restoration actions and broad objectives for injured resources. The policies for identifying and conducting restoration actions are:

1. The restoration program will take an ecosystem approach.
2. Restoration activities may be considered for any injured resource or service.
3. Most restoration activities will occur within the spill area. However, restoration activities outside the spill are, but within Alaska, may be considered when the most effective restoration actions for an injured migratory population are in a part of its range outside the spill area or when the information acquired from research and monitoring activities outside the spill area will be important for restoration or understanding injuries within the spill area.
4. Restoration activities will emphasize resources and services that have not recovered. Resources and services will be enhanced, as appropriate, to promote restoration. Restoration projects should not adversely affect the ecosystem.
5. Projects designed to restore or enhance an injured service must have a sufficient relationship to an injured resource; must benefit the same user group that was injured; and, should be compatible with the character and public uses of the area.
6. Competitive proposals for restoration projects will be encouraged.
7. Restoration projects will be subject to independent scientific review before Trustee Council approval.
8. Meaningful public participation in restoration decisions will be actively solicited.
9. Government agencies will be funded only for restoration work that they do not normally conduct.

Four types of restoration actions are identified and discussed in the Draft Restoration Plan: general restoration, habitat protection and acquisition, monitoring and research, and public information and administration. Alternatives to the proposed action will place different emphases on each of these categories of restoration actions, while satisfying the policies and objectives for injured resources described in the Draft Restoration Plan.

General Restoration consists of activities that fall within manipulation of the environment, management of human use for reduction of marine pollution. Decisions about conducting general restoration projects would look at the following factors: Extent of natural recover, the value of an injured resource to the ecosystem and to the public, the duration of benefits, the technical feasibility of the project, the likelihood of success, the relationship of costs to expected benefits, potential for harmful side effects, benefits to more than one resource, effects on health and human safety, consistency with applicable laws, and policies, and duplication with other actions.

Habitat Protection and Acquisition is a category that included purchase of private land or interests in land such as conservation easements, mineral rights, or timber rights. It also includes recommendations for changing public agency management practices. Specific policies that relate to habitat protection and acquisition are proposed. These policies deal with ranking potential lands to determine potential benefits, the need for a willing seller, purchasing at fair market value, post acquisition management of the acquired lands and involving the public in the prioritization process.
Monitoring and Research consists of recovery monitoring, restoration monitoring and ecological monitoring and research. Specific policies governing the selecting and performance of monitoring activities are discussed in the Draft Restoration Plan.

Public Information and Administration is the last category of restoration actions. It consists of all necessary administrative actions that are not attributable to a particular project. The Draft Restoration Plan goal for this category is for administrative costs to average no more than 5% of overall restoration expenditures for the remainder of the settlement period.

General restoration objectives have been developed for resources that are recovering, resources not recovering, resources where the recovery is unknown, resources such as archaeological resources and wilderness, and services. These broad objectives will guide in the development of annual work plans.

Using an Interdisciplinary approach, the important issues that arose from the proposed Restoration Plan were analyzed and alternative restoration plans developed. These alternatives were analyzed and a draft Environmental Impact Statement was written and made available to the public and Trustee Council. The public and agencies commented on the Draft Environmental Impact Statement. After the comments are analyzed and the draft statement revised a Final Environmental Impact Statement will be issued. The Trustee Council will then be able to adopt a Final Restoration Plan. A Record of Decision will be prepared, signed and distrubuted.

A. Resources and/or Associated Services

The Final Restoration Plan EIS will address all resources and services addressed in the Final Restoration Plan. This includes bald eagles, black oystercatchers, killer whales, sockeye salmon, common murres, harbor seals, harlequin ducks, marbled murrelets, Pacific

herring, pigeon guillemots, pink salmon, sea otters, intertidal ecosystem, subtidal ecosystem, clams, cutthroat trout, Dolly Varden, river otter, rockfish, archaeological resources, and designated wilderness areas. Services addressed will include subsistence, commercial fishing, and recreation and tourism.

B. Objectives

The FY94 objective of this project was to identify relevant issues from implementing the proposed Draft Restoration Plan, analyze the environmental and social consequences of implementing the Draft Restoration Plan and alternative Restoration Plans, and display the information in an Environmental Impact Statement. In 1995 we will complete this project with the publication and distribution of the Record of Decision.

C. Methods

An interdisciplinary team of State and Federal resource specialists will review available resource information, analyze the proposed action and alternatives, and write a Draft Environmental Impact Statement..

D. Location

All of the analysis and writing will be conducted in Anchorage, Alaska.

E. Technical support

Federal and State agency personnel will provide technical expertise to assure compliance with National Environmental Policy Act requirements. Personnel will also be available to review resource reports and specific sections of the Draft and Final EIS to assure accuracy.

F. Contracts

Printing the Record of Decision will be contracted.

SCHEDULES

A Draft Environmental Impact Statement was released for public comment in June 1994. The Final Environmental Impact Statement will be completed by September 30, 1994. The Record of Decision will be prepared in October 1994.

ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

None

PERFORMANCE MONITORING

The project team leader will be responsible for coordinating the work of all team members and assuring work is completed on time. Agency specialists will review draft products before the Draft EIS is released to assure the document is accurate and complete.

FY95 PROJECT BUDGET ($K)

	Total FY95
Personnel	$14.8
Travel	$0
Contractual	$2.8
Commodities	$0
Equipment	$0
Capital Outlay	$0
Subtotal	$17.6
General Administration	$2.4
Project Total	$20.0
NEPA Compliance	

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Exxon Valdez Restoration Reserve

Project Number: 95424

Name of Project Leader or Principle Investigator: Not applicable.

Lead Agency, University or Organization: All Trustee Agencies.

Cost of Project (for FY 95/future years, including reports, if known): Approximately $12 million per year for each year from FY 1994 through FY 2002 for a total of $108 million (plus interest).

Project Start-up/Completion Dates (month/year): FY 2003

Project Duration (number of years): Unknown.

Geographic Area (locations where field work will be conducted): Oil Spill Area

Contact Person (name, address, phone): Not Applicable

B. Introduction — What You Propose as a Project.

Complete recovery from the *Exxon Valdez* oil spill will not occur for decades. Scientists have identified a clear need to establish the capability to act in the years after 2001. For example, some salmon return in cycles of four to six years, and other resources have lives that are much longer. To be effective, activities may have to span more than one generation. Sometimes research is necessary to understand why a resource is not recovering. In many cases, research must precede effective restoration or improved management decisions that will protect a resource or service. For these reasons, some restoration activities may continue for a long time.

Annual payments to the Restoration Fund end September 2001. The *Exxon Valdez* Restoration Reserve provides a location to hold funds for restoration activities after the last annual payment. Allocation of the Reserve to specific activities will be made by the Trustee Council at a later date.

Previous Related Projects. The $12 million of this project would be the second payment toward the *Exxon Valdez* Restoration Reserve. One payment of $12 million was authorized by the Trustee Council on January 31, 1993 as part of the 1994 Work Plan. Additional annual deposits of $12 million payments made each of the remaining seven years would provide a reserve of $108 million plus interest. This amount is expected to be appropriate to carry out long-term restoration activities needed after Exxon payments end.

Resources and Services Addressed: The *Exxon Valdez* Restoration Reserve could potentially benefit any resource or service injured by the oil spill.

C. Need for the Project — Why the Project will Help Restoration

The $12 million of this project and future payments to the *Exxon Valdez* Restoration Reserve will fund restoration activities after the annual payments end. Interest earned on the Reserve's principal will remain with the Reserve until needed.

D. Project Design — Objectives, Methods, Schedule and Location

1. **Objectives.** The sole objective for the Reserve is to assure the availability of funds to allow the Trustees to continue restoration activities that are necessary for recovery of resources and services injured by the oil spill after the last annual payment to the Restoration Fund.

2. **Methods.** Not Applicable.

3. **Schedule.** Approximately $12 million per year for each of FY 1994 through FY 2002 for a total of $108 million (plus interest).

4. **Technical Support.** Not applicable.

5. **Location**. Oil Spill Area.

E. Project Implementation — Who Should Implement the Project.

The Reserve will be held by the Court Registry. Expenditures from the Reserve will be made only at the direction of the Trustee Council. Any spending from the Reserve must be consistent with the Consent Decrees that established the Restoration Funds and with the Memorandum of Understanding between the state and federal governments.

F. Coordination of Integrated Research Effort. Not applicable.

G. Public Process. Not applicable.

H. Personnel Qualifications. Not applicable.

I. Budget. Not applicable.

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Harlequin Duck Recovery Monitoring

Project Number:	95427
Principal Investigator:	Dan Rosenberg
Lead Agency:	Alaska Department of Fish and Game
Cooperating Agencies:	USFWS, NOAA,NMFS
Cost of Project FY94:	$40.4K
Cost of Project FY95:	$221.8
Project Startup Date:	January 1, 1995
Duration:	6 years
Geographic Area:	Prince William Sound
Contact:	Dan Rosenberg Alaska Department of Fish and Game 333 Raspberry Rd. Anchorage, AK 99518 (907)267-2453

INTRODUCTION

Oil spill studies of harlequin ducks in western Prince William Sound (PWS) 1989-93 indicate an initial mortality up to 1,000 birds (spill-wide), consistently low numbers of birds during the breeding season, a lack of breeding activity on suitable streams 1991-92, negligible production of broods through 1993, and an apparent decline in post-breeding molting birds in the region. Two main hypotheses have been followed to explain these findings: (1) ingested oil is continuing to cause either mortality and/or sublethal impairment of reproduction; and/or (2) initial mortality caused significant losses to the local western PWS breeding component and subsequent low production. To date, oil has been found in a few harlequins collected during 1989-90 and 1993, and they continue to feed in oiled areas year around. However, no conclusive evidence has been found of histological or physiological effects from oil.

The most important conditions for successful restoration are: (1) establishment of a monitoring program for spring and summer population structure and detection of reproductive effort, and (2) mitigation of physiological impairment that may result from ingesting contaminated foods. Otherwise, natural improvements in productivity or enhancement efforts will be undocumented or ineffectual.

Because of the consequences of a continued harlequin duck reproductive failure, it is particularly important to understand what factors are responsible for limiting reproduction. Given the lack of recovery and the suspected high degree of site fidelity of harlequin ducks, it cannot be assumed that the population in oiled areas will return to pre-spill levels. In fact, the population may continue to decline because of a lack of recruitment and limited immigration. It is necessary both to continue monitoring population and reproductive trends, and identify factors limiting recovery.

The goal of this project is to continue monitoring the harlequin duck breeding population and annual productivity. Proposed surveys will provide trend indices to assess recovery of resident populations of harlequin ducks and determine factors inhibiting or contributing to recovery and restoration. Specific information on habitat associations and structure of the breeding population will provide a measure of recovery or guide development of further investigations. Technical information is applicable to evaluating habitat acquisitions and intertidal habitat restoration projects that benefit a variety of species (e.g. shorebirds, sea otters).

PROJECT NEED

Regardless of ultimate causes, collective results of EVOS studies indicate serious population-level concerns for harlequin ducks in western PWS. Prompt focus on specific population parameters is necessary to determine the status and recovery potential of harlequin ducks. Sea duck populations, in general, are composed of long-lived birds that have delayed sexual maturity, low annual production rates, and "boom and bust" years. Consequently, sea duck population dynamics are quite sensitive to adult survival rates, size of the breeding component, and variable breeding propensity (% of adults breeding annually). Data on sex and age composition are very useful in examining these aspects of a population. To date, EVOS projects have gathered abundance and distribution data only on total harlequin ducks, with little information on sex and age composition, or proportions of paired birds. The focus of these projects has been extensive survey coverage and a diverse array of other time-consuming objectives. Also, efficient techniques for the kind of intensive survey required have not been developed for sea ducks.

Currently, there are no sufficiently measured parameters of harlequin population dynamics with which to construct a population model for Prince William Sound. A reliable breeding bird survey is a critical prerequisite to evaluating the remaining reproductive potential in the western Sound and acquiring data to fill in several important model elements. The survey described below is intended to establish quantified restoration goals and implement an effective monitoring program for harlequin ducks in PWS.

Evidence of oil ingestion and physiological effects on harlequin duck reproduction have been investigated through 1993. Some intertidal sites remain contaminated. Nearshore studies (NOAA-NMFS) of intertidal zone recovery and contamination of invertebrates are a vital corollary to the harlequin duck project.

PROJECT DESCRIPTION

1. Objectives:

The objectives of this study are to: (1) document abundance, distribution, and age-sex structure of the pre-nesting population in PWS through May-June breeding bird surveys; (2) document annual harlequin production and post-breeding abundance in the EVOS region through brood and molting surveys; (3) Classify streams and shoreline habitats in western Prince William Sound to correlate habitat parameters with eastern Prince William Sound; and (4) pending 1993 results of contaminant analysis of harlequin duck tissues and blood chemistry, document continued exposure of sea ducks to oil and physiological links to reproductive impairment through blood and tissue sampling.

2. Methods:

This project uses established methodology including boat surveys of shoreline and suitable breeding streams during May-June throughout PWS; and molting and brood rearing habitats. during July and August. Sex-age classification methodology currently being developed will be used to determine population structure during spring and summer surveys. Results from the oil spill area will be compared to 1990-93 results and to data collected in unoiled areas of eastern and southern PWS. Habitat use associations will be recorded during both surveys and integrated with a database being developed from previous work.

Contingent on 1993 results indicating evidence of continued oil ingestion by harlequin ducks or physiological anomalies related to reproduction, an effort may be mounted to sample blood and/or tissues from breeding harlequin duck in 1994 and contract for analytical services. Blood samples could be analyzed for normal blood parameters and abnormalities. Presence of elevated levels of haptaglobins and interleukins in blood sera or positive P450 enzyme activity may indicate continued petroleum exposure if statistically correlated to the oil spill area.

3. Schedules:

The course of this monitoring program is projected for five years. Survey schedules are in accordance with the draft EVOS Restoration and Monitoring Plan This project will be conducted during the 1995 field season, with survey effort focused on May-June and July August periods. Interim analyses and reporting will occur throughout 1995 and early 1996. Contract laboratory analyses should be completed by December 1, 1996. Report preparation will begin in September, and a progress report will be completed before January 30, 1996.

4. Technical Support:

If warranted Dr. D. M. Fry will provide blood chemistry interpretation following analysis of clinical chemistry by California Veterinary Diagnostics, West Sacrmento, CA, perform plasma electrophoresis for evidence of protein changes, and provide histologic interpretation of tissues.

NOAA-NMFS Auke Bay Laboratory is the preferred source for hydrocarbon analyses of any food items and tissues that are collected. Videography to aid in population structure will be contracted.

5. Location:

The proposed project will be conducted in the oil spill area of Prince William Sound and unoiled eastern PWS from Valdez to Cordova. Communities affected by the project include Chenega, Whittier, Valdez, and Cordova.

PROJECT IMPLEMENTATION

This study will be conducted and managed by the Division of Wildlife Conservation, Waterfowl Program, under supervision of the Waterfowl Coordinator. The Alaska Department of Fish and Game has been conducting EVOS harlequin duck investigations and monitoring since 1989. Data collection will be accomplished by Division staff during field periods, with data analyses and reporting assigned to appropriate project participants. The Waterfowl Coordinator will be responsible for administrative and technical aspects of the project, including planning and budget preparation, tracking expenditures, personnel assignments, contract oversight, and quality control of products.

Data collection will be controlled by employee training, supervision and compliance with methods and techniques described in SOP's. Chain-of-custody procedures as outlined in State/Federal Damage Assessment Plan: Analytical Chemistry QA/QC are being followed. Samples and data will be archived at the Department of Fish and Game. The products of this study will be interim and final reports with maps, figures, and tables.

Costs of tissue analysis for petroleum exposure are paid through a contract with NOAA Auke Bay Laboratory. An RSA will be issued for technical support on Harlequin Ducks at University of California, Davis. Costs of videography and editing will be contracted, source to be determined.

COORDINATION OF INTEGRATED RESEARCH EFFORT

There are no other projects directly related to the work planned in this project, although results may be integrated with USFWS boat surveys for birds and mammals and NMFS intertidal invertebrate surveys. Techniques developed on this project will provide a basis for future monitoring efforts for all sea ducks. Subsequent EVOS program development can incorporate sea duck population dynamics information with intertidal and nearshore ecosystem projects.

PUBLIC PROCESS

All efforts will be made throughout the restoration process to participate in and provide public involvement in the design and implementation of this project.

PERSONNEL QUALIFICATIONS

Daniel H. Rosenberg ¾ Project Leader

Dan Rosenberg has worked as a waterfowl biologist for The Alaska Department of Fish and Game (ADFG) since 1985. From 1980¾1983 Mr. Rosenberg worked as a waterfowl biologist for the U.S. Fish and Wildlife Service and from 1983¾1984 as a Habitat Biologist for ADFG. Mr. Rosenberg served on the adjunct faculty of Anchorage Community College from 1984 - 1987 as an instructor for courses in Ecology and Animal Behavior, and Fish and Wildlife Management.

Mr. Rosenberg has conducted extensive waterfowl population monitoring and habitat assessment surveys on the Copper River delta, Stikine River delta, Kenai wetlands, upper Cook Inlet, Aleutian Islands, and Kodiak Island. As project leader, Mr. Rosenberg has assessed impacts to waterfowl and wildlife populations from hydroelectric development, urban expansion, habitat alterations, chemical pollutants, timber harvest, and surface mining.

Mr. Rosenberg has conducted studies to assess impacts from chemical pollutants on waterfowl populations in Alaska wetlands. Mr. Rosenberg designed, supervised, and conducted the first definitive study to assess the physiological effects from the ingestion of spent lead shot on mallards and pintails in Alaska. As the ADFG representative on the Biological Technical Assistance Group for the Eagle River Flats (ERF), Mr. Rosenberg has been responsible for overseeing the investigation into the identification, and remediation of white phosphorous, and restoration of the ERF, the site of one of the largest waterfowl die-offs in Alaska from chemical pollutants.

Mr. Rosenberg has been responsible for ecological assessment, design, construction, and post¾project monitoring of the first large scale experimental waterfowl habitat enhancement projects in Alaska and coordinated ADFG review of fish and wildlife impact analysis and mitigation planning for the Susitna Hydroelectric Project.

Mr. Rosenberg received a Bachelor of Science degree in Wildlife Management from Humboldt State University, Arcata, CA in 1979. Mr. Rosenberg was ADFG Wildlife Biologist of the Year in 1991, and Alaska Outdoor Council Waterfowl Conservationist of the Year in 1993.

Thomas C. Rothe, Project Supervisor

Tom Rothe earned a Bachelor of Science degree in Population Dynamics from the University of Wisconsin (1973), including background in environmental impact analysis, environmental law and public policy, and natural resource economics. He received a Master of Science degree in Animal Ecology from Iowa State University (1977) after research work on wetland ecology and behavioral biology of prairie ducks.

Mr. Rothe conducted wetland and waterbird studies in relation to petroleum development on

Alaska's North Slope 1976-83 for the U.S. Fish and Wildlife Service. During 1980-83 he supervised the Office of Special Studies in a program of baseline, pre-development, and mitigation studies for petroleum, mining, and wetland impact activities in northern, southcentral and southeastern Alaska. This work included studies of sea duck food habits and potential contamination from oil in Port Valdez and from metals near the Quartz Hill molybdenum mine near Ketchikan. In these capacities, Mr. Rothe has had extensive experience with the petroleum industry and their consultants (TAPS, Prudhoe/Kuparuk, NPR-A, ANGTS), interagency coordination, management of major field studies, and public involvement processes on natural resource issues.

Since 1983, he has been Waterfowl Coordinator for the Alaska Department of Fish and Game, responsible for a wide variety of waterfowl and habitat management programs. He currently serves as the Alaska member of the Pacific Flyway Council's Study Committee and the Council's technical representative to the international Arctic Goose Joint Venture. Mr. Rothe has been involved with flywaywide and international population management issues for over 10 years and has accumulated broad knowledge of waterfowl biology and ecology.

BUDGET ($K)

	ADF&G	**TOTAL**
Personnel	136.4	136.4
Travel	7.1	7.1
Contractual	26.0	26.0
Commodities	18.0	18.0
Equipment	12.0	12.0
Capital Outlay	0.0	0.0
	199.5	199.5
General Administration	22.3	22.3
Project Total	221.8	221.8

Subsistence Restoration Planning and Implementation

Project Number: 95428

Project leader: James A. Fall

Lead Agencies: Alaska Department of Fish and Game, United States Department of the Interior, U.S. Forest Service

Cooperating Agencies: Alaska Department of Community and Regional Affairs; AlaskaDepartment of Law

Cost of Project: $81.0K

Project Startup Date: October 1, 1994

Duration: October 1, 1994 - September 30, 1995

Geographic Area: Prince William Sound, lower Kenai Peninsula, Kodiak Island, and Alaska Peninsula

Contact Person: James A. Fall
Alaska Department of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99518
907-267-2359

B. INTRODUCTION

In FY 1994, the Trustee Council funded a subsistence planning and implementation project to develop a coordinated approach to subsistence restoration and to work with subsistence users to design restoration projects. The purpose of this project in FY 95 is to continue to address the need to restore subsistence uses by cooperatively developing subsistence restoration project proposals for the Trustee Council Work Plan for FY 96. An important goal is to insure the participation of subsistence users in these and other FY 96 planning efforts. Such projects could propose to directly restore resources used for subsistence, provide alternative natural resources, or restore access or people's use of the resource. Guidelines for project content will be developed, project ideas will be solicited and prioritized through a public process, project proposals will be evaluated, and a set of project proposals will be presented to the Trustee Council for funding consideration.

Project ideas developed through this planning process which do not become part of the FY 96 Work Plan may be eligible for funding through grants from a $5 million appropriation of Exxon Valdez criminal settlement funds by the Alaska Legislature. The legislature authorized the Department of Community and Regional Affairs to award grants to unincorporated rural

communities in the oil spill area in order to restore, replace, or enhance subsistence resources or services damaged or lost as a result of the spill (Section 11, Chapter 79, SLA 1993). The legislation requires that selection of grant recipients shall be made after consultation with the state members of the Trustee Council.

C. NEED FOR THE PROJECT

The purpose of the project is to collaboratively develop and evaluate proposals to restore or enhance injured subsistence resources and lost or diminished subsistence uses. Subsistence uses of fish and wildlife are a vital service that was impaired as a result of the Exxon Valdez oil spill. After the spill, harvest levels declined, sharing of resources was reduced, and the transmission of skills and knowledge about natural resources was disrupted. While harvest levels and participation in subsistence activities have rebounded somewhat since the first two post-spill years, effects of the spill remain. These include concerns about the long term health effects of using resources from the spill area, a loss of confidence in individuals' abilities to judge if resources are safe to eat, scarcity of certain injured subsistence resources (natural resources such as harbor seals, marine invertebrates, and waterfowl) in traditional harvest areas, increased costs associated with subsistence harvests, and reduced opportunities for young people to learn the subsistence way of life. Subsistence uses can be restored only if the natural resource base is healthy and if subsistence users are directly involved in restoring injured natural resources. Projects designed during this process will focus on these goals. During the limited time available in FY 94 to begin this project (funding was only available beginning in June 1994), planning efforts were focused on Prince William Sound and lower Cook Inlet communities. Much of the planning team's time was devoted to developing background information for communities and organizing a comprehensive approach to the subsistence restoration process. In FY 95, therefore, efforts need to expand to involve the remaining spill area communities in the subsistence restoration planning process and to follow-up on project ideas identified during the first round of community meetings in 1994.

D. PROJECT DESIGN

1. Objectives. The project has three primary objectives for FY 95. The first objective is to implement a comprehensive approach to subsistence restoration begun in FY 94. The second objective is to meet with residents of the subsistence communities in the spill area to identify community needs and priorities related to injured subsistence resources and services. The third is to work with communities to develop proposals to restore reduced or lost subsistence resources and services.

2. Methods. Guidelines for appropriate topics for projects have been developed as part of a coordinated approach to subsistence restoration by the Alaska Department of Fish and Game (Division of Subsistence), the Alaska Department of Community and Regional Affairs (DCRA) (Division of Municipal and Regional Assistance), the U.S. Department of the Interior, and the U.S. Forest Service (the latter two agencies representing the federal Trustee Council members), with assistance from the Alaska Department of Law, Trustee Council staff, and representatives

of spill-area communities. An outreach program in subsistence communities will be conducted to solicit ideas and priorities for restoration of subsistence resources and lost or reduced subsistence uses. A local community facilitator will be hired as a nonpermanent employee within the Division of Subsistence to assist with the planning and implementation of community meetings and workshops. Following the meetings, interested parties may develop projects as proposals for funding, for which project staff will provide assistance. After evaluation of the proposals, recommendations will be presented to the Trustee Council for review.

3. Schedule.

October 1994. Community meetings to review FY 95 Work Plan; continue work on project ideas developed in FY 94 but not part of the FY 95 work plan, identify new project ideas for FY 96 work plan.

November 1994 - March 1995. Continue working with communities and other organizations to develop project descriptions and designs; as necessary, monitor implementation of FY 95 subsistence restoration projects; complete report for FY 94.

March 1995. Conduct community meetings to review project proposals and develop priorities.

April 15 1995. Submit project descriptions for Trustee Council approval.

August 1995. Finalize FY 96 Work Plan; complete final report.

4. Technical Support. This project will not need technical support as described in the proposal guidelines.

5. Location. Prince William Sound, Cook Inlet, Kodiak Island Borough, and the Alaska Peninsula within the spill area

E. PROJECT IMPLEMENTATION

The ADF&G Division of Subsistence maintains an ongoing program of data collection and report preparation about the role of subsistence activities in Alaska, including the spill area communities. The division is currently involved in a joint project with the U.S. Minerals Management Service, which, among other things, is investigating social effects of the spill. The division is also actively engaged in research on subsistence harbor seal and sea lion harvests in coastal communities of southcentral and southwest Alaska, supported by the National Marine Fisheries Service. In addition, the division is the lead agency on two FY 94 oil spill restoration projects: Project 94279, Subsistence Foods Safety Testing; and Project 94244, Harbor Seal and Sea Otter Co-op Subsistence Harvest Assistance. The Division of Community and Regional Assistance (within DCRA) provides technical assistance services, including grants administration, to communities and has administered an emergency oil spill impact program in the spill area. The U.S. Department of the Interior and the U.S. Forest Service are responsible

for management of subsistence activities on federal lands and are member agencies of the Trustee Council.

2. Relation to Other Damage Assessment/Restoration work. The FY 94 Restoration Plan includes two subsistence restoration projects: 94244 (Harbor Seal and Sea Otter Co-op Subsistence Harvest Assistance) and 94279 (Subsistence Food Safety Testing). Aspects of these projects may be continued as part of projects developed during the cooperative planning effort. Projects more appropriately supported through grants from the $5 million appropriation from the criminal settlement money may also be identified.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

As a planning project, a goal of this project will be to coordinate the subsistence restoration program with other research efforts.

G. PUBLIC PROCESS

Community meetings and workshops will be held to solicit project ideas and priorities. Information about the projects will be communicated in the Subsistence Restoration Newsletter produced by the Division of Subsistence. Additionally, state, federal, and private land managers, Native regional non-profit corporations, and federal subsistence regional councils will be kept informed of the process and their ideas and input will be sought.

H. PERSONNEL QUALIFICATIONS

James Fall. Dr. Fall is the regional program manager for the Division of Subsistence, ADF&G, for southcentral and southwest Alaska. Since 1989, he has supervised the division's oil spill response and research program.

Rita Miraglia. Ms Miraglia has served as the oil spill coordinator for the Division of Subsistence since 1990. As such, she has organized and participated in the subsistence resource collection and testing program of 1990, 1991, and 1993. She has also been the lead communicator of study findings to communities through organizing community meetings and writing newsletters.

Craig Mishler. Since 1989, Dr. Mishler has been the subsistence resource specialist with the Division of Subsistence with responsibility for the Kodiak Island Borough and the division's multi-regional harbor seal and sea lion project.

Lisa Scarbrough. Ms Scarbrough is the subsistence resource specialist with the Division of Subsistence with responsibility for the Alaska Peninsula communities (among others), a position she has held since 1989.

Pat Poland. Mr. Poland is Deputy Director, Division of Community and Regional Assistance, DCRA. He has been responsible for day-to-day management of the division's Technical Assistance and Program Delivery services for a number of years. This experience includes oversight of an emergency oil spill impact grant program following the Exxon Valdez spill.

John Gliva. Mr. Gliva is a Planner IV with the MARAD division and has worked extensively at providing technical assistance services to Prince William Sound communities. Additionally, he developed regulations for administration of the Emergency Oil Spill Impact Program and generally administered the application and award process.

Don Callaway. Dr. Callaway is a subsistence specialist with the National Park Service (USDOI) Alaska regional office. Prior to this appointment, he helped design studies of the sociocultural effects of the oil spill as a member of the staff of the socioeconomic studies unit of the U.S. Minerals Management Service.

Steve Zemke. Mr. Zemke is the subsistence coordinator for the Chugach National Forest (USFS). He has contributed to the environmental impact statement (EIS) for the oil spill restoration program.

I. FY95 BUDGET

Personnel:	$63,000

Subsistence Resource Specialist IIs. 6 months ($27,300)
(Miraglia, Mishler, Scarbrough)
Regional Program Manager (Fall), 2 months ($14,600)
Fish and Wildlife Technician III, 2 months (local community facilitator) ($5,000)
U.S. Department of the Interior Representative (Don Callaway), 1 month ($6,300)
U.S. Forest Service Representative (Steve Zemke), 1 month ($6,300)

Travel	$15,000
General Administration	$ 2,000
Supplies	$ 1,000
TOTAL	$81,000

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Channel Type Habitat Relationships

Project Number: 95505-A

Project Leaders: Steven V. Zemke
Robert A. Olson

Agency: USDA Forest Service
Chugach Nation Forest

Cost of Project: $261,600 (FY95)
$ 63,300 (FY96)

Dates of Study: 1 October 1994 to 30 May 1995

Study Area: Prince William Sound

Contact Person: Steven V. Zemke (Project Co-Leader)
USDA Forest Service, Chugach NF
201 E. 9th Ave., Suite 206
Anchorage, AK 99501
(907)-271-2500

B. Introduction

Rates of salmon mortality are highest during their early stream dwelling life forms. Because the mortality is often related to the condition and availability of the in-stream habitat, it is critical that habitat limiting to juvenile salmon be protected or restored. Basinwide in-stream habitat surveys are essential to predict those habitat conditions that limit survival. In remote areas of Alaska it is impractical to physically survey all streams within a geographic area, therefore , a hierarchical approach lends itself to remote sensing techniques. This hierarchical approach, aided by photo interpretation, would greatly increase the efficiency of large scale habitat inventories.

Preliminary data, collected on the Kenai Peninsula in 1991, suggests that channel types, as defined from aerial photographs, may be a predictor of at least several micro habitats found in a stream channel. A multi-variate analysis of variance, indicated that channel types were a significant predictor ($p < 0.0001$) for eight of thirteen micro habitats (e.g. rapids, plunge pools, and dammed pools) as modified from Bission (1981). Further data collection, for the EVOS Trustee Council Channel Type Classification Study (90505, Part C) indicated that channel types are a significant predictor of the amount of spawning and rearing habitat in a given segment of stream.

The existing data bases will be analyzed to firmly establish the relationship between aerial photo channel type interpretations, and the presence of in-stream spawning and rearing habitat. These analysis and report will serve as a basis for larger scale in-stream habitat surveys for oil spill affected areas in PWS.

C. Need for the Project

Anadromous fish were injured by oil spill contamination from the Exxon Valdez oil spill of March 1989. The oil spill affected anadromous fish in several ways; pink salmon had high egg and fry mortalities, reduced growth rates, and possible morphological abnormalities; and sockeye salmon suffered poor smolt survival due to over-escapement. In addition to the oil spill impacts, freshwater rearing habitat for anadromous fish within the PWS area impacted by the oil spill may be affected by habitat modification, especially logging (Murphy, el al, 1986). Frissel, et al, 1986, advocated that classification of streams and the habitat contained would be useful in determining the impacts of land use practices, assessing basin wide cumulative affects of management practices on stream habitats, and provide useful generalized information on stream habitats from site specific data.

Inventories of habitat are a primary source of information for the evaluation of watershed conditions and the management and protection of aquatic resources. Data collected in comprehensive surveys can be used for the basis of habitat restoration and improvement programs and can be used to monitor changes in the quality and quantity of resources. The proposed study would provide the relationship between channel type designations and the presence of in-stream micro habitats, both rearing and spawning. These data would provide valuable information in comparing relative values of all watersheds with PWS area, particularly those contained within comprehensive evaluation parcels.

D. Project Design

1. Objectives

The purpose of the study is to characterize preselected habitat characteristics in an entire representative reach and /or watershed. The study will provide data from all habitat types and locations within a channel type or watershed. The information will be used to develop habitat evaluation rankings for all areas affected by the oil spill within PWS. Focus will be on large and small parcels proposed for acquisition. A GIS based analysis will provide a tool for efficient comparison.

2. Methods

Field sampling will focus on sites identified as having significant spawning and rearing habitat value. These areas were identified in the Stream Channel Type study (in draft). All of these sites will be located within the oil spill area within Prince William Sound.

The habitat sampling will occur in two steps. The first will require sampling teams to classify individual habitat units by channel type and document visual observation of habitat characteristics, such as water surface area and stream bottom composition. In the second step, the visual observations will be compared to actual measurement of habitat characteristics at a predetermined number of units. These measurements will be used to develop calibration ratios for the visual observations. These data will be entered into the Chugach National forest database. Comparative analysis of the comprehensive evaluation parcels will be accomplished using models developed from habitat relations of the channel types.

3. Schedule

Field inventory would occur during summer of 1995. Data input and analysis October 1995 through February 1996. Report preparation and acquisition parcel comparison analysis would be completed by June 1996.

4. Technical Support

This project will require 62 person months of effort. Robert Olson and Steven Zemke will each dedicate ten months to the project and will act as co-project leaders and joint authors of the final project report. Field work will largely be accomplished by two crews of bio-technicians each composed of two fisheries biologists. The four fisheries biologists will work for a total of four months each. One bio-technician will work an additional 3 months entering data into the database.

5. Location

The survey area within which study sites will be located in watershed randomly selected within oil spill zone in Prince William Sound.

E. Project Implementation

The channel type habitat relations project will provide a GIS based tool allowing comparative evaluations of streams throughout the oil spill affected area. The R10 Channel Type system is a unique system developed for classification of streams on National Forest system lands in Alaska. The streams of the EVOS areas have been classified using this system under a previous project (Stream Classification Study, Project Number 99505, Part C). The staff of the Chugach National Forest have extensive knowledge of this system, and are familiar with the techniques to estimate basinwide fish habitat.

F. Coordination of Integrated Research

This project is an extension of previous projects designed to provide comparative evaluations of fish habitat within comparative evaluation parcels.

H. Personnel Qualifications

Project Co-leader: Steve Zemke received his B.S. in fisheries science from the University of Idaho in 1973. Steve has worked for the Forest Service as a fisheries biologist in Regions 4, 6, and 10. He has extensive experience in planning, inventory, and enhancement of anadromous fish resources. From 1985 to 1991, he was fisheries program leader on the Ketchikan Area of the Tongass National Forest. One of the primary accomplishments of his tenure was the implementation of the R10 Channel type classification on the Ketchikan Area. He co-authored the 1994 Stream Channel Type Classification report for the EVOS area.

Project Co-leader: Robert Olson received his M.S. in aquatic ecology from the State University of New York in 1983. Robert worked for the USFWS on Kodiak Island performing research on red salmon population dynamics. He has extensive Alaskan field experience, and h a detailed background in statistical analysis. He has also worked as the Chugach National Forest Fish Habitat Relationship Program Coordinator. Hew is extremely familiar with PWS and the R10 channel type classification system. He co-authored the EVOS Stream Channel

Classification report for the oil spill area.

H. Budget
(see attached budget sheets)

Data Analysis for Steam Habitat

Project Identification Number: 95505B

Project Leader: Robert A. Olson, Fisheries Biologist. 271-2518 or 561-4062.

Lead Agency: USDA Forest Service

Cost of Project, FY95: $17.2K

Project Startup Date: 1/1/95 **Duration:** four months

Location: Anchorage, Alaska.

Objective: Complete data analyses and professional publication for an existing stream habitat data base, to establish the relationship between channel type designations and the presence of in-stream micro habitat (spawning and rearing).

Description: Rates of salmon mortality are highest during their early stream dwelling life stages. Because the mortality is often related to the condition and availability of in-stream habitat, it is critical that habitat limiting to juvenile salmon be protected or restored. Basin-wide in-stream habitat surveys are essential to predict those habitat conditions that limit survival. In remote areas of Alaska it is impractical to physically survey all streams within a given drainage, therefore, a hierarchical approach that lends itself to photo interpretation would greatly increase the efficiency of large scale habitat inventories.

Preliminary data, collected on the Kenai Peninsula, suggests that channel types, as defined from aerial photographs, may be a predictor of at least several micro habitats found in a stream channel. A multivariate analysis of variance indicated that channel types were a significant predictor ($P<0.0001$) for eight of thirteen micro habitats (e.g., rapids, plunge pools, and dammed pools). Further data collection, for the Oil Spill Trustee Channel Type Classification Study, indicated that channel types are also a significant predictor of the amount of spawning and rearing habitat in a given segment of stream.

The existing data bases will be analyzed to firmly establish the relationship between aerial photo channel type interpretations, and the presence of in-stream habitat (spawning and rearing). In addition the results will be published in a professional fisheries management journal. These analyses and the publication will serve as a basis for any larger scale in-stream habitat surveys that are tied to the Channel Type Classification Study and habitat protection proposals.

BUDGET ($K)

	TOTAL
Personnel	$10.0
Travel	$0
Contractual	$4.0
Commodities	$0
Equipment	$1.0
Capital Outlay	$0
Sub-total	$15.0
General Administration	$2.2
Project Total	$17.2
NEPA Compliance	None

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BROAD AGENCY ANNOUNCEMENT

50ABNF400104

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL WORK PLAN

National Oceanic and Atmospheric Administration
Western Administrative Support Center
Procurement Division, WC33
7600 Sand Point Way N.E., BIN C15700
Seattle, WA 98115-6349

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Broad Agency Announcement

52ABNP400104

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PART I

INTRODUCTION

This document serves as Broad Agency Announcement No. 52ABNF400104, for the following Exxon Valdez Oil Spill Restoration Work: Food Limitation on Recovery of Injured Resources. Please see Part IV for a description of the evaluation process for Spill Restoration Work projects. There is no guarantee that any contract will be awarded as a result of this Announcement.

This work is not restricted to any group; large and small businesses, educational institutions, non-profit organizations, individuals, and small disadvantaged businesses are encouraged to submit proposals. Proposals which include provisions for cost-sharing or teaming arrangements are also encouraged.

You are cautioned against discussing any technical or proposal preparation questions directly with Government technical personnel. If you have questions concerning any aspects of the Announcement, you should direct them, in writing, to Heide Sickles, the Contracting Officer, referencing BAA No. 52ABNF400104. Facsimile inquiries will be accepted at (206) 526-6025.

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PART II

RESEARCH AREA OF INTEREST

Food Limitation on Recovery of Injured Resources

Background. Five years after the Exxon Valdez oil spill, some injured resources are not recovering, others are recovering only slowly. For these resources, restoration requires an understanding of the factors constraining recovery: Why aren't these resources recovering? If they are recovering only slowly, why? Without answers to those questions, restoration may be ineffective.

There is evidence that some of the food webs that interconnect injured resources have changed in response to natural events or the spill. In fact, many of the oil spill impacts are expressed in disrupted food webs: limited prey, or increased predation and competition. The natural and oil-induced changes have profound implications on the populations of injured resources, and understanding the changes is important to restoration.

Statement of the Problem

One of the questions the Trustee Council wishes to address is: "Is food limiting?". Since the mid-1970's, a variety of species of marine mammals and seabirds that feed in pelagic (offshore) areas have been declining in the northern Gulf of Alaska and Prince William Sound. These include harbor seals, marbled murrelets, and pigeon guillemots as well as sea lions and kittiwakes. In contrast, resources using nearshore habitats, such as sea otters and sea ducks, have been stable or increasing during the same time period. This has led biologists to think that differences inherent to the food webs of these declining species may be responsible for differing trends. However, the mechanisms of the declines are unknown. In the case of seals, it may be poor juvenile survival. In the case of seabirds, it may be poor survival of chicks.

All of the declining species rely at least in part on forage fishes such as herring, capelin, sandlance, smelt, and juvenile pollock for food. During the approximately 20 years that marine mammals and seabirds have been declining, the estimates of pollock biomass have increased substantially. The biomass of other species of forage fishes may have decreased, but there are almost no data on these species. The northern Gulf has experienced a warming trend during the same time, which may have affected the abundance of these forage fishes.

If food or increased competition is limiting recovery, it may be related to the oil spill or it may be due to natural causes. In some cases, it may be caused by decadal changes in nutrient or climatological cycles. In any case, understanding the causes of

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the decline of the pelagic-feeding resources is a prerequisite for taking action to accelerate recovery from the oil spill effects. It is a high priority area of research for all the species that feed in pelagic areas.

"Is food limiting?" is considered a high priority factor that may be constraining recovery for the following injured resources that are not recovering: herring, sockeye salmon, common murre, marbled murrelet, pigeon guillemot, sea otter, and harbor seal.

Request for Research Proposals

NOAA, on behalf of the Trustee Council, is requesting research proposals concerning the energetic values of different prey -- effects of diet composition on factors such as reproductive success, juvenile (chick) survival and adult conditions. These factors may be influencing the recovery from the oil spill of one or more pelagic-feeding marine mammal or seabird species. These species have also been experiencing a long-term decline in the northern Gulf of Alaska and Prince William Sound.

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PART III

PROPOSAL PREPARATION

1. GENERAL INFORMATION

A. Proposal Submission

Proposals shall be submitted in original and three (3) copies, and must reference Announcement No. 52ABNF400104. Proposals should be mailed to:

NOAA, WASC Procurement Division
Attn: WC33
7600 Sand Point Way NE, BIN C15700
Seattle, WA 98115-6349

B. Proposal Due Date

All proposals submitted in response to this BAA shall be received at the WASC Procurement Division address indicated in paragraph 1.A. above no later than 2:00 P.M. local time on June 30, 1994.

C. Technical Format

To the extent possible, proposals should be prepared in the following format:

- documents should be in WordPerfect v.5.1, IBM compatible
- primary font should be Helvetica 12 point
- text left justified
- top and bottom margins 0.75 inches; left and right 0.75 inches
- paginate bottom center
- bold subheadings, not underlined
- double line spacing between sections
- sections with tabular columns and numbers should use WordPerfect's "math format" to align numbers and decimal points
- numeric quantities for units of measures should be clearly identified (e.g., kilometers, kilograms, etc.)

Offeror's are requested, but not required, to provide a copy of the brief project description on an IBM-compatible disk in addition to the printed copies required above.

2. DISCLOSURE INFORMATION

In addition to scientific and technical review of the proposal, the brief project descriptions may be subjected to review by the Exxon Valdez Public Advisory Group. Please note that information released to the Public Advisory Group

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is considered public information. After review and evaluation, project descriptions for those proposals deemed to have sufficient merit to be considered for funding in FY 95 will be published in the Draft Work Plan.

3. CONTENTS OF RESEARCH PROPOSALS

Research proposals submitted under this Broad Agency Announcement should conform to the following Exxon Valdez Oil Spill Trustee Council requirements for brief project descriptions (3-5 pages):

A. Cover Page
B. Introduction
C. Project Need
D. Project Design
E. Project Implementation
F. Coordination of Integrated Research Effort
G. Public Process
H. Personnel Qualifications
I. Budget

A. Cover Page

The cover page should contain the following information:

1. Project Title
2. Name of Project Leader or Principle Investigator
3. Lead Agency, University, or Organization (if known)
4. Cost of Project (for Fiscal Year 1995 and future years, including the cost of writing the FY 95 report, if known)
5. Project Start-up/Completion Dates (month/year)
6. Project Duration (number of years)
7. Geographic Area (locations where field work will be conducted)
8. Contact Person (name, address, telephone number for further project information)

With respect to Project Duration, long-term projects can frequently be broken into smaller increments. Your proposal should include the minimum number of years that your project can be funded in order to achieve useful results. If you believe a project should not be funded unless the work can be supported for a number of years, that information should be provided.

B. Introduction

A basic statement should be provided that describes what you propose as a restoration project. This statement should identify the injured resources and services that the project would address. Identify specific accomplishments that would result from implementation of the project. Finally, if you

know that the Trustee Council has previously funded work in this area, or if the project is a continuation of prior efforts, please include that information.

C. Project Need

This section should identify why the proposed project would help restore one or more injured resources or services. A clear statement of why the proposed project will contribute to the recovery of an injured resource or service is essential to ensure that the project is eligible for funding under the terms of the court-approved civil settlement. Your information should explain how the proposed project will help take the resource from its present condition to its restoration objective.

D. Project Design

This section should identify specific objectives (tasks) that would be undertaken as part of the project. Describe the project methodology. Describe methods that would be used to implement the project, as well as technical support or services that may be necessary. Your discussion should address each of the following points:

1. Objectives: Identify specific and measurable project objectives.

2. Methods: Describe proposed methods in general terms. While extensive technical detail is not needed, specific information will make it possible to more effectively evaluate suggested projects.

3. Schedule: Identify dates (month/year) for project activities including, at a minimum, field work, sampling events, data compilation and analysis, major contract deliverables, opportunities for public involvement, and report submissions.

4. Technical Support: Identify technical support necessary to complete the project (e.g., computer services, laboratory analysis, data archiving, etc.)

5. Location: Identify where the project will be undertaken, including areas or communities that may be affected by the project.

E. Project Implementation

Identify the agency, organization, or other entity that would implement the project. Identify what portion of the project, if any, would be appropriate to implement through a competitive procurement process. If you propose to

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accomplish the work yourself, explain your unique technical and/or scientific expertise.

F. Coordination of Integrated Research Effort

Multi-disciplinary or collaborative partnerships to implement projects are encouraged. Describe how the project will be coordinated or integrated with any related projects proposed for the FY95 Work Plan.

G. Public Process

Discuss what efforts have been, or will be, made to involve the public in development or implementation of the project and what further opportunity there will be for public involvement (e.g., workshops, meetings, document reviews, etc.).

H. Personnel Qualifications

Include a statement on the qualifications of each key personnel. Include relevant background information and noteworthy experience such as published work or similar or related projects.

I. Budget

Provide a Federal Fiscal Year 1995 (FFY 95) (October 1, 1994 - September 30, 1995) budget summary for the proposed project that identifies estimated costs for each of the following: (1) personnel, (2) travel, (3) contractual services, (4) commodities, (5) equipment, (6) capital outlay, (7) general administration (including environmental compliance), and (8), fixed fee.

The budget should reflect the FFY 1995 work including the cost to prepare a final report. That is, a project cost estimate should reflect the cost of any needed data analysis or report preparation, even if that cost would be incurred after September 30, 1995 (the end of the Federal fiscal year). In addition, include in your budget the cost of two trips to Anchorage and seven days time for the principal investigators. That time will be used for winter workshops to discuss the results of the 1994 field season and make any adjustments for 1995.

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PART IV

PROPOSAL EVALUATION

1. EVALUATION OF PROPOSALS

This Broad Agency Announcement is one part of the Exxon Valdez Oil Spill Trustee Council's request for restoration work ideas for their FY 95 Work Plan. The Council has also formally issued an "Invitation to Submit Restoration Projects for Fiscal Year 1995" to the public and government agencies to submit restoration project ideas. This document also provides additional material that would be valuable for the development of your project proposal. To request a copy of the "Invitation to Submit Restoration Projects for Fiscal Year 1995," call the Exxon Valdez Restoration Office at (907) 278-8012 (toll free within Alaska at 1-800-478-7745 or outside Alaska at 1-800-283-7745).

Proposals received in response to this BAA will be initially evaluated by a technical and scientific review panel. In addition, project proposals may be reviewed by the Public Advisory Group. In consultation with the technical review panel, the Public Advisory Board, the Restoration Work Force, and the Trustee Council Executive Director, the Exxon Valdez Oil Spill Trustee Council will then decide which projects received under their Invitation and this BAA have sufficient technical merit for consideration for FY 95 funding, taking into account the amount of funds available, and policy considerations to achieve a balanced approach toward restoration. Factors contained in the "Guiding Principals" identified in the "Invitation" will guide these decisions. Brief project descriptions will be published and made available for public comment in their Draft Work Plan. After the public comment period, the Trustee Council will decide which projects to approve. The Trustee Council may approve projects as proposed, approve projects contingent on modifications or further development, disapprove projects, or defer action. Project funding will be approved in October, 1994.

2. PROPOSAL IMPLEMENTATION

Contracts may be negotiated directly with offerors whose proposals submitted under this Announcement are approved by the Trustee Council and determined to be unique and innovative. Contracts awarded as a result of this process will follow the general guidelines of the Federal Acquisition Regulations.

Other proposed projects, which are approved by the Trustee Council but not considered unique or innovative, may serve

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as the basis for a competitive procurement action. The Government will not release specific details of an offeror's proposed methodology if an area suggested is determined to be more properly a competitive proposal.

3. EVALUATION CRITERIA

A. Threshold Criteria

1. The project meets the terms of the settlement:

   a. Restoration funds must be used "... for the purposes of restoring, replacing, enhancing, or acquiring the equivalent of natural resources injured as a result of the Oil spill or the reduced or lost services provided by such resources..."

   b. Restoration funds must be spent on restoration of natural resources in Alaska unless the Trustee Council unanimously agrees that spending funds outside of the state is necessary for effective restoration.

2. The project proposal is responsive to the BAA.

3. The project has sufficient detail for evaluation.

B. Technical Evaluation Criteria

The proposals will be rated on each of the following factors, listed in descending order of importance. Factor 6 will be considered separately and after factors 1 through 5 are rated.

1. The overall scientific (research) merits of the proposal as demonstrated through (1) understanding of the problem, (2) soundness of the technical approach, (3) innovation and uniqueness of the project, and (4) feasibility.

2. The potential contribution of the proposal to the identified needs. For research proposals, this should reflect the priority given to the research need to which the proposal is addressed.

3. The organization's capabilities, related experience, facilities, techniques, or unique combinations thereof that are integral factors for achieving the proposal objectives.

4. The qualifications, capabilities, and experience of the key personnel, including the proposed principal investigator, team leader, and other critical personnel who are necessary to achieve the proposal objectives.

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5. The organization's record of past performance with similar types of projects.

6. The cost effectiveness of the project proposal.

DOC.#950615022

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Alaska Research Associates, Inc.

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Suite 101, 4175 Tudor Centre Dr.
Anchorage, Alaska 99508
(907) 562-3339
FAX: (907) 562-7223

June 15, 1994

Molly McCammon
Director of Operations
Exxon Valdez Oil Spill Trustee Council
645 G Street
Anchorage, AK 99501-3451

Dear Molly:

LGL Alaska Research Associates, Inc. is pleased to respond to the Invitation to Submit Restoration Projects for Fiscal Year 1995 prepared by the Exxon Valdez Oil Spill Trustee Council. While LGL has had limited time to prepare this response, we wish to offer our services to participate in the restoration effort.

LGL can provide scientific research and monitoring services to the Council. We are submitting several restoration project ideas and are interested in responding to the forthcoming Request for Proposals. Please consider this letter a statement of interest in the restoration project categories of marine mammals, terrestrial mammals, birds, fish and shellfish, other resources, and services (from p. 21-22 of the Invitation).

LGL is a multidisciplinary environmental research and consulting firm specializing in marine, freshwater, and terrestrial ecology; fish and wildlife population biology and stock assessment; molecular genetics; genotoxicology; fishery management analysis; and geographic information systems and data base management. We have two offices in the United States - Anchorage and Bryan, Texas, and three in Canada - British Columbia, Ontario, and Newfoundland. LGL's Alaska office supports environmental research and monitoring projects throughout Alaska.

LGL is very interested in participating in the Trustee Council's research and monitoring program for FY 1995 and beyond. We would bring to the program scientific research and monitoring capabilities that would support the goals of the Restoration Plan (draft, November 1993). Our performance record demonstrates our ability to conceptualize and complete complex ecological studies on time and within budget. We have a publishing record in peer-reviewed literature that we believe is

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unsurpassed by any firm or government agency in the Northwest. LGL's research and monitoring capabilities which are relevant to the Council's need for restoration work are described in the following.

Marine Ecology

LGL scientists have been involved in numerous studies in Alaska, Texas, and Canada pertaining to the potential and actual effects of spilled oil on marine mammals, seabirds, and macrobenthic, intertidal, and subtidal communities. They have also conducted many investigations into marine mammal and seabird feeding ecology and energetics. Species of concern have included gray and bowhead whales, beluga whales, cormorants, common and thick-billed murres, pigeon guillemots, kittiwakes, and puffins. Field work has included aerial and shore-based surveys. Shipboard-based work has included measurement of temperature, salinity, currents, nutrients, and primary productivity; sampling of zooplankton, benthos, and fish; hydroacoustic surveys of fish and zooplankton; studies of feeding habits of seabirds and fish; and surveys of sea lions and other marine mammals.

Specifically, LGL marine ecologists have completed studies for MMS to monitor the effects of oil drilling on the coral reef communities and EPA/NMFS to monitor the effects of off-shore oil and gas production (including produced water discharges) on fish and invertebrates in the Gulf of Mexico; researched and prepared a series of impact assessments on harvests of salmon, groundfish, halibut, herring, crab and shrimp for the Trans-Alaska Pipeline Liability Fund regarding the Exxon Valdez oil spill; monitored the effects of Arctic oil development on marine benthic and macrophyte communities of the Beaufort Sea under partial National Science Foundation funding; and planned and implemented an integrated ecological study of a barrier-island lagoon system for NOAA/BLM that focused on the multidisciplinary interrelationships among fish, birds, marine invertebrates, primary productivity, nutrient regeneration, and geological and physical processes. LGL also revised the U.S. Army Corps of Engineers' procedural guide for designation surveys of ocean dredged material disposal sites. In Texas, LGL has reviewed for the U.S. Army Corps of Engineers the Environmental Impact Statement concerning the direct and indirect effects of ship navigation on the oyster communities of Galveston Bay and conducted both shallow and deep-water (down to 3,000 m) biological assessments of meiofaunal, macroinfaunal, and epifaunal communities in the Gulf of Mexico in collaboration with MMS.

LGL has monitored the effects of oil and gas exploration and development in Alaska's Arctic since 1978. Beginning with a landmark ecological study of a barrier island-lagoon system along the Beaufort Sea coast from 1978 to 1982, LGL marine ecologists have continuously worked in the nearshore marine environments of Alaska's Arctic up to the present time. Since 1982 we have completed various

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projects that have assessed effects of coastal developments on the Beaufort Sea coastal zone, particularly fish resources, and since 1988 LGL scientists have monitored the long term effects of Alaskan Beaufort Sea causeway development on nearshore marine habitats and fish populations.

Freshwater Ecology

LGL's fishery scientists and freshwater ecologists have experience in field data gathering throughout Alaska. For example, LGL implemented freshwater fisheries surveys along the proposed Northwest Alaskan Natural Gas Pipeline route to identify critical freshwater habitat and to assess the potential for wetlands degradation; we also have conducted under-ice surveys of fish overwintering habitat in the Sagavanirktok River of northern Alaska. LGL fishery scientists specialize in salmonid ecology, stream invertebrates, population dynamics, and instream flow assessment. Our fishery and aquatic scientists are experienced with coastal forest landscapes throughout the Pacific Northwest. We also conduct commercial fishery management studies for industry and government (described below).

Capabilities in the study of freshwater ecology include water quality and physical measurements; determination of seasonal and spatial variations and abundance of phytoplankton, zooplankton, and benthic invertebrates and estimates of production and standing crop; determination of fish life history patterns; and identification of critical regions for fish, such as spawning and overwintering areas.

Terrestrial Ecology

LGL terrestrial ecologists specialize in disturbed habitat impacts to a range of wildlife from large, migratory ungulates to shorebirds and waterfowl. Many of these studies are baseline surveys to determine habitat use and biologically critical periods, both temporally and spatially. The studies relate primarily to resource development activities and are focused on avoiding or mitigating detrimental impacts. LGL scientists are also involved in habitat restoration studies in both urban and remote sites. In recent years, LGL terrestrial ecologists have developed state-of-the-art techniques for use in monitoring wildlife distribution and behavior. They were among the first to use the NAVSTAR Global Positioning System (GPS) linked to lap-top computers and GIS databases. Both ARC/INFO and MapInfo databases are supported. LGL's use of this innovative technology has increased accuracy for large mammal and waterfowl aerial surveys. High-resolution time-lapse videography has been used successfully by LGL to monitor wildlife behavior in disturbed habitats within the Prudhoe Bay oil field.

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Ecological Genetics

LGL's genetics capabilities include two general categories: genetic toxicology and molecular population genetics. In genetic toxicology, flow cytometry and other advanced methods are used to assess genetic damage to biotic resources from toxins. Our capabilities include assessing petrochemical, radioactive, and other toxic materials effects on animal genetic material. Our facilities include state-of-the-art equipment used through collaboration with Texas A & M University.

LGL's molecular population genetics capabilities include most of the varied methods of modern molecular biology. This includes cloning, automated DNA sequencing and variable number tandem repeat (VNTR) analysis. We have developed many methods for mitochondrial DNA (mtDNA) and nuclear DNA analyses in fish, birds, and mammals. We have developed sex-specific markers for forensic applications as well as automated DNA fingerprinting methods for wild and domestic animals.

Projects have included analyses of natural populations for "genetic stock identification" of fish, and population genetics of marine and terrestrial mammals. We have conducted genetic studies on salmon, polar bears, sea otters, and sea lions for the U. S. Fish and Wildlife Service, National Marine Fisheries Service, Canada Dept. of Fisheries and Oceans, and British Columbia Dept. of Fisheries. We are actively developing the most modern genetic technologies and applying them to both wild and domestic animals. This includes collaboration with researchers at the forefront of genetic mapping and application of genetics technology to conservation and animal science.

Fishery Management

U.S. commercial fishery development in the North Pacific, particularly in the Gulf of Alaska and Bering Sea, has been rapid in the past decade. Also, the State of Alaska's commercial finfish and shellfish fisheries are continuously evolving and diversifying. These fishery activities carry with them a complex regulatory and management structure that requires biological, economic, and social data analyses for decision making.

LGL established a fishery management group in the early 1990s to provide analytical services to government and industry. Our specialists develop and analyze commercial fishery management alternatives, and assess the ecological and economic consequences of various management alternatives. Our staff expertise includes groundfish, salmonid, crustacean, and scallop fishery management; federal and state regulatory requirements; fish population dynamics; marine mammal interactions with commercial fishing operations; fishery data and information

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management systems; statistics; fish and shellfish biology; and fishery economics.

GIS and Data Base Management

LGL has integrated the fields of computer science and ecological research, monitoring, and impact assessment to develop capabilities in design, implementation, and maintenance of large data bases and geographic information systems. LGL provides innovative approaches to improving the accuracy of data collection in the field and the integration of these data into our inhouse computer and geographic information systems. Our GIS capabilities have been used in past studies to develop integrated models of spatial locators and attribute data bases in order to facilitate information query and analysis; these GIS systems have been used for decision support and, ultimately, resource management for bird and mammal populations on Alaska's North Slope.

We have experience in the use of low level aerial spectrographic imaging to map vegetation communities at a fine scale and remote sensing and global positioning survey techniques for location-specific fish and wildlife data collection. Currently LGL's British Columbia office is pioneering an Oil Spill Response Information System which provides a comprehensive natural resource inventory and sensitivity atlas in a geographic information system that is used by Canada and the People's Republic of China, and is now being marketed throughout the world.

RESTORATION PROJECT CONCEPTS

LGL has been interested in the progress of resource damage assessment since the Exxon Valdez oil spill occurred in 1989, and we have attended the public forums that have been held to provide progress reports on the damage assessments conducted by both industry and government (conferences in Anchorage and Atlanta). Although we have not conducted specific field studies in the spill area to support the damage assessments to date, we believe we are well positioned to bring a fresh and enthusiastic capability to the ongoing restoration effort. LGL has considerable expertise in project design, field data gathering, QA/QC and project management, quantitative assessment and statistical interpretation of data, and the publication of study results. Our track record of publishing research results demonstrates LGL's commitment to submitting our work to peer review.

Attached find several brief restoration project ideas. I realize we have not adhered to the suggested format for submitting project ideas, but we have not been able to readily acquire reports on the past several years' of research and monitoring in Prince William Sound, and thus do not have the background to provide a detailed response. Nonetheless, our staff have some restoration project concepts which may

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merit review by the Council and inclusion in the RFP package later this summer, and I have attached these project ideas. LGL submits these project ideas as an indication of our interests and capabilities and not as a measure of our research design capabilities; these project statements are far too brief to demonstrate a detailed restoration approach. At this time we are unable to write meaningful study designs due to a lack of available published information on the spill effects on natural resources. Given the opportunity to obtain oil spill study results and to research these issues in depth, LGL would be able to provide more comprehensive descriptions.

Our staff would be pleased to meet with you or other Council staff if you have questions concerning our firm or our capabilities. We look forward to the opportunity to work with you.

Sincerely,

LGL ALASKA RESEARCH ASSOCIATES, INC.

William J. Wilson
Office Manager

WJW/ab

Attachments

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Mussel Bed/Harlequin Duck Trophic Ecology

We understand that some Prince William Sound mussel beds were never cleaned after the spill (but see below) because there was concern that disturbance would negatively affect the predators of mussels, primarily harlequin ducks. Mussel beds, however, continue to harbor toxic, unweathered oil below their byssal mats, and this may be the source of contamination that is suspected of keeping reproduction very low in harlequin ducks in western Prince William Sound. Recovery of the harlequin population in western Prince William Sound probably cannot occur until this source of contamination is removed or significantly lessened.

LGL is proposing a program involving active restoration of the mussel beds, in incremental steps, to rid them of contamination and yet produce minimal impacts upon the harlequins which are dependent upon mussels for food. The idea is to remove as much of the subsurface oil as possible in selected test locations which will undoubtedly involve disturbance and mortality to the mussel beds above, and then to "seed" these areas with patches of cobbles and attached mussels collected from unoiled beds in eastern Prince William Sound. In addition, any patches of mussels still intact from the cleaned bed can be seeded back into the original bed. The use of the treated bed by harlequin ducks and other bird species (such as oystercatchers) will be monitored at regular intervals throughout the year to document the effects of the restoration treatment on mussel predators over a multi-year effort.

Caveat 1: This procedure will obviously disrupt a food source for harlequin ducks, but the reasoning is that as long as a mussel bed persists in an area, regardless of its level of contamination, the birds will use it for feeding. And as long as that food source remains contaminated, the birds will probably be suffering reproductive failures. Birds are very mobile and very adept at locating food sources, and probably can move to feed in other nearby mussel beds while the treated bed is recovering, i.e., the treated bed will be unattractive for feeding because of relatively low densities of mussels. Only one bed will be treated in any year so that other nearby beds will be available to absorb birds seeking a new food source.

Caveat 2: It is possible that cleaned mussel beds will become quickly recolonized by other intertidal species, i.e., algae. This may prolong the process of reestablishment of mussels in the area.

Caveat 3: Apparently a pilot mussel bed cleaning project is underway this summer. We are not aware of the cleaning methodology proposed for this project, but presume our program could be coordinated with or assimilated into this ongoing effort.

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Restoration Strategies Using the BACI Model of Ecological Assessment

Effects of the oil spill on biotic resources in Prince William Sound could be evaluated using the Before-After Control-Impact (BACI) model [Stewart-Oaten et al. 1986; Ecology 67(4): 929-940]. In this design, impact and control sites are sampled "simultaneously" at times before and after the perturbation (oil spill). Measurements taken over time represent true replicates, enabling statistical analysis. Changes in the difference between control and impact sites "after" the perturbation as compared to the "before" period reflect effects attributable to the perturbation. With knowledge of true effects in hand, more effective restoration strategies may be implemented.

LGL has successfully applied the BACI model in recent published ecological studies, including assessment of the effects of the Endicott Development on the boulder patch kelp community of Stefansson Sound in the Beaufort Sea [Martin and Gallaway 1994; Arctic 47(l):54-64] and an assessment of Beaufort Sea causeways on growth of arctic fishes [Griffiths et al. 1992; Trans. Am. Fish. Soc. 121:557-577]. In each case, we used the model to quantify development effects on marine biotic resources which enabled managers to ascertain whether the effects were within permit stipulations.

For the Exxon Valdez oil spill restoration program, the BACI model could be applied to commercial rockfish trawl catches in the Gulf of Alaska (GOA). LGL has recently developed a fishery information management system (FIMS) that includes trawl data before and after the spill in the GOA. The FIMS data base could be queried for trawl catch data before and after the spill in various locations inside and outside the spill trajectory to compare rockfish catch parameters such as CPUE, by species, by cohort; size and age composition by species and cohort; or species composition (rockfish are caught in assemblages, usually by depth zone; changes in species mix may be indicative of a direct or indirect effect of hydrocarbon contamination). The objective of comparing before-after parameters inside and outside the spill area would be to develop a linkage between the spill and rockfish population health, a relationship that has, to this date, not been established. Once established, a restoration strategy could be developed and implemented.

We believe that the BACI model could be applied to other restoration studies. Unfortunately, the lack of pre-spill data sets may restrict the model's utility, since "before" data sets are not generally available for all damaged resources. However, some assumptions might be made regarding the "before" condition; we might use laboratory hydrocarbon dosing experiments or conduct field experiments in other nearby or ecologically comparable marine systems in a manner that could gain scientific consensus among the research community and thus be acceptable as a proxy for the "before" condition. We have conceptualized several approaches to using this approach on the mussel-harlequin duck problem and on the recovering mussel bed issue. Without specific project reports on the past studies in these areas, however, we cannot readily prepare a program approach at this time.

Assessing Recovery of Recreation and Tourism in Prince William Sound

The oil spill has impacted recreation and tourism in various ways. Recreational opportunities such as fishing, pleasure-boating, sailing, and kayaking were disrupted in the spill area. Wildlife viewing opportunities were also affected due to the detrimental effects on important wildlife species such as killer whales, sea lions, seals, sea otters, and several species of marine birds. Tourism, an economically important industry in the local area, has also been affected.

To monitor the recovery of these services, LGL would use existing strategies and develop new strategies when appropriate. Beach surveys would be conducted to identify and evaluate beaches with persistent oil and to monitor recreational use of such beaches. Information from recreational user groups will also be solicited to supplement beach survey data. We are expressing interest in conducting these kinds of studies at this time.

A. Population genetics of fish, marine mammals, and birds

For three species of fish (herring, pink salmon, and sockeye salmon), genetic stock identification studies have been approved by the Trustees (Projects 94165, 94189, and 94504). According to the 1994 work plan, two of these (herring and pink salmon) will include ADF&G requests for proposals for the laboratory analyses. Our firm, which has widely advertised our ability to conduct such analyses with ADF&G and other agencies, will be eager to bid on such RFPs. We understand the RFPs have not yet been released. In any event, we propose to the Trustee Council that an LGL program using modern genetics methods be initiated on these species as well as several marine mammals of concern.

Why will the project help accomplish restoration? As indicated, three fish genetic stock identification projects have been approved and the rationale should be available from the agency proposals. In addition, the description for harbor seals in the invitation to submit project ideas (page A-18) indicates population genetic information for marine mammals would be useful.

However, upon closer inspection, the relevance of population genetic studies for restoration is not immediately clear (particularly for populations in Cook Inlet). It could be asserted that identification of distinct stocks will aid in management, although exactly how is not described in the Invitation to Submit Restoration Projects. Identification of rates of recruitment or exchange (straying) among populations may result from genetic data, but molecular data typically give such estimates for long time frames. It seems that straying rates estimated from fish tagging would be better for short time frame estimates.

The very term "genetic stock identification" implies that "stocks" are genetically differentiated to begin with. Because this is not necessarily the case, the term population genetics may be more appropriate. Recent post-glacial colonization by pink and sockeye salmon and migration to non-natal streams (straying) may prevent genetic differentiation. One of our projects, then, is to assess the relevance of molecular genetics for fishery and marine mammal stock assessment, particularly management and restoration. That is, in addition to applying the modern *molecular genetics* methods, apply modern population genetic *theory* to assess the relevance of genetic data. Population genetic theory has developed along with the molecular genetic advances of the last two decades, and perhaps should be employed *before* investing in molecular genetic studies.

<u>Population Genetics Project 1: Theoretical population genetics of salmonids</u>

Assessment of population genetic expectations could be made, given the times of colonization of systems (estimated from geological data) and migration (straying) rates among spawning areas of different spatial scales. Data on hatchery releases and recovery in non-hatchery spawning areas could also be incorporated. These types of data could be applied to Prince William Sound and Cook Inlet salmon populations

to assess the predicted rates of gene flow and genetic differentiation among populations. It is widely known in population genetics that direct estimates of gene flow (e.g., from tagging studies) and indirect estimates of gene flow (e.g., from genetic data) may not be concordant and may reflect different processes and time scales. It would seem prudent to include both types of analyses in population genetic studies of salmon.

Population Genetics Project 2: Empirical assessment of population genetics of fish in Prince William Sound.

LGL has been involved in developing advanced molecular genetic systems for both natural populations and domestic animals throughout the United States and Canada. Population genetics of fish can be better understood with the application of modern systems. In particular, a multilocus approach, incorporating both nuclear and cytoplasmic genes, is warranted. Because allozymes require several different tissues and careful handling (ultra cold freezing), they may be subject to selection, and they reveal minimal genetic variation compared to DNA, we suggest a DNA-based approach. Many coding loci can be developed for fish (e.g., growth hormone, major histocompatability loci) as well as non-coding hypervariable loci (e.g., microsatellites). These types of loci would be amenable to automated analysis on autosequencers and allow processing of many samples quickly.

Population Genetics Project 3: Population genetics of non-recovering marine mammals I: sea otters.

LGL has already completed a study of sea otter genetics (under contract to the U.S. Fish and Wildlife Service) including mitochondrial DNA (mtDNA) and allozymes. One paper has been submitted to a peer-reviewed journal and others are in preparation. Our studies showed considerable population genetic structure among major geographic areas in Alaska. Finer scale studies, using both nuclear DNA and mtDNA within the Prince William Sound area, could improve understanding of local population structure. We have already conducted nuclear DNA analyses on several mammalian species including carnivores, primates, and artiodactyls, and methods for marine mammals are readily available.

Population Genetics Project 4: Population genetics of non-recovering marine mammals II: harbor seals.

LGL has completed a study of sea lion population genetics, including mtDNA, under contract to NMFS. A paper is in press in a peer-reviewed journal. Studies of harbor seal mtDNA and nuclear DNA could improve understanding of population structure and recruitment into the Prince William Sound area.

Population Genetics Project 5: Population genetics of marbled murrelets

As this species is of major concern in southeast Alaska (because of timber harvest) it seems appropriate to determine the relationships of the Prince William Sound birds to those of southeast Alaska. The same molecular and theoretical approaches can be applied as for marine mammals and fish.

B. Genetic damage assessments of fish and mussels

As outlined in the 1994 work plan and in the Invitation to Submit Restoration Projects, assessment of genetic damage is thought to be relevant to restoration efforts. LGL, through Texas A&M University, has conducted considerable research in this field and are interested in bidding on projects including those listed in the 1994 work plan and the Invitation. These include:

Genetic Damage Assessment Project 1: Herring and salmon

The 1994 work plan describes the methods used to assess genetic damage to pink salmon as experimental, in incubators with oiled substrate. It is not clear if the "heritable genetic damage" referred to in the Invitation to Submit Restoration Projects is in the experimental salmon or the wild fish. The wild fish study consists of crosses and survival assessment in incubators. Assessment of the genetic condition of the fish in the wild should be conducted. If there is heritable genetic damage, gametes from fish in oiled and unoiled streams should be compared. These comments apply to the herring study also.

Until genetic damage data are available, it will be difficult to assess the conclusions that genetic damage may have occurred and is heritable. Because the focus on restoration is on the natural populations, the experimental approach seems a bit irrelevant. It may be appropriate to take eggs or fry from oiled and unoiled streams and raise them in hatcheries to compare fitnesses for a few generations.

In addition to documenting the existence of genetic damage, the question should be asked: "If the presence of oil is no longer a problem, won't natural selection remove deleterious mutations caused by the spill?" Couldn't stock from nearby streams be used to enhance streams which may have suffered oil damage? If genetic damage is identified, how will it help in restoration?

We suggest a study be done on returning adults and fry from the *actual populations* in oiled and unoiled streams. This should include assessment of genetic damage for a large enough sample to estimate variation within populations. The extent of damage, and a clear restoration strategy, could then be developed.

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Genetic Damage Assessment Project 2: Mussels

Genetic damage in mussels was not mentioned in the Trustee Council documents, but seems as appropriate as the studies for the other species given the fact that mussel beds were oiled. Benthic organisms might be expected to be more susceptible because of their low motility as adults.

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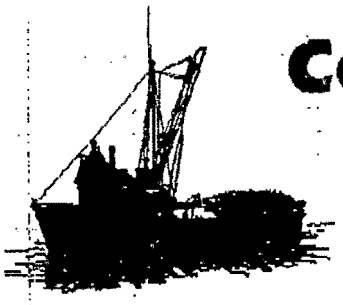

Cook Inlet Seiners Association

P.O. Box 4311
Homer, Alaska 99603
235-2656

June 15, 1994

Exxon Valdez Oil Spill Trustee Council
Restoration Office
645 "G" Street
Anchorage AK 99603

Re: 1995 Work Draft Plan

Dear Trustee Council:

Cook Inlet Seiners Association (CISA), a non-profit group representing Lower Cook Inlet salmon seiners would like to take this opportunity to submit projects for the 1995 Work Draft Plan. In the near future, CISA will be sending more information about these projects. Also, we are more than happy to assist the Trustee staff in any way we can to get these projects approved and implemented.

Below is the list of the restoration projects we think are the most workable and appropriate:

(1.) The stocking of Paint River. The Paint River Fish Ladder Stocking Program needs to be expanded to include four years chum stocking, at least two years pink stocking, and additional sockeye stocking. This is not a hatchery project and would be terminated at the end of the stocking plan and allowed to run a natural cycle of instream spawning and adult return. Total cost of a four year project is estimated at 2 million dollars. Though little can be done to restore the impact of EVOS in the much-damaged area in the Kenai National Fiords, the Paint River project is an opportunity to mitigate for those lost resource.

(2.) Egg incubation box at Island Creek. Because of the oil damages sustained as a result of the 1989 spill at Island Creek, Port Dick, we have lost the inter-tidal chum spawning that occurred there. By increasing the survival of eggs of returning adults, an instream incubation box would be a significant restorative step toward bringing back a healthy chum run to this area and, thus, help reestablish these runs to pre-spill levels.

(3.) Delight and/or Desire Lake sockeye incubation. This project would provide

an important aspect of restoring the health of lost salmon runs in the outer coast of the Kenai Peninsula. Prompt timing of this project is vital because CISA believes that in the near future much of the native landholdings within the Kenai Fiords National Monument will be purchased which would further limit restoration potential from Seward to Gore Point.

(4.) Petroff River. CISA believes strongly that a restoration project needs to be developed for this area which received the most oil damage in LCI. We have no exact idea or specific project to present at this time. We want to express the need and request your assistance in developing a project that would re-vitalize run strength here.

As both the Trustees and CISA are aware, to date there have been no restoration projects conducted in Lower Cook Inlet (LCI). The time is long over due for restoration activities to be initiated here since the outer coast of the Kenai Peninsula is second only to Prince William Sound in the extent of oil spill damages experienced.

Also, we are both cognizant, little to no oil spill related studies have been implemented in LCI. As a result, the typical "study evidence " to substantiate restoration activity is not available. CISA believes that LCI should not be penalized because of this lack of "study" evidence--such studies have been discontinued or not even begun. Furthermore, CISA believes there is more than ample evidence to support significant restoration activity in LCI. (Since 1989, almost all salmon runs across the area, have failed.) It is imperative that restoration of pink, chum, and sockeye stocks begin immediately in order to preserve these unique runs and the fishermen that harvest them.

CISA requests your strong support of these projects. We welcome the opportunity to discuss them in more detail with you.

Thank you.

Sincerely,

AlRay Carroll

AlRay Carroll, President
Cook Inlet Seiners Association

Exxon Valdez Oil Spill Trustee Council

Restoration Office
645 "G" Street, Anchorage, AK 99501
Phone: (907) 278-8012 Fax: (907) 276-7178

TO: Reviewers

DATE: July 6, 1994

FROM: Molly McCammon
Director of Operations

TELE: 278-8012
FAX: 276-7178

SUBJECT: New Proposals

Five additional proposals were received since the June 15th deadline. Please review these proposals (as time allows), and we will include them in next week's meeting to the extent we are able.

Habitat Protection

95110-Closeout. Closeout: Habitat Protection Data Acquisition and Support: $140,000. This project was included in the Table of Contents of the *Preliminary Review Draft* for $60,000, but the project description was not available at that time.

General Restoration

95115. Sound Waste Management Plan. $275,900. Submitted by Prince William Sound Economic Development Council.

95116. Restoration of Intertidal Oiled Mussel Beds by Non-destructive Manipulation/Flushing with PES-51. $435,186. Submitted by a coalition: PES Services, Inc. Chenega Corporation, UAF, University of California - Santa Cruz, and Foss Environmental Services Inc.

Research

95114. Eelgrass Community Structure Restoration Assessment Using Stable Isotope Tracers. $192,100. Submitted by Prince William Sound Science Center.

95113. Energetics of Intertidal Fish: The connection between lower and upper trophic levels. $392,552. Submitted by UAF

Project 95110 - Closeout

EXXON VALDEZ OIL SPILL PROJECT DESCRIPTION

Project Title: Habitat Protection-Data Acquisition and Support

Principal Investigator: Habitat Work Group

Lead Agency: Alaska Department of Natural Resources

Cooperating Agencies: Alaska Department of Fish and Game; U.S. Department of Interior, Fish and Wildlife Service; U.S. Department of Agriculture, Forest Service

Project Cost: $140K

Project Term: October 1, 1994 to December 31, 1994

Geographic Area of Project: Prince William Sound, Kenai Peninsula, Alaska Peninsula, and Kodiak Archipelago

B. INTRODUCTION

This project is designed to support habitat protection activities of the Trustee Council and is a close-out of project 94110. In 1993 Habitat Protection Work Group conducted a survey and assessment of selected parcels of private land within the oil spill zone. The lands were scored, ranked and mapped using the Trustee Council approved Evaluation Process to determine the value of these areas to injured resources and services and the benefits that could be achieved through habitat protection. The evaluation was done using a variety of available data and information gathered from various agencies and technical experts, data collected during The Nature Conservancy Workshop, Natural Resource Damage Assessment reports, and site reconnaissance field visits.

In 1994, a method was developed for nominating, processing, evaluating and ranking parcels of private land less than 1000 acres, i.e., *The Small Parcel Process*. Responses to the solicitation for nominations of small parcels are currently being processed and evaluated.
Evaluations, starting with field surveys, of large and small parcels submitted this Spring will also continue into the Fall.

C. NEED

The need for the close-out work on project 94110 is to complete evaluations of lands nominated during this summer and fall and to prepare reports. Results of large parcel evaluations will be submitted to the Trustee Council as a supplement to Volume I of the Comprehensive Habitat Protection Process document. The results of the Small Parcel Process will be submitted to the Trustee Council as a separate volume of the Process.

D. PROJECT DESIGN

1. Objectives:

- Evaluation, restoration unit design, scoring and ranking of selected private parcels.

- Mapping of evaluation units.

- Preparation of supplement to Volume I of the Comprehensive Habitat Protection Process document for Trustee Council review and negotiations with landowners.

- Preparation of Volume III *Small Parcel Evaluation and Ranking Comprehensive Habitat Protection Process* for Trustee Council review and negotiations with landowners.

2. Methods:

Existing data and data obtained by HPWG in 1993 and 1994 will be analyzed to fill data gaps to the maximum extent possible. This will include some additional programming, data base management, and GIS work to sort data and to map resource information where appropriate.

Primary and secondary evaluations, for large and small parcels, will be conducted by the HWG using evaluation formats developed by the group.

Comparative Benefit Analysis will be carried out on all parcels or packages of parcels that have completed evaluations and appraisals. This technique, developed in 1994, utilizes appraisal values, parcel or package score and acreage to facilitate the acquisition of those lands that result in the greatest benefit at the lowest cost.

Volume III and the supplement to Volume I will be prepared in a format consistent with Volumes I and II.

3. Schedule

Evaluation and ranking of small parcels will occur during this summer and fall. It is anticipated that negotiations for small parcels will commence in January, 1995. Field surveys of recently nominated large parcels will occur this summer. Evaluation results, including scoring and ranking, of both large and small parcels will be submitted to the Trustee Council in the fall.

4. Technical Support:

The Alaska Department of Natural Resources LRIS group will produce all maps. The HWG will produce all documents.

5. Location:

The analysis will cover all selected lands within the oil spill zone. Lands are located within

Prince William Sound, Kenai Peninsula, Kodiak/Afognak Archipelago and on the Alaska Peninsula.

E. PROJECT IMPLEMENTATION

The proposed project is a continuation of 94110. Habitat protection projects were started in 1992 by the Restoration Planning Work Group and outlined in concept in Volume I of the *Restoration Framework*. Implementation of this project would be by the Habitat Work Group. This group includes four members representing ADNR, USFS, ADF&G and USFWS. The HWG includes three individuals who have been working on the spill since early 1989 and who participated in the genesis and development of habitat protection as a restoration strategy. All four members are authors of the *Comprehensive Habitat Protection Process* report and participated in the development of the *Small Parcel Process*.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

All habitat protection efforts including this project are dependent upon the results of on-going research and monitoring projects. For example, the Large Parcel Element used information from the anadromous fish stream catalog, colonial seabird catalog, bald eagle nesting maps, and data from Trustee Council funded studies on black oystercatchers, marbled murrelets and pigeon guillemots.

G. PUBLIC PROCESS

The public has reviewed and commented favorably on all habitat protection efforts and has been highly supportive of habitat protection as a major restoration strategy into the future. All reports published as part of the Comprehensive Habitat Protection Process have been reviewed by the public. Input from natural resource and services specialists in the public sector was collected in a workshop conducted by The Nature Conservancy.

H. PERSONNEL QUALIFICATIONS

Resumes of all HWG members are available on request.

I. BUDGET

Personnel	$ 73.2
Travel	6.0
Contractual	48.0
Commodities	2.4
Equipment	0.0
Subtotal	129.6

Project 95110

General Administration	14.3
Total	$ 143.9

95113

SFOS 94-179

PROPOSAL

94506

TO: *Exxon Valdez* Oil Spill Trustee Council
Restoration Office
645 G Street, Suite 402
Anchorage, AK 99501

FROM: School of Fsheries and OceanSciences
P.O. Box 757220
University of Alaska Fairbanks
Fairbanks, AK 99775-7220

TITLE: Energetics of Intertidal Fish: The connection between lower and upper trophic levels

PRINCIPAL INVESTIGATOR: Willard E. Barber
Associate Professor
SS# 527-50-6406

NEW/CONTINUING: New

PROPOSED START DATE: October 1, 1994

PROPOSED DURATION: 2 Years

AMOUNT REQUESTED: $396,552

Willard E. Barber 6/22/94
Willard E. Barber /Date
Principal Investigator
(907) 474-7177

Vera Alexander 6/24/94
Vera Alexander /Date
Dean
School of Fisheries and Ocean Sciences

Joan Osterkamp 6-23-94
Joan Osterkamp /Date
Executive Officer
School of Fisheries and Ocean Sciences

Ted DeLaca /Date
Director, Office of Arctic Research
University of Alaska Fairbanks

Project 95113
SFOS 94-179

ENERGETICS OF INTERTIDAL FISH:

THE CONNECTION BETWEEN LOWER AND UPPER TROPHIC LEVELS

Project Leader:	W. E. Barber, Associate Professor School of Fisheries and Ocean Sciences University of Alaska Fairbanks Fairbanks, AK 99775-7220
Cost:	FY 95 - $140,284 FY 96 - $147,580 FY 97 - $108,688
Start-up/Completion:	1 January 1995 to 1 June 1997
Duration:	3.5 years
Geographic Area:	Prince William Sound and Cook Inlet
Contact:	W. E. Barber, Ph. D. School of Fisheries and Ocean Sciences University of Alaska Fairbanks Fairbanks, AK 99775-7220 (907) 474-7177; FAX 474-7204

Introduction:

The recent emphasis on understanding ecosystem processes to interpret the influenced of the Exxon Valdez oil spill on the numerous impacted species, and their recovery, has brought to the forefront the interaction between forage species and their predators. A number of the impacted birds and mammals prey not only on subtidal and pelagic organisms fishes but also those inhabiting the intertidal area. This is particularly true of the pigeon guillemot and river otter. The intertidal area bore the brunt of the spill, impacting plants, invertebrates, and fishes. To understand the influence of the spill on species such as these and their recovery, from an ecosystem perspective, intertidal fishes must be considered and incorporated into models developed. This study proposes to study the bioenergetic aspects of the three fish species inhabiting the intertidal area of Prince William Sound utilized by pigeon guillemot and river otter.

Objectives:

1. Determine the seasonal changes in energy content of the high cockscomb prickleback ((Anoplarchus purpurescens), the cresent gunnel (Pholis ornata), and the tidepool sculpin (Oligocottus maculosus).
2. Determine prey organisms of these three fish species.
3. Determine the energy content of major prey species of these three intertidal fish species.

Methods and Materials:

Energy content (kJ/g), percent water, total energy (kJ), will be determined for the major body components (gonads, body, gastrointestinal tract, and liver) will be determined. This will be done for four size groups of each species and four seasons. For the four seasons foods will be determined and for the major prey species energy content determined for each species. Samples will be dried and energy determined using a Parr adiabatic bomb calorimeter following standard methods.

Budget:	FY95	FY96	FY97
SALARIES	103.8	109.9	80.7
TRAVEL	6.6	6.6	5.3
CONTRACTUAL	2.5	2.5	3.2
COMMODITIES	4.0	4.0	1.4
EQUIPMENT	0.0	0.0	0.0
SUBTOTAL	116.9	122.9	90.6
ADMINISTRATIVE COSTS	23.4	24.7	18.1
TOTAL	140.3	147.6	108.7

Abstracted Qualifications

Education:

Arizona State University, 1961-1967; B.A. and M.S.

Michigan State University, 1967-1970; Ph.D.

Experience:

Assistant and Associate Professor, School of Fisheries and Ocean Sciences, 1976 to present.

Project Leader, Fisheries and Wildlife Division, Victoria (Australia), 1975-1976.

Research Scientist and Officer in Charge, Commonwealth Scientific Industrial Research Organization, Brisbane, Australia, 1971-1975.

Example Publications:

Barber, W. E., M. Vallarino, and W. P. Erickson. Manuscript. The biology and impact of the Exxon Valdez oil spill on the biology of the high cockscomb in Prince William Sound, Alaska. Marine Biology Progress Series, Submitted.

Barber, W. E., L.L. McDonald, W. P. Erickson, and M. Vallarino. Manuscript. Effect of the Exxon Valdez Oil Spill on Intertidal Fish: a Field Study. Transactions of the American Fisheries Society, in press.

West, R. L., M. W. Smith, W. E. Barber, J. B. Reynolds, and H. Hop. 1992. Autumn migration and overwintering of Arctic Grayling in coastal streams of the Arctic National Wildlife Refuge, Alaska. Transactions of the American Fisheries Society 121:709-715.

Barber, W. E., and J. N. Taylor. 1990. The importance of goals, objectives, and values in the fisheries management process and organization: a review. North American Journal of Fisheries Management 10:365-373.

Project 95113
SFOS 94-179

Budget
FY95

SALARIES AND BENEFITS			
Wages	***Mos.***		
Barber, W.	2.00	$13,892	
Smith, R.	2.00	$15,528	
Technician	6.00	$21,565	
Ph.D. Student	12.00	$16,247	
Leave Accrual			
Barber, W.		$2,792	
Smith, R.		$3,121	
Technician		$4,615	
Ph.D. Student		$0	
Benefits			
Barber, W.		$4,888	
Smith, R.		$5,464	
Technician		$10,655	
Ph.D. Student		$0	
TOTAL SALARIES AND WAGES			$98,767
TRAVEL			
4 R/T Fairbanks-Cordova (@$300/trip)		$1,200	
Per diem - Cordova (12 days @$103/day)		$1,236	
3 R/T Fairbanks-Anchorage (@$300/trip)		$900	
Per diem - Anchorage (12 days @170/day)		$2,040	
4 R/T Anchorage-Seward (@$300/trip)		$1,200	
R/T Fairbanks-National Meeting			
Per diem - Meeting (5 days @$140/day)			
TOTAL TRAVEL			$6,576
SERVICES			
Communications (FAX, phone, photocopy, etc.)		$400	
Report Preparation (@$35/hour)		$2,100	
TOTAL SERVICES			$2,500
SUPPLIES			
Jars		$300	
Chemicals		$1,000	
Office		$100	
Miscellaneous lab glassware		$500	
Standards		$1,000	
Preservatives		$1,100	
TOTAL SUPPLIES			$4,000
EQUIPMENT			
None requested			
TOTAL EQUIPMENT			$0
TUITION			
2 Semesters		$5,060	
TOTAL TUITION			$5,060
TOTAL DIRECT COSTS			$116,903
INDIRECT COSTS			$23,381
TOTAL FUNDING REQUESTED			$140,284

Project 95113
SFOS 94-179

Budget
FY96

SALARIES AND BENEFITS			
Wages	***Mos.***		
Barber, W.	2.00	$14,585	
Smith, R.	2.00	$16,304	
Technician	6.00	$22,647	
Ph.D. Student	12.00	$18,197	
Leave Accrual			
Barber, W.		$2,932	
Smith, R.		$3,277	
Technician		$4,846	
Ph.D. Student		$0	
Benefits			
Barber, W.		$5,132	
Smith, R.		$5,737	
Technician		$11,190	
Ph.D. Student		$0	
TOTAL SALARIES AND WAGES			$104,847
TRAVEL			
4 R/T Fairbanks-Cordova (@$300/trip)		$1,200	
Per diem - Cordova (12 days @$103/day)		$1,236	
3 R/T Fairbanks-Anchorage (@$300/trip)		$900	
Per diem - Anchorage (12 days @170/day)		$2,040	
4 R/T Anchorage-Seward (@$300/trip)		$1,200	
R/T Fairbanks-National Meeting			
Per diem - Meeting (5 days @$140/day)			
TOTAL TRAVEL			$6,576
SERVICES			
Communications (FAX, phone, photocopy, etc.)		$400	
Report Preparation (@$35/hour)		$2,100	
TOTAL SERVICES			$2,500
SUPPLIES			
Jars		$300	
Chemicals		$1,000	
Office		$100	
Miscellaneous lab glassware		$500	
Standards		$1,000	
Preservatives		$1,100	
TOTAL SUPPLIES			$4,000
EQUIPMENT			
None requested			
TOTAL EQUIPMENT			$0
TUITION			
2 Semesters		$5,060	
TOTAL TUITION			$5,060
TOTAL DIRECT COSTS			$122,983
INDIRECT COSTS			$24,597
TOTAL FUNDING REQUESTED			$147,580

Project 95113
SFOS 94-179

Budget
FY97

SALARIES AND BENEFITS			
Wages	***Mos.***		
Barber, W.	2.00	$15,313	
Smith, R.	1.00	$8,559	
Technician	3.00	$11,890	
Ph.D. Student	12.00	$18,197	
Leave Accrual			
Barber, W.		$3,078	
Smith, R.		$1,720	
Technician		$2,544	
Ph.D. Student		$0	
Benefits			
Barber, W.		$5,389	
Smith, R.		$3,012	
Technician		$5,875	
Ph.D. Student		$0	
TOTAL SALARIES AND WAGES			$75,577
TRAVEL			
4 R/T Fairbanks-Cordova (@$300/trip)		$1,200	
Per diem - Cordova (12 days @$103/day)		$1,236	
3 R/T Fairbanks-Anchorage (@$300/trip)		$900	
Per diem - Anchorage (12 days @170/day)			
4 R/T Anchorage-Seward (@$300/trip)			
R/T Fairbanks-National Meeting		$1,300	
Per diem - Meeting (5 days @$140/day)		$700	
TOTAL TRAVEL			$5,336
SERVICES			
Communications (FAX, phone, photocopy, etc.)		$400	
Report Preparation (@$35/hour)		$2,800	
TOTAL SERVICES			$3,200
SUPPLIES			
Jars			
Chemicals		$200	
Office		$100	
Miscellaneous lab glassware		$500	
Standards		$600	
Preservatives			
TOTAL SUPPLIES			$1,400
EQUIPMENT			
None requested			
TOTAL EQUIPMENT			$0
TUITION			
2 Semesters		$5,060	
TOTAL TUITION			$5,060
TOTAL DIRECT COSTS			$90,573
INDIRECT COSTS			$18,115
TOTAL FUNDING REQUESTED			$108,688

Project 95114

A.

EXXON VALDEZ OIL SPILL
Brief Project Description

Project Title:	Eelgrass Community Structure Restoration Assessment Using Stable Isotope Tracers
Name of Principal Inveetigator:	Dr. Thomas C. Kline, Jr. Prince William Sound Science Center
Lead Agency:	Alaska Department of Fish and Game
Cost of Project :	$ 192.1K
Project Start-up Date:	March 1995
Duration of Project:	One year
Geographic Area:	Western Prince William Sound
Contact Person:	Joe Sullivan

Project 95114

B. Introduction.

Stable isotope ratios of carbon ($^{13}C/^{12}C$) can serve as effective tracers of energy supply in the study area due to conservative transfer of carbon isotope ratios between the lower tropic levels (primary producers such as eelgrass, invertebrates, and forage fishes, etc.) of Prince William Sound waters up to the top consumers. Isotope ratio analysis of harmed species, their prey and their predators can provide insight into both habitat usage and assist in quantifying amounts of food derived from various areas. Nitrogen stable isotope ratios ($^{15}N/^{14}N$), in turn, provide excellent definition of relative trophic level. The heavy isotope of nitrogen is enriched by about 0.34 % with each feeding process and thus can accurately indicate the relative trophic status of species within an ecosystem. The combined use of $^{15}N/^{14}N$ and $^{13}C/^{12}C$ measurements can be used to reconstruct food web structure. The data obtained from these measurements are unique in that they trace material actually assimilated and thus can be used for more accurate ecosystem modeling.

It can be postulated that natural stable isotope abundance of Prince William Sound (PWS) biota will shift because of changes in trophic level, food web structure, and primary producer in the context of species and community recovery following the Exxon Valdez Oil Spill (EVOS), thus providing an independent tool to verify, quantify and model ecosystem processes during ecosystem recovery and restoration. The tracer nature of the approach will enable the integration of ecosystem components. It will enable us to monitor both "top down" (predatory) and "bottom up" shifts (food supply) during recovery and restoration of harmed species and habitats.

This project is part of an interdisciplinary effort focused on the food web dynamics of eelgrass beds in PWS. The study is providing an integrating function to projects focusing on several levels in the food chains and will employ the stable isotope ratios of carbon and nitrogen to trace trophic transfers of carbon and nitrogen between levels. One focus will concern building the data base regarding eelgrass communities whereas the remaining work will seek to build a comprehensive base of isotopic data for the PWS region. In cases where regional gradients in isotope ratios exist, it may also be possible to identify critical habitats used by marine biota.

This project is designed to supplement the on-going EVOS eelgrass community monitoring project that is under the direction of Stephen C. Jewett (UAF), the FY95 BPD is already submitted. The stable isotope analysis in this project is anticipated to provide that project an added dimension for use in collaborative data interpretation.

C. Need for Project

The eelgrass community is a significant habitat for the production of terrestrial and aquatic species harmed by EVOS. In addition to the flora, harmed species include epi- and infauna of eelgrass beds as well as transient terrestrial and

Project 95114

aquatic organisms that use the habitat or feed there. The restoration strategy has been to allow the natural recruitment processes re-establish the eelgrass communities. However, the eelgrass and other intertidal to subtidal communities contain organisms that are recovering from EVOS as well as species that are not recovering. In a holistic sense, these communities are not at their pre-spill status. Thus, there is a need to assess the recovery of community structure within eelgrass communities. In particular, there is a need to compare epifauna (e.g. amphipods) in control and oiled areas because of their role as forage for higher trophic levels. The rebound and then return to damaged state by several community species, including amphipods, suggests that although populations may appear to temporally recover, the ecological balance in terms of interorganismic relationships has not. Thus techniques such as natural stable isotope abundance that reveal ecological relationships must supplement studies that focus on assessing population size and structure. This will enable an assessment of restoration not otherwise possible. This assessment could then lead to modifications or development of new restoration strategies based re-establishing normal ecological roles of different species.

A further benefit of this project is that it will provide the needed littoral isotopic signatures for use in conjunction with concurrent pelagic studies to assess the roles of different communities in the recovery of motile species, e.g herring and salmon. This project will also provide an isotopic signature database of forage biota for projects concerned with higher trophic levels (birds and mammals) enabling them to interpret their data.

D. Project Design

1. Objectives:

1.1 Hypotheses.

Hypothesis 1. Carbon and nitrogen stable isotope ratios of biota from Prince William Sound can be used to identify major food sources to top trophic levels and to assign trophic positions to specific consumers of given age classes and habitat.

Hypothesis 2. Isotope ratios in consumers provide a means to validate conceptual food web structures, identify trophic variability by individuals within species, and to validate quantified energy flows in ecosystem models.

1.2 Specific objectives of this project are:

1.2.1. To determine the $^{15}N/^{14}N$ and $^{13}C/^{12}C$ of species collected from oiled and unoiled sites in the stratified sampling design specified in the proposal "Subtidal Monitoring: Eelgrass Communities", Principal Investigator Stephen C. Jewett. These paired site comparisons will be used to assess recovery from the EVOS by comparing food web structure as determined by stable isotope abundance in conjunction with the approach specified in the Jewett proposal.

Project 95114

1.2.2. Synthesize the data obtained in context with conceptual food webs to validate feeding models and expand to other isotope studies being conducted in PWS by Kline and others.

2. Methods.

2.1 Design/Strategy.

Because this project will be done in collaboration with Jewett, sampling will follow his strategy. Briefly, sampling will be conducted at four oiled and four control eelgrass sites. This will enable comparison of site effects and oil effects on community structure. Obtaining isotopic signatures of biota from several littoral sites will also be useful in synthesis of this projects results with those of projects form the adjacent pelagic habitats (PWS system investigations)

2.2 Analytical methods.

The methodology involved in the isotopic analyses and the interpretation of the data are well-established and documented in several publications resulting from prior work of the Principal Investigator. The UAF Stable Isotope Facility has three isotope ratio mass spectrometers including a new automated system which facilitates faster sample processing and allows more replication in small samples.

Field sampling protocols are well established and will be used. Predator isotopic data will be compared with values obtained from prey species in the same habitats. Where samples of prey species are missing or few, we will try to select proxy samples from the same area (zooplankton, benthos) which will enable a similar comparison. After the isotopic values are in hand, we will synthesize the data with past unpublished data and with other literature isotope ratio values to establish a trophic model.

3.Schedules.

Field activities will take place during a two-week cruise in July 1995 as planned by Jewett. Preliminary sample preparation will take place during the cruise followed by laboratory preparation for mass spectrometry at the Prince William Sound Science Center. Mass spectrometric analysis will take place at the UAF stable isotope facility with completion anticipated in December, 1995. The completion of the draft final report is anticipated during February 1996.

4. Technical Support.
Technical Support is being provided for this project through the Jewett project.

Project 95114

Additional support will come from the University of Alaska Stable Isotope facility: N. Haubenstock will receive prepared samples from Dr. Kline and will report the data to Dr. Kline.

5. Location.

A total of 4 oiled (O) and 4 control (C) sites will be sampled per the Jewett proposal. The paired sites are as follows: Bay of Isles (O) / Drier Bay (C); Herring Bay (O) / Lower Herring Bay (C); Sleepy Bay (O)/ Moose Lips Bay (C); and Clammy bay (O)/ Puffin Bay (C). Analytical work will be carried out using the stable isotope facility at UAF. Sample preparation for stable isotope analysis and data interpretation will take place at the Prince William Sound Science Center.

E. Project Implementation

This project is derived from the Jewett project that has been implemented by ADF&G for the past three years.

F. Coordination of Integrated Research Effort

This project will coordinate via Jewett with the monitoring of oil in subtidal (<20 m) sediments (conducted by NOAA). These projects have several sites in common. This project will also coordinate with other stable isotope projects in the EVOS studies.

G. Public Processes

Results of thie project will be made available to the public via:

1. Final report. A final report will be provided. Technical results in these reports will be shared with EVOS collaborators. Thus they will be apprised of the development of the stable isotope methodology and will provide feedback to the investigators such that areas of their interest will be addressed.

2. Peer-reviewed publications. Peer-reviewed publications will be generated throughout the course of this project. Papers describing isotopic ecology at the species or site level will be generated depending on the outcome of results. Synthesis papers will combine results from species and site level papers and work of other authors. Later papers will bring together results from collaborators.

3. Papers at scientific society meetings. Support is requested for T. Kline to attend at a minimum, one national-level scientific meeting per year, e.g. ASLO to present an above paper and to discuss results with colleagues at other institutions.

4. Public lectures. Through our interactions with our colleagues and other organizations, we conduct lectures to inform the general public on the research being conducted as it affects them. An example was a lecture given by T. Kline at the community college in Barrow on his stable isotope research. These outreach efforts in addition to proving public service, greatly aid in public relations of funding agencies. In this spirit, public lectures will be given as opportunities to do so present themselves.

H. Personnel Qualifications

Dr. Thomas C. Kline, Jr, Principal Investigator and Research Scientist at the Prince William Sound Science Center will be responsible for the implementation of this stable isotope study which will be conducted in close collaboration with the eelgrass project being supervised by Stephen C. Jewett of the University of Alaska Fairbanks. We will be collaborating during data synthesis and interpretation and the writing of reports and scientific papers. We have in the past collaborated on subtidal projects including the development of techniques related to assessment of the EVOS. Dr. Kline's expertise lies in the use of natural stable isotope abundance in aquatic ecological settings. He has been or is involved in stable isotope aquatic ecology studies in southeastern Alaska, Prince William Sound, the Kenai Peninsula, Kodiak Island, Bristol Bay, and the Arctic Coastal Plain. New approaches in the use of $^{15}N/^{14}N$ and $^{13}C/^{12}C$ abundance in fisheries ecology settings have been a product of his research studies. Dr. Kline is also an active scientific diver in the University of Alaska Scientific Diving Program.

I. Budget Summary

	FY95	FY96	Project Total
1. Personnel	34.4	34.0	68.4
2. Travel	1.8	7.1	8.9
3. Contractual Services	33.0	1.5	34.5
4. Commodities	6.0	2.0	8.0
5. Equipment	35.1	0.0	35.1
6. Capital Outlay	0	0	0
7. General Administration	26.5	10.7	37.6
	136.8	55.3	192.1

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Project 95115

EXXON VALDEZ TRUSTEE COUNCIL
FY '95 GENERAL RESTORATION DESCRIPTION

A. TITLE PAGE

Project Title: Prince William Sound Restoration Strategy: Sound Waste Management Plan (SWMP)

Project Leader: Kelley Weaverling, Chair, PWSEDC Solid Waste Management Committee

Lead Agency: Alaska Department of Environmental Conservation

Cooperating agencies:
Prince William Sound Economic Development Council
City of Cordova
City of Valdez
City of Whittier
Alaska Department of Environmental Conservation
Alyeska Pipeline Service Company
Valdez Fisheries Development Association (VFDA)
Prince William Sound Aquaculture Corporation (PWSAC)
Prince William Sound Conservation Alliance (PWSCA)

Cost of Project: FY '95 - $275,900

Project Start-up / Completion Dates: FY '95 - November 1, 1994 - August 1, 1996

Duration: 1 - 2 years, starting with FY '95

Geographic Area: Prince William Sound

Contact Person:

Kelley Weaverling
Vice President
PWSEDC
Valdez, AK 99686
Tel: (907) 424-7261
Fax: (907) 424-7259

-or-

Paul A. Roetman
Executive Director
PWSEDC
Valdez, AK 99686
Tel: (907) 835-3775
Fax: (907) 835-5770

Project 95115

Prince William Sound Restoration Description:
Sound Waste Management Plan (SWMP)

B. INTRODUCTION

The Sound Waste Management Plan (SWMP) is a comprehensive plan to identify and remove existing oily and other solid waste from the waste stream, of the oil-impacted communities of Prince William Sound. The plan will improve upon current waste management and join past efforts into a unified regional effort. The SWMP, will put into action an oily and solid waste management system that will operate in all Prince William Sound communities to eliminate the potential for further encroachment or damage to the local ecology.

Problem:

Currently each community in Prince William Sound is out of compliance with federal regulations as it relates to permitting of waste sights. There are no regional goals for managing, reducing and handling of oily and solid waste. Because there is no plan, Prince William Sound is at a potential risk to further environmental harm. Prince William Sound Economic Development Council's regional Solid Waste Management Committee was formed, therefore as a task force of the area's largest contributors of waste. This included both cities, villages, industry, and hatchery representatives. They identified the following regional problems:

1. Costs to manage and handle oily and solid waste continue to rise and tap declining revenue resources.
2. Existing landfills have limited life spans.
3. There is no long term solution in sight.

Solution:

A three phase approach is needed to: 1. identify 2. reduce the cost of handling oily and solid waste, and 3. implement an oily and solid waste management plan.

Phase I will identify the options and most cost-effective means for handling and managing oily and solid waste in Prince William Sound. The PWSEDC regional committee will contract a firm to accomplish this phase;
Phase II will handle all required ADEC/EPA permitting to implement a regional management project, and
Phase III is the implementation of the SWMP that includes construction of the identified, chosen project i.e. regional landfill, regional incineration, etc.

*** It is important to note that as a regional project, local input and coordination is crucial to the long-term success of the SWAMP project by creating local ownership. This proposal was developed and intended to be coordinated by PWSEDC's Solid Waste Management Committee in cooperation with ADEC.**

The EVOS Trustee Council has funded a similar project, number 94417 entitled "waste oil disposal facilities." The SWMP broadens that project approach and greatly increases the effectiveness of enhancement and restoration efforts due to its regional coverage, local expertise and long term monitoring.

Funding for SWMP will allow an effective and necessary approach to enhancement, clean-up and collection of valuable data as it relates to oily and solid waste management in Prince William Sound in 1995. The SWMP will restore, enhance and promote long-term preservation of Prince William Sound from the effects of oily and solid waste. This document describes the plan of work to be undertaken during FY '95

C. NEED FOR THE PROJECT

To further enhance, improve the rate of natural recovery of, and reduce future events of marine pollution in Prince William Sound, the SWMP, is crucial. To ensure the protection and preservation of the Prince William Sound oil-impacted region, implementation of this plan is needed. Under EVOS Designated Wilderness Area objectives, "any restoration objective which aids recovery of injured resources, or prevents further injuries, will assist recovery of these areas." This is the SWMP focus.

The current primary waste stream for oily waste are local harbors. From boats, both domestic waste water (sewage) and oily waste are discharged directly into Prince William Sound. The secondary stream is smaller in direct amounts, but no less damaging to the oil-impacted environment. This includes leechates from community landfills that contribute to the total impact of waste to the local ecology. To add to this, all area landfills in Prince William Sound including both cities and villages are out of compliance with federal regulations. **The SWMP is the only regional effort identified to date that could provide a solution to oily and solid waste management in Prince William Sound.**

D. PROJECT DESIGN

1. Objectives:

The development of the Sound Waste Management Plan (SWMP) originated with Prince William Sound Economic Development Council's regional Solid Waste Management Committee. The primary objectives include the development and implementation of a regional strategy to limit the exposure of hazardous waste material in oil-impacted communities in Prince William Sound. The SWMP will provide a design and recommend an oily and solid waste collection and disposal alternative and provide a plan for future management of oily and solid waste in Prince William Sound. The following outlines the objectives to be accomplished in FY '95:

a) Gather background information on the composition and rate of oily and solid waste generation in Prince William Sound

b) Analyze waste management processing and disposal alternatives and select the most appropriate solution for Prince William Sound

c) Address regulatory requirements

d) Establish public participation program to understand and address community concerns and needs

Project 95115

e) Analyze oily and solid waste reduction and recycling options

f) Evaluate sites for a new regional landfill

g) Develop cost estimates for oily and solid waste management alternatives

h) Recommend financial planning to fund oily and solid waste services

2. Methods:
The SWMP will include a scoping of the current Prince William Sound situation by qualified firm. This scoping will determine both the options and costs related to each in implementing a regional oily and solid waste management system.

3. Schedule:
(FY 95 - Plan of Work)
Phase I

Nov 1	Distribute Request for Proposals (RFP's) for regional oily and solid waste management plan.
Dec 1	Coordinating meeting (Review of submitted proposals)
Jan 1995	Select consulting firm and draft contract
Feb 1	Coordinating meeting (contractor and committee)
Mar 1	Review of scoping firm's draft plan findings with PWSEDC Solid Waste Committee comments.
Apr 1	Public Review of findings (held in each PWS community)
Apr 2	Determination of most efficient and cost effective regional oily and solid waste system.

Phase II

Apr 1	Start process for implementation of regional oily and solid waste system.
Apr 15	Scope ADEC/EPA permitting for project implementation
Jun 1	Committee review and evaluation of FY 95 Work Plan.
July 15	Meeting to review draft ADEC/EPA permits
Aug 15	Submit ADEC/EPA permit
Oct 1	Meeting with ADEC/EPA about questions on permit
Nov 1	Submit revised permit

Project 95115

Jan 1996 Coordinating meeting

Phase III

May 1 Initiate construction of permitted facility

Aug 1 Facility complete and operational

4. Technical Support:
Prince William Sound Economic Development Council's Solid Waste Management Committee will play both an evaluative and advisory role to the scoping firm.

5. Location: Prince William Sound

E. PROJECT IMPLEMENTATION
To maintain the direct link from development and implementation of the SWMP, Prince William Sound Economic Development Council's regional Solid Waste Management Committee is the only appropriate entity to implement this regional project. Alaska Department of Environmental Conservation will additionally play an advisory, and coordinating role with the Committee's efforts.

F. COORDINATION OF INTEGRATED RESEARCH
The SWMP program is a coordinated effort of the Prince William Sound Economic Development Council in cooperation with: Department of Environmental Conservation, Alyeska Pipeline Service Company, Chugachmiut, Valdez Fisheries Development Association, Prince William Sound Aquaculture Corporation, Prince William Sound Conservation Alliance, the City of Valdez, the City of Whittier, the City of Cordova, and the Villages of Tatitlek and Chenega.

G. PUBLIC PROCESS
Public involvement has been of the highest priority to all PWSEDC Solid Waste Management Committee meetings. In order to provide a representative cross-section of all Prince William Sound, each community is represented, including both fishing and petroleum industry representatives. The process will continue with public review at local city council and tribal council meetings for comment of the SWMP. An integral part of the SWMP is community education on oily and solid waste issues.

H. PERSONNEL QUALIFICATIONS
Each member of PWSEDC's Solid Waste Management Committee through both experience and knowledge contributes to the overall effectiveness of the SWMP (see committee list appendix A). The expertise of the scoping firm will be procured through the bid process, requiring an evaluative application process.

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I. BUDGET (FY '95)

1. Personnel	
Phase I & II	
PWSEDC will staff and coordinate project efforts	$ -0-
Phase III	
To be determined	
2. Travel	
Phase I & II	
10 trips for Solid Waste Committee Members	
14 members @ $200 for airfare	$ 28,000
Room & Board @ $120/day	$ 16,800
2 air trips to Anchorage for 5 principal investigators	$ 2,000
7 days time for 5 principal investigators @ 150/day	$ 5,250
Phase III	
To be determined	
3. Contractual Services	
Phase I	
Engineering Consulting Fees	$ 100,000
Accounting Services - project audit	$ 3,500
Teleconferencing fees 10 @ 150	$ 1,500
Copy costs- quarterly reporting @ 200	$ 800
Phase II	
Permitting for project implementation	$ 100,000
Phase III	
To be determined	
4. Commodities	
N/A	
5. Equipment	
N/A	
6. Capital outlay	
N/A	
7. General administration (including environmental compliance)	
Phase I & II	
7% Administrative Support and Coordination	$ 18,050
Phase III	
To be determined	
Total Phase I & II	**$ 275,900**

Project 95115

Prince William Sound Economic Development Council

P.O. Box 2353 • Valdez, Alaska 99686
Phone: 835-3775 • Fax: 835-5770
Representing the communities of Chenega Bay, Cordova, Tatitlek, Valdez and Whittier.

Solid Waste Management Committee

Jack Lamb, Committee Chair
Board of Directors, PWSEDC
Cordova
P: 424-7442 F: 424-6000

Kelley Weaverling
Board of Directors, PWSEDC
Cordova
P: 424-5305 F: 424-3430
H: 424-5565

Paul Jackson
Chugachmiut Corp.
Chenega Bay
P: 562-4155 F: 563-2891

Jeff Courier
Director, Public Works
City of Cordova
P: 424-6200 F: 424-6000

Gary Kompkoff
Board of Directors, PWSEDC
President, IRA Council
Tatitlek
P: 325-2311 F: 325-2298

Scott Walther
Board of Directors, PWSEDC
Vice Mayor
City of Whittier
P: 472-2311 F: 472-2399

Gary Williams
City Manager
City of Whittier
P: 472-2327 F: 472-2404

Dan Lawn, ex-officio
Environmental Engineer,
AK Dept. Environmental Conservation
Valdez
P: 835-4698 F: 835-2429
Cordova
P: 424-4385 F: 424-4386

Bill Wilcox
City Engineer
City of Valdez
P: 835-4313 F: 835-3420

Lee Schlitz
Director, Public Works
City of Valdez
P: 835-4473 F: 835-4900

Marnie Graham
PWS Conservation Alliance
Valdez
P: 835-2799 F: 835-5395

Dave Cobb
Board of Directors, PWSEDC
Valdez Fisheries Development Assoc.
P: 835-4874 F: 835-5951

Tony Zamora
Senior Environmental Specialist
Alyeska Pipleline Service Company
Environment/Operations Department
P: 835-6477 F: 835-6420

Rob Terrell
Maintenance Manager
Prince William Sound Aquaculture
P: 424-7511 F: 424-7514

Appendix A

Project 95116

RESTORATION OF INTERTIDAL OILED MUSSEL BEDS BY NON-DESTRUCTIVE MANIPULATION/FLUSHING WITH PES-51®.

Project Team

PES Services, Inc. Chenega Corporation, University of Alaska Fairbanks, University of California - Santa Cruz, Foss Environmental Services, Inc.

Submitted by

Stephen R. Rog and Dennis C. Owens
PES Services, Inc.
Anchorage, AK and San Antonio, TX

June 30, 1994

Project 95116

A. COVER PAGE

1. Project Title: Restoration of Intertidal Oiled Mussel Beds by Non-Destructive Manipulation/Flushing with PES-51®.

2. Project Leader: Mr. Stephen R. Rog

3. Lead Organization:
PES Services AK, Inc.
552 W. 58th, Unit E
Anchorage, AK 99518
Phone: (907) 562-8881
Fax: (907) 562-8883

4. Cost of Project: Cost Estimate - $453,186 for FY95

5. Project Startup/Completion Dates:
Startup: July, 1995
Completion: July, 1996

6. Project Duration: One (1) Year

7. Geographic Area: Chenega Island area

8. Contact Person:
Dennis C. Owens
PES Services, Inc.
P.O. Box 680488
San Antonio, TX 78268-0488
Phone: (210) 680-2950
Fax: (210) 523-5700

B. INTRODUCTION

This project will focus on restoration of the mussel beds in the Chenega area, and as a result contribute to the recovery of injured resources that use these mussels as a food source, e.g. harlequin ducks, sea otters and black oystercatchers. In addition, these mussels are an integral component of the subsistence of humans residing in the Prince William Sound area. These mussel beds were impacted by the 1989 Exxon Valdez oil spill. The Chenega area remains as one of the sites of the most persistent heavy and medium oil residue concentrations (1993 Shoreline Assessment sponsored by the Exxon Valdez Trustee Council). A team of companies and universities to be led by PES Services proposes to work with the Trustees Council and the Alaskan Department of Environmental Conservation (ADEC) on this project. The project will be conducted to demonstrate the efficacy of a non-destructive manipulation/flushing method using PES-51® to remove the oil found in mussel beds and to demonstrate that this method is not toxic to the mussels or other resident fauna. This project builds on the successful demonstration of PES-51® for the removal of persistent oil from a rocky shoreline in Prince William Sound as was funded by the Hazardous Substance Spill Technology Review Council (HSSTRC) in 1993. The shoreline project also demonstrated that there were no observable acute toxic effects from PES-51® on the mussels and other invertebrate fauna observed near the treatment site. It is reasonable to propose, therefore, that PES-51® application to oiled mussel beds will be effective while not being toxic to the mussels and other resident fauna.

Dense clusters of the blue mussel, *Mytilus edulis*, occur on rocky shores throughout the region impacted by the Exxon Valdez oil spill that began in March of 1989. Mussels secrete byssal threads which enable them to attach to the substrate. In addition to providing stability, the matrix of threads extending from a bed of mussels, forms an environment that offers shelter for a diverse mix of marine invertebrates. These other fauna find shelter from wind, waves and sunlight within the mussel threads.

It is documented that liquid oil persists in the sediments and organic materials that compose the mussel beds in the Chenega area (Piper,E. and Gibeaut,J.,1993). These oiled mussel beds offer the opportunity to evaluate the efficacy of new shoreline treatment technology, like PES-51®, to restore these beds and to establish baseline information for future oil spills. Currently, there is no established best method for removal of the oil from within oiled mussel beds. It is, therefore, important to take this opportunity to develop a method of effectively and efficiently removing the oil while not damaging the mussel bed.

C. NEED FOR THE PROJECT

This project is being undertaken to demonstrate the efficacy of a non-destructive/flushing methodology utilizing PES-51® to remove oil persisting in mussel beds in the Chenega Island area. The impact of these oiled mussel beds is evident from information provided in the "Invitation to Submit Restoration Projects for Fiscal Year 1995" in response to which this proposal is submitted:

> "Oil trapped in the sediments beneath certain mussel beds has degraded slowly and has retained toxic components since the spill. The protected beds are one of the few sources of unweathered oil remaining from the oil spill. This oil may be a route for continued exposure and contamination to higher trophic levels such as harlequin ducks that feed on the mussels."

This project will demonstrate that this new shoreline cleaning technology is a minimally intrusive manipulative technique that will remove oil from beneath oiled mussel beds and accelerate natural attenuation processes without harming the mussels and other resident fauna. Restoration of the mussel beds to their pristine condition will enable ADEC to determine whether removal of the persistent oil in the mussel beds is a critical factor in speeding up the recovery of harlequin ducks sea otters and black oystercatchers.

Project 95116

D. PROJECT DESIGN

1. **Objective**: To evaluate the effectiveness of a new shoreline cleaning technology, using PES-51®, to remove oil from an impacted mussel bed and to demonstrate the potential impact of this removal methodology on the mussels and the fauna residing in the nearshore/shoreline.

2. **Methods**: The overall design and performance of the project is shown in Table 1. The project site design will depend in part on the size of oiled mussel beds available for the project. The candidate mussel bed will be selected by the Trustees Council in conjunction with regulatory and recovery agencies, e.g. ADEC, NOAA, etc. If the area is relatively limited, the design will include two mussel bed areas; one oiled bed and another nearby that has no evidence of retained oil (control area). Each of these beds will be divided into three plots; one to be treated with the PES-51® methodology, one that will be treated, but without PES-51®, while the third is left untreated. These six plots will enable us to evaluate the efficacy of the PES-51® on oiled mussel beds as well as the potential for toxicity on mussels and other resident fauna in oiled and non-oiled beds. Measures will be undertaken to minimize the possibility of PES-51® migrating from treated plots to untreated ones. The second approach to be used, if the beds are large enough, will have a randomized block design and include test and control blocks. Choice between these two designs will be made during an initial visit by representatives of the project team and the Trustees Council. With either design, mussel bed, water column and lower and middle tidal zone sediment samples will be obtained for analyses prior to and after treatment with the PES-51® methodology.

Post treatment samples will be obtained at least at one and seven days with other sample times to be determined by the UAF and UCSC associate investigators. One day samples will be analyzed for the potential toxicity on mussels and other resident fauna, whereas the seven day sample will also be analyzed for impact on microbial populations. Subsequent samples are likely to be proposed for the last possible date that access is permitted to the site due to winter weather and then the following spring.

Mussel bed samples will be obtained from the proposed oiled and control areas using the NRDA methods and prepared for hydrocarbon and biological analyses. Hydrocarbon analyses will be conducted on these samples by the Zymax Envirotechnology, Inc. of San Luis Obispo, CA using gas chromatography/mass spectrometry techniques (EPA 8240/8270) to establish baseline levels present in these beds. Biological analyses of the mussels will be conducted by Dr. Highsmith at the UAF and will establish the pretreatment characteristics of the mussel beds in the oiled and control areas. Note that the project design also includes administration of PES-51® to control areas. This is necessary to fully analyze the potential impact of this methodology on mussel beds because: a) mussels and other resident fauna exposed to chronic oiling for four years may be highly susceptible to injury by the treatment, b) conversely, those organisms remaining may be extraordinarily hardy or resistant, and c) the other faunas may be different (samples collected during the initial visit may answer this question prior to the experiment). Additionally, biological analyses will include determination of potential toxicity of the PES-51® treatment on other aquatic life, i.e. the other resident fauna. This phase of the project will be conducted by Dr. Tjeerdema at UCSC. Potential impact of PES-51® treatment on total heterotrophs and hydrocarbon degrading microbes in the lower and middle intertidal zones will be determined by Dr. Braddock at UAF from water column and sediment samples.

3. **Schedule**: Timelines for all critical aspects of the project are also shown Table 1 with all times represented as month and year when the activity will be accomplished.

Project 95116

Table 1: Restoration of Intertidal Oiled Mussel Beds - Project Methodology and Timelines

Activities	PES	UAF	Chenega Corp	UCSC	Foss	Time (mo/yr)
Project Lead	X					
Initial Visit - Project Site Design and Baseline Mussel Bed, Water Column and Sediment Samples	X	X	X		X	6/95
Project Site Preparation	X		X		X	7-8/95
Logistics and Support			X			
PES-51® Application	X		X			9/95
Obtain Post Treatment Mussel, Water and Sediment Samples	X	X				9-10/95, 9/96
Hydrocarbon Analyses	X					7-10/95, 9/96
Analyses of Mussel Bed Samples for Potential Toxicity of Mussels		X				7-10/95, 9/96
Analyses of Mussel Bed Samples for Potential Toxicity of Other Resident Fauna		X		X		7-10/95, 9/96
Microbial Analyses of Water Columns, and Lower and Middle Tidal Zone Sediment Samples		X				7-10/95, 9/96
Hydrocarbon Waste Collection and Disposal	X				X	10/96
Interim and Final Reports	X					11/95, 10/96

4. **Technical Support:** The selected mussel beds will be double boomed and contained prior to the PES-51® treatment. Sea water deluge and flush pumps, air compressors, recovered oil storage tank and equipment and supplies will be staged on a sixty (60) foot landing craft, moored adjacent to or "beached" at the treatment site. Crew support will be provided using a berthing vessel. Foss Environmental Services, Inc. will provide qualified spill response equipment and services including booms, pumps, etc.

Methodology to be employed in this project involves application of PES-51® using a modified version of the air knife, pneumo-hydrodynamic system used at Sleepy Bay in 1993 that was sponsored by HSSTRC. For mussel bed application, the air knives will be regulated for a low pressure fracturing (or dilation) so that PES-51®, via an aerosol infusion, can reduce the interfacial tensions and move through the vertical sections of the oiled mussel beds. During the PES-51® infusion, sea water will follow the route of the PES-51® induced subsurface pathway. In addition, sea water deluge and flushing (low pressure, large quantities) using 6 inch pumps and fire monitors, will be used to move the oil to the double boomed area for collection and recovery. Oil recovered during the project will be contained and collected for disposal in accordance with standard spill techniques, e.g. containment booms, skimmers and absorbents. This oil will be pumped

to the storage tank, excess water will be decanted and the volume of oil recorded. At the completion of the project, the recovered oil will be disposed of or recycled at a permitted facility, e.g. Alaska Pollution Control, Inc., in accordance with state and federal laws and guidelines. Application of PES-51®, operation of the flushing equipment, and recovery of the oil will be handled by Chenega Corporation.

Samples obtained from the mussel beds, water column and lower and middle tidal zone sediments will undergo biological and chemical analyses as described in Section D.2. The work will be performed by Zymax Envirotechnology, Inc. (hydrocarbon analyses), UAF (potential toxicity on mussels and impact on the microbial populations) and UCSC (potential toxicity on other resident fauna). Results of the analytical activities will be provided to PES for evaluation, coordination and archiving. Each associate investigator will generate interim and final reports that will be integrated into the overall project reports that will be developed by PES.

5. **Location:** As was stated earlier, the Chenega areas is known to have some of the most persistent, heavy- and medium oil residue concentrations. For this reason the Chenega area is proposed as the site for this project. Additionally, involvement of the Chenega Corporation throughout the project is likely to serve a secondary purpose, i.e. involving local residents in critical resource restoration activities (1993 Trustee Council sponsored Assessment Survey). ADEC and the National Oceanographic and Atmospheric Administration have surveyed and sampled mussels and sediments from these oiled sites. One of the locations monitored during this survey is proposed for the proposed project.

E. PROJECT IMPLEMENTATION

PES Services is proposed as the lead organization for this project. PES Services, Inc. is well qualified to lead a multidisciplinary team of companies and universities having led the effort that was sponsored by HSSTRC at Sleepy Bay in 1993. The only portion of the project that could be implemented through a competitive contract process is the logistics support of the environmental contractor services. Foss Environmental Services, Inc. is listed as the contractor of choice due to their expertise in oil spills and the use of PES-51® under these conditions. The UAF and UCSC have both established marine science programs dealing with highly specialized testing for marine toxicology of selected species found in the Prince William Sound area. Chenega Corporation is well qualified and experienced in conducting projects as the one described in this proposal having performed similar duties during the 1993 HSSTRC sponsored project. Zymax Envirotechnology, Inc. is recognized for its capabilities in the types of chemical analyses and conducted analyses for PES on previous projects.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project involves collaborative partnerships among three companies and two universities and will involve oversight by a number of state and federal agencies, e.g. ADEC and NOAA, as well as community advisory groups. Depending on the outcome of the competition for funding from the Trustee Council, collaborative efforts may be undertaken with other groups having projects with related objectives and activities.

G. PUBLIC PROCESS

PES Services will make every possible effort to participate in workshops, public meetings, document reviews, etc. that are needed to insure understanding of the objectives and results of the proposed project so as to fulfill the requirements of the Trustee Council. PES Services has taken an aggressive approach to publishing its research and has presented results of the 1993 HSSTRC sponsored project at several national and international oil spill conferences. National Geographic will carry an article about this project in the August, 1994 issue.

H. PERSONNEL QUALIFICATIONS

1. Mr. Steve R. Rog, VP of Oil Spill Response and Industrial Cleaning for PES Services AK, Inc., will be the Project Leader. Mr. Rog has twenty years experience as an environmental geologist, served on an Oil Spill Response Team as the Environmental Coordinator for Tesoro Alaska Petroleum Company; has an extensive working knowledge of the proposed application technology; has been at every major oil spill in 1994 representing PES Services; and also was the manager for the 1993 HSSTRC sponsored project.

2. Dr. Raymond Highsmith is to be an Associate Investigator on this project. He is a Professor at UAF and a lead investigator in the Institute Of Marine Science. He is recognized as a worldwide expert on bivalves found in Alaskan waters.

3. Dr. Ron Tjeerdema is to be an Associate Investigator on this project. He is an Associate Professor at UCSC and a researcher in the Institute of Marine Science and recognized as a worldwide expert on aquatic toxicity testing procedures and protocols. His research team has developed dispersant toxicity testing protocols that have been adopted as industry standards.

4. Dr. Joan Braddock is to be an Associate Investigator on this project. She is a Assistant Professor of Microbiology and is associated with the Institute for Arctic Biology at UAF and has extensive experience in studies of the impact of hydrocarbons on shoreline microbiology and was a participant in the 1993 HSSTRC sponsored project.

5. Mr. Dennis Owens, VP for R&D of PES Services, will be the Project Coordinator responsible for all contract matters relating to the sponsor and subcontracts to the team members. He has twenty years experience as a corrosion oilfield chemist and microbiologist and is one of the developers of PES-51®. Most recently, he was the technical project coordinator for the 1993 HSSTRC sponsored project.

6. Dr. William Alter III, Director of Research and Technology Development for PES Services, will be responsible for coordinating the analyses of data and for integrating the team's reports into those that will be delivered to the Trustees Council. He is an Environmental Physiologist with over 25 years experience in research and development for the Air Force and academia and most recently was a Space Grant Fellow for the National Aeronautics and Space Administration.

7. Gail Evanoff and Chuck Totemoff of the Chenega Corporation and will be responsible for organizing the work crews that will participate in this project. The Chenega Corporation participated in the 1993 HSSTRC sponsored project at Sleepy Bay.

I. BUDGET

The budget was developed on the basis of an initial visit to the Chenega area for selection of the field site, project site design and acquisition of baseline samples, and a proposed 10 day field effort that includes travel to/from project site and one weather day. The costs for efforts in the field by PES and its team members are estimates which are subject to revision after finalizing the field aspects in discussions with the Trustees Council, regulatory and recovery agencies. A more detailed description of the budget appears as an appendix.

1.	Personnel - PES Services, Inc. (only)	48,900
2.	Travel	6,300
3.	Contractual Services	
	a. UAF - Environmental Technology Laboratory	66,297

	b. UCSC	95,940
	c. Chenega Corporation	31,800
	d. Foss Environmental Services	21,000
	e. Zymax Envirotechnology, Inc.	8,000
	f. Alaska Pollution Control, Inc.	2,000
	g. Videography services	7,500
4.	Commodities	0
5.	Equipment	122,750
6.	Capital Outlay	0
7.	General Administration	1,500
8.	Subtotal Direct	411,987
9.	Indirect (10% MTD)	41,199
10.	Total Estimated Cost	453,186

Project 95116

APPENDIX: Detailed Description of Budget

1. Personnel

Stephen Rog - Project Management (100 hrs@95/hr)	9,500
and Field Supervision (120hrs@65/hr)	7,800
Dennis Owens - Project Technical Coordination (50 hrs@95/hr)	4,750
William Alter III - Data Analysis and Reports Integration (50hrs@95/hr)	4,750
PES Services AK - Field Crew (3) 10 days (12hr/day)@65/hr	15,600
(2) 5 days (10hr/day)@65/hr	6,500

2. Travel

PES Services, Inc.

Dennis Owens, William Alter - 2 trips to Alaska for Exxon Trustees Meetings	
Air Fare To/From Texas and Room/Board	3,800
PES Services AK Travel to/from Project Site	
Initial Visit - Float Plane	1,000
Field Demonstration - Float Plane	1,000
Bus Charter Anchorage to Whittier	500

3. Contractual Services

A. UAF-ETL

Personnel: Dr. Raymond Highsmith, lab. tech. & graduate student	20,787
Travel: Airfare and Room & Board for 2 Trustees Council Mtgs.	1,100
Initial Visit, Field Demonstration and Followup Sampel Acq.	2,070
Commodities	2,000
Equipment	0
General Administration/Indirect	10,790
Personnel: Dr. Joan Braddock and graduate student	19,550
Travel: Airfare and Room & Board	1,000
Commodities	8,000
Equipment	0
General Administration	1,000
Subtotal for UAF-ETL	66,297

B. UCSC

Personnel: Dr. Tjeerdema and Scientific Staff	50,000
Travel	5,000
Commodities	10,000
Equipment	0
General Administration/Indirect	30,940
Subtotal for UCSC	95,940

C. Chenega Corporation 31,800

D. Foss Environmental Services, Inc. 21,000

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E.	Zymax Envirotechnology Inc. Hydrocarbon analysis (EPA 8240/8270)	8,000
F.	Alaska Pollution Control, Inc. Oil Recycle or Disposal Est. 1,000 gal.@2/gal	2,000
G.	Videography service Est. 10 days@750/day	7,500
	Subtotal Contracts	166,240
4.	Commodities	0
5.	Equipment	
	Work Barge (or 2 Berthing Vessels and Landing Craft) 10 days@7,500/day	75,000
	Skimmer 10 days@1,000/day	10,000
	Fuel	2,000
	2 Air Knife Systems 10 days@ 500/day	10,000
	PES-51® 3 drums@1,250/each	3,750
	1 Skiff and outboard 10 days@200/day *	2,000
	1 - 5,000 gallon oil storage tank 10 days@150/day *	1,500
	2 - 6" pumps 2 weeks@600/week *	1,200
	For Hose for pumps *	500
	1 - 250 cfm air compressors 2 weeks@600/week *	1,200
	Air Hose for compressor *	500
	Personal Protective Equipment 12 men/10 days@ 30/day	3,600
	Pads, Sorbents, Sweekps, Booms, etc.	3,000
	Containment Boom 500LF@12/LF	6,000
	Miscellaneous Supplies and Freight	2,500
	Subtotal Equipment	122,750
6.	Capital Outlay	0
7.	General Administration	
	a. Reports	1,000
	b. Miscellaneous Communications	500
8.	Subtotal Direct	411,987
9.	Indirect (10% MTD)	41,199
10.	Total Estimated Cost	453,186

* These items may be provided on-board the Work Barge and be part of the overall rate for the barge. This would reduce the proposed equipment cost by $6,900.

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PES-51® Shoreline Restoration of Weathered Subsurface Oil in Prince William Sound, Alaska

By

Steve Rog (1), Dennis Owens (2), Leslie Pearson (3), Mark Tumeo (4),Joan Braddock (4), Tamara Venator (4)

1-Tesoro Alaska Petroleum Co., 2-Petroleum Environmental Services, Inc., 3- Alaska Department of Environmental Conservation, 4-University of Alaska Fairbanks

ABSTRACT

On July 1-7, 1993, a shoreline restoration project was conducted by Tesoro Alaska Petroleum Company and Tesoro Environmental Products Company using PES-51®, a biosurfactant, and a modified air knife injection system on a 120 ft. x 135 ft. area of Sleepy Bay on LaTouche Island in Prince William Sound (Figure 1).

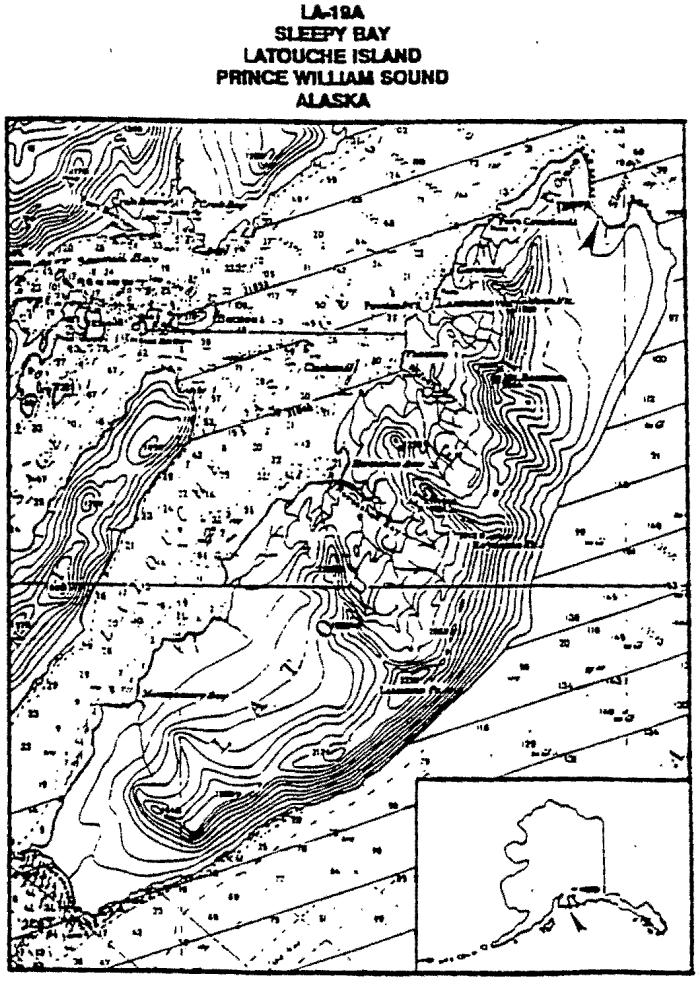

Figure 1

PES-51® contains naturally occurring components and is biodegradable. The product is listed on the National Contingency Plan Product Schedule List as a miscellaneous oil spill agent. The objectives for the project were: to test the effectiveness of PES-51® in removing petroleum contamination from the substrate in the intertidal zone; examine the levels of hydrocarbon in the water resulting from the application; examine the microbial response to the PES-51® treatment; and, nutrient analysis. During the project, the test beach was further subdivided into treatment sections approximately 120 ft long and 20 ft. wide from the upper to lower intertidal zones. Sediment, pore water and oil/water samples were collected by the University of Alaska-Fairbanks (UAF) Environmental Technology Laboratory from the treatment beach and adjacent control beach for geochemical analysis.

Materials

PES-51® is listed as a miscellaneous oil spill agent on the EPA's National Contingency Plan product schedule. PES-51® is a biological hydrocarbon cleanser designed to be used in removing oil from impacted rocks, beaches, concrete, bulkheads, pilings, tanks, oil spill response equipment, and other solid surfaces. PES-51® is composed of biosurfactant, d-limonene, and biospersan. The d-limonene fraction, a citrus derivative, provides solvent characteristics to the mixture and allows it to penetrate into porous surfaces and extract hydrocarbons. It also acts as a suitable carrier solution and re-odorant for the bacterial by-products.

Once the product is applied by spraying, it forms a product/oil mixture. The product is designed to decrease the surface tension between oil/sediment mixtures, allowing the oil to float to the surface after the introduction of water. Because the oil/product mixture does not change the surface chemistry of the hydrocarbon, the mixture is readily adsorbed by oleophillic/hydrophobic materials or by convention skimming or vacuum methods from the water surface. After surface treatment with PES-51®, a temporary molecular protein film is left by the product. This protein film minimizes re-attachment of oil to the treated surface.

Test Site Description

Beach segment LA-19A is naturally divided into two sections by a large outcropping of boulders in the middle and bedrock protrusions on either side. The eastern portion which served as the control site, is composed of small cobble over gravel. The western portion of the beach, which served as the test site, is covered with larger cobble and

boulders over gravel and bedrock. Both sections of LA-19A exhibited an extensive growth of yellow-brown algae in the lower inter tidal zone, as well as sporadic mussels, limpets, starfish, and anemones. Populations seemed somewhat larger along the western portion of the beach.

Treatment History

On July 3, 1989 treatment of LA-19 commenced. Throughout the course of the 1989 season, physical treatment techniques observed by State shoreline monitors consisted of the following:

1. Hand wiping
2. Cold and warm water header hose flood
3. Cold water/high pressure
4. Warm/Hot water, medium pressure wash
5. Hot/steam water, high pressure wash
6. Omni booms

Bioremediation treatment was applied to LA-19 with approximately 220 ga. of Inipol and 948 lbs. of Customblen. LA-19 was demobilized on September 14, 1989 with gross contamination still remaining throughout the segment.

During the 1990 treatment season approximately 21 days were spent at LA-19. Mousse and oil contaminated soils were removed using only manual techniques. Customblen was applied in the upper intertidal zone (UITZ) and behind boulders where concentrations of oil exist.

On May 2, 1991 a multi-agency shoreline assessment team evaluated the oiling conditions at LA-19A. Manual pickup and bioremediation treatment recommendations were made to remove the easily accessible asphalt between the boulders. The Technical Advisory Group (TAG) evaluated the recommendations and decided that no treatment should take place during the 1991 field season. Although shoreline assessment data from 1991 and 1992 indicated a significant amount of surface and subsurface oil on LA-19A no treatment had been applied since 1990.

Oil Characteristics

On June 3, 1993, a shoreline assessment survey was conducted personnel from the Alaska Department of Environmental Conservation/Exxon Valdez Oil Spill (ADEC/EVOS) office. The oiling summary indicated that asphalt and oil contaminated residual sediments were found throughout the mid-intertidal zone (MITZ) to

the upper intertidal zone (UITZ). Within the boulder-cobble interstitial spaces, oiling occurred in distinct patches and was characterized as asphaltic, saturated oil residual and mousse which often extended subsurface. Twenty one pits were dug with an average depth of 10 inches throughout the sub-segment. Sub-surface oiling characteristics ranged from oil-filled pores, high-moderate-low oil residual, oil film and no oil.

Treatment

The western portion of the beach, covering an area roughly 120 ft. long by 135 ft. wide, was treated with 165 gallons of PES-51® over a period of 5 days. A modified air-knife injection system was used to inject compressed air beneath the surface, loosening the substrate, followed by injections of PES-51®. PES-51® was injected as both an aerosol or liquid. The amount of injection and pneumatic agitation was operator dependant, based on the visual efficacy and the amount of oil removed in the injection area. Treated areas were then flushed with cold sea water (55-57F) to liberate the product/oil mixtures for cleanup.

Methodology

The test and control beaches were divided into six 20-foot wide strips that spanned the length of each site. Five shallow pits located at random were dug along each strip. Triplicate sediment composites were collected in sterile plastic bags from strips 1-6 at the test site and strips 2 and 4 at the control site. Triplicate sea water samples were collected in sterile polyurethane bottles offshore of each site, six inches beneath the surface.

On June 6, 1993, researchers completed a preliminary sampling run to verify that contamination existed on the beach and to allow the researchers to better understand the conditions under which the experiment would be performed. Five grab samples of beach material were collected from random locations on the beach. The five grab samples were analyzed for petroleum contamination using a Gas Chromatograph (GC) for constituents in the C-4 to C-16 range (EPA method 8220 and 8270).

At the same time as material was being collected for GC analysis, three replicate composite beach material samples from the five holes and three water column grab samples wee collected for microbiological analysis of the total heterotrophs and oil degrading bacteria populations.

Before and after the application of PES-51®, grab samples of seawater directly below the site were collected and analyzed for petroleum constituents (C4 through C16) using EPA method 8260. Grab samples were also collected in the water column above the treated beach during high tide to determine if any of the petroleum contamination seen floating to the surface and being removed by the skimming was dissolving into the water column. These were also analyzed by Gas Chromatography using EPA Method 8260.

In order to allow consistent, repetitive sampling of the beach material before and after sampling, the beach was divided into six strips, 135 feet long by 20 feet wide, starting at the mean low tide line. A control area which was not treated was selected immediately adjacent to the test plot and similarly divided.

Five holes were randomly spaced along strip 1, strips 2 and 3 combined, strip 4 and strip 5. A composite sample was collected from each of the five holes for GC analysis of constituents in C-4 to C-16 range (EPA method 8220 and 8270). An individual sample was collected from each hole, extracted with a hexane/MTBE mixture and stored. These forty sample extracts (20 for before treatment, 20 from after treatment) were subsequently weighed, dried and gravimetric calculation of contamination performed. The samples were then reconstituted with Freon and analyzed using infra-red spectrophotometry according to Standard Methods (Greenburg, 1992).

Sediment and sea water samples were assayed for numbers of hydrocarbon-degrading microorganisms using the Sheen Screen technique (Brown and Braddock, 1990). Sheen Screen is a miniaturized 5-tube most probable-number (MPN) method using Bushnell-Haas as growth medium and sterile crude oil as the sole carbon source. The serial dilutions were carried out in sterile, 24-well Cell Well plates. The plates were incubated at room temperature for three weeks and then scored. Emulsification of the oil sheen in an individual cell indicated the presence of organisms capable of metabolizing the hydrocarbons. All sediment results were standardized to 100% dry weight. Total heterotrophs were assayed using a similar MPN method. Samples were diluted serially in saline Marine Broth, incubated for one week at room temperature, then scored. Cell turbidity indicated the presence of heterotrophic organisms.

Radiorespirometry was used to assay the hydrocarbon-oxidation potential of microorganisms in the sediment and sea water samples (Brown et al, 1991; Lindstrom et al, 1991). Radiolabelled :14C:-hexadecane, :14C:-phenanthrene, and :14C:-Glutamate were used as representative aliphatic and polycyclic aromatic hydrocarbons

and served as sole carbon sources during incubation. Samples of filtered sea water or sediment slurries were pipetted into sterile Teflon-lined septa vials and injected with the appropriate,radiolabelled hydrocarbon. All samples were run in duplicate. After incubation, the samples were killed and the evolved radiolabelled-CO_2 fixed with NaOH. Later, to recover the carbon, the samples were acidified with HCl and purged with nitrogen g s. The gaseous stream was then bubbled into scintillation vials filled with radiolabelled-CO_2-sorbing phenethylamine cocktail. The radioactivity was measured with a Beckman Instruments model LSC 1800 liquid scintillation counter with automatic quench correction.Quality Assurance. The "5-tube" MPN method employed in the biomass assays is a more reliable statistical procedure than the more commonly used "3-tube" method. Negative controls were also run periodically by preparing sterile media plates that were not inoculated with sample. A number of controls were also run to assure the quality of the data for the biodegradation potentials. They included time-zero killed controls ("blanks") to monitor for abiotic CO2 production, CO2 recovery efficiencies and careful monitoring for leaking vials during the purging process.

RESULTS

The results of the preliminary soil sampling for petroleum contamination are shown in Table 1.

TABLE 1: Soil Contaminant Levels (mg/kg)
Preliminary Sampling (6/04/93)

Constituents	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Benzene	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND
Xylenes	ND	ND	ND	ND	ND
TPH (Volatile)	ND	ND	ND	ND	ND
TPH (Diesel)	13	11	16	29	6.9
TPH (semivolatile)	1700	410	3700	3900	240

Note that there are no volatile components left in the beach material. This is expected as the crude oil has been weathered for over four years at the time of the sampling. Because of the verified lack of volatile components, these will not be discussed further.

Beach Remediation Experiment Sampling

Water Sampling: The concentration of volatile petroleum hydrocarbons (BTEX) and total petroleum hydrocarbons (diesel range and semivolatile) as determined by GC in the water column samples are shown in Table 2. The "before treatment" samples were collected in June and immediately before the July application. The "during treatment" samples were collected below the treatment sites during application and from above the treated site as the tide rose and covered the beach. The "after treatment" samples were collected immediately after the tide fell below the treated beach and one month after the beach treatment experiment. In all instances, there was no hydrocarbon contamination found in the water column.

Table 2: Water Column Contaminant Levels (mg/L) Before, During and After Treatment with PES-51®

Constituents	Before Treatment*	During Treatment*	After Treatment*
Benzene	ND**	ND	ND
Toluene	ND	ND	ND
Ethylbenzene	ND	ND	ND
Xylenes	ND	ND	ND
TPH (Volatile)	ND	ND	ND
TPH (Diesel)	ND	ND	ND

* Four to six grab samples taken from the water column for each period. All results were the same.

** Not detectable at limit of method.

Beach Material Sampling: The concentration of total petroleum hydrocarbons (diesel range and semivolatile) as determined by GC in the composite samples analyzed are shown in Table 3. The reduction of semivolatile petroleum hydrocarbons is presented graphically in Figure 3.

Microbial Effects of Treatment

The data collected in the microbial sampling from the preliminary, during treatment and post treatment surveys provide a time-series of information on the effects of the PES-51® treatment on the microbial population. Because of the wide, inherent variability of contamination in a beach environment after a spill, microbiological indices were selected as the most efficient and cost effective way to examine the

effects of a beach remediation project. The data for the microbial studies are shown graphically in Figures 4 through 7.

Table 3: Soil Contaminant Levels (mg/kg)
Before and After Treatment with PES-51®

	Diesel TPH		Semivolatile TPH	
	Before	**After**	**Before**	**After**
Strip 1	13	ND*	1700	63
Strip 4	29	ND	3900	2600
Strip 5	8	ND	3500	1600
Composite Strips 2 & 3	13	ND	3700	100
Composite Strips 1-4	24	ND	5100	1400

ND* Not detected at level of analysis (0.5 mg/kg)

FIGURE 3: Soil Contaminant Levels (mg/kg)
Before and After Treatment with PES 51®

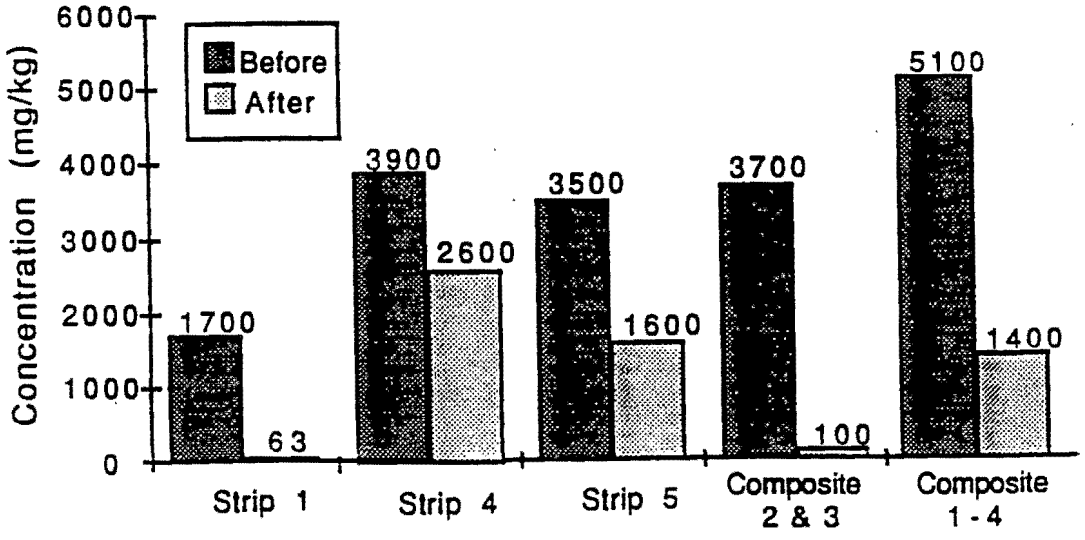

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FIGURE 4a
Sediment Mineralization: Hexadecane

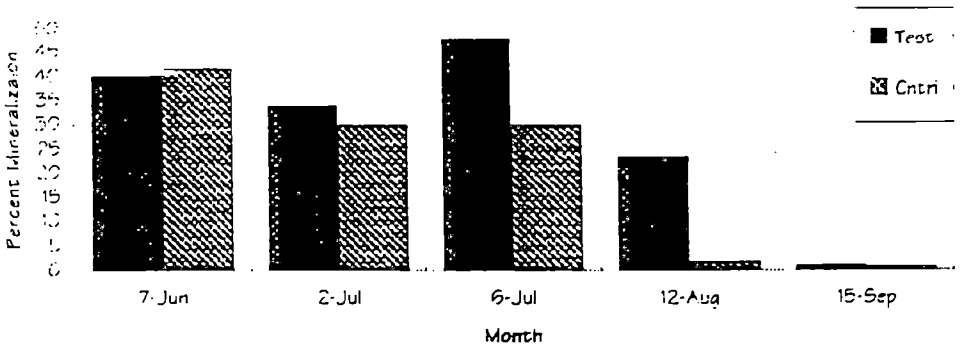


FIGURE 4b
Sediment Mineralization: Phenanthrene

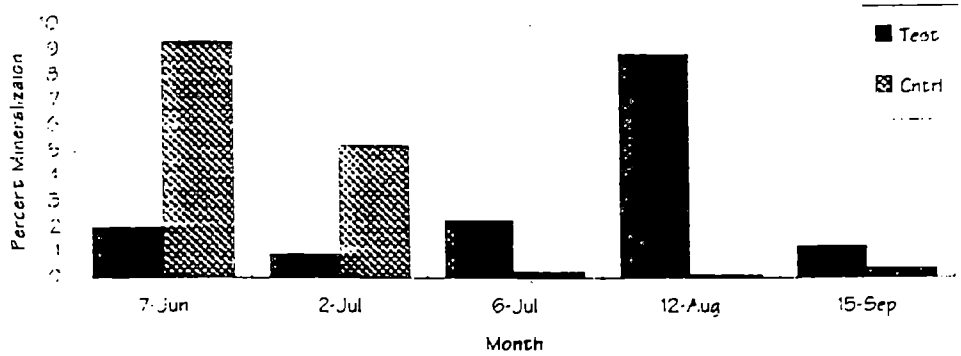
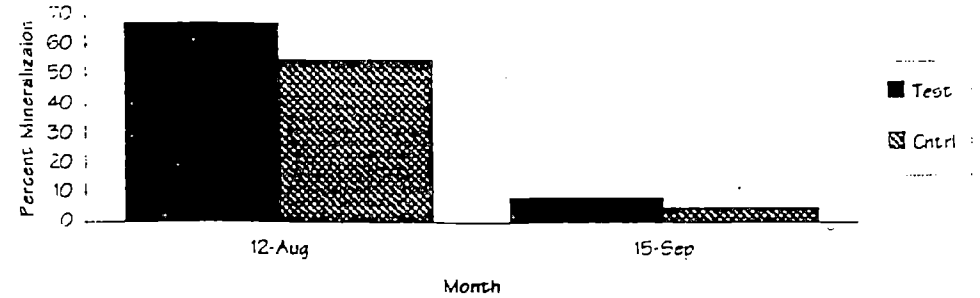


Figure 4c
Sediment Mineralization: Glutamate



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PES-51 Sleepy Bay Study

Figure 5a
Sea Water Mineralization: Hexadecane

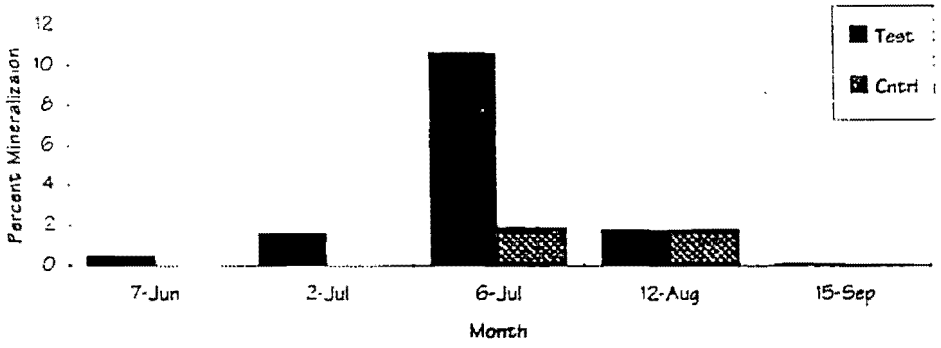


FIGURE 5b
Sea Water Mineralization: Phenanthrene

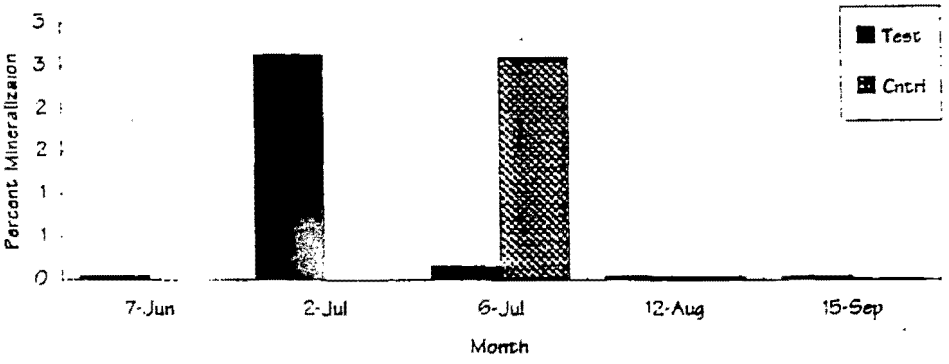
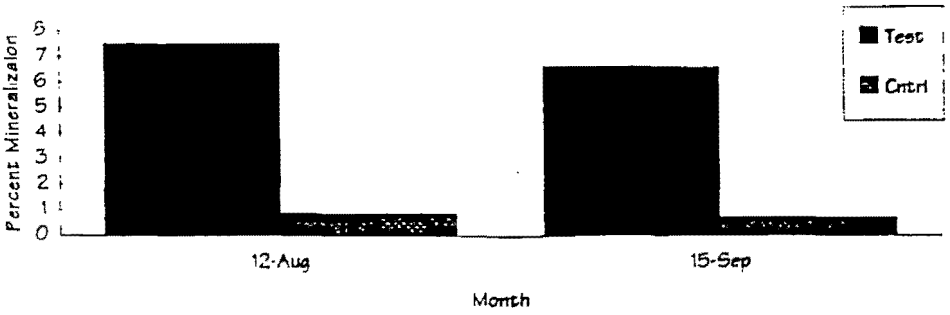


FIGURE 5c
Sea Water Mineralization: Glutamate



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PES-51 Sleepy Bay Study

FIGURE 6a
Standardized Sheen Screen Sediment MPN Data

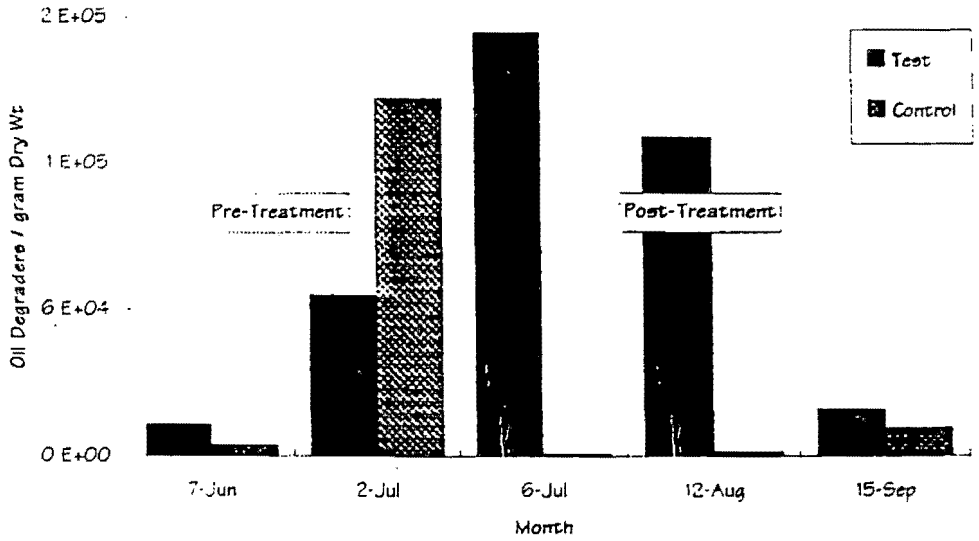
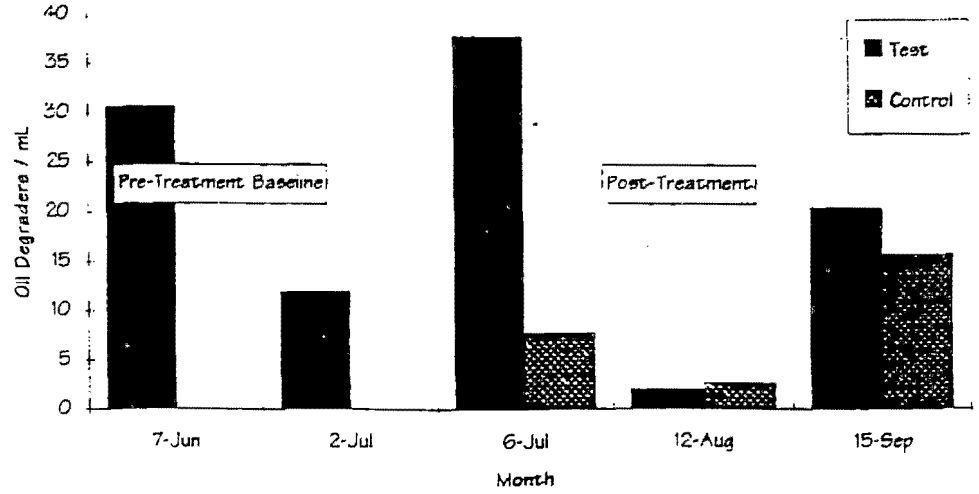


FIGURE 6b
Sheen Screen Sea Water MPN Data



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PES-51 Sleepy Bay Study

FIGURE 7a
Standardized Heterotroph Sediment MPN Data

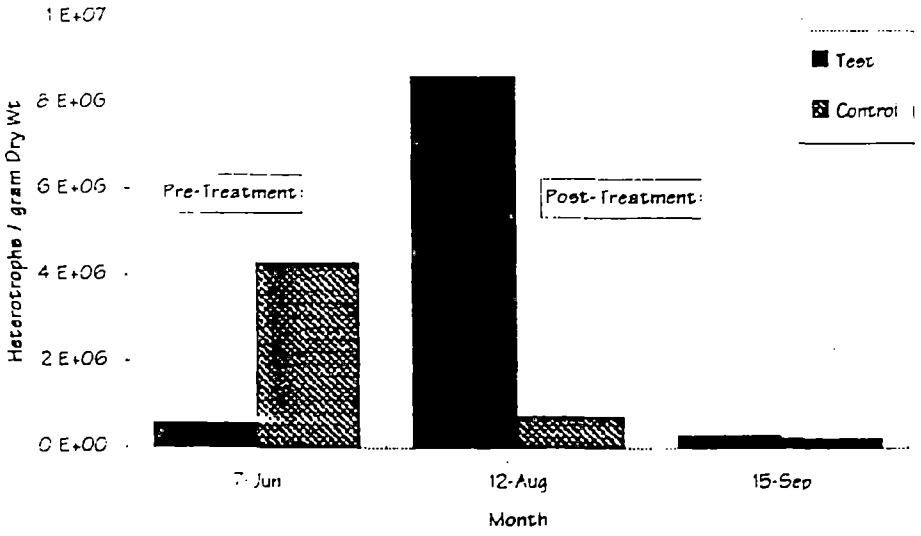
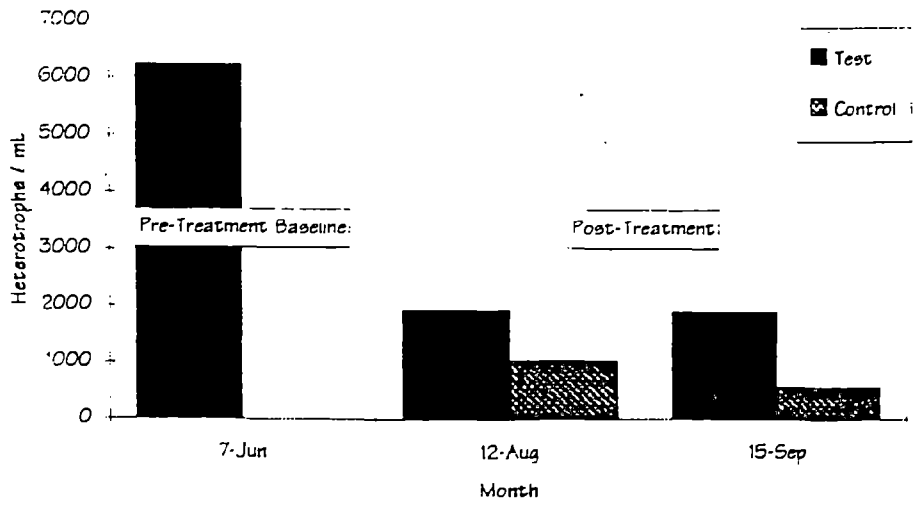


FIGURE 7b
Heterotroph Sea Water MPN Data



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Conclusion

The air/PES-51® injection system was extremely effective at removing weathered subsurface oil throughout the five day experiment. The shoreline selected for the test was one of the most difficult types to effectively treat as indicated in the treatment history section of this report.

As can be seen in the data from the preliminary sampling run, the concentration of non-volatile contaminants in the diesel and semivolatile range (up to about C-16) varies significantly from location to location. There appears to be a heavier layer of concentration in the mid-tidal zone (Samples 3 and 4). In all cases, the contamination was found 2 to 4 inches below the surface material and was noted to extend to observed depths of 12 inches.

The treatment process recovered substantial quantities of buried oil but also resulted in some re-oiling of surface sediments. The data from he actual treatment experiment (Table 2) show that diesel-range petroleum hydrocarbons are completely removed to levels below the detection limit of 0.5 mg/kg. Semivolatile petroleum hydrocarbons are reduced an average of 70%. This indicates that treatment with PES-51® significantly reduces the contamination within the beach material below the surface.

The microbial data collected indicates that, unlike many other hydrocarbon cleaners, no inhibition of microbial activity in sediments is caused by treatment. While microbiological tests were not conducted to determine toxic effects, if the PES-51® were extremely toxic, microbe populations may be expected to be effected. Instead, the population counts are for comparison with the large database of information from other beaches in the Prince William Sound area.

There was an enhancement in the numbers and activity of hydrocarbon-degraders immediately following treatment remained elevated relative to the control sediments for about a month. There is also no evidence of increased microbiological activity in sea water samples, indicating that oil was not transported offshore during the treatment process. The data collected from the water column support this conclusion and indicate that the contaminant released from the beach material is not solubilized into the water column. No samples of the water column had detectable petroleum hydrocarbon contamination.

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References

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PES®

COMPENDIUM OF PES-51® AQUATIC TOXICITY DATA

P.O. Box 680488 • San Antonio, Texas 78268-0488 • Phone (210) 680-2950 • FAX. (210) 523-5700

Project 95116

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I.INTRODCUTION

Petroleum Environmental Services,Inc. has prepared this compendium of aquatic toxicity data in an effort to provide a single source for this information. The compendium will be updated as more data becomes avaliable.

As you review this information, please keep in mind that each toxicity test is different and requires its own interpretation. The brief interputations are a general explanation of the results.

It should be noted that PES-51®, when used in accordance with the application instructions, has a in the field use concentration of less than 200 ppb. The dilution effect is created by the product application technique which involves instantaneous water diluge. Subsequently, the in the field toxicity of the product is greatly minimized.

Should any questions or comments arise from your reading of this information, please address then to:

Dennis C. Owens
PES,Inc.
P.O. Box 680488
San Antonio,Tx 78268-0488
210-680-2950 or 210-283-2644 Office
210-523-5700 Fax

Project 95116

II.STATE OF CALIFORNIA OIL SPILL CLEANING AGENT TOXICITY DATA

The toxicity tests required by the State of California utilize some of the more sensitive aquatic species. You will note that the average LC50 of 580 mg/l for Acute toxicity is well above the States acceptance level of 400 mg/l for these tests.

It is interesting to note that the state requires that the product (neat) and the test oil (neat) as well as a product/oil mixture be tested for toxicity. The reasoning behind this testing is to insure that the product/oil mixture does not increase toxicity to the environment.

You will note that the product/oil mixture in these tests actually reduced the toxicity of the hydrocarbon by a thousand fold.

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OIL SPILL CLEANUP AGENT TOXICITY TESTING

LAB NO.: V-9105003 CLIENT/ID: PETROLEUM ENVIR. SERV. PES-51™

Three test species, fathead minnow (pimphales promelas), inland silversides (menidia beryllina), and brine shrimp (artemia salinas), were exposed to various concentrations of the Osca product, Osca plus No. 6 fuel oil, and Osca plus No. 6 fuel oil after 20 days of degradation. Test procedures follow the protocols given in "Evaluating Oil Spill Cleanup Agents", Publication No. 43 of the California State Water Resources Control Board (CSWRCB) 1970 and verbal guidance provided by CSWRCB.

ACUTE TOXICITY OF AGENT TO AQUATIC ORGANISMS

SPECIES	WATER TYPE	24 HR LC50	48 HR LC50	96 HR LC50
P. promelas	Fresh (42 mg/l)	810 mg/1	810 mg/1	810 mg/1
M. beryllina	Sea (20 ppt)	100 mg/1	100 mg/1	100 mg/1
A. salinas	Sea (20 ppt)	980 mg/1	840 mg/1	N/A

Average LC50 (94 hr for fish + 48hr for Artemia): 580 mg/1 OSCA

ACUTE TOXICITY OF 1:5 MIXTURE OF OSCA AND #6 FUEL OIL TO AQUATIC ORGANISMS

SPECIES	WATER TYPE	24 HR LC50	48 HR LC50	96 HR LC50
P. promelas	Fresh (42 mg/l)	>1600 mg/1	>1600 mg/1	>1600 mg/1
M. beryllina	Sea (20 ppt)	>1600 mg/1	>1600 mg/1	>1600 mg/1
A. salinas	Sea (20 ppt)	>1600 mg/1	>1600 mg/1	N/A

Average LC50 (94 hr for fish + 48hr for Artemia): >1600 mg/1 OSCA

ACUTE TOXICITY AFTER 20 DAYS OF AGING AT 15°C OF 10 TIMES INITIAL 96 HR LC50 CONC.

SPECIES	Pimephales promelas	Menidia beryllina	Artemia salinas
OSCA + #6 Fuel Oil	100% Surv. @ 1600 mg/l	85% Surv. @ 1600 mg/l	0% Surv. @ 1600 mg/l

OSCA = 10,000 mg/l of the 1:5 OSCA to #6 Fuel Oil Mixture (highest conc. used).

* Tests were conducted by Enseco, Ventura, California.

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III. U.S. EPA NCP LISTING TOXICITY DATA

The results of these tests are very similar to the California toxicity tests with the same organism. The only difference in the tests involve different hydrocarbons ,#2 fuel oil instead of #6 fuel oil.

Additionally, this test contains data on the toxicity of the hydrocarbon. Under normal conditions, the results of the product/oil mixture would be an average of the two numbers (eg. 665 and 58) however, the mixture exhibits a reduction of toxicity by a thousand fold. The reduction in toxicity is directly due to the products ability to form a interfacial barrier that does not allow the water soluble toxic fraction to enter the water column. This phenomeum is unique to this product and caused the EPA to request that the tests be rerun several times in order to verify that this action was for real.

Project 95116

United States Testing Company, Inc.

Report #064553
Petroleum Environmental

STANDARD DISPERSANT TOXICITY REPORT

ient: Petroleum Environmental Services
P.O. Box 680488
San Antonio, Texas 78268-0488

Testing Facility: United States Testing Company
Biological Services
1415 Park Avenue
Hoboken, New Jersey 07030

Sample Description, Handling & Stability: Sample identified by Client as Petroleum Environmental Service's PES-51 oil spill dispersant: Chemical composition proprietary. Pale yellow, mobile liquid, pale reddish-brown sediment, with with a strong citrus odor. Sample stored in original sealed container, considered stable.
Received 2/ 3/92.

Project: 48 hour acute toxicity versus Artemia sp. (brine shrimp). Toxicity of PES-51 alone, PES-51 + #2 Fuel Oil, #2 Fuel Oil alone, and Dodecyl Sodium Sulfate.
Test dates 5/13 - 15/92.

Summary of Results: Acute toxicity, expressed as LC50, is as follows:

PES-51	PES-51 + #2 Fuel Oil	#2 Fuel Oil	DSS
665 ppm	1,542 ppm	58 ppm	5.0 ppm

STANDARD DISPERSANT TOXICITY REPORT

Client: Petroleum Environmental Services
P.O. Box 680488
San Antonio, Texas 78268-0488

Testing Facility: United States Testing Company
Biological Services
1415 Park Avenue
Hoboken, New Jersey 07030

Sample Description, Handling & Stability: Sample identified by Client as Petroleum Environmental Service's PES-51 oil spill dispersant: Chemical composition proprietary. Pale yellow, mobile liquid, pale reddish-brown sediment, with with a strong citrus odor. Sample stored in original sealed container, considered stable. Received 2/ 3/92.

Project: 96 hour acute toxicity versus Fundulus heteroclitus (killi fish). Toxicity of PES-51 alone, PES-51 + #2 Fuel Oil, #2 Fuel Oil alone, and Dodecyl Sodium Sulfate. Test dates 3/5 - 14/92.

Summary of Results: Acute toxicity, expressed as LC50, is as follows:

PES-51	PES-51 + #2 Fuel Oil	#2 Fuel Oil	DSS
1,425 ppm	5,650 ppm	5,200 ppm	7.1 ppm

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IV.U.S. EPA TOXICITY DATA

-Oncorhynchus mykiss (Rainbow trout)

These toxicity test are very sensitive due to the fact that the test organisms are juvenile fish (<8 weeks old). Factors such as age and small size generally maximize toxic effect, numerically expressed as the LC50.

There was no significant difference in the response of O.mykiss to USEPA #2 Fuel Oil and to PES-51 in the presence of USEPA #2 Fuel Oil. The 96hr O.mykiss LC50 for PES-51 was determined to be 98 ppm (see USTC Report #065505-1). The 96hr LC50 for both PES-51 + #2 Fuel Oil and #2 Fuel Oil alone was determined to be approximately 500 ppm.

PES-51 in a working mixture of #2 Fuel Oil does not pose a significant toxic threat to this test organism.

-Crassostrea gigas (Pacific oyster) and Mytilus edulis (Bay mussell)

The oyster larvae exhibited and EC50 value of 19 ppm when exposed to PES-51®. PES-51, in the presence of oil, yielded and EC50 of 128 ppb. #2 fuel oil was toxic to oyster larvae at 185 ppb. As with the trout, mysids and urchins, these results demonstrate an expected trend; PES-51 was less toxic than PES-51 plus oil.

The oysters were less sensitive than the urchin to PES-51. This is due to organism life stage. Urchins were tested by first exposing the sperm for one hour, and then adding the eggs; the oyster sperm and egg were mixed together for one hour before exposure. The oysters were exposed as fertilized embryos, and the urchins were not.

The mussel larvae exhibited and EC50 value of 9 ppm when exposed to PES-51. This result was, as expected, very similar to the result of the oyster larvae test (EC50= 19 ppm).

Under actual field use conditions PES-51 will average concentrations of less than 200 ppb.

Project 95116

Report #065625-1
PES-51

United States Testing Company, Inc.

AQUATIC TOXICITY TESTING REPORT

Client: Petroleum Environmental Services, Inc.
P.O. Box 680488
San Antonio, Texas 78268-0488

Testing Facility: United States Testing Company
Biological Services Division
1415 Park Avenue
Hoboken, New Jersey 07030

Sample Description, Handling & Stability: Sample identified by Client as PES-51: Organic Biocleanser, chemical composition proprietary. Yellow, mobile liquid, with a strong citrus odor. Not water soluble. Sample stored in original sealed container, at room temperature, considered stable.
Sample received 3/26/93.

Project: 96 Hour Acute Toxicity of PES-51, in the presence of #2 Fuel Oil, versus Rainbow Trout (O. mykiss)

Test Dates: 6/24 - 28/93

Summary of Results:

PES-51 + #2 Fuel Oil	96hr LC50 = 500 ppm NOEC = 250 ppm
#2 Fuel Oil	96hr LC50 = 518 ppm NOEC = 250 ppm
PES-51	96hr LC50 = 98 ppm * NOEC = 62.5 ppm *

* see USTC Report #065505-1

Project 95116
Report #065505-5
PES-51

United States Testing Company, Inc.

AQUATIC TOXICITY TESTING REPORT

lient:	Petroleum Environmental Services, Inc. P.O. Box 680488 San Antonio, Texas 78268-0488
Testing Facility:	United States Testing Company Biological Services Division 1415 Park Avenue Hoboken, New Jersey 07030
Sample Description, Handling & Stability:	Sample identified by Client as PES-51: Organic Biocleanser, chemical composition proprietary. Yellow, mobile liquid, with a strong citrus odor. Not water soluble. Sample stored in original sealed container, at room temperature, considered stable. Sample received 3/26/93.
Project:	Larval Development vs Pacific Oyster (C. gigas)
Test Dates:	5/21 - 23/93
Summary of Results:	48hr EC50 = 18.7 ppm No Observed Effect Concentration = 6.25 ppm

AQUATIC TOXICITY TESTING REPORT

Client: Petroleum Environmental Services, Inc.
P.O. Box 680488
San Antonio, Texas 78268-0488

Testing Facility: United States Testing Company
Biological Services Division
1415 Park Avenue
Hoboken, New Jersey 07030

Sample Description, Handling & Stability: Sample identified by Client as PES-51: Organic Biocleanser, chemical composition proprietary. Yellow, mobile liquid, with a strong citrus odor. Not water soluble. Sample stored in original sealed container, at room temperature, considered stable.
Sample received 3/26/93.

#2 Fuel Oil: USEPA Reference Oil (lot WP-681), obtained through Fisher Scientific.

Project: Larval Development vs Pacific Oyster (C. gigas) PES-51 in the presence of #2 Fuel Oil

Test Dates: 5/21 - 23/93

Summary of Results:

PES-51 + #2 Fuel Oil:	48hr EC50 = 127.7 ppb No Observed Effect Concentration = 62.5 ppb
#2 Fuel Oil:	48hr EC50 = 185.3 ppb No Observed Effect Concentration = 62.5 ppb

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Report# 065505-4
PES-51

United States Testing Company, Inc.

AQUATIC TOXICITY TESTING REPORT

Client: Petroleum Environmental Services, Inc.
P.O. Box 680488
San Antonio, Texas 78268-0488

Testing Facility: United States Testing Company
Biological Services Division
1415 Park Avenue
Hoboken, New Jersey 07030

Sample Description, Handling & Stability: Sample identified by Client as PES-51: Organic Biocleanser, chemical composition proprietary. Yellow, mobile liquid, with a strong citrus odor. Not water soluble. Sample stored in original sealed container, at room temperature, considered stable.
Sample received 3/26/93.

Project: Larval Development vs Bay Mussel (M. edulis)

Test Dates: 5/28 - 30/93

Summary of Results: 48hr EC50 = 9.6 ppm
No Observed Effect Concentration = 3.125 ppm

Exxon Valdez Oil Spill Trustee Council

Restoration Office
645 "G" Street, Anchorage, AK 99501
Phone: (907) 278-8012 Fax: (907) 276-7178

TO: Work Plan Reviewers

DATE: July 7, 1994

FROM: Bob Loeffler

TELE: 278-8012
FAX: 276-7178

SUBJECT: Work Plan Supplement #2: Five Proposals (four received as part of the BAA).

Four proposals were received by NOAA as part of their Broad Agency Announcement. They are below:

95117-BAA. Harbor Seals and EVOS: Blubber and lipids as indices of food limitation. $184,316. Dr. Castellini, UAF

95118-BAA. Diet composition, reproductive energetics, and productivity of seabirds damaged by the *Exxon Valdez* Oil Spill. $413,689. Dr. Daniel Roby, UAF.

95119-BAA. Food Limitation on Recovery of Injured Marine Bird Populations. $124,883. William J. Sydeman. Point Reyes Bird Observatory.

95120-BAA. Proximate Composition and Energetic Content of Selected Forage Fish Spies in Prince William Sound. $38,400. Graham Worthy, Texas A & M University.

In addition, we are distributing a proposal that we were holding because we mistakenly believed it duplicated one delivered as part of the BAA. (It was received prior to June 15th).

95121. Stable Isotope Ratios and Fatty Acid Signatures of Selected Forage Fish Species in Prince William Sound, Alaska. $42,000. Graham Worthy, Texas A & M University.

Project 95117-BAA

BAA 52ABNF400104 SFOS 94-186

PROPOSAL 94855

TO: NOAA, WASC Procurement Division
ATTN: WC33
7600 Sand Point Way, NE, BIN C15700
Seattle, WA 98115-6349

FROM: Institute of Marine Science
School of Fisheries and Ocean Sciences
P.O. Box 757220
University of Alaska Fairbanks
Fairbanks, AK 99775-7220

TITLE: Harbor seals and EVOS: Blubber and lipids as indices of food limitation.

PRINCIPAL INVESTIGATORS: Dr. Michael Castellini
Associate Professor

NEW/CONTINUING: NEW

DURATION: 2.5 Years

PROPOSED START DATE: Oct 1, 1994 to March 31, 1997

AMOUNT REQUESTED: $ 184,316

6/15/94
Dr.Michael Castellini /Date
Principal Investigator
(907)474-6825

Joan Osterkamp 6/16/94
Joan Osterkamp /Date
Executive Officer
School of Fisheries and Ocean Sciences

6/17/94
A. V. Tyler /Date
Associate Dean
School of Fisheries and Ocean Sciences

16 June 94
Donald M. Schell /Date
Director
Institute of Marine Science

6/17/94
Ted DeLaca /Date
Director, Office of Arctic Research
University of Alaska Fairbanks

Project 95117-BAA

B. Introduction

This proposal deals with the theoretical impact of potential food limitation as a factor in the non-recovery of harbor seals in Prince William Sound (PWS) and northern Gulf of Alaska regions after the Exxon Valdez Oil Spill (EVOS) event in 1989. The hypothesis proposed in the Broad Agency Announcement (52ABNF400104) (BAA) is that food limitation could have a multi-level impact on marine mammals from reproductive success to juvenile survival to adult body condition.

For reasons detailed below, we feel that accurate data on how food may impact reproductive success and juvenile survival cannot be obtained from Alaskan harbor seals in the wild. Therefore, we are proposing that the hypothesis be reconsidered as follows:

IF food limitation does indeed impact reproductive success, juvenile survival or adult body condition, then it follows that there should be differences in body condition of adult harbor seals before and after EVOS and within and outside of the EVOS area.

The University of Alaska is ALREADY addressing the issues of adult body condition in harbor seals in collaboration with Alaska Department of Fish and Game (ADF&G), and has recently submitted requests for additional support of this work through the EVOS FY95 program. However, all of our current work utilizes standardized and clinical methods (such as body shape, size, and veterinary blood chemistry) in order to compare animals both in time and space. The enclosed proposal is to utilize blubber analysis methods to test body condition status of harbor seals. Blubber is a critical fuel source for marine mammals...its quality and energy density are prime descriptive characteristics of the energy available to the animal. We feel that by analyzing the blubber of harbor seals, a picture of metabolic status can be obtained. A key factor to this proposal is that HISTORICAL samples of blubber collected well before the EVOS event have been archived by ADF&G and would be available for analysis. It is our proposal that by working with the ADF&G historical samples and by comparing those samples to ones collected AFTER the EVOS event, we can determine whether or not there has been a shift in the quality of this important body component of harbor seals. By combining these blubber data with the ongoing commitment of UAF to body condition studies of harbor seals in this region, we feel that the restated hypothesis can be tested: That is, we will be able to determine whether or not there has been a shift in the body condition of harbor seals over time and space in relation to EVOS. IF there has been no change, then searching for mechanisms of how body condition could have been altered becomes irrelevant. On the other hand, if we show that there has been a shift, then detailed studies of the responsible factors can be explored. Thus, we provide here a generalized test of the BAA hypothesis...if we can't show any change, then there is no need to explore the mechanisms. If there is a change, then work can focus on the causes whether related to EVOS, ecosystem changes or food limitation.

C. Project need

As noted above, it may be virtually impossible to test the hypothesis as stated in wild populations of harbor seals in Alaskan waters. To fully and completely test this food limitation hypothesis would require years of captive work on the impact of different feeding regimes on the energetics, feeding efficiency, reproductive success and body condition of animals. There are no facilities to do this type of work in Alaska. Furthermore, the application of those findings to the field would be difficult. In the field, harbor seals are elusive and difficult

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animals to capture. Repeated captures of the same individuals are essentially impossible. Marking and identification of specific pups in relation to weaning success by the mothers is not possible nor can accurate determinations of diet or changes in diet be determined. For these reasons, body condition of adults may be the ONLY way to address this question and even then, INDIRECT methods to assess potential food limitations on animals must be considered. The University of Alaska proposes to approach the question from a unique perspective: If the BAA hypothesis is valid, then harbor seal body condition should have changed. We can determine whether that shift has occurred. If it has, then addressing the difficult tasks of finding the CAUSE of the shift becomes valid.

This type of analysis is critical to recovery studies. If there has been no change in body condition of harbor seals from before EVOS, then recovery efforts aimed at modifying their health status would not be necessary. On the other hand, if seals are currently compromised, then this provides a direction to follow in terms of enhancing their health and body condition.

C. Project design

1. Objectives. The essential elements of this proposal are very basic and are contained in three tasks:

Task 1. Obtain and analyze blubber from historical samples.
Task 2. Obtain and analyze blubber from contemporary samples.
Task 3. Model changes in blubber with independent data on body condition and change over time relative to EVOS.

2. Methods.

A. Collection of historical samples: The ADF&G has archived, frozen samples of harbor seal blubber collected well before the EVOS event that are available for this analysis. They have given us permission to utilize this collection if personnel from UAF can travel to Anchorage to transfer and collate the samples. About 250-300 samples are arhived.

B. Collection of contemporary samples: UAF currently works with ADF&G on harbor seal projects in the EVOS region and has an RSA with ADF&G to continue this work through Dec, 1994. ADF&G and UAF have recently submitted to the EVOS Trustee Council a MARINE MAMMAL ECOSYSTEMS joint proposal to continue collecting samples through 1996. All field work, and associated costs of logistics are covered in that proposal and are not included here. Blubber samples will be collected by tissue biopsy using standard techniques already being employed.

C. Analysis of blubber: Samples of blubber will be analyzed for quality and density of energy. Four specific tests will be conducted on each sample:

1. Density of blubber.
2. Total lipid content of blubber.
3. Hydration state of blubber.
4. Total energy content of blubber.

These determinations completely describe the energetic state of blubber in terms of its potential as a fuel source. Our hypothesis is that since blubber is a major component of the body tissues of seals (27-30% of body mass (Pitcher 1986)), contains 90% of the lipid fuel

Project 95117-BAA

sources in seals (Beck et al. 1993) and since lipid utilization makes up approximately 85% of the energy utilized by seals (Ryg et al. 1990), then changes in the lipid content, blubber density and energy content should reflect seasonal and interannual changes in body condition of the seals. It is known that the blubber content of an animal and the lipid content of blubber varies with season, age and sex (Pitcher 1986; Ryg et al. 1990; Beck et al. 1993). The archived historical blubber samples have complete data sets on animal condition associated with them, and these data are also collected for the contemporary animals.

Blubber density is determined with an automated pycnometer which is a specialized instrument made to determine the volume and mass (and therefore density) of solid and semi-solid materials. The total lipid content of blubber is determined by organic extraction of lipids using a Soxhlet apparatus and standard extraction techniques. Hydration state of blubber is determined by changes in the wet and dry weight of a sample. Finally, the total energy content of blubber is determined by bomb calorimetry of the sample to determine calories available. One-way and multi-factorial analyses of variance will be performed to assess the affects of age, sex, season and year on these measures of blubber quality.

The density pycnometer will need to be purchased as there is no such instrument at UAF. Lipid extractions using a purchased Soxhlet apparatus will be performed by graduate students. The bomb calorimetry will be carried out as a service contract with other departments at UAF.

References:

Beck, G.G., T.G. Smith and M.O. Smith. 1993. Evaluation of body condition in the northwest Atlantic harp seal (Phoca groenlandica). Can. J. Fish. Aquat. Sci. 50:1372-1381.

Pitcher, K.W. 1986. Variation in blubber thickness of harbor seals in southern Alaska. J. Wildl. Manage. 50:463-466.

Ryg, M., T.G. Smith and N.A. Øritsland. 1990. Seasonal changes in body mass and body composition of ringed seals (Phoca hispida) on Svalbard. Can. J. Zool. 68:470-475.

3. Schedule:

Historical samples will be obtained and analyzed during year one. Field samples will be collected during 2-3 field trips/year with ADF&G and analyzed throughout the period of the proposal. A final report will be presented by March 31, 1997.

4. Technical support:

As noted above, only the bomb calorimetry will be conducted on a pay per sample basis to other departments on campus. All field costs for ship logistics are covered in the MARINE MAMMAL ECOSYSTEMS proposal to the EVOS Trustees.

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5. Location:

Laboratory work will be conducted on the UAF campus in Fairbanks. Field work will be conducted in Prince William Sound.

E. Project implementation

All laboratory work will be conducted by UAF personnel. Dr. Castellini has worked on metabolic biochemistry questions in marine mammals for almost 20 years. A short CV is attached. B. Fadely is a PhD student in the laboratory and has a MSc degree in marine mammal nutritional and water balance physiology. Other research associates and graduate students will be necessary on the project during times of intense sample analysis.

F. Coordination of Integrated Research Effort

This project requires the integrated efforts of ADF&G and UAF with both current RSA agreements and proposed coordinated efforts (MARINE MAMMAL ECOSYSTEMS) currently under consideration by the EVOS Trustees for FY95. Without that support, the field component of this project cannot be done. It also requires the donation of historical samples from ADF&G archives.

G. Public processes

Through scientific publications, lectures and generated reports, results from this work will be made available to both the research and public sectors. Dr. Castellini presents many guest lectures each year on marine mammal research at UAF and will include these data in those presentations.

H. Personnel qualifications.

As noted above in section E, Dr. Castellini specializes in metabolic chemistry problems associated with marine mammals. B. Fadely, the PhD student involved in this project, has a Masters degree in marine mammal nutrition and water balance physiology. Research associates and other graduate students in Dr. Castellini's laboratory are all specialists in various fields of marine mammal physiology.

Project 95117-BAI

I. Budget

Year 1; October 1, 1994 to Sept 30, 1995

Wages				
Personnel	Time	Amount		
M. Castellini	2 months	9466		
J.M. Castellini	3 months	7155		
B. Fadely	6 months	7308		
Total Wages			23929	
Leave				
M. Castellini		1902		
J.M. Castellini		1530		
Total leave			3432	
Benefits				
M. Castellini		3330		
J.M. Castellini		3534		
Total benefits			6864	
TOTAL SALARIES				34225
Travel				
EVOS workshop per diem/Anchorage				
M. Castellini 14 days @ $170		2380		
Sample collection from ADF&G				
B. Fadely 7 days @ $170		1190		
4 RT airfare FBKS/Anch @ $375		1500		
TOTAL TRAVEL				5070
Services				
Bomb calorimetry (175 @ $20)		3500		
Phone		500		
Postage		200		
Cargo shipping		1000		
TOTAL SERVICES				5200

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Commodities			
Organic solvents (lipid extraction)	500		
Soxhlet glassware (5 @ $225)	1125		
Extraction expendables	400		
Freezer inventory supplies	500		
Computer supplies	1000		
TOTAL COMMODITIES		3525	
Equipment			
Sample shipper	1000		
Soxhlet heater	1025		
Density meter	10000		
Shipping costs for above items	300		
TOTAL EQUIPMENT		12325	
Student aid			
Fadely 1 semester	2530		
TOTAL STUDENT AID		2530	
TOTAL DIRECT		62875	
INDIRECT			
(41.8% minus equipment and tuition)		20072	
TOTAL REQUESTED YEAR 1			82947

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Year 2: Oct 1, 1995 to Sept 30, 1996

All wages taken as Year 1 values * 1.05)

Personnel	Time	Amount		
M. Castellini	2 months	9939		
J.M. Castellini	3 months	7513		
B. Fadely	6 months	7673		
Total Wages			25125	
Leave				
M. Castellini		1998		
J.M. Castellini		1608		
Total leave			3606	
Benefits				
M. Castellini		3498		
J.M. Castellini		3712		
Total benefits			7210	
TOTAL SALARIES				35941
Travel				
2 RT FBKS/Anchorage @ $375		750		
EVOS workshop per diem/Anchorage				
M. Castellini 14 days@ 170		2380		
TOTAL TRAVEL				3130
Services				
Bomb calorimetery (175 @ $20)		3500		
Phone		500		
Postage		200		
Cargo shipping		1000		
TOTAL SERVICES				5200
Commodities				
Organic solvents (lipid extraction)		500		
Extraction expendables		400		
Freezer inventory supplies		500		
Computer supplies		1000		
TOTAL COMMODITIES				2400

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Equipment		
No equipment planned		
TOTAL EQUIPMENT		0
Student aid		
Fadely 1 semester	2530	
TOTAL STUDENT AID		2530
TOTAL DIRECT		49201
INDIRECT		
(41.8% minus equipment and tuition)		19508
TOTAL REQUESTED YEAR 2		68709

Project 95117-BAA

Year 3: Oct 1, 1996 to March 31, 1997

All wages taken as Year 2 values * 1.05)

Personnel	Time	Amount		
M. Castellini	1 months	5218		
J.M. Castellini	1 months	2629		
B. Fadely	3 months	4029		
Total Wages			11876	
Leave				
M. Castellini		1049		
J.M. Castellini		563		
Total leave			1612	
Benefits				
M. Castellini		1836		
J.M. Castellini		1299		
Total benefits			3135	
TOTAL SALARIES				16623
Travel				
1 RT FBKS/Anchorage @ $375		375		
M. Castellini				
Per diem EVOS workshop Anchorage				
M. Castellini 7 days @$170		1190		
TOTAL TRAVEL				1565
Services				
Bomb calorimetry (50 @20)		1000		
Phone		500		
Postage		300		
Publication costs		1000		
TOTAL SERVICES				2800
Commodities				
Organic solvents		400		
Extraction expendables		400		
Computer supplies		650		
TOTAL COMMODITIES				1450

Project 95117-BAA

Equipment		
No equipment planned		
TOTAL EQUIPMENT	0	
Student aid		
Fadely 1 semester	2530	
TOTAL STUDENT AID	2530	
TOTAL DIRECT		24968
INDIRECT		
(41.8% minus equipment and tuition)		9379
TOTAL REQUESTED YEAR 3		34347

Project 95117-BAA

TOTAL COSTS

Personnel				
Wages				
M. Castellini	24623			
J.M. Castellini	17297			
B. Fadely	19010			
Total wages		60931		
Leave				
M. Castellini	4949			
J.M. Castellini	3700			
Total leave		8649		
Benefits				
M. Castellini	8664			
J.M. Castellini	8545			
Total benefits		17209		
Total salaries			86789	
Travel				
Airfares	2625			
Per diem	5950			
Total travel			8575	
Services			13200	
Commodities			7375	
Equipment			12325	
Student aid			7590	
TOTAL DIRECT				135854
INDIRECT				48462
TOTAL REQUESTED				184316

Project 95117-BAA

Appendix: Castellini CV

NAME: Michael Angelo Castellini
PLACE OF BIRTH: Upland, California, January 22, 1953
EDUCATION:
B.A. Biology 1975 University of California, San Diego
PhD. Marine Biology 1981 Scripps Institution of Oceanography

EMPLOYMENT RECORD:
1976-80 Research assistant, University of California, San Diego
1981 Postdoctoral research fellow, Scripps Institution of Oceanography
1982 NATO postdoctoral fellow, Univ. of British Columbia, Vancouver
1983-86 NIH postdoctoral fellow, University of British Columbia, Vancouver
1986-87 Visiting assistant research physiologist, UC San Diego
1987 Adjunct lecturer, Department of Biology, UC San Diego
1987-89 Assistant research biologist, University of California, Santa Cruz
1990-92 Research associate in Marine Sciences, Univ Calif Santa Cruz
1989-93 Assistant professor marine biology, Univ. of Alaska, Fairbanks
1993- Associate professor marine biology, Univ. of Alaska, Fairbanks

Publications relevant to proposal

Castellini, M.A., D.P. Costa and A.C. Huntley. Fatty acid metabolism in fasting elephant seal pups. Journal of Comparative Physiology B. 157(4):445-449. 1987.

Castellini, M.A., R.W. Davis and G.L. Kooyman. Blood chemistry regulation during repetitive diving in Weddell seals. Physiological Zoology. 61(5):379-386. 1988.

Castellini, J.M., Castellini, M.A. and M.B. Kretzmann. Circulatory water balance in suckling and fasting northern elephant seal pups. Journal of Comparative Physiology B. 160(5):537-542. 1990.

Castellini, M.A. and D.P. Costa. Relationships between plasma ketones and fasting duration in neonatal elephant seals. American Journal of Physiology. 259:R1089-R1090. 1990.

Davis, R.W., M.A. Castellini, T.M. Williams and G.L. Kooyman. Fuel homeostasis in the harbor seal during submerged swimming. Journal of Comparative Physiology B. 160:627-635. 1991.

Castellini, M.A. The biology of diving: biochemical, physiological and behavioral limits. In: Advances in Comparative and Environmental Physiology. Vol 8. R. Gilles, ed. Springer-Verlag, Berlin. pp 105-134. 1991.

Castellini, M.A., G.L. Kooyman and P.J. Ponganis. Metabolic rates of freely diving Weddell seals: Correlations with oxygen stores, swim velocity and diving duration. Journal of Experimental Biology. 165: 181-194. 1992.

Castellini, M.A., J.M. Castellini and V.L. Kirby. Blood glucose handling methods can compromise analytical results: Evidence from marine mammals. Journal of the American Veterinary Association. 201(1): 145-148. 1992.

Castellini, M.A., D.P. Costa and J.M. Castellini. Blood glucose distribution, brain size and diving in small odontocetes. Marine Mammal Science. 8(3): 294-298. 1992.

Castellini, M.A. and L.D. Rea. The biochemistry of natural fasting at its limits. Experientia. 48: 575-582. 1992.

Castellini, M. and D. Calkins. Mass estimates using body morphology in Steller sea lions. Marine Mammal Science. 9: 48-54. 1993.

Castellini, M.A., R.W. Davis, T.R. Loughlin and T.M. Williams. Blood chemistries and body condition of Steller sea lion pups at Marmot Island, Alaska. Marine Mammal Science. 2: 202-208. 1993.

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Project 95118-BAA.

IAB Proposal No. 94.102

A Research Proposal

To: NOAA
WASC Procurement Division
7600 Sand Point Way NE
BIN C 15700
Seattle, WA 98115-6349

From: Alaska Cooperative Fish and Wildlife Research Unit
University of Alaska Fairbanks
209 Irving Building
Fairbanks, Alaska 99775-7020

Date: June 28, 1994

Title: **Diet composition, reproductive energetics, and productivity of seabirds damaged by the *Exxon Valdez* Oil Spill**

Amount Requested: $ 413,689

Project Duration: 1 January 1995 - 30 September 1997

David D. Roby 6/28/94
Dr. Danied Roby, Principal Investigator Date
Alaska Coop. Fish and Wildlife Research Unit
209 Irving Building, University of Alaska Fairbanks
Fairbanks, Alaska 99775
907/474-6673

Gerald F. Shields 6/28/94
Robert G. White, Director Date
Institute of Arctic Biology
Fairbanks, AK 99775-1080

Ted DeLaca/cb 6/28/94
Dr. Ted DeLaca Date
Director, Office of Arctic Research
Fairbanks, AK 99775-1720

Project 95118-BAA

A. COVER PAGE

Project Title: **Diet Composition, Reproductive Energetics, and Productivity of Seabirds Damaged by the *Exxon Valdez* Oil Spill**

A Proposal in Response to: **BAA No. 52ABNF400104**

Principal Investigator: Daniel D. Roby

Lead Agency: University of Alaska Fairbanks

Cost of Project: $413,689

Project Dates: 1 January 1995 - 30 September 1997

Project Duration: 3 years[a]

Geographic Area: Prince William Sound and adjoining portions of the *Exxon Valdez* oil spill area

Contact Person: Daniel D. Roby
Alaska Cooperative Fish and Wildlife Research Unit
209 Irving Building
University of Alaska
Fairbanks, Alaska 99775-0990
907-474-6673

[a] Useful results can be obtained in two years, but to be maximally effective the project should be supported for a minimum of three years.

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B. INTRODUCTION

Three seabird species that were damaged by the *Exxon Valdez* oil spill (EVOS) are failing to recover at an acceptable rate: pigeon guillemot (*Cepphus columba*), common murre (*Uria aalge*), and marbled murrelet (*Brachyramphus marmoratus*). Damage from the spill to a fourth species of seabird, black-legged kittiwake (*Rissa tridactyla*), is equivocal, but recent reproductive failures of kittiwakes within the spill area may be due to longer term ecosystem perturbation related to the spill (D. Irons, pers. comm.). The status of pigeon guillemots and marbled murrelets in Prince William Sound (PWS) and the Northern Gulf of Alaska has been of concern for nearly a decade due to declines in numbers of adults observed on survey routes (Laing and Klosiewski 1993).

The failure of these seabirds to recover has been attributed to low reproductive success, but there is a troubling lack of information on the factors ultimately responsible for low productivity. One prevalent hypothesis is that changes in the abundance and species composition of forage fish resources within the spill area has resulted in food provisioning rates that are below the requirements of growing nestlings. Concurrent population declines in some marine mammals, particularly harbor seals, have also been blamed on food limitations. Whether these changes in forage fish availability are related to or have been exacerbated by EVOS is unknown.

Reproductive success in seabirds is largely dependent on foraging constraints experienced by breeding adults. Previous studies on the reproductive energetics of seabirds have indicated that productivity is energy-limited, particularly during brood-rearing (Roby 1991a). Also, the young of most seabird species accumulate substantial fat stores prior to fledging, an energy reserve that is crucial for post-fledging survival. Data on foraging habitats, prey availability, and diet composition are critical for understanding the effects of changes in the distribution and abundance of forage fish resources on the productivity and dynamics of seabird populations.

The composition of forage fish is particularly relevant to reproductive success because it is the primary determinant of the energy density of chick diets. Parent seabirds that transport chick meals in their stomachs (e.g., kittiwakes) or in a specialized pouch (e.g., auklets) normally transport meals that are close to the maximum load. Seabirds that transport chick meals as single prey items held in the bill (e.g., guillemots, murres, murrelets) experience additional constraints on meal size if optimal-sized prey are not readily available. Consequently, seabird parents that provision their young with fish high in lipids are able to support faster growing chicks that fledge earlier and with larger fat reserves. This is because the energy density of lipid is approximately twice that of protein and carbohydrate. Also, forage fish are generally very low in carbohydrate, and metabolism of protein as an energy source requires the energetically expensive process of excreting the resultant nitrogenous waste. While breeding adults can afford to consume prey that is low quality (i.e., low in lipid) when it is abundant, reproductive success is largely dependent on provisioning young with high quality food items. If prey of adequate quality to support normal nestling growth and development are not available, nestlings either starve in the nest or prolong the nestling period and fledge with low fat reserves.

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Forage fish vary considerably in lipid content, lipid:protein ratio, energy density, and nutritional quality. Much of the energy content of prey consumed by seabirds is in the form of neutral lipids, especially triglycerides and wax esters, and wax esters in particular are known to be difficult to digest (Nevenzel 1970, Lee et al. 1972, Benson et al. 1972, Sargent 1976, Clarke 1984, in press). In some seabird prey, such as lanternfishes (Myctophidae), lipids may constitute as much as 50% of dry mass (A. R. Place, pers. comm.); while in other prey, such as juvenile walleye pollock (*Theragra chalcogramma*), lipids are less than 5% of dry mass (J. Wejak, unpubl. data). This means that a given mass of lanternfish has more than twice the energy content of the same mass of juvenile pollock. Published values for lipid content (% dry mass) of other forage fish are intermediate between those of lanternfish and juvenile pollock: herring (Clupeidae)- 36.7%, sandlance (Ammodytidae) - 24.4%, smelt (Osmeridae) - 15.8%, capelin (*Mallotus villosus*) - 15.3% (Montevecchi et al. 1984, Barrett et al. 1987, Massias and Becker 1990). These studies have shown that for a particular species of forage fish, lipid content can vary widely with season, sex, reproductive status, and age class. For example, sandlance can vary from 10% lipid (% dry mass) to 31.5% lipid (Hislop et al. 1991) and gravid female capelin have nearly twice the energy density of male capelin (Montevecchi and Piatt 1984). By increasing the proportion of high-lipid fish in chick diets, parents can increase the energy density of chick meals in order to compensate for the low frequency of chick feeding (Ricklefs 1984a, Ricklefs et al. 1985).

C. PROJECT NEED

This study is relevant to EVOS Restoration Work because it is designed to develop a better understanding of how shifts in the diet of seabirds breeding in PWS affects reproductive success. Unlike marine mammals, seabirds offer the possibility of directly measuring diet composition and feeding rates, and their relation to productivity. By monitoring the composition and provisioning rates of seabird nestling diets, prey preferences can be assessed. Measuring provisioning rates is crucial because even very poor quality prey may constitute an acceptable diet if it can be supplied at a high rate. Understanding the diet composition, foraging niche, and energetic constraints on seabirds breeding within the spill area will be crucial for designing management initiatives to enhance productivity in species that are failing to recover from EVOS. If forage fish that are high in lipids are an essential resource for successful reproduction, then efforts can be focused on assessing stocks of preferred forage fish and the factors that impinge on the availability of these resources within foraging distance of breeding colonies in PWS. As long as the significance of diet composition is not understood, it will be difficult to interpret shifts in the utilization of forage fishes and develop a management plan for effective recovery of damaged species.

There is a definite need for information on the relationship between diet and reproductive success for pigeon guillemots, common murres, and marbled murrelets, all seabird species that are failing to recover from EVOS at an acceptable rate. However, the latter two species pose serious problems for studies of diet composition in the spill area. For common murres it is difficult to collect quantitative data on diet composition, feeding rate, meal size, and chick

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growth rates without seriously impacting productivity because this species nests in dense colonies on narrow ledges where human activity can cause high losses of eggs and chicks. Also, murre chicks leave the nest site to go to sea at only c. 21 days post-hatch, when they are only 20% of adult mass. In addition, the murre colonies most damaged by the spill and slowest to recover are located in the Barren Islands, where few nesting ledges are accessible. Marbled murrelet nests are usually located high in mature conifers and are very difficult to locate. Most nest visits by parents provisioning young occur at night, so monitoring chick diets is highly problematic. While some limited information on chick diets may be obtained as part of on-going EVOS studies of common murres in the Barren Islands (D. Roseneau, pers. comm.) and marbled murrelets breeding on Naked Island (K. Kuletz, pers. comm.), neither of these species are feasible study subjects for assessing the role of diet composition for seabird reproductive success in the spill area.

Guillemots are the most neritic members of the marine bird family Alcidae (i.e., murres, puffins, and auks), and like the other members of the family, capture prey during pursuit-dives. Pigeon guillemots are a well-suited species for monitoring forage fish availability for several reasons: (1) they are a common and widespread seabird species breeding in Prince William Sound (Sowls et al. 1978); (2) they primarily forage within 5 km of the nest site (Drent 1965); (3) unlike most seabird species, they do not breed in large, dense colonies; (4) they raise their young almost entirely on fish; (5) they prey on a wide variety of fishes, including schooling forage fish (e.g., sandlance, herring, smelt) and subtidal/nearshore bottom fish (blennies, sculpins; Drent 1965, Kuletz 1983); (6) the one- or two-chick broods are fed in the nest until the young reach adult body size. In addition, there is strong evidence that most guillemot pairs breeding at Naked Island within the spill area have specialized on schooling forage fish during the chick-rearing period, and that these pairs fail to raise young when forage fish are not available (Kuletz 1983). Guillemots carry whole fish in their bills to the nest-site crevice to feed their young. Thus individual prey items can be identified, weighed, measured, and collected for composition analyses.

Black-legged kittiwakes also breed abundantly in the spill area and rely largely on forage fish during reproduction. Unlike guillemots, kittiwakes are efficient fliers, forage at considerable distances from the nest, and capture prey at or near the surface. Although kittiwakes are highly colonial, cliff-nesting seabirds, they construct nests and can be readily studied at the breeding colony without causing substantial egg loss and chick mortality. Several breeding colonies of black-legged kittiwakes in PWS are easily accessible so that chicks can be weighed regularly without resorting to technical climbing (D. Irons, pers. comm.). Diets fed to kittiwake chicks in PWS consist primarily of schooling forage fish (i.e., sandlance, herring, juvenile walleye pollock), but when forage fish are scarce, euphausiids may be substituted. Like guillemots, kittiwakes can raise one- or two-chick broods, and chicks remain in the nest until nearly adult size. Together with pigeon guillemots, black-legged kittiwakes are excellent bioindicators of the distribution and abundance of preferred forage fish in PWS.

The proposed research is the first focused study to investigate the effects of diet composition on reproductive energetics and productivity of piscivorous seabirds in PWS. The research will result in a fundamental advance in our understanding of the significance of prey composition for pigeon guillemot and

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black-legged kittiwake reproduction, as well as for other seabirds and marine mammals that breed in PWS. The research will also provide new information relevant to several additional areas of study: (1) comparative biochemical composition and physiological condition of forage fishes, (2) factors such as age class, sex, size, and reproductive status as they influence the nutritional quality of forage fishes, (3) responses of breeding seabirds to shifts in prey availability, and (4) the energetic consequences of foraging on different prey with differing energy content. This research will be the first to (1) measure the nutritional quality of various forage fishes used by breeding seabirds in PWS, (2) use data on diet composition and provisioning rates to construct energetics models of chick growth and survival, and (3) monitor fat deposition rates of individual seabird chicks on differing dietary regimes by repeated, noninvasive analysis. In addition, the results will have broader implications for our understanding of dietary constraints on reproductive success in other piscivorous seabirds damaged by the spill (common murre, marbled murrelet) and will enhance our understanding of the adaptive significance of prey preferences in these seabirds. These results are crucial for understanding the factors constraining recovery of marine birds and mammals damaged by the spill.

D. PROJECT DESIGN

1. Objectives

The overall objective of the proposed research is to determine the energy content and nutritional value of various forage fishes used by seabirds breeding in the EVOS area, and to relate differences in prey quality and availability to reproductive success and physiological condition of breeding adults. The proposed research will emphasize pigeon guillemots and black-legged kittiwakes for practical reasons, but prey composition and quality will be evaluated for common murres, marbled murrelets, and tufted puffins as data and samples permit. Specific objectives are enumerated below:

1. To determine the nutritional quality of various forage fish species consumed by seabirds in the EVOS area as a function of size, sex, age class, and reproductive status, including:
    a) lipid content
    b) water content
    c) ash-free lean dry matter (protein) content
    d) energy density (kJ/g fresh mass)
    e) lipid composition (triglyceride, wax ester, mono- and diglyceride, free fatty acid, phospholipid)
2. To determine dietary parameters of pigeon guillemot and black-legged kittiwake chicks in PWS, including:
    a) provisioning rate (meal size X delivery rate)
    b) taxonomic composition of the diet
    c) biochemical composition of the diet
    d) energy density of the diet
3. To determine the relationship between diet and the growth, development, and survival of seabird nestlings. Variables measured will include:
    a) growth rates of total body mass, lean body mass, and total body fat
    b) rates and patterns of flight feather development

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c) fledging age and fledgling body mass and fat reserves

4. To determine the contribution of specific forage fish resources to the overall productivity of seabird breeding pairs, including:
   a) body composition (physiological condition) of parents raising chicks
   a) gross foraging efficiency of parents
   b) conversion efficiency of food to biomass in chicks
   c) net production efficiency of the parent/offspring unit

2. Methods

The proposed research approach utilizes a combination of sample/data collection in the field (in conjunction with other EVOS seabird studies in PWS) and laboratory analyses. Sample collection and field data collection will be conducted concurrently during the 1995, 1996, and 1997 breeding seasons at three guillemot and three kittiwake colonies in PWS. Thirty active and accessible nests of each species will be located and marked during early incubation at each of the study colonies during the three breeding seasons. These nests will be closely-monitored until the young fledge or the nesting attempt fails.

Fresh samples of forage fishes for proximate analysis will be collected using three techniques: (1) temporarily placing "neckties" on guillemot chicks to prevent them from swallowing prey delivered by parents and retrieving samples from chicks, (2) temporarily placing screens in the entrance of puffin nest burrows and retrieving the chick meals left by adults, and (3) collections from at sea trawls conducted as part of proposed studies of the distribution and abundance of forage fish in PWS. Kittiwakes transport chick meals in the stomach, so chick diet samples will consist of semi-digested food. Kittiwake meal samples are normally collected when chicks regurgitate during routine weighing and measuring. Fresh fish samples and kittiwake regurgitations will be weighed (± 0.1 g) in the field and immediately frozen for shipment to my laboratory at University of Alaska Fairbanks, where they will be kept in an ultra-low freezer at -70° C until proximate analysis. In the lab, forage fish specimens will be reweighed (± 0.1 mg), identified to species, aged, sexed, measured, and reproductive status (gravid, recently spawned, nonreproductive) determined. Kittiwake regurgitations will be sorted into prey classes to the extent feasible, but otherwise handled as with fresh prey samples. Forage fish specimens will be dried to constant mass in a convection oven at 60° C to determine water content. Lipid content of a subsample of dried forage fish will be determined by solvent extraction using a soxhlet apparatus and petroleum ether as the solvent system. Lean dry fish samples will then be ashed in a muffle furnace at 500° C in order to calculate ash-free lean dry mass by subtraction. A subsample of dried forage fish samples will be combusted in a bomb calorimeter to determine energy density. Energy content of chick diets will be calculated from both the energy densities determined by bomb calorimetry and the composition (water, lipid, lipid-free dry matter, and ash) of forage fish along with published energy equivalents of these fractions (Roby 1991).

The lipid composition of forage fish (percentage wax esters, triglycerides, mono- and diglycerides, free fatty acids, and phospholipids of total lipids) will be determined by extracting total lipids from a subsample of fresh-frozen forage fish using the Bligh and Dyer (1959) technique. Extracted lipids will then be separated into the various lipid classes and quantitated using TLC/FID analysis procedures. This procedure will allow us to determine the percentage of total lipids in forage fish that are in the form of wax esters and other refractory (hard to digest) lipid classes (Roby et al. 1986). My laboratory is equipped with all the instrumentation required for proximate analysis of samples, including a Soxtec HT-12 soxhlet apparatus; an Iatroscan TLC/FID system; and a Parr automated adiabatic bomb calorimeter.

Chick provisioning rates for pigeon guillemots and black-legged kittiwakes in PWS will be determined by monitoring active nests to determine meal delivery rates throughout the 24 h period. Average meal size, taxonomic and biochemical composition of the diet, and average energy density of chick meals will be determined as part of analyses of diet samples collected from guillemot and kittiwake chicks.

Known-age chicks will be weighed and measured regularly to determine individual growth rates throughout the nestling period. Total body fat of chicks at 20 and 30 days post-hatch will be determined by noninvasive (nondestructive) measurement of total body electrical conductivity

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(Walsberg 1988, Roby 1991). Fat reserves of chicks will be measured in the field using a total body electrical conductivity (TOBEC) fat analyzer (SA-3000 Small Animal Body Composition Analyzer from EM-SCAN, Inc., Springfield, IL) that I currently have in my lab. The TOBEC method relies on the major difference in conductivity between lipids and other body constituents to estimate total lean body mass (Pethig 1979; Van Loan and Mayclin 1987). The difference between total body mass, as determined by weighing, and lean body mass, estimated by TOBEC, provides an estimate of total body lipid. A major advantage of the technique is that measurements can be obtained rapidly and repeatedly without harm to the subject. Also, validation studies to date indicate that accuracy is high (r^2 = .996) (Bracco et al. 1983, Walsberg 1988, Roby 1991b). The SA-3000 TOBEC analyzer can be used in the field and powered from a 12 volt battery, so chicks can be measured for TOBEC and returned to their nest in a matter of minutes. Body mass, primary feather development, and total body fat measurements will be used to develop a condition index for each chick at 20 and 30 days post-hatch.

The effects of diet composition on the physiological condition of breeding adults will be monitored using a combination of direct and indirect methods. Attentiveness of adults will be monitored during the incubation period. Adults will be captured on the nest early in the chick-rearing period and body composition determined nondestructively by TOBEC analysis. Frequency of chick meal delivery and meal size will be determined during the chick-rearing period as part of diet composition studies.

Data on chick age-specific body mass, wing chord, and primary feather length will be separated by year and diet, and fit to Gompertz sigmoidal growth models. Growth constants (K), inflection points (I), and asymptotes (A) of fitted curves will be statistically analyzed for significant differences among years and diets. Lipid deposition rates from TOBEC analysis will be compared using slopes of least squares linear regression models. Gross foraging efficiency of adults will be calculated from daily energy expenditure by the following equation:

$$([M \cdot F \cdot D] + DEE) / DEE = GFE,$$

where M is average chick meal mass in grams, F is average frequency of meal delivery in meals day^{-1} $parent^{-1}$, D is energy density of chick meals in kJ/gram, DEE is adult daily energy expenditure in kJ/day, and GFE is adult gross foraging efficiency in kJ consumed/kJ expended. Daily energy expenditures of pigeon guillemots, black-legged kittiwakes, and common murres have been measured previously using the doubly-labeled water technique and are available in the published literature (Birt-Friesen et al. 1990). Net production efficiency of chicks as a function of age will be calculated by regressing the change in body mass over a 24 hour period against the mass of food consumed during the period, as determined by periodic weighing. Comparison of food conversion efficiency of chicks will provide an estimate of the relative energetic efficiency of diets composed of various forage fishes. The net production efficiency of the parent/offspring unit will be calculated for each diet and each year for both species using the equation:

$$CFCE / ([DEE \cdot 2] + [M \cdot F \cdot D]) = TNPE,$$

where CFCE is chick food conversion efficiency in grams of body mass gained per gram food ingested, TNPE is the total net production efficiency of the parent/offspring unit in grams gained by chicks per kJ of energy expended by both parents, and other variables are as described above.

3. Schedule

Field work in Prince William Sound will be conducted during the 1995, 1996, and 1997 breeding seasons. Data collection during three field seasons will be necessary in order to provide minimal information on interannual variation in diet composition and reproductive success. Guillemots and kittiwakes normally lay eggs from late May to late June and raise their young during July and early August. Active, accessible nests of the two study species will be located and marked early in the incubation period during late May and early June. Marked nests will be checked daily during the hatching period to determine hatching date, and chicks will be banded soon after hatching so that individual growth rates can be monitored throughout the nestling period. Samples of chick meals and measurements of chick feeding rates will be collected throughout the nestling

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period. Chicks will be monitored throughout the nestling period in order to determine growth rates, fledgling age and mass, and survival until fledging.

Following the field season, chick meals will be analyzed in the lab in order to determine the taxonomic and biochemical composition of guillemot and kittiwake diets and their relationship to chick growth and survival. These analyses will be completed before the next field season in order to determine the results prior to collecting additional samples from the field. A draft annual report will be prepared in April and a final report will be submitted in June.

Following the analysis of samples collected during the 1997 field season, data collected during the three field seasons will be analyzed for relationships between diet composition and reproductive success by May 1998. The results of these analyses of diet composition and its relation to productivity and chick growth will be prepared in manuscript form and submitted by the end of FY 1998.

4. Technical Support

Laboratory analyses of the biochemical composition and energy content of forage fishes will be conducted in the laboratory of the PI. No analyses will be subcontracted to other laboratories. No new laboratory equipment will need to be purchased for the proposed research with funds provided by the grant. A laboratory technician will be hired to help the PI and graduate research assistant with processing chick meals and diet samples, and with performing of routine laboratory analyses.

5. Location

The proposed field work will be conducted in PWS. PWS supports accessible breeding population of guillemots and kittiwakes that are more than adequate for the proposed research. Field work on guillemots will be conducted at breeding colonies on Naked Island, Fool Island, and Jackpot Island. Approximately 800 pigeon guillemots nest along the shores of Naked Island (Sanger and Cody 1993), as well as smaller number of marbled murrelets and tufted puffins. The Naked Island base camp would offer an ideal base for field studies on guillemots (D. Irons, pers. comm.), and Naked Island supports the highest breeding densities of guillemots in PWS (Sanger and Cody 1993). Fool Island has approximately 80 guillemot nests and Jackpot Island has about 60 guillemot nests and pairs are breeding at high densities in both sites (G. Sanger, pers. comm.).

Field work on kittiwakes in PWS will be conducted at breeding colonies at Shoup Bay, Icy Bay, and Blackstone Bay. Approximately 400 black-legged kittiwakes nest at the Shoup Bay colony, 1,100 at Icy Bay, and 2,000 at Blackstone Bay.

The at-sea foraging distribution of pigeon guillemots near Naked Island Fool Island, and Jackpot Island has been the subject of previous study (Sanger and Cody 1993), as has the species composition of the diet (Kuletz 1983). Kittiwake foraging distribution and reproductive success has been monitored at the Shoup Bay colony for several years (D. Irons, pers. comm.). A field camp operated by the U.S. Fish and Wildlife Service is available for field workers on Naked Island and Shoup Bay and is within walking distance of colonies where adequate numbers of accessible guillemot and kittiwake nests are available.

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E. PROJECT IMPLEMENTATION

The proposed research will be implemented by the University of Alaska Fairbanks, with assistance from and in cooperation with U.S. Fish and Wildlife Service biologists with expertise on the proposed study species in the proposed study area. The PI (Daniel D. Roby) has extensive experience with studies of the reproductive energetics of high latitude seabirds and the relationship between diet composition and productivity. The PI currently has in his laboratory the analytical equipment necessary to accomplish the proposed laboratory analyses and is familiar with the relevant analytical procedures. To the PI's knowledge, the expertise and equipment necessary for the proposed research are not available within the federal and state agencies that compose the Trustees Council. The PI will be assisted by a Graduate Research Assistant (Ph.D. candidate), Field Technician, and undergraduate field assistant who will be carefully selected from the applicant pool as qualified to participate in the proposed research.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

The research described in this proposal dove-tails nicely with on-going research to assess factors limiting recovery of seabird and marine mammal populations damaged by EVOS . It is also relevant to efforts toward developing seabird models as upper trophic level sentinels of changes in the availability of forage fish, such as sandlance, juvenile pollock, herring, capelin, smelt. The proposed research approach utilizes prey composition, reproduction rates, and energetics models to help identify and quantify the present level of forage fish availability within the PWS ecosystem. This approach is necessary because evaluation of the stocks of various forage fishes is extremely complex due to temporal and spatial variability and unpredictability in the distribution of forage fish in PWS.

Studies of foraging, reproduction, and population recovery following the EVOS are on-going for pigeon guillemots, common murres, and marbled murrelets. Black-legged kittiwakes are currently being used as indicators of ecosystem function and health within PWS. This proposal complements those studies without duplication of effort. The PI on the present proposal will work closely with Drs. David Irons, Kathy Kuletz, and David Roseneau to coordinate data collection in the field so as to minimize project cost and maximize data acquisition.

Cooperators include Dr. David Irons of the Migratory Bird Branch, U.S. Fish and Wildlife Service. Dr. Irons has had extensive experience working in the field with both guillemots and kittiwakes nesting in PWS, and is project leader for on-going studies of the reproductive success and status of these two species in PWS. Close coordination with Dr. Irons research teams at Naked Island and Shoup Bay will be essential for the success of the proposed research.

In order to understand dietary factors responsible for poor reproductive performance of seabirds in PWS, it will be important to conduct simultaneous shipboard work (hydroacoustics) to assess the distribution and abundance of forage fish at sea. That research was recently funded by the Trustees Council and will be invaluable for interpretation of data on diets collected as part of the present proposal. The research presented in this proposal is also highly relevant to a proposal for a Forage Fish Study entitled "Food limitation on recovery of

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injured resources: an ecosystem approach to the restoration of marine birds" (Project Coordinator: Dr. Scott A. Hatch). Dr. Hatch and I have been working closely to insure that the present proposal, if funded, would provide an important component of his larger proposed study without duplication of research he and his Co-PIs have proposed. Similarly, the results of the research proposals described in Dr. Hatch's proposal would substantially enhance interpretation of results from this proposed research.

G. PUBLIC PROCESS

The ideas, methods, and scope of work encompassed in this proposal were introduced and refined at both the April 1994 EVOS restoration planning workshop and at a follow-up meeting of public and government representatives interested in forage fish research. Similar opportunities for public input will be available on an annual basis, including two winter workshops sponsored by the Exxon Valdez Spill Restoration Office.

All the data generated during the proposed study will be duplicated, with one copy remaining in the permanent files of the PI at the University of Alaska Fairbanks, and the other copy will be retained by the Graduate Research Assistant. The Exxon Valdez Trustees Council Restoration Office and any other interested scientist, organization, or agency will be supplied with copies of any reports, thesis, or publications that result from the proposed research. The results of the proposed study will be part of the dissertation of the Graduate Research Assistant.

H. PERSONNEL QUALIFICATIONS

The PI (Daniel D. Roby) will be assisted by a doctoral student (graduate research assistant), a field technician, and two undergraduate research assistants with the field component of this research. They will collect most of the data on feeding rates, food types, and chick growth rates at the colony, assisted by and in cooperation with U.S. Fish and Wildlife Service personnel who are conducting on-going research on guillemots and kittiwakes as part of other EVOS restoration projects. The PI will visit the field sites during the peak of hatching for guillemots and kittiwakes in order to assist in setting up field data collection, validate the TOBEC technique for noninvasive measurement of body composition, and finalize the sampling protocol for chick feeding rates, meals sizes, and chick diet composition. The PI has had prior field research experience with the proposed study species in Alaska and Newfoundland. Laboratory analyses of samples collected in the field will be accomplished in the PI's laboratory at the University of Alaska Fairbanks by the Graduate Research Assistant and the Laboratory Technician under the direct supervision of the PI. Vita of the PI is attached as an appendix to this proposal.

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NOAA Budget			
	Oct94-Sept95 FY 95	Oct94-Sept96 FY 96	Oct96-Sept97 FY 97
SALARY			
Graduate Student, Ph.D.	$15,840	$16,315	$16,804
Field Technician, 4 mo.($8.79/hr:9.22/hr	$8,091	$8,274	$8,462
Lab Technician, 9 mo (10.70,Range 74)	$16,692	$17,193	$17,708
Benefits:			
- Lab Technician -Staff -	$10,951	$11,278	$11,616
TRAVEL			
Presentation at National Meeting - 2 RT		$3,000	$3,000
FAI/Valdez/FAI - 4 RT- $330/rt	$1,320	$1,320	$1,320
Per Diem for volunteer- $300/mo x 2	$2,400	$2,400	$2,400
2 rt Anc for workshop	$1,000	$1,000	$1,000
SERVICES			
Duplication/computer fees	$500	$700	$900
excess baggage	$300	$300	$300
Publication - page charges, reports	$500	$500	$2,400
Lease porta-shelter	$1,350	$1,350	$1,350
Lease - optical equipment	$450	$450	$450
Boat charter to study sites:			
Naked Is., Fool Is., Jackpot Is. & Shoup Bay,	$9,000	$9,000	$9,000
Blackstone, Icy Bay			
Vehicle rental	$800	$800	$800
Lease Zodiac	$800	$800	$800
Lab equipment maintenance	$3,000	$3,000	$3,000
Lease - battery top-loading balance	$1,000	$1,000	$1,000
Lease computer	$1,800	$1,800	$1,800
Lease HP 100 LX Palmtop	$1,200		
Lease Boat motor	$600	$600	$600
Telephone services	$400	$400	$400
EQUIPMENT			
none			
COMMODITIES			
Chemicals	$3,000	$3,000	$3,000
Chroma rods	$600	$600	$600
Thimbles, extraction	$450	$450	$450
Lab Supplies/analysis	$4,500	$4,500	$4,500
Food	$4,000	$4,000	$4,000
Sleeping bags	$1,000	$250	
scales	$350	$150	$150
sample bags	$200	$200	$200
tents	$600	$600	$600
miscellaneous camp supplies	$600	$600	$600
climbing equipment	$2,400		
STUDENT ASSISTANCE			
Tuition	$4,824	$2,512	$2,600
Total Direct Costs	$98,518	$96,342	$99,810
INDIRECT			
41.8%, less tuition & equipment			
	$39,164	$39,221	$40,634
SUBTOTAL COST OF PROJECT	$137,682	$135,563	$140,444
TOTAL COST OF PROJECT		**$413,689**	

MPW 6/28/94

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Project ~~95~~ 95119-BAA

A PROPOSAL TO NOAA PROCUREMENT DIVISION AND
EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL

EXXON VALDEZ OIL SPILL RESTORATION WORK

Response to Broad Agency Announcement 52ABNF400104

TITLE: Food Limitation on Recovery of Injured Marine Bird Populations

Principal Investigator:	William J. Sydeman
Co-Principal Investigator:	Nadav Nur
Lead Agency:	Point Reyes Bird Observatory Stinson Beach, CA 94970

Date: 30 June 1994

Total Cost of Project:	$275,815
Fiscal Year 1995:	$124,883
Requested Start Date/Completion Date:	January 1995/December 1996
Project Duration:	Two years
Geographic Area:	Central California
Contact Person:	William J. Sydeman
Address:	Point Reyes Bird Observatory 4990 Shoreline Highway Stinson Beach, CA 94970
Telephone No.	(415) 868-1221 FAX: 868-1946

Project 95119-BAA

INTRODUCTION: PROJECT NEED

In response to **NOAA BAA 52ABNF400104** we propose to investigate the role of food limitation on the recovery of injured marine wildlife resources, with a focus on marine birds c the family Alcidae. Alcids, the group of marine birds most seriously impacted by oil spills (c.f. Page et al. 1990, Piatt et al. 1990), include the Common Murre (Uria aalge), Pigeon Guillemot (Cepphus columba), Marbled Murrelet (Brachyramphus marmoratus), Rhinoceros Auklet (Cerorhinca moncerata) and Cassin's Auklet (Ptychramphus aleuticus). These species were killed or debilitated during the 1989 **Exxon Valdez** oil spill (Piatt et al. 1990), as well as other oil spills along the west coast of North America (e.g. Page et al. 1990).

An investigation of the relationship between forage availability, diet, and effects of diet on demographic factors is needed to explain marine bird population dynamics, forecast the growth and recovery of affected marine bird populations, and guide oil-spill related restoration options for marine birds. Predicting the growth potential and recovery time of affected populations and species requires information on the balance between recruitment rate and adult mortality, immigration and emigration characteristics of a population, and the availability of other, less affected stock to repopulate affected resources and populations (Burgman, Ferson, and Akackaya 1993). Many of these parameters are unknown for alcids (Hudson 1985), although some parameters have been recently estimated (e.g. Emslie, Sydeman, and Pyle 1992; Sydeman 1993; Nur 1993; Beissinger and Nur in prep.).

With extended periods of time, injured alcid populations may recover from catastrophic mortality associated with oil spills. However, the population recovery process may, in some cases, be enhanced with proactive restoration efforts. Restoration projects using decoys and playback of vocalizations (e.g. Podolsky and Kress 1989) have been proposed to restore Common Murre colonies affected by oil spills, such as the **Exxon Valdez**. However, restoration efforts of this type will meet with limited success if ecological resources, such as prey availability, are insufficient to sustain growing or recovering populations. The answers to basic ecological questions, e.g. how food controls or limits marine bird populations and the relationship between resource availability and critical population parameters (reproduction, survival, and recruitment), are thus required to predict the success of proposed restoration projects (see Birkhead and Furness 1985; Croxall and Rothery 1991; Cairns 1992).

Moreover, restoration of injured resources should be guided by knowledge of sensitive demographic traits. Yet, for most seabirds, the sensitivity of the intrinsic rate of population increase or the annual rate of population growth (lambda) to variation in specific demographic traits and/or variation in food supply has not been determined (Nur, Ford and Ainley 1994). Without this type of understanding, restoration may focus upon demographic parameters which have little or no effect on population growth.

To further our understanding of food limits on population growth and seabird demography, we propose a two part investigation involving (1) a retrospective analysis of alcid diet and at-sea foraging ecology in relation to demographic parameters, and (2) development and application of stochastic population models (Caswell 1989; Burgman, et al. 1993) to predict population recovery and estimate the sensitivity of population growth to specific demographic and prey availability parameters. The second part of the study includes application of findings and models developed to Alaskan alcid populations. The core of the proposed work exploits a unique 24-year time-series of alcid ecology, including year-round information on diet, age-specific diet composition, breeding ecology, and oceanic habitat use. collected by Point Reyes Bird Observatory (PRBO) on the Farallon Islands and in the Gulf c the Farallones in central California, 1971-1994 (see Table 1). In conjunction with

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Table 1. Available PRBO data on diet composition, demographic parameters, and foraging ecology of 4 species of alcids in the Gulf of the Farallones, California. na=not available.

Parameter	Common Murre	Pigeon Guillemot	Cassin's Auklet	Rhinoceros Auklet
chick diet	1973-1994	1971-1994	1977-1994[1]	1987-1994
feeding rate	1973-1994	1988-1994	1977-1994	1987-1994
adult diet	1985-1988	na	1985-1988	na
offspring production	1972-1994	1971-1994	1969-1994	1986-1994
chick growth	na	1971-1994[1]	1970-1994[1]	1987-1994
adult condition index	na	na	1978-1994	1987-1994
adult survival	1985-1994	1979-1994	1978-1994	1986-1994
juvenile survival	1992-1994	1979-1994[1]	1978-1994[1]	1987-1994
population size/index	1972-1994	1971-1994	1971-1994	1971-1994
oceanic habitat use	1985-1994	1985-1994	1985-1994	1985-1994

[1] Annual data for these parameters are intermittent.

NOAA/NMFS and CDFG fish and zooplankton stock assessments, these data provide a powerful tool for relating resource availability and marine bird population dynamics.

STUDY DESIGN AND OBJECTIVES

We will investigate the hypothesis that food limits population growth, hence the recovery of injured marine bird populations, through its effects on demographic traits: growth, mortality, reproduction, and recruitment. Our principle goal is to determine the functional relationship between variation in food supplies and demographic parameters for the alcids: Common Murre, Pigeon Guillemot, Rhinoceros Auklet, and Cassin's Auklet. To accomplish this goal, we will:

(1) Investigate temporal (annual, seasonal, and inter-decadal) and spatial variation in the diet of alcids in central California,

(2) Analyze available demographic data (growth, reproduction, survival, and recruitment) for alcids of the Farallon Islands,

(3) Investigate and establish relationships between diet composition and demographic parameters for Farallon Island alcids,

(4) Evaluate the energetic value of different alcid prey using bomb calorimetry (of previously collected samples) and estimate annual prey consumption based on observations of feeding rates and diet composition of chicks,

(5) Develop stochastic population models for 4 species to predict population trajectories and growth,

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(6) Incorporate variation in food availability in population models and project population growth and recovery under varying scenarios of resource availability,

(7) Apply models developed in (5) and (6) to Alaskan populations, utilizing available demographic information (e.g., reproductive success), and

(8) Conduct sensitivity analyses on population growth to guide restoration activities in Alaska under varying scenarios of resource availability, diet composition, and demographic parameters.

In addition, the project will involve the integration of diet and demographic results with NOAA/NMFS fish and zooplankton stock assessments. NMFS, Tiburon Laboratory, has conducted standardized mid-water trawls each year from 1983 to the present on the availability of rockfish (Sebastes spp.) and krill (Euphausidae) in the Gulf of the Farallones (Adams 1993). Farallon Island alcids feed extensively on these prey throughout the year (Ainley and Boekelheide 1990). Thus, the NMFS data provides a unique opportunity to relate an independent measure of resource availability with alcid diet and demographic parameters. Finally, in conjunction with the NMFS cruises, we have conducted censuses of alcids at sea during the breeding and pre-breeding seasons. These data are critical to understanding the relationship between productivity and diet. Birds forage at different locations depending upon the type of prey sought. The distance between the colony and feeding locations varies, hence diet selection may influence feeding rates, chick growth and, ultimately, reproductive success. For this aspect of the project, we will map foraging locations using GIS software and correlate oceanic habitat characteristics with diet and demography. This effort will provide habitat-specific understandings of the relationship between ocean resources and alcid population dynamics.

PRODUCTS

Our investigation will provide the Trustee Council with a comprehensive ecological understanding of the importance of food limitation on the recovery of injured marine bird populations, with a focus on the group of birds most often injured by oil spills. The investigation will help to explain why marine bird resources have not recovered more rapidly following the **Exxon Valdez** oil spill and why, for some colonies, long-term problems persist. The importance of determining the relationship between ocean resources, diet and population dynamics cannot be understated; the successful restoration of affected marine bird populations is wholly dependent upon resource variability and its effect on alcid demography. These relationships have, in general, been inadequately studied. Thus, the project will contribute to the restoration of injured resources through an understanding of basic ecological relationships. Furthermore, our modeling efforts will predict population growth under realistic ecological constraints. Lastly, sensitivity analyses will provide information on which demographic traits strongly influence population growth and which have minimal effects. For example, given the longevity of alcids, we may discover that maximizing adult survival, rather than attempting to increase productivity is more important to the population recovery process. These analysis should guide future restoration programs. Overall, the project will help NOAA and other agencies prioritize management goals and restoration options, given ecological constraints associated with food resources.

PROJECT IMPLEMENTATION AND COORDINATION

PRBO will be the lead organization in the project; our qualifications are listed below. Because of the unique nature of the data available to us, we feel that competitive

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procurement process is not necessary. The project is collaborative with UC Davis, NOAA's NMFS, NSF's GLOBEC program (through James Quinn, UC Davis), USFWS Farallons National Wildlife Refuge, and California Department of Fish & Game.

PUBLIC PROCESS

In addition to public involvement through the usual channels appropriate to activities of the Exxon Valdez Oil Spill Trustee Council (e.g., review by the Public Advisory Group), results of the project will be presented at major scientific conferences to which the public is invited.

STATEMENT OF QUALIFICATIONS

PRBO and its key personnel (PI Sydeman, co-PI Nur; together with D. Ainley and L. Spear) are uniquely qualified to meet the goals of this research program. In addition, Dr. James Quinn (UC Davis) will make an important contribution to research efforts, especially in relation to analysis and modeling of spatial variation in prey distribution. PRBO biologists on the proposed project have over six decades of direct field experience with marine birds and have been involved with oil spill damage assessments in California and elsewhere in the world for the past 25 years. We have investigated and published upon many aspects of seabird ecology over the past decade, including over 20 peer-reviewed scientific contributions specifically concerning alcid demography, population dynamics, and food web interactions (curriculum vitae provided upon request).

William Sydeman is Director of Farallon Island Research at PRBO. He has published extensively on seabird demography including relationship to the environment. He is PI or co-PI on several relevant seabird projects currently being conducted on the Farallon Islands, including two for the Gulf of the Farallones National Marine Sanctuary and the California Department of Fish & Game (Oil Spill Response Program). The latter is a project investigating the long-term effects of chronic oiling on Common Murres of Central California and is being carried out with Nadav Nur and David Ainley, among others.

Nadav Nur is Theoretical Ecologist at PRBO. He has expertise in state-of-the-art analysis of demographic parameters and recently organized a workshop on this subject. He has carried out demographic modeling of Common Murres, Brandt's Cormorants, Western Gulls (this work done with David Ainley; see Nur et al. 1994) and Marbled Murrelets (Nur 1993), as well as terrestrial species, e.g., Osprey (Nur & Geupel 1994). Together with David Ainley he carried out a literature review of marine bird population recovery potential for the **Exxon Valdez** Restoration Working Group (Nur and Ainley 1992).

David Ainley is Director of Marine Research at PRBO. He has been working on prey diet of seabirds for decades, first at the Farallon Islands (summarized in Ainley & Boekelheide 1990), and more recently in the Pacific and the Antarctic (these results summarized in numerous scientific publications in peer-reviewed ecological journals). Since 1985 he has been collaborating with National Marine Fisheries Service regarding habitat characteristics of pelagic seabirds in the Gulf of the Farallones. Current work includes demography of endangered shearwaters on Kauai island (together with Nadav Nur).

Larry Spear is seabird biologist at PRBO. He has extensive experience with calorimetry analyses (see Spear 1993) and with studies of at-sea seabirds in the Gulf of the Farallones and elsewhere in the Pacific Ocean, conducted over the past 15 years. He has published 31 peer-reviewed articles on seabirds in scientific journals.

James Quinn is Professor of Environmental Studies at University of California, Davis. He has worked extensively on spatial modeling of planktonic populations in relation to

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oceanographic factors, work currently supported by the NSF GLOBEC program and Sea Grant. This work would contribute directly to the proposed project, as would the Geographic Information System (GIS) laboratory that Quinn has established at UC Davis.

PRBO has demonstrated its ability to successfully administer large contracts and grants in the past. The institution has administered over $2M in grants and contracts in the past 5 years.

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BUDGET SUMMARY

			Total Project	Fiscal Year
1995				
1.	Personnel		175600.00	75600.00
	Wm. Sydeman	1600 Hours		
	D. Ainley	1200 Hours		
	N. Nur	1040 Hours		
	L. Spear	400 Hours		
	Other	1520 Hours		
	Benefits @ 15%		26340.00	11340.00
2.	Travel/Per Diem		12948.00	4316.00
3.	Contractual Services		3000.00	1500.00
4.	Commodities/Supplies, etc.		1000.00	500.00
5.	Equipment		4000.00	4000.00
6.	Capital Outlay		8500.00	8500.00
7.	General Administration		44427.00	19127.00
8.	Fixed Fee		.00	.00
		TOTAL:	275815.00	124883.00

BUDGET SUMMARY BY TASK

		Personnel	Total Hours
(A)	RETROSPECTIVE DATA ANALYSES:		
1.	Analysis of Annual, Seasonal and Spatial Diet Composition:	4 FTE	800.00
2.	Analysis of Demographic Parameters:	4 FTE	720.00
3.	Relationships Between Diet Composition and Demography, Growth and Condition:	5 FTE	720.00
4.	Consumption of Prey and Prey Bioenergetics:	5 FTE	720.00
5.	Ocean Habitat Use in Relation to Diet:	2 FTE	880.00
(B)	MODEL DEVELOPMENT AND SENSITIVITY ANALYSIS:		
1.	Compilation of published/unpublished Alaskan data	2 FTE	320.00
2.	Model development and application	2 FTE	480.00
(C)	SUMMARY, INTERPRETATION AND REPORT PREPARATION:	5 FTE	1120.00

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Project 95120-BAA

1. Project Title: Proximate Composition and Energetic Content of Selected Forage Fish Species in Prince William Sound, AK

2. Project Leader: Graham A.J. Worthy, Ph.D.

3. Lead Agency: Physiological Ecology Research Laboratory,
Marine Mammal Research Program,
Texas A&M University
4700 Avenue U, Bldg 303
Galveston, TX 77551

4. Cost of Project: FY95: $38.4K
FY96: $37.0K
FY97: $37.0K

5. Project Dates: October, 1994 - September 30, 1998

6. Project Duration: 3 Years

7. Geographic Area: Prince William Sound, AK

8. Contact Person: Graham A.J. Worthy
Marine Mammal Research Program
4700 Avenue U, Bldg 303
Galveston, TX 77551
(409) 740-4721
(409) 740-4717 FAX
e-mail *WORTHY_G@TAMUG2.TAMU.EDU*

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INTRODUCTION

As a result of damage assessment studies initiated after the T/V *Exxon Valdez* struck Bligh Reef in March, 1989, it was noted that several pelagic-feeding marine mammal and seabird species found in Prince William Sound, AK were apparently not recovering back to predisturbance population levels. This lack of recovery may be due to a number of factors, including possible food limitations. Food limitations have been suggested to be a problem for a variety of species which are found throughout the Bering Sea and Gulf of Alaska (Wooster 1993). While cause-effect relationships are difficult to demonstrate, changes in the energetic value of prey species can be quantified and these values used in the interpretation of energy availability to the impacted species. In Prince William Sound, two marine mammal species [harbor seals (*Phoca vitulina*), and sea otters (*Enhydra lutris*)] and several seabird species [common murre (*Uria aalge*), harlequin duck (*Histrionicus histrionicus*), marbled murrelet (*Brachyramphus marmoratus*), and pigeon guillemot (*Cepphus columba*)] have been impacted and are not recovering (Anonymous 1993). Others, such as killer whales (*Orcinus orca*) are recovering but may be indirectly inhibiting the recovery of other species if food competition is a problem.

There is increasing interest in the use of energetic models to study interactions between marine mammals or seabirds and their prey species (*e.g.* Jones and DeGange 1988). Often these models are based upon energy transfer between predator and prey (*e.g.* Wooster 1993). Although these models require information on the energy content or proximate composition of these species, few data are available. Those data which have been published have limited application due to the inherent seasonal and annual variability in the value of the prey (Stansby 1976, Hislop *et al.* 1991, Perez 1994). The goal of this proposed research is to assess on a seasonal and annual basis, the value of the major prey species which would be of significance to the mammalian and avian predators listed above. These data will allow for the development of models which may yield reasons for the lack of recovery of these species.

NEED FOR THE PROJECT

This study will provide the background data necessary for future studies of food web dynamics and ecology of many species of fish, birds and mammals of Prince William Sound. In any long term study of foraging ecology, especially those investigating the recovery of impacted species, knowledge of prey species composition and energetic value is critical in the interpretation of consumption rates and therefore the impact of consumer species upon prey species stocks. Compositional analysis will also yield important information on the general quality of the environment by assessing the condition of important prey species.

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PROJECT DESIGN

1. Objectives: The objectives of this study are to assess the seasonal and annual changes in the proximate composition of the major forage fish species in Prince William Sound, AK. Data on the composition and energetic value of prey species for marine mammals and sea birds are very limited. Most data which are available are for commercial species which are consumed by humans. These data are further limited, in their ecological application, because they usually only analyze the edible fillets which people consume. Another major limitation in the database relates to the lack of an appreciation for the magnitude of seasonal variability which occurs. For example, herring (*Clupea harengus*) can vary from as little as 3% lipid to as much as 22% lipid seasonally (Worthy 1985). Knowing the energy content and composition of these species will allow us to further enhance our understanding of the energetics and physiological ecology of the major consumer species in the Sound.

2. Methods: Species which should be collected are listed in Table 1. Samples should be frozen immediately after collection and be representative of the size classes which are known to be consumed by the consumer species in question.

All analytical techniques are described in detail in Worthy and Lavigne (1983) and Hislop *et al.* (1991). Analysis will be performed on freeze-dried, ground fish and will include determinations of water content, total lipid content, total protein content, ash content and energy density. Initially, wet mass, sex and length of each individual specimen will be recorded. Specimens would then be combined, ground and homogenized prior to freeze-drying. Water content will be determined gravimetrically by lyophilization of ground homogenized prey until constant mass has been obtained. This will be accomplished using a LabConco Lyophilizer over a period of 4-5 days. Once the samples are dried, they are finely ground using a Spex 8000 Mixer/Mill. This ground material will be used in all subsequent analyses and will be available for other investigators to use for future studies.

Lipid content will be measure gravimetrically by Soxhlet extraction using petroleum ether as the solvent. Protein content will be assessed using a modified Kjeldahl analysis and ash content will be determined by ashing at 550°C for 24 h in an ashing oven. Ground lyophilized samples will be analyzed for energy content by means of a Parr adiabatic bomb calorimeter.

3. Schedule: It is suggested that sampling be conducted a minimum of two seasons per year, when maximum productivity is occurring. If samples can be opportunistically obtained on a more regular basis, then a more detailed assessment of seasonal changes can be undertaken.

4. Technical Support: Collections will be done during NMFS and ADF&G cruises, charter cruises, and through the purchase of fish from local fishermen. All of the required equipment and expertise for this project are on-site at Texas A&M University - Galveston. This includes all of the specialized equipment required for the

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composition and energetics analysis, as well as archival capabilities for samples and the computer related software for full statistical analysis of the data.

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5. Location: Collections will take place throughout Prince William Sound and surrounding waters.

PROJECT IMPLEMENTATION

This proposal is being submitted by the Physiological Ecology Research Laboratory (PERL) of the Marine Mammal Research Program (MMRP) of Texas A&M University - Galveston. The PERL is already collaborating with National Marine Fisheries Service, National Marine Mammal Laboratory, on two other projects related to the ecology of killer whales and use of stable isotope tracers in Prince William Sound. All of the data obtained in the present study will also be incorporated into the Integrative Marine Mammal Ecosystem Program.

The PERL has 20 years of combined experience in the analysis of prey species of marine mammals for their composition and energetic value. The ultimate aim of the PERL is to develop a library of prey species samples which could be made available to researchers for future analyses, as well as to make available data on long-term changes in prey species energetic values. The PERL currently is involved in similar projects in California, Texas, Florida and eastern Canada.

COORDINATION OF INTEGRATED RESEARCH EFFORT

Collection of prey species will be undertaken by NMFS as well as other agencies operating in Prince William Sound. Additionally dedicated cruises may be required for the collection of certain species. Samples will be archived for potential future use by other investigators interested in this area.

PUBLIC PROCESS

We encourage all aspects of public input into this proposal.

PERSONNEL QUALIFICATIONS

Dr. Graham Worthy's research interests relate to the understanding of the physiological ecology of marine mammals through the study of their energetics, growth and nutrition. His research program integrates laboratory and field based investigations utilizing stable and radioisotopes, calorimetry, compositional analyses, and radio/satellite tracking techniques in an attempt to elucidate the capabilities of different species to withstand normal seasonal variation in their environment. Worthy's program includes on-going investigations into the life history parameters and the physiological ecology of manatees, cetaceans, and pinnipeds. The overall program centers around the energy requirements of marine mammals and how the availability and

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quantity of food impacts their survival and growth. To that end Worthy is involved in studies investigating the thermoregulatory capabilities, water balance, feeding ecology and free-ranging energetics of several important species of marine mammals.

Tamara Miculka's research experience is in the analysis of prey species for proximate composition. Miculka has been involved in studies relating to the seasonal changes in prey species composition of the 13 major prey species of the bottlenose dolphin in the Banana River region of Florida, analysis of diet of captive marine mammals at Sea World parks, annual variability in the composition of herring in three California bay systems, and the assessment of assimilation efficiency in captive marine mammals. Miculka has also been involved in studies of the composition and insulative quality of cetacean and manatee blubber, and metabolism and thermoregulatory capabilities of manatees.

BUDGET

	FY95	FY96	FY97
1. Personnel:	$15.5K	$15.5K	$15.5K
2. Travel:	$ 3.0K	$ 3.0K	$ 3.0K
3. Contractual Services		$ 0.0K	$ 0.0K $ 0.0K
4. Commodities	$ 3.5K	$ 3.5K	$ 3.5K
5. Equipment	$ 1.0K	$ 0.0K	$ 0.0K
6. Capital Outlay	$ 0.0K	$ 0.0K	$ 0.0K
7. General Administration		$ 3.5K	$ 3.5K $ 3.5K
8. Indirect Costs (45%)		$11.9K	$11.5K $11.5K
Total Project Costs	$38.4K	$37.0K	$37.0K

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Table 1: Forage fish species, of significance in the Prince William Sound System, which are proposed to be studied for composition and energetic value in the present study. Suggested species were determined by assessing their importance to the various seabirds and marine mammals which are found in Prince William Sound. Some species are of importance only to the larger species such as killer whales (*Orcinus orca*).

Common Name	Scientific Name
Pacific herring	*Clupea harengus pallasi*
Rockfish	*Sebastes sp.*
Cutthroat trout	*Salmo clarkii*
Capelin	*Mallotus villosus*
Rainbow smelt	*Osmerus mordax*
Sand lance	*Ammodytes hexapterus*
Eulachon	*Thaleichthys pacificus*
Pacific cod	*Gadus macrocephalus*
Walleye pollock	*Theragra chalcogramma*
Sablefish	*Anopoploma fimbria*
Pacific sandfish	*Trichodon trichodon*
Pink salmon	*Onchorhynchus gorbuscha*
Sockeye salmon	*O. nerka*
King salmon	*O. tshawytscha*
Silver salmon	*O. kisutch*
Chum salmon	*O. iceta*