12.06.04 2of 5

Recruitment patterns of Nearshore Clam Populations in Prince William Sound

Project Number:	95025-G
Project leader:	Glenn R. VanBlaricom Washington Cooperative Fish and Wildlife Research Unit, Division of Cooperative Research National Biological Survey
Cost of project:	FY 95: $121.3K Future years: $401,4K Total project cost: $522,7K
Start up date:	1 October 1994
Completion date:	30 September 1999
Project duration:	5 years
Geographic area:	Central and western Prince William Sound
Contact person:	Glenn R. VanBlaricom Washington Cooperative Fish and Wildlife Research Unit School of Fisheries, WH-10 University of Washington Seattle, Washington 98195 (206) 543-6475, FAX 685-7471

B. INTRODUCTION

Nearshore clam populations in Prince William Sound (PWS) are a biological resource injured by the *Exxon Valdez* oil spill (EVOS). Patterns of recovery of clam populations from the EVOS are unknown. Clams are an important food resource for sea otters in PWS, a biological resource also injured by the EVOS. Sea otters in PWS have not recovered from the oil spill. It is possible that damage to clam populations has contributed to the failure of sea otter populations to recover from the EVOS.

Dynamics of clam populations often are influenced substantially by patterns of recruitment. Intensity of recruitment in clams may vary significantly among years, and there may be some years in which recruitment does not occur. Large interannual variations in recruitment may cause coincident large variations in clam abundance, with important consequences for species that feed on clams.

This project will describe patterns of recruitment in nearshore clam populations known to be significant prey for sea otters in FWS. Age structure of clam populations will be used to determine the frequency and intensity of successful recruitment events in years recently past.

Present rates of recruitment will be measured and coorelated with environmental variables such as current pattern, water temperature, and primary production in the water column. The results will be used to examine the hypothesis that low rates of clam recruitment are contributing to lack of recovery from EVOS damage in clam and sea otter populations in PWS. In addition, results may be useful in evaluating the hypothesis that recent fluctuations in clam populations, and consequent effects on predators such as sea otters, are largely independent of EVOS damage.

This project is most likely to be effective in achieving stated goals if it is pursued over several years. However, limitation of work to FY-95 will provide sufficient information to complete some tasks (see Project Design).

C. NEED FOR THE PROJECT

This project will address three important issues regarding the restoration of nearshore clam populations and sea otter populations in PWS. First, it will provide useful information about how injured resources are recovering. Clam populations are recognized as an injured resource, but recovery trends are unknown. Documentation of recruitment patterns will provide useful information for determination of population growth trends for clams. Second, the project will contribute to resolution of problems that may be constraining a second injured resource, sea otters, from recovery. Clams are the most important source of nutrition for sea otters in PWS. If current and recently past recruitment patterns are contributing to low productivity in clam populations, sea otters may be suffering a consequent inability to recover effectively from EVOS damage. Third, clams are locally important subsistence and commercial fishery resources in certain portions of the PWS region. An improved understanding of recruitment effects on clam availability will contribute to more judicious management of clam resources for human use during the recovery period.

Improved understanding of clam recruitment, clam population dynamics, and resulting effects on sea otters will provide managers with better abilities to select restoration options likely to succeed, and to discard options likely to be ineffective and wasteful of limited resources. Recruitment data therefore will contribute directly to improved efficiency in restoration activity. In addition, an improved recruitment database may permit informed estimates of the time course required for recovery of clam populations. finally, information on effects of adult transplantation for broodstock enhancement may provide managers with insight to a pro-active technique for clam population restoration.

D. PROJECT DESIGN

1. Objectives

1. Assemble, synthesize, and evaluate published literature on recruitment patterns of clam species that are common in nearshore habitats of PWS and are a significant part of the diet of PWS sea otters. Incorporate relevant information on recruitment for clam

species closely related to those common in PWS.

2. Determine the age structures of existing clam populations in nearshore habitats at selected sites in PWS. Taxa to be evaluated will include, but are not limited to: *Saxidomus giganteus, Protothaca staminea, Tresus capax, Clinocardium nuttallii, Serripes groenlandicus, Mya arenaria, Mya truncata, Macoma* spp., and *Hiatella arctica*. Some of the above taxa may be deleted because of individual site characteristics. Populations wil be sampled in the intertidal zone and at two subtidal depths within the dive range of foraging sea otters. We will gather samples at three similar sites in each of four study areas. Age structure data will be used to determine interannual variation in recruitment intensity in years recently past for the subject taxa.

3. Determine effects of adult transplantation on local patterns of clam recruitment. Groups of adult clams of selected species will be transplanted to areas characterized both by low density of adults and low recruitment rates, as determined by work done in tasks 1 and 2. Annual samples will be gathered in transplant areas and in corresponding control areas to determine differences in rate of recruitment.

4. Determine rate and pattern of recruitmen to settlement containers. Containers will be placed in habitats comparable to those sampled in Task 2. Containers will hold defaunated natural sediments. Settlement data ill be collected quarterly, allowing assessment of current variation in recruitment intensity by season and year.

5. Examine correlations of recruitment intensity of clams with habitat and oceanographic variables assessed in other EVOS-related projects. Determine if such variables as current pattern, planktonic primary production, water temperature, run-off, or other factors can be used to predict recruitment intensity for clams.

2. Methods

1. This work will be done primarily by library database searches and consultation with present and past participants in EVOS Damage Assessment, General Restoration, Research and Monitoring, Habitat Protection, and related activities. Compilation of information will be completed by 30 June 1995, and a report will be completed by 30 September 1995. Work will be done in the library system at the University of Washington, and through direct contact with individuals involved in the listed EVOS-related activities.

2. Samples will be gathered at three sites in four study areas during summer 1995. Tentative study areas are north Knight Island/Naked Island, South Knight Island, Green Island/Montague Island, and Port Nellie Juan. In randomly-selected plots, clams will be gathered from intertidal habitats by digging and screening sediments, and from subtidal depths by diver-deployed suction dredge. Tentative depths for subtidal samples are 6 and 12 m. Measuring and aging of clams will be completed during field work. Data

entry and analyses will be completed by 30 November 1995. A technical manuscript will be completed and submitted for publication by 31 March 1996.

3. Based on field work for task 2 in summer 1995, sites characterized by low adult clam density and low recruitment frequency will be identified. In alte summer 1995 adult clams will be collected from outside study areas by digging (intertidal) or diver-deployed suction dredge (subtidal) and placed at least three locations. A like number of sites with similar characteristics will be designated as controls. Experimental and control sites will be sampled (digging or suction-dredging) for juvenile densities during summers of 1996, 1997, and 1998. Data entry and analyses will be completed by 31 December 1998. A technical manuscript will be completed and submitted for publication by 31 March 1999.

4. Settlement containers will be placed in study sites as indicated for task 2. Initial deployment will be done in summer 1995. During quarterly visits to study sites, containers will be retrieved for processing, and replaced with new containers. Thus, each container will have an exposure period of three months. quarterly sampling will continue through summer 1988. Data entry and analyses will be completed by 31 January 1999. A technical manuscript will be completed and submitted for publication by 30 August 1999.

5. This task primarily will involve consultation with other EVOS Restoration participants working on oceanographic characteristics and planktonic ecology during the period of our study. We will attempt to collaborate with other investigators to determine associations and correlations among clam recruitment patterns and significant oceanographic and planktonic events. Recruitment data will be integrated with other relevant data anlually during the project, with a completion date of 1 March each year beginning in 1996 and concluding in 1999. A technical report will be completed and submitted for publication by 30 September 1999.

Technical support for each task will be managed through the Washington Cooperative Fish and Wildlife Research Unit (WACFWRU; computer analyses and data archiving) and the University of Washington (library services and bibliographic database searches).

Field work for the project will be done at study sites in western and central Prince William Sound, Alaska, as specified above for task 2. Laboratory work, data analyses, and production of reports will be done primarily at WACFWRU, School of Fisheries, University of Washington, Seattle, Washington.

E. PROJECT IMPLEMENTATION

The proposed project will be done by WACFWRU. WACFWRU is part of the Division of Cooperative Research, National Biological Survey, U.S. Department of the Interior. WACFWRU has an established history of success in interdisciplinary studies of the effects of human activities on natural ecosystems. WACFWRU is in a position to take advantage of the substantial expertise and resources of the University of Washington in data management and analyses, coastal marine ecology, and fisheries.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

We propose that our work will be integrated with other new and existing studies of damaged resources relating to sea otters and their habitats in Prince William Sound. These include new work proposed for study of intertidal mussels, sea urchins, subtidal bivalves, and their predators, especially sea ducks and sea otters. In addition, we propose to integrate our work with studies of eater column oceanography and ecology as noted in task 5 above. Integration will be achieved by coordinating proposal submission and project management through the Alaska Science Center of the National Biological Survey, a process which has already begun. In addition, we will pursue frequent communication and meetings with investigators in related projects in order to refine project goals, minimize overlap in field sampling, and maximize sharing and efficient use of vessel charters, sampling supplies and equipment, and field time.

G. PUBLIC PROCESS

We will participate in all public meetings, workshops, and related activities organized by the EVOS Trustee Council, and in related meetings as requested by the Council. In addition, we will present interim results at technical workshops and meetings of Scientific Societies in order to maximize input from the scientific community on refinement of project goals and questions, and quality, relevance, and clarity of data analyses and conclusions.

H. PERSONNEL QUALIFICATIONS

Glenn R. VanBlaricom has done research on coastal ecosystems since 1970, and has been involved in research on sea otters and their ecosystems for 17 years. VanBlaricom studied relationships of sea otters and intertidal mussels in Prince William Sound from 1978 through 1986 and published papers on population age structure and individual growth rate of mussels, and effects of foraging by sea otters (see attached vita). VanBlaricom worked on sea otter rescue and rehabilitation in the immediate aftermath of EVOS, primarily in the Kenai region, and has published one paper on rehabilitation strategies. Currently VanBlaricom is Assistant Unit Leader (Wildlife), Washington Cooperative Fish and Wildlife Research Unit, and is Associate Professor of Fisheries in the School of Fisheries, University of Washington. VanBlaricom currently serves on the Scientific and Statistical Committee of the Pacific Fisheries Management Council, the Committee of Scientific Advisors of the Alaska Sea Otter Commission, and the board of Governors of the Society for Marine Mammalogy (SMM), the world's preeminent technical society for research and management of marine mammals. In 1993 VanBlaricom was recognized by SMM with the first Award for Excellence in Scientific Communication at the SMM Biennial Conference in Galveston, Texas.

Graduate student: This project will provide partial support for the doctoral dissertation research of Mr. Allan K. Fukuyama. Fukuyama has studied the ecology of coastal marine habitats for 20 years, and has experience in the study of coastal marine mammal populations including sea otters. Fukuyama has extensive experience in studies of the effects of EVOS on benthic, planktonic, and fish communities, with particular emphasis on affected intertidal habitats (see attached vita). He has published papers on EVOS effects, and on the ecology of marine bivalves, shorebirds, sea otters, and other marine mammals. Fukuyama will enter the doctoral program at the School of Fisheries, University of Washington, in fall 1994 under the sponsorship of Dr. VanBlaricom.

I. FY95 BUDGET($K)

Salary for Dr. VanBlaricom and administrative and analytical support will be provided by the Washington Cooperative Fish and Wildlife Research Unit, National Biological Survey (WACFWRU). Stipend support for Mr. Fukuyama will be provided by the Hazardous Marerials Response and Assessment Division, National Oceanic and Atmospheric Administration (NOAA/HAZMAT), through a research work order to the University of Washington (UW) and WACFWRU. The University of Washington will waive $36,925 in overhead costs through its cooperative agreement with WACFWRU. The following summarizes estimated cost chare totals by contributing organization:

National Biological Survey	$ 10.0K
NOAA/HAXMAT	$ 30.0K
University of Washington	$ 37.0K

Estimated proposal costs, excluding cost-share contributions, FY 95:

Personnel	$ 0.0K
Travel	
Airfare (5 trips, 2 people)	$ 6.0K
Transportation-Whittier	$ .5K
Per diem	$ 6.0K
Subtotal	$12.5K
Contractual Services	
Vessel charter (@ $1500/d)	$45.0K
Subtotal	$45.0K
Commodities	
SCUBA tanks	$ 2.0K
Other SCUBA gear	$ 2.0K
Collection & storage supplies	$12.5K
Computer supplies	$ .5K
Gasoline	$ 3.0K
Subtotal	$20.0K
Equipment	
SCUBA compressor	$11.0K
Dissecting microscope	$ 8.0K
Laptop computer	$ 4.0K
Binoculars	$ 2.0K
Spotting telescope/tripod	$ 3.0K
Subtotal	$28.0K
General administration	
Indirect costs, UW (@15%)	$15.8K
Subtotal	$15.8K
Total	$121.3K FY 95

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Effects of Predatory Invertebrates on Nearshore Clam Populations in Prince William Sound

Project 95025 H

Project leader: Glenn R. VanBlaricom

Lead agency: Washington Cooperative Fish and Wildlife Research Unit
Division of Cooperative Research
National Biological Survey

Cost of project:

FY 95:	$118,350
Future years:	$138,320
Total project cost:	$256,670

Start up date: 1 October 1994

Completion date: 30 September 1997

Project duration: 3 years

Geographic area: Prince William Sound

Contact person: Glenn R. VanBlaricom
Washington Cooperative Fish and Wildlife Research Unit
School of Fisheries, WH-10
University of Washington
Seattle, Washington 98195
(206) 543-6475, FAX 685-7471

B. INTRODUCTION

Nearshore clam populations in Prince William Sound (PWS) are a biological resource injured by the *Exxon Valdez* oil spill (EVOS). Patterns of recovery of clam populations from the EVOS are unknown. Clams are an important food resource for sea otters in PWS, a biological resource also injured by the EVOS. Sea otters in PWS have not recovered from the oil spill. It is possible that damage to clam populations has contributed to the failure of sea otter populations to recover from the EVOS.

Dynamics of clam populations often are influenced substantially by patterns of predation by invertebrates such as sea stars, crabs, and snails. This project will describe patterns of predation by such invertebrates on nearshore clam populations known to be significant prey for sea otters in PWS. Data on diet, activity, and density of predators will be used to estimate rates of clam mortality as a result of invertebrate predation. The results ill be used to examine the hypothesis that high rates of clam mortality are contributing to lack of recovery from EVOS damage in clam and sea otter populations in PWS.

This project is most likely to be effective in achieving stated goals if it is pursued over several years. However, limitation of work to FY-95 will provide sufficient information to complete some tasks (see Project Design).

C. NEED FOR THE PROJECT

This project will address three important issues regarding the restoration of nearshore clam populations and sea otter populations in PWS. First, it will provide useful information about how injured resources are recovering. Clam populations are recognized as an injured resource, but recovery trends are unknown. Documentation of patterns of consumption by predatory invertebrates will provide useful information for determination of population growth trends and recovery potential for clams. Second, the project will contribute to resolution of problems that may be constraining a second injured resource, sea otters, from recovery. Clams are the most important source of nutrition for sea otters in PWS. If patterns of predation by invertebrates are contributing to low productivity in clam populations, sea otters may be suffering a consequent inability to recover effectively from EVOS damage. Third, clams are locally important subsistence and commercial fishery resources in certain portions of the PWS region. An improved understanding of recruitment effects on clam availability will contribute to more judicious management of clam resources for human use during the recovery period.

Improved understanding of clam recruitment, clam population dynamics, and resulting effects on sea otters will provide managers with better abilities to select restoration options likely to succeed, and to discard options likely to be ineffective and wasteful of limited resources. Invertebrate predation data therefore will contribute directly to improved efficiency in restoration activity.

D. PROJECT DESIGN

1. Objectives

1. Assemble, synthesize, and evaluate published literature on patterns of predation on bivalves by predatory invertebrate species known to occur with reasonable abundance in Prince William Sound, both in intertidal habitats and in subtidal habitats within the foraging range of sea otters. Incorporate relevant unpublished information available in the public domain and through contacts with other investigators of benthic ecosystems in PWS.

2. Determine the diets of potentially important invertebrates in nearchore habitats of PWS. Initially, efforts will focus on the following species or taxa known to consume bivalves in PWS: Sea stars: *Pycnopodia helianthoides, Evasterias troschelli*; Crabs: *Telmessus cheirogonus, Cancer* spp.; Snales: *Nucella* spp. Predatory species of concern may be added or deleted from the list depending on the results of task 1 (above) and early phases of field work. Dietary data will include species composition, numbers or biomass of individuals consumed, and size/age distribution of individuals consumed. Dietary data will be gathered in the intertidal zone and at two subtidal depths, 6 m and 12 m.

3. Determine activity-time budgets of predatory invertebrates that forage on bivalves in PWS. Observations of the proportion of individuals actively foraging will be gathered by observation periods placed throughout the day and night. Activity data will be integrated with dietary data (task 2 above) to estimate prey consumption rate for each species of predator.

4. Determine patterns of density for predatory invertebrates. Appropriate survey methods will be used to estimate densities of predatory invertebrates studied as indicated in tasks 2 and 3 (above). Data from tasks 2 and 3 will be integrated with results to provide an estimate of age specific mortality rate of clam populations as a result of predation by invertebrates.

5. Determine by experimental removal the effects of predation by invertebrates on mortality, population density, and size structure of clam populations. Based on data from tasks 2, 3, and 4, species of predator will be evaluated for likely intensity of effects on clam populations and tractability of a removal experiment. If field data suggest such an experiment is feasible, individuals will be removed periodically from study sites. Populations of clams in study sites and corresponding control sites iwll be monitored for evidence of the effects of predator removal. Execution of this task will also be contingent on identification of clam species with rates of recruitment sufficiently high that a meaningful result is plausible for the experiment.

2. Methods

1. This work will be done primarily by library database searches and consultation with present and past participants in EVOS Damage Assessment, General Restoration, Research and Monitoring, Habitat Protection, and related activities. Compilation of information will be completed by 30 June 1995, and a report will be completed by 30 September 1995. Work will be done in the library system at the University of Washington, and through direct contact with individuals involved in the listed EVOS-related activities.

2. Samples will be gathered at three sites in four study areas beginning in summer 1995 and continuing on a quarterly basis through fall 1996. Tentative study areas are north Knight Island/Naked Island, South Knight Island, Green Island/Montague Island, and Port Nellie Juan. Samples will be gathered at three depths (intertidal, 6 m, and 12 m) at three locations within each of the four study areas. Data will be collected by direct observation during low tide or SCUBA dives (all species), and where necessary will be supplemented by examination of stomach contents. Data entry and analyses will be completed by 31 December 1996. A technical manuscript will be completed and submitted for publication by 30 September 1997.

3. Individuals will be observed and scored for activity type during samples placed by stratified random assignment through the 24-hour cycle in each of the four study areas.

Intertidal organisms will be observed directly at low tide or using SCUBA gear if necessary. Subtidal species will be observed during SCUBA dives. Sampling, data analyses, and report production will follow the schedule described for task 2 (above).

4. Densities of predatory invertebrates will be assessed at three sites within each of the four study areas on a quarterly schedule beginning in summer 1995 and concluding fall 1996. Techniques will vary with species depending on distributional characteristics, activity, and visibility. In most cases sampling will be done by counts in randomly-placed plots or belt transects. Intertidal species will be surveyed during low tide, subtidal species with SCUBA dives. Data analyses and report production will follow the schedule described above for tasks 2 and 3.

5. Individuals of the species selected for removal will be gathered during low tide or SCUBA dive on a quarterly basis and transported alive to a distant location to be released unharmed. Clam populations at removal and control sites (minimum of two each) will be ssampled by digging and screening (intertidal populations) or by suction dredging (subtidal populations) in randomly-placed plots within the study sites. Predator removals and clam population samples will be done quarterly, beginning in summer 1995 and continuing through fall 1996.

Technical support for each task will be managed through the Washington Cooperative Fish and Wildlife Research Unit (WACFWRU; computer analyses and data archiving) and the University of Washington (library services and bibliographic database searches).

Field work for the project will be done at study sites in western and central Prince William Sound, Alaska, as specified above for task 2. Laboratory work, data analyses, and production of reports will be done primarily at WACFWRU, School of Fisheries, University of Washington, Seattle, Washington.

E. PROJECT IMPLEMENTATION

The proposed project will be done by WACFWRU. WACFWRU is part of the Division of Cooperative Research, National Biological Survey, U.S. Department of the Interior. WACFWRU has an established history of success in interdisciplinary studies of the effects of human activities on natural ecosystems. WACFWRU is in a position to take advantage of the substantial expertise and resources of the University of Washington in data management and analyses, coastal marine ecology, and fisheries.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

We propose that our work will be integrated with other new and existing studies of damaged resources relating to sea otters and their habitats in Prince William Sound. These include new work proposed for study of intertidal mussels, sea urchins, subtidal bivalves, and their predators, especially sea ducks and sea otters. In addition, we propose to integrate our work with studies of eater column oceanography and ecology as noted in task 5 above. Integration will be achieved by coordinating proposal submission and project management through the Alaska Science Center of the National Biological Survey, a process which has already begun. In addition, we will pursue frequent communication and meetings with investigators in related projects in order to refine project goals, minimize overlap in field sampling, and maximize sharing and efficient use of vessel charters, sampling supplies and equipment, and field time.

G. PUBLIC PROCESS

We will participate in all public meetings, workshops, and related activities organized by the EVOS Trustee Council, and in related meetings as requested by the Council. In addition, we will present interim results at technical workshops and meetings of Scientific Societies in order to maximize input from the scientific community on refinement of project goals and questions, and quality, relevance, and clarity of data analyses and conclusions.

H. PERSONNEL QUALIFICATIONS

Glenn R. VanBlaricom has done research on coastal ecosystems since 1970, and has been involved in research on sea otters and their ecosystems for 17 years. VanBlaricom studied relationships of sea otters and intertidal mussels in Prince William Sound from 1978 through 1986 and published papers on population age structure and individual growth rate of mussels, and effects of foraging by sea otters (see attached vita). VanBlaricom worked on sea otter rescue and rehabilitation in the immediate aftermath of EVOS, primarily in the Kenai region, and has published one paper on rehabilitation strategies. Currently VanBlaricom is Assistant Unit Leader (Wildlife), Washington Cooperative Fish and Wildlife Research Unit, and is Associate Professor of Fisheries in the School of Fisheries, University of Washington. VanBlaricom currently serves on the Scientific and Statistical Committee of the Pacific Fisheries Management Council, the Committee of Scientific Advisors of the Alaska Sea Otter Commission, and the board of Governors of the Society for Marine Mammalogy (SMM), the world's preeminent technical society for research and management of marine mammals. In 1993 VanBlaricom was recognized by SMM with the first Award for Excellence in Scientific Communication at the SMM Biennial Conference in Galveston, Texas.

Graduate student: This project will provide partial support for the Masters thesis research of Ms. Tamara Gage. Ms. Gage recently graduated with distinction from the University of Michigan with a degree in Biology, and was actively recruited by the graduate program in fisheries of the University of Washington. Gage has worked on database management and statistical analyses in a study of fish populations in a midwestern lake, and she has worked as a field technician for a study of land-water interface interactions at Toolik, on Alaska's North Slope. She also has laboratory experience with studies of molecular biology. Ms. Gage will enter the Masters Program at the School of Fisheries, University of Washington, in fall 1994 under the sponsorship of Dr. VanBlaricom.

I. BUDGET

As directed in proposal submission instructions, this budget is for fiscal year 1995 only. The entire proposed project has a duration of five years. An estimate of the total project budget (including fiscal year 1995), should it run for the entire proposed duration, is indicated on the cover sheet.

Salary for Dr. VanBlaricom and administrative and analytical support will be provided by the Washington Cooperative Fish and Wildlife Research Unit, National Biological Survey (WACFWRU). Stipend support (nine months salary and benefits) for Ms. Gage will be provided by the School of Fisheries, University of Washington (UW) and WACFWRU. The UW will waive $36,015 in overhead costs through its cooperative agreement with WACFWRU.

The following are estimated cost share totals by contributing organization:

National Biological Survey $	10,000
NOAA/HAXMAT	15,700
University of Washington	36,015

Estimated proposal costs, excluding cost-share contributions, FY1995:

Personnel	
Project Leader	$ 0.0
Graduate Student	$ 4.9
Subtotal	$ 4.9
Travel	
Airfare (5 trips, 2 people)	$ 6.0
Transportation to Whittier	$ .5
Per diem (includes meetings)	$ 6.0
Subtotal	$12.5
Contractual Services	
Vessel charter (@ $1500/d)	$45.0
Commodities	
SCUBA tanks	$ 2.0
Other SCUBA gear	$ 2.0
Sample collection & storage supplies	$ 5.0
Computer supplies	$ .5
Gasoline	$ 3.0
Subtotal	$12.5
Equipment	
SCUBA compressor	$11.0
Dissecting microscope	$ 8.0
Laptop computer	$ 4.0
Binoculars 2,000	
Spotting telescope/tripod	$ 3.0
Subtotal	$28.0
General administration	
Indirect costs, UW (@15%)	$15.4
Subtotal	$15.4
Total	$118.4

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Primary Productivity as a Factor in the Recovery of Injured Resources in Prince William Sound

Project #95025J

Project leader:	Dr. Michael S. Stekoll University of Alaska
Lead agency:	National Biological Survey
Cost of project:	FY 95 $315.4K FY 96 $310.0K FY 97 $310.0K FY 95 report: $81.6K
Start up date:	1 October 1994
Completion date:	30 September 1997
Geographic area:	Prince William Sound, Alaska
Contact person:	Michael S. Stekoll JCSFOS University of Alaska 11120 Glacier Highway Juneau, Alaska 99801 (907) 465-6279, FAX 465-6447

B. INTRODUCTION

This project will investigate the production and flow of fixed carbon in the nearshore ecosystem of Prince William Sound and will determine the importance of benthic primary productivity in the recovery of injured intertidal and subtidal species. Results from this project would lay the foundation for understanding how fixed carbon is moved through the Prince William Sound nearshore system, and how this carbon flow is altered by seasonal events. The study will determine the relative importance of carbon input from phytoplankton, benthis production, terrestrial plants, and episodic transport (e.g., herring spawn), Understanding the flow of carbon will increase our understanding of factors that limit recovery of nearshore organisms.

The results of the study will give information on the relative importance of the various sources of carbon that are introduced into the nearshore system. Importance is measured by the relative abundance of each source of carbon present in the higher trophic organisms. Information will also be generated on how these proportions change seasonally and how they are affected by physical and chemical processes.

From the above information it may be possible to estimate the relative importance of the various plant communities in supplying the nearshore invertebrate community with carbon.

Further, a model could be created to predict the disturbance to a community if there are changes in the normal flow of carbon into the system. Such disturbances could be effected by oil spill treatment, El Nino events, winter storms, etc.

C. NEED FOR THE PROJECT

Injury to the biological resources of Prince William Sound as a result of the *Exxon Valdez* (EVOS) oil spill have been documented since 1989. Although recovery has occurred for many species and is progressing for others, many injured resources have been listed as not recovering. The range of such injured and not recovering species includes bird, marine mammals, fish, and both intertidal and subtidal organisms.

One hypothesis for the lack of recovery for injured species is that recovery is limited by food/prey availability. Most of the injured species from the higher trophic levels (birds, fish, mammals) are predators on nearshore, marine organisms. These nearshore organisms make their living as predators themselves, as scavengers, as graziers, and/or as suspension/deposit feeders. The ultimate source of carbon/energy for all of these organisms is from primary production. In the nearshore there are four possible sources for carbon: the first three are primary production from terrestrial plants, benthic marine plants and phytoplankton, and the fourth is episodic transport of carbon. Benthic plants (seaweeds and marine grasses) provide carbon for graziers, such as littorines, urchins, and limpets. These organisms in turn serve as food for higher trophic level organisms. Populations of many of these grazers have been altered by the EVOS. Phytoplankton and organic detritus (along with zooplankton) provide carbon for suspension and deposit feeders, such as barnacles, mussels, and clams. The relative importance of these forms of carbon depend on the organisms and area of concern, but contributions from both phytoplankton and benthic plants may be important. Carbon production provided by terrestrial plants will be important in nearshore areas in the vicinity of streamsw and rivers. Episodic transport could bring in carbon from areas outside of the nearshore system. Two examples of this type of transport are the annual Pacific herring spawnings in the spring and the salmon runs in the summer and fall.

A decline in primary productrivity in PWS as a direct or indirect effect of the oil spill could explain the lack of recovery of some injured resources. For example, sea otters may have less prey, which feed on seaweeds, available in an area where benthic production has been depressed as a result of the spill.

This project proposes to look at primary production as one aspect of an ecosystem approach to understanding recovery of the biological resources. The general approach is to determine the relative contributions of the various sources of production into the nearshore system and alsso to determine whether this pattern has been altered in areas affected by the oil spill and treatment.

D. PROJECT DESIGN

1. Objectives

1. To determine the productivity and standing biomass of benthic marine plants in the nearshore.
2. To determine the productivity and biomass of phytoplankton in the nearshore.
3. To determine the organic input to the nearshore from terrestrial sources.
4. To determine the relative contribution of these sources of carbon to the carbon budget of higher trophic level organisms.
5. To determine what factors may limit primary productivity in the nearshore.

2. Methods

Site selection. About four to six sheltered rocky sites in PWS will be selected based on intertidal and subtidal vegetation and associated communities. Areas of use by higher trophic level organisms such as sea otters, herring, and birds will be targeted, if possible. Site selection will be coordinated with the nearshore study groups of the National Biological Survey (NBS) and University of Alaska (UAF).

Primary productivity will be measured by C-14 fixation *in situ*. Productivity will be normalized both by chlorophyll content and by biomass. Determinations will be made during the period of algal blooms for phytoplankton and at quarterly intervals for benthic algae and eel grasses. Extrapolations will be made to determine the total productivity for the system on an annual basis. Water chemistry for the determination of nutrients will be performed on samples taken in and near to the selected sites. Light irradiance data will be collected as often as feasible for correlation with productivity rates.

Streams that flow into the nearshore area will be sampled for total organic carbon four times during the year. Stream flow rates and capacities will be estimated in order to estimate the total carbon input from this source.

Stable carbon isotope ratios can be used to determine the source of primary productivity used by various organisms (Duggins et al. 1989). Nitrogen isotopes can be used to look at differences in trophic feeding. Isotope ratios will be determined for the sources of carbon including phytoplankton, benthic seaweeds, detritus, participate and dissolved organic matter and herring eggs. Additionally, stable isotope ratios (C and N) will be determined for several different organisms which use different feeding strategies. Such organisms will include a grazer, suspension feeder, detritus feeder and predator. Isotope ratios will be compared to those from the sources of carbon. The isotope ratio will be determined throughout the year in order to determine seasonal variation in feeding strategies and relative importance of carbon sources. This aspect of the study will be closely coordinated with other trophic interaction studies proposed by NBS and UAF.

3. Schedule

Spring 1995. Site selection.

June 1995-June 1997. Sampling for photosynthesis, nutrients, light levels and isotopic rations. These will be done four times a year at quarterly intervals. One sampling date will coincide with the spring algal bloom in March.

Data compilation and analysis will be on-going through the year. There should be a minimum of two years of sampling for estimation of year to year variation. Annual reports will be submitted by April of each year.

4. Technical Support

Laboratory analysis of stable isotope samples and CHN samples will be required.

5. Location

Field work will take place near and at selected sheltered rocky sites in Prince William Sound. Laboratory analyses will be done at the University of Alaska, both at Fairbanks and at the Juneau Center, School of Fisheries and Ocean Sciences.

E. PROJECT IMPLEMENTATION

This project should be implemented by the National Biological Survey as part of its nearshore ecosystem study. The study should be closely coordinated with others that propose to look at energy flows in the nearshore food webs.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project is designed to be closely coordinated with nearshore food web studies of University of Alaska Fairbanks and the Prince William Sound Science Center, and with the nearshore trophic studies proposed by the National Biological Survey. Collaboration will occur with the SEA study through oceanography, herring projects, nearshore fish and avian predation. This study will provide information to other studies concerning how fixed carbon is routed to the nearshore organisms.

G. PUBLIC PROCESS

Public input has been received via the EVOS Trustee Research Priorities Workshop held in April 1994 and from reviews of publications and reports from previous projects completed for the EVOS damage assessment and monitoring studies (Herring Bay monitoring and Coastal Habitat Injury Assessment studies).

J. PERSONNEL QUALIFICATIONS

Michael Stekoll. Professor of Chemistry and Biochemistry at the University of Alaska Southeast and UAF/SFOS. He has expertise in plant biochemistry, phycology and pollution biology. He has been involved since 1989 as a co-PI with Coastal Habitat Injury Assessment, Herring Bay Restoration and Monitoring and in the subtidal injury assessment projects. He has published on oil pollution effects and on nearshore ecology since 1980.

K. FY95 BUDGET($K)

Personnel	$141.0
Travel	$11.4
Contractual services	$77.2
Commodities	$16.3
Equipment	$6.5
Capital outlay	$0.0
General administration	$63.0
Total	$315.4
Report Completion	$81.6
Total budget for one year with final report	$397.0

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Hydrocarbon Monitoring: Integration of Microbial and Chemical Sediment Data

Project Number: 95026

Name of Project Leader or Principle Investigator: Joan Braddock (Principal Investigator) and Bret Luick (Co-PI) Institute of Arctic Biology, University of Alaska-Fairbanks

Lead Agency, University or Organization: Alaska Department of Environmental Conservation; Institute of Arctic Biology, University of Alaska-Fairbanks

Cost of Project: $84,400

Project Start-up/Completion Dates (month/year): Start-up, October 1994; Completion, October 1995.

Project Duration (number of years): One year

Geographic Area (locations where field work will be conducted): There is no field work for this project. The project will use existing data sets and will be completed at Institute of Arctic Biology, University of Alaska-Fairbanks.

Contact Person: Project Contact:

Joan Braddock
Assistant Professor of Microbiology
University of Alaska, Fairbanks
Institute of Arctic Biology
Fairbanks, Alaska 99775-7000
Tele: (907) 474-7991; Fax: (907) 474-6967

Trustee Agency Contact:

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

Biodegradation of hydrocarbons by microorganisms is a major mechanism for removal of petroleum contaminants from marine systems. Since the *Exxon Valdez* oil spill in 1989 we have amassed a great deal of data on microbial numbers and activities in sediments. These studies are unique in the extent of information collected following a major spill and the results provide valuable information on marine sediment microbial responses to hydrocarbon pollutants. For example, numbers of hydrocarbon oxidizers appear to be a good indicator of exposure of sediments to hydrocarbons. Some of these results have been recently accepted for publication in the journal, Marine Pollution Bulletin.

We originally designed our assays, in particular the microbial activity measurements, to stand on their own as much as possible. In other words we wanted some measure that would provide useful site-to-site comparison information without being reliant directly on chemistry data. We feel that we were successful in this goal. However, a great deal of predictive power is lost by not combining our results with sediment chemistry data. An analysis of these combined data sets will allow estimates of removal rates of hydrocarbons from contaminated sediments by biological processes. This will help determine the natural rate of recovery of oiled sediments.

The Trustee Council has previously funded sediment analyses to determine whether intertidal and subtidal sediments are contaminated with oil, and to assess the concentrations and rate of degradation of the oil in these sediments. Microbial activity data can be used in concert with the hydrocarbon chemistry data to calculate the absolute *in vitro* rates of mineralization of the fractions assayed (hexadecane, phenanthrene and naphthalene) in these sediments. These rate data can then be used in turn to estimate persistence of these fractions in sediments in Prince William Sound. In fact the major criticism of our damage assessment final report by the Trustee-appointed peer reviewer was that the microbiology and chemistry data need to be combined so that field rate calculations can be estimated. We wholeheartedly agree with the peer reviewer that these data should be combined both to validate the mineralization assays and to allow predictions of persistence of these hydrocarbons in the environment.

The microbial and sediment chemistry field work was coordinated so that samples for both were collected at the same time in a similar manner. The sampling scheme was designed so that the chemistry and microbiology data could be integrated at some later date. Now that the hydrocarbon data is available, combining the data will yield valuable information on the rates of biodegradation of petroleum in contaminated sediments. The two data sets are quite large and the resources have not yet been available to combine them. Synthesis of the data is a large undertaking, but was the major peer-review recommendation of the final report ST001B on microbial activity. The proposed project would fund a researcher to complete that synthesis.

Synthesis of the intertidal and subtidal data on the microbial response to oil pollution, with the sediment chemistry data would:

1. Allow the calculation of field rates of biodegradation for hydrocarbon fractions in areas previously monitored for sediment contamination and microbial activity.

2. Establish upper and lower estimates of the persistence of these hydrocarbons in the sediments of the spill area to help establish a natural rate of recovery of oiled sediments.
3. Refine the tool of using relatively inexpensive microbial analyses as predictors of oil residue in sediments for future use in *Exxon Valdez* hydrocarbon monitoring and for future spills.
4. Comply with the peer-reviewer's recommendation that microbiology and chemistry data be synthesized.

We have two tremendous resources with the chemistry and microbiology data sets. A great deal of critical information about the relationship between numbers of oil degraders and oil concentrations and about the persistence of various fractions of oil in the environment will be lost if this analysis is not done.

Resources and Services Addressed: This project is important for **sediments, and intertidal and subtidal organisms.** In addition, while oil itself is not an injured resource or service, it is the cause of the injuries. Monitoring the continued presence of surface oil in the environment including location, concentration, and degradation provides current information and predictions about remaining oil contamination in the ecosystem.

Previous Related Projects: Assessing the location, concentration, and degradation of *Exxon Valdez* oil has been an important activity since the spill. Several microbial degradation projects were funded as part of the Natural Resource Damage Assessment and as part of the oil spill response. In addition to these data sets, the Trustee Council funded sediment and microbial projects in 1992, 1993 and 1994.

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

By using the actual hydrocarbon concentrations provided by the chemistry data, we can make predictions about the actual field rates of oil degradation, and use those values to predict the persistence of oil fractions and the natural rate of recovery of spill area sediments.

This information would help the Council meet the restoration objectives in the following manner:

- The Council's recovery objective for residual oil contamination of sediments is,"...recovery has been achieved when remaining oil concentrations are reduced to a level comparable to pre-spill levels." Since biodegradation is one of the major natural mechanisms for removal of oil from contaminated sediments, this technique will help predict when that occurs.
- Information on the rates of decomposition and persistence of oil is important foundation information for research involving any injured resource or service that exists in the nearshore environment.

It would bring previous Council-funded activities to the close recommended by Trustee Council peer reviewers.

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

1. **Objectives.** As discussed previously, the study would have the following objectives:
   - Allow the calculation of rates of biodegradation for hydrocarbon fractions in areas previously monitored for sediment contamination and microbial activity.
   - Establish upper and lower estimates of the persistence of these hydrocarbons in the sediments of the spill area to help establish a natural rate of recovery of oiled sediment.
   - Refine the tool of using microbial analyses as predictors of oil residue in sediments for future use in *Exxon Valdez* hydrocarbon monitoring and for future spills.
   - Comply with the peer-reviewer's recommendation that microbiology and chemistry data be synthesized.

A further objective of this study will be to produce a manuscript from these results for publication in a peer reviewed journal. This publication is important in the transfer of lessons learned from the *Exxon Valdez* spill to the broader community of scientists, regulators and decision-makers. The information gained from this study will be very valuable to decision-makers in future oil spills.

2. **Methods.** All of the post-spill sediment microbiology data available was collected by personnel associated with our laboratory. This extensive data set (from 6 cruises) has already been included in LOTUS 1-2-3 spread sheets. Corresponding sediment chemistry data is available in a data base from the NOAA Auke Bay Laboratory. To achieve the objectives of this proposal we would first obtain the chemistry data and merge this data with our existing microbiology data. From this combined data set we can estimate rates of biodegradation of hydrocarbon fractions from intertidal and subtidal sediments. It is expected that we would first focus on data from Prince William Sound.

3. **Schedule.** The project will begin as soon as funding is available. Assuming a start date of October 1994, we would complete a draft report by July 1995 and a final report in October 1995. If funding is not received by October 1994 these dates will need to be adjusted to reflect the actual start date.

4. **Technical Support.** Access will be needed to the microbial and sediment chemistry data. Support will be needed by those most knowledgeable with the sediment chemistry and microbial data sets. These include ADEC and NOAA personnel (for the sediment chemistry), and Dr. Joan Braddock, for the microbial data.

5. **Location.** With the exception of one trip to Juneau to coordinate with the Auke Bay Laboratory for chemistry data, the project will be located at the Institute of Arctic Biology at the University of Alaska-Fairbanks.

E. Project Implementation – Who Should Implement the Project.

Significant involvement is required by the Institute of Arctic Biology, University of Alaska-

Fairbanks, as well as Trustee Agency personnel who worked with the sediment chemistry. The most cost-effective way to meet the project objectives is through a research associate who will work closely with Dr. Braddock. Dr. Bret Luick has agreed to do this work. Dr. Luick will bring to the project a broad background in chemistry, biology and in data reduction and manipulation.

F. Coordination of Integrated Research Effort.

The focus of this project is to integrate the results from two previous projects-- sediment microbiology and sediment chemistry. Representatives of Trustee agencies that are knowledgeable about the data and who will use the results will be integrated into the process.

G. Public Process.

This is a highly technical project with important, but technical results. Trustee agencies that help oversee the project will present the results in Trustee Council newsletters, etc. The personnel conducting the project will present results wherever needed. The general public will not, however, be otherwise integrated into the process.

H. Personnel Qualifications.

Dr. Braddock has extensive experience in developing techniques for measuring microbial activity in the environment. In addition Dr. Braddock has been integrally involved with collection of sediment microbiology data since the spill. Dr. Luick brings to the project substantial training in chemistry and data reduction and analysis. See attached biographical sketches for Drs. Braddock and Luick.

I. Budget (figures in thousands)

Alaska Department of Environmental Conservation

Personnel	$0
Travel	$0
Contractual Services	$78.9
Commodities	$0
Equipment	$0
Capital Outlay	$0
Subtotal	$78.9

7. General administration	$5.5
Total:	$84.4

University of Alaska. This project will be implemented using a Reimbursable Services Agreement with the University of Alaska. The detail of the amount listed above as Contractual Services is below.

Personnel (salary + benefits)		
PI, J.F. Braddock (80 hrs)	$3.4	
Co-PI, B. Luick (1670 hrs)	$45.3	
Travel (One RT to Juneau to coordinate retrieval of chem data)	$1.2	
Service (phone, fax, publication)	$1.0	
Equipment (computer)	$4.0	
Subtotal	$56.8	
Indirect costs (less equipment) @ 41.8%		$22.1
TOTAL	$78.9	

JOAN FORSHAUG BRADDOCK
Biographical Sketch

Institute of Arctic Biology, University of Alaska Fairbanks, Fairbanks, Alaska 99775-7000.

EDUCATION:

1989 Ph.D. Oceanography, University of Alaska; Dissertation Title: Competition between two aquatic microorganisms for oscillating concentrations of phosphorus.
1983 M.S. Microbial Physiology, University of Alaska/Michigan State University; Thesis Title: Iron-limited growth kinetics of *Thiobacillus ferrooxidans* isolated from arsenic mine drainage.
1977 B.S. Biological Sciences, University of Alaska, cum laude.

PROFESSIONAL EXPERIENCE:

1990-present	Assistant Professor of Microbiology, Institute of Arctic Biology, University of Alaska Fairbanks
1989-1990	Research Associate, Water Research Center, University of Alaska Fairbanks
1985-1989	Graduate Research Assistant, Water Research Center,University of Alaska Fairbanks
1984-1985	Research Associate, Water Research Center, University of Alaska Fairbanks
1983-1984	Agricultural Assistant, Agricultural Experiment Station, University of Alaska
1980-1983	Graduate Research Assistant, Institute of Water Resources, University of Alaska
1979-1980	Chemist, Syva Company, Cupertino, CA
1977-1978	Research Assistant, Inst. of Marine Science, University of Alaska
1976-1977	Microbiologist, U.S. Environmental Protection Agency, Fairbanks AK

RECENT FUNDING

Biodegradation of Petroleum Contaminants in Soils at the Naval Arctic Research Laboratory, Barrow, Alaska. U.S.G.S., Water Resources Division, P.I., $28,500, May 1994 to September 1994.

Structure and Function of the Biosurfactant from *Pseudomonas aeruginosa*. U.S.G.S. through Water Research Center, P.I., $7,460, Sept. 1994 to Sept. 1995.

Microbial Degradation of Aromatic Hydrocarbonsin Marine Sediments. Coastal Marine Institute, NMFS, P.I., $25,412, July 1994 to June 1995.

Microbial Ecology of Subarctic Soils: the Key to Successful Land Reclamation for Alaska's Resource Industries. UANatural Resources Fund, P.I., $22,387, May 1994 to Dec. 1995.

Biodegradation of Hydrocarbon Contaminants. U.S.G.S. through Water Research Center, P.I., $9,500, Sept. 1993 to Sept. 1994.

Biodegradation of Petroleum Contaminants in Soils at the Naval Arctic Research Laboratory, Barrow, Alaska. U.S.G.S., Water Resources Division, P.I., $14,164, August 1993 to March 1994.

Evaluation of the Effectiveness and Impacts of PES-51: Remediation of a Contaminated Beach. Tesoro Alaska Petroleum co-P.I. with M. Tumeo, $32,400, June 1993 to June 1994.

Monitoring Microbial Populations in Marine Sediments as Indicators of Environmental Disturbance and Restoration. Oil SpillRestoration Planning Office, P.I., $62,400, April 1993 to Feb.1994.

Hydrogen Utilization by *Thiobacillusferrooxidans* Isolated from Neutral pH Mine Drainage (year 2). U.S.G.S. through Water Research Center, P.I., $29,058, Sept. 1990 to Sept. 1992.

Oil Spill Microbiology, Alaska Department of Environmental Conservation, P.I. with E.J. Brown, $90,923, July 1991 to June1992.

Damage Assessment Microbiology, Alaska Department of Environmental Conservation, P.I. with E.J. Brown, $81,018, June1990 to June 1991.

Bioremediation Monitoring Program, AlaskaDepartment of Environmental Conservation, co-P.I. with E.J. Brown, $81,600, July1990 to June 1991.

Bioremediation Research Program, AlaskaDepartment of Environmental Conservation, co-P.I. with E.J. Brown, $74,400, July1990 to June 1991.

Bioremediation Monitoring Program, Exxon Corporation, co-P.I. with E.J. Brown, $32,000, July 1990 to Dec. 1990.

Damage Assessment-- *Exxon Valdez* Oil Spill, Alaska Department of Environmental Conservation,co-P.I. with E.J. Brown, $75,000, March 1990 to Sept. 1990.

Oil Spill Microbiology, Alaska Department of Environmental Conservation, P.I. with E.J. Brown, $47,545, October 1989 to July1990.

Microbial Hydrocarbon Degradation in Sediments Impacted by the *Exxon Valdez* Oil Spill, Science Applications International Corporation (contract to National Oceanic and Atmospheric Administration), co-P.I. with E.J. Brown and J. Lindstrom, $132,311, May 1989 to December 1989.

AWARDS AND FELLOWSHIPS

Druska Carr Schaible Memorial Award (for outstanding Biological Sciences major), 1977; Graduate Resource Fellowship, 1981and 1982.

PROFESSIONAL ORGANIZATIONS

American Society for Microbiology, American Society of Limnology and Oceanography, American Association for the Advancement of Science, Association for Women in Science, Sigma XI, Phi Kappa Phi.

GRADUATE ADVISORY COMMITTEE CHAIR FOR:

Ph.D.: Jon Lindstrom, Biology; Richard Smith, Biochemistry and Molecular Biology; Dave Guinn, Environmental Quality Engineering (co-chair)
M.S.: Sharon Moore, Environmental Quality Science; Lee Nix, Environmental Quality Engineering, graduated Dec. 1993;Tamra Venator; Environmental Quality Engineering; Chris Kjellmark, Environmental Quality Science; Emy Plakke, Univ. of N. Iowa (co-chair); Zachary Richter, Univ.of N. Iowa (co-chair).
M.A.: Qiaofei Zheng, Chemistry,graduated May 1993.

PUBLICATIONS

Reviewed Papers

Tumeo, M.A., J.F. Braddock, T. Venator and S. Rog. Effectiveness of PES-51 in removing weathered crude oil from sub-surface beach material. Submitted to Spill Sci. Technol. Bull.

Braddock, J.F., J.E. Lindstromand E.J. Brown. Distribution of hydrocarbon-degrading microorganisms in sediments from Prince William Sound, Alaska following the *Exxon Valdez* oil spill. Mar. Pollut. Bull. IN PRESS.

Braddock, J.F. and E.J. Brown. Phosphate uptake by the yeast, *Rhodotorula rubra,* and the greenalga, *Selenastrum capricornutum* Printz, after phosphate additions to steady-state continuous cultures. FEMS Microbiol. Ecol. IN PRESS.

Braddock, J.F., J.E Lindstrom, T.R. Yeager, B.T. Rasley and E.J. Brown. Patterns of microbial activity in oiled and unoiled sediments in Prince William Sound. Proceedings of the *Exxon Valdez* Oil Spill Symposium, Feb. 1993. In Review.

Wolfe, D.A., M.J. Hameedi, J.A.Galt, G. Watabayashi, J.W. Short, C.E. O'Clair, S. Rice, J. Michael, J.R. Payne, J.F. Braddock, S. Hanna and D.M. Sale. Fate of the oil spilled from the *T/V Exxon Valdez* in Prince William Sound. In Review, Environ. Sci. Technol.

Prince, R.C., J.R. Clark, J.E. Lindstrom, E.G. Butler, E.J. Brown, G. Winter, M.J. Grossman, P.R. Parrish, R.E. Bare, J.F. Braddock, W.G.Steinhauer, G.S. Douglas, J.M. Kennedy and P. Barter. Bioremediation of the *Exxon Valdez* oil spill: monitoring safety and efficacy in 1990. 1993. Proceedings of the International Symposium on In Situ and On-Site Bioreclamation, April 1993.

Lindstrom, J.E., R.C. Prince, J.R. Clark, M. Grossman, J.F. Braddock, T. Yeager, G. Winter and E.J. Brown. 1991. Microbial hydrocarbon degradation potentials and populations in fertilized shoreline sediments impacted by the *Exxon Valdez* oil spill. Appl. Environ. Microbiol. 57:2514-2522.

Brown, E.J. and J.F. Braddock.1990. Sheen Screen: a miniaturized Most Probable Number technique for oil-degrading microorganisms. Appl. Environ. Microbiol. 56:3895-3896.

Luong, H.V., J.F. Braddock andE.J. Brown. 1984. Microbial leaching of arsenic from low-sulfide gold mine material. Geomicrobiol. J. 4:85-90.

Braddock, J.F., H.V. Luong andE.J. Brown. 1984. Growth kinetics of *Thiobacillus ferrooxidans* isolated from arsenic mine drainage. Appl. Environ. Microbiol. 48:48-55.

Brown, E.J., H.V. Luong and J.M. Forshaug. 1983. Geomicrobiology of arsenic associated with gold deposits in Alaska. p.570-580 In G. Rossi and A.E. Torma(ed.), Recent progress in biohydrometallurgy. Associazione Mineralia Sarda,09016, Iglesia, Italy.

Brown, E.J., H.V. Luong and J.M.Forshaug. 1982. The occurrence of *Thiobacillus ferrooxidans* and arsenic on subarctic streams affected by gold mine drainage. Arctic. 35:417-421.

Reports

Braddock, J.F., B.T. Rasley and L. Nix. 1992. Hydrogen utilization by *Thiobacillus ferrooxidans* isolated from neutral pH mine drainage. Water Research Center, University ofAlaska, Completion Report.

Braddock, J.F., B.T. Rasley, T.R.Yeager, J.E. Lindstrom and E.J. Brown. 1992. Hydrocarbon mineralization potentials and microbial populations in marine sediments following the *Exxon Valdez* oil spill. Final Report to Alaska Department of Environmental Conservation. Peer reviewed and revised in 1993.

Brown, E.J., B.T. Rasley, D.A. Dixson, S. Hong, H.V. Luong and J.F. Braddock. 1990. Microbial Ecology of*Thiobacillus ferrooxidans*. Final Technical Report to U.S. Dept. of the Interior, contract number14-08-0001-61313.

Braddock, J.F., J.E. Lindstromand E.J. Brown. 1990. Microbial hydrocarbon degradation in sediments impacted by the *Exxon Valdez* oil spill. Final Report to Science Applications International Corporation for the National Oceanic and Atmospheric Administration, NOAA contract number50-DSNC-8-00141.

Brown, E.J. and J.M. Forshaug.1983. Metabolic properties of *Thiobacillus ferrooxidans* isolated from neutral pH mine drainage. Institute of Water Resources, University of Alaska, Completion Report 81-11.

Schell, D.M., K.H. Dunton, S.V. Schonberg and J.M. Forshaug. 1983. Potential environmental effect of seabed strengthening using cement injection in the Beaufort Sea, Alaska. Institute of Water Resources/Engineering Experiment Station, University of Alaska, Fairbanks, Report I84-20.

Luong, H.V., J.M. Forshaug andE.J. Brown. 1981. Biogeochemistry of arsenic mine drainage. Institute of Water Resources, University of Alaska, Completion Report 79-21.

Published Abstracts

Braddock, J.F., T. Venator and M.A. Tumeo. 1994. Microbial response to a field test of the hydrocarbon cleanser PES-51. Abstract of the 94th General Meeting of the American Society for Microbiology, Las Vegas, NV.

Smith, R., T. Yeager, E. Brown and J. Braddock. 1993. The effect of synthetic surfactants on the biodegradation of a petroleum hydrocarbon by *Pseudomonas aeruginosa*. Abstract from the 1993 International Symposium on Subsurface Microbiology,Bath, UK.

Braddock, J.F., J. Lindstrom andE.J. Brown. 1993. Microbial biodegradation of oil in sediments following the T/V *Exxon Valdez* oil spill. Abstract from the 93rd General Meeting of the American Society for Microbiology, Atlanta, GA.

Wolfe, D.A., M.J. Hameedi, J.A.Galt, G. Watabayashi, J.W. Short, C.E. O'Clair, S. Rice, J. Michael, J.R. Payne, J.F. Braddock, S. Hanna and D.M. Sale. 1993. Fate of the oil from the T/V *Exxon Valdez* in Prince William Sound. Expanded and peer reviewedabstract from the Exxon Valdez Oil Spill Symposium, Feb. 1993,

Braddock, J.F., J.E. Lindstrom, T.R. Yeager, B.T. Rasley, G. Winter and E.J. Brown. 1993. Microbial activity insediments following the T/V *Exxon Valdez* oil spill. Expanded and peer reviewed abstract from the *Exxon Valdez* Oil Spill Symposium, Feb. 1993, Anchorage, AK.

Braddock, J.F., M. O'Malley and B.T. Rasley. 1991. Hydrogen utilization in *Thiobacillusferrooxidans*. Abstract from the American Society for Microbiology 91stAnnual Meeting, Dallas, TX.

Brown, E.J. and J.F. Braddock.1990. Microbial activity in marine sediments off the South Coast of Alaska after the *Exxon Valdez* oil Spill. Invited paper for a special oil symposium at the 90th AnnualMeeting of the American Society for Microbiology, Anaheim, CA, May 1990.

Brown, E.J. and J.F. Braddock.1989. How phosphate pulses alter species composition in carbon-limited aquatic systems. Abstract # P-11-10 from the Fifth International Symposium on Microbial Ecology, Kyoto, Japan.

Braddock, J.F. and E.J. Brown.1989. Competition between a yeast, *Rhodotorula rubra*, and a green alga, *Selenastrum capricornutum*, for phosphorus pulses in phosphate-limited cultures. Abstract from the American Society of Limnology and Oceanography 52nd Annual Meeting, Fairbanks, AK.

Braddock, J.F. and E.J. Brown.1989. Competition between two aquatic microorganism for oscillating supplies of phosphorus. Abstract from the American Society for Microbiology Annual Meetings, New Orleans, LA.

Braddock, J.F. and E.J. Brown.1988. Competition between aquatic microorganisms for oscillating supplies of phosphorus. Abstract from the 39th Alaska Science Conference, Fairbanks, AK.

Braddock, J.F. and E.J. Brown.1987. Microplankton competition for oscillating concentrations of phosphorus. Abstract from the American Society of Limnology and Oceanography 50th AnnualMeeting, Madison, WI.

Forshaug, J.M., H.V. Luong, E.J. Brown. 1983. Iron-limited growth kinetics of *Thiobacillusferrooxidans*. Abstract from the Third International Symposium on Microbial Ecology, East Lansing, MI.

Luong, H.V., J.M. Forshaug andE.J. Brown. 1983. Geomicrobiology of arsenic. Proceedings of the 34th Alaska Science Conference, Whitehorse, Yukon.

Forshaug, J.M., H.V. Luong andE.J. Brown. 1982. The role of *Thiobacillus ferrooxidans* in the arsenic cycle in interior Alaska. Abstract from the 33rd Alaska Science Conference, Fairbanks, AK.

Luong, H.V., J.M. Forshaug and E.J. Brown. 1982. Arsenic mine drainage. Abstract from the American Society for Microbiology Annual Meetings, Atlanta, GA

CURRICULUM VITAE
BRET ROGER LUICK

. Personal

Birth date 12/19/54
Birthplace Woodland, California

. Address

Institute of Arctic Biology
University of Alaska, Fairbanks
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Phone 907 474 5472
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. Education

B.S. Biology 1979 University of Alaska, Fairbanks
M.S. Nutrition 1985 University of California, Davis
PhD. Food Science 1991 Oregon State University

. Research interests and Technical skills

Animal nutrition & digestion kinetics
Computer systems design & programming

.Position

Research Associate

.Recent publications

B.R. Luick, J.A. Kitchens, R.G. White and S.M. Murphy. 1994. Modeling energy and reproductive costs in caribou exposed to low flying military jet aircraft. Rangifer (submitted).

Luick, B.R. and R.G. White, 1994. Computer Simulation Model for Jet Aircraft Disturbance of Free Ranging Caribou. Handbook, v 1.0. Prepared for United States Air Force, NSBIT, Wright-Patterson AFB, OH 45433-7901.

Cheeke, P.R., B.R. Luick and W. Debessai. 1993. Effects of feeding endophyte-infected tall fescue seed on lamb performance and serum prolactin. New Zealand Vet. J. 41:214.

Debessai, W.T., B.R. Luick and P.R. Cheeke. 1993. Effects of feeding endophyte-infected tall fescue seed on lamb performance and serum prolactin. Proc. West. Sect. Amer. Soc. Anim. Sci. 44:267-270.

Luick, B.R., A. Ayers and P.R. Cheeke. 1992. Rate of passage of black locust leaf and alfalfa meal in the rabbit gut. J. Appl. Rabbit Res.15:914-921.

Luick, B.R., G.A.E. El-Sayaad and P.R. Cheeke. 1992. Effect of fructooligosaccharides and yeast culture on growth performance of rabbits. J.Appl. Rabbit Res. 15:1121-1128.

Tor-Agbidye, J., B. Luick, P.R. Cheeke, N.M. Patton and A.M. Craig.1992. Performance of weanling rabbits fed endophyte-infected tall fescue seed containing ergot alkaloids. J. Appl. Rabbit Res. 15:1314-1320.

Luick, B.R. and M.H. Penner. 1991 Nominal response of passage rates to fiber particle size in rats. J. Nutr. 121:1940-1947.

Kodiak & Alaska Peninsula Shoreline Assessment: Monitoring Surface and Subsurface Oil

Project Number: 95027

Principal Investigator: Unknown

Lead Agency: Alaska Department of Environmental Conservation. Cooperating agencies include all other Trustee agencies.

Cost of Project: $873,100
FY 95: $759,500
FY 96: $113,600

Project Start-up/Completion Dates (month/year):
- Start: December 1994
- Field Work: May through early September 1995
- Draft Report: April 15, 1996

Project Duration (number of years): approximately one year (fiscal year 1995, with final report continuing into fiscal year 1996)

Geographic Area (locations where field work will be conducted): Kodiak Archipelago, Alaska Peninsula, (plus a few sites on the Kenai Peninsula, as logistics allow)

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

This project will determine the areal extent and toxicity of *Exxon Valdez* oil on the surface and under Kodiak Archipelago and Alaska Peninsula shorelines. Most of these shorelines were last surveyed in 1990. The information about the remaining oil is necessary to determine whether recovery is proceeding at an acceptable rate; to determine whether winter storms have brought subsurface oil to the surface; to help local people assess whether the presence of remaining oil is still affecting shoreline activities; determine the origin and toxicity of any remaining oil; and determine if any beaches need additional treatment.

This project is expected to be the last comprehensive shoreline assessment of the Kodiak and Alaska Peninsula areas, though it may locate additional "hot spots" that need continued monitoring or treatment. Also, the project will include monitoring of Cook Inlet and Outer Kenai Peninsula beach segments as logistics allow. In that way, these areas will be completed by this and subsequent shoreline assessments without funding an additional project for those areas.

Resources and Services Addressed: This project is important for **subsistence, recreation, sediments, mussels, and intertidal and subtidal organisms.** It is also relevant to harlequin ducks, sea otters, and other injured species that feed in the intertidal area. In addition, while oil itself is not an injured resource or service, it is the cause of the injuries. Monitoring the continued presence of oil in the environment including location, extent, origin, and toxicity provides current information about the remaining oil contamination in the ecosystem.

Previous Related Projects: Assessing the amount and location of *Exxon Valdez* oil has been an important activity since the moment of the spill. From 1989 through 1992 extensive shoreline assessment surveys were funded as part of response activities in various parts of the spill area. In 1993 and 1994, the Trustee Council funded two projects:

Project Number	Project Title	Amount Budgeted	Amount Spent
93038	Shoreline Assessment	$539,200	$353,000
94266	Shoreline Assessment & Oil Removal	$365,000	Unknown

- *Prince William Sound.* Limited shoreline surveys and limited clean-up work occurred in 1991, 1992, and 1993. In 1994, clean-up work for surface oil and mussel beds was authorized.

- *Kodiak Archipelago, Alaska Peninsula, Cook Inlet, and Outer Kenai Coast.* No sites have been surveyed by the Department of Environmental Conservation on Kodiak or the Alaska Peninsula, and only limited general assessment work has been completed in Cook Inlet and the Kenai Coast since 1990. Six study sites were established by the National Park Service in 1992 along national park coast lines. Those sites will be revisited in 1994 by the National Biological Survey.

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

Subsistence. The objective for subsistence restoration adopted by the Trustee Council reads in part, "Subsistence will have recovered when...people are confident that the resources are safe to eat."

In 1993, representatives of the Trustee Council held 22 public meetings throughout the spill area, including nine in the project area. At almost every meeting, residents indicated that they believe the oil remains and it is contaminating their subsistence foods. Based on previous assessments, agency scientists expected that oil would have mostly disappeared from Kodiak and Alaska Peninsula shorelines by 1993. However, there has been no shoreline assessment since 1990 to confirm or contradict these beliefs. If oil is not found, a believable assessment of that fact on the Kodiak and Alaska Peninsulas areas will be an important step toward restoring confidence in subsistence resources. It oil is found, it will be important for allowing residents to make their own assessment of the safety and reliability of the resources, and to determine if additional beach treatment is warranted. Determining the absence of oil is at least as important as determining the presence of oil.

Some examples from the 1993 Kodiak village meetings illustrate the concern.

> "There's many people in our community still afraid to eat subsistence foods. My uncle found a tar ball just the other day. That stuff is still around and it affects our kelp beds, clams beds, and our mussels." (Ouzinkie public meeting, April 1993)
>
> "...I know a lot of people in the room who are still injured. They won't eat the seafood because they don't trust it." (Larsen Bay public meeting, April 1993)
>
> "All these studies you've done are in Prince William Sound...you're going to tell us they apply here too? When they first did testing in 1989 and the first part of 1990, they sent out brochures but we haven't heard anything here since then..." (Larsen Bay public meeting, April 1993)

Recreation. Recreation, like subsistence, is affected by the visual recognition of oil. The objective for recreation restoration adopted by the Trustee Council reads in part, "Recreation and tourism will have recovered, in large part, when the fish and wildlife resources on which they depend have recovered, [and] *when recreation use of oiled beaches is no longer impaired...*" Monitoring the presence or absence of oil is an important part of monitoring the ability of the Kodiak and Alaska Peninsula shorelines to provide for recreational and tourism use.

Sediments, mussels, intertidal and subtidal organisms, and other natural resources. Shorelines treated in 1989 and 1990 and other potentially oiled sites need to be evaluated to determine if the shorelines responded to treatment, or if additional localized treatment is required to restore resources and services. The resources most affected are sediments, mussels, and intertidal and subtidal organisms. Monitoring the shorelines provides current information that helps scientists understand the recovery of these and other resources and services in the Kodiak and Alaska Peninsula areas.

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

1. Objectives:

a. Provide current information about the presence or absence of oil that is useful for all injured resources and services; that is, the project will update the 1990 information base necessary for other research and restoration in the Kodiak and Alaska Peninsula areas.

b. Create a common understanding that does not now exist among scientists, local residents, subsistence and recreation user groups, and the general public about the presence or absence of *Exxon Valdez* oil.

c. Where (and if) surface oil is found, the project will locate "hot spots" where continued monitoring, and possibly treatment, is necessary. Where oil is found, analysis will be done to determine toxicity and origin of the oil. Where oil is *not* found or found only in trace amounts, the project will end the need for continued shoreline assessments. Thus, this project is expected to be the last comprehensive shoreline assessment project for these areas.

d. Maintain (and possibly end) the record of the extent, concentration, and degradation of surface and subsurface oil from the 1989 *Exxon Valdez* oil spill in these areas.

2. Methods:

a. *Identifying shorelines for survey.*

- Agency component. The Alaska Department of Environmental Conservation, in conjunction with the other Trustee Agencies and in consultation with the U.S. Coast Guard, will review the 1990 shoreline survey and other information and produce a prioritized list of shorelines to be surveyed in 1995. For planning purposes, we have assumed that all necessary sites will be surveyed with 75 days of boat time. This assumes six trips of 12 days each plus three additional weather days.

- Community component. Representatives of the Trustee Agencies will work with community organizations and landowners to identify sites where community residents believe that oil is present, and to identify important subsistence or recreation shorelines where it is important to know whether or not oil is present. To avoid deluging communities with independent visits from representatives of various projects, community work will be coordinated with other restoration work. For that reason, the exact method cannot be determined until the 1995 work plan is approved. However, it will require at least one visit to most communities to identify areas for survey.

b. *Survey Identified Shorelines.* Agency technical experts, upland owners, and representatives of local communities will together assess the shoreline segments and document oiling conditions, if any. Survey techniques developed in prior years will be used again to ensure comparability of data from year to year. Some samples will be collected and analyzed to determine the toxicity and source of the oil.

The survey team will use various methods of transport: they may be berthed on a vessel and use skiffs to access the shoreline; in some cases, they may stay in communities and use daily boat, plane or helicopter access. Previous *Exxon Valdez* surveys have used these logistics as the most cost effective and time efficient support structure.

c. *Results.* As usual, a final report and database will provide the scientific record of the project. In addition, each community will be made aware of the results pertaining to their use areas, as well as to the entire shoreline assessment. Final methods of conveying the information have not been determined but they may include community visits, meetings, or special community-specific publications.

3. **Schedule:**

December - March 1995. Initial identification of shoreline segments (agency component). Submit requests for vessel and float plane charter. Solicit professional services to accompany shoreline assessment team (See Section E: Project Implementation).

April, and May 1995. Review shoreline segments (agency component), and identify segments (community component). Produce final shoreline list. Receive approvals from landowners and resource agencies to access shorelines for survey activities.

June through early September 1995. Perform Survey

October through April. Analyze samples to determine toxicity and source of the oil. Complete report and documentation; hold community meetings or perform other method of community outreach to distribute results to the community.

4. **Technical Support**. The project will require technical support for the following tasks: data processing support to update existing files detailing the conditions of the specific beach segments surveyed; mapping and GIS information concerning the beach segments; database manipulation to identify beach segments and categorize results; and lab work for analyzing oil samples.

5. **Location.** The Kodiak Archipelago and Alaska Peninsula areas including the following communities:

Kodiak Area	Alaska Peninsula
City of Kodiak Ouzinkie Port Lions Larsen Bay Karluk Akhiok Old Harbor	Chignik Village Chignik Lake Chignik Lagoon Perryville Ivanof Bay

In addition, some beach segments on the Kenai Peninsula or in Cook Inlet will be included as logistics allow. That is, important beach segments in these areas will be surveyed if a boat or plane is available (for example, on the way to other areas). In that way, these areas will be completed by this and subsequent shoreline assessments without funding an additional project.

E. Project Implementation — Who Should Implement the Project

The location and assessment of hazardous wastes and oil pollution is a basic statutory responsibility of the Alaska Department of Environmental Conservation. ADEC has maintained the state lead in discharging these responsibilities since the date of the spill. In addition, working with local communities to develop trust in the conclusions regarding the safety and condition of their resources is a public responsibility. For these reasons, and to maintain consistency with previous shoreline assessments, control over the decisions and judgements regarding the shoreline assessment, and contact with communities will remain with the Alaska Department of Conservation in cooperation with other Trustee Agencies. However, specific professional and technical portions of the project will be contracted including portions where the expertise is not available within the agency, or in some cases where competition may result in decreased costs.

Specifically the project manager and beach survey crews will be ADEC or other trustee agency employees. A professional services contract will be sought for geomorphological expertise to help the survey crews identify and assess beach segments. Technical contracts will be sought for technical projects needs such as vessel charters and aircraft logistics.

F. Coordination of Integrated Research Effort

Until other projects in the area are identified, it is not possible to describe exactly how this project will coordinate with them. Every effort will be made to coordinate logistics with other projects. The project will maintain and update a database and knowledge of oiling that provides fundamental baseline data for investigations of the problems with injured resources and services in the Kodiak and Alaska Peninsula areas. Section D.2., Methods, describes how the project's methods and locations will be coordinated with the needs of resource agencies, landowners, and local communities.

G. Public Process

One of the fundamental objectives of this project is to create a common understanding among scientists, local residents, subsistence and recreation user groups, and the general public about the presence or absence of *Exxon Valdez* oil. For that reason, the project has been designed to integrate community concerns and personnel into the project planning, the actual beach surveys, and into understanding the results. (See description under C. Need for the project; D.1., Objectives; and D.2., Methods.)

H. Personnel Qualifications

Agency Personnel. Agency personnel will be chosen for their environmental and habitat experience. To the extent possible, each person will have extensive *Exxon Valdez* spill experience. Surveys will be conducted daily during both low tide windows with appropriate weather and light conditions. Field information will be gathered using techniques developed during previous shoreline assessment surveys. Information will be recorded on previously generated forms to facilitate comparison and familiarity of the existing databases.

Community Personnel. Community individuals will be involved on a volunteer basis, and need to be chosen in part on their ability to help represent community needs to the agency, and agency methods and conclusions to the community. They will be chosen by representative community groups such as native corporations, village councils, or municipal governments in cooperation with the ADEC project manager.

Professional Service Qualifications. A professional service contract will be sought to provide ADEC with geomorphological expertise to help locate and assess likely areas of residual oil. The contractor should have a high degree of knowledge of beaches processes likely to concentrate, degrade, and retain oil, and if possible, have previous experience with the *Exxon Valdez* oil spill.

I. Budget

	DEC FY95	DEC FY 96	NOAA
Personnel	$202.5	$78.7	$45.0
Travel	$46.4	$4.0	$0.0
Contractual Services	$362.3	$15.0	$0.0
Commodities	$17.3	$3.0	$4.0
Equipment	$24.0	$0.0	$0.0
Capital Outlay	$0.0	$0.0	$0.0
Subtotal	$652.5	$100.7	$50.0
General Administration	$50.1	$12.9	$6.9
TOTAL	$702.6	$113.6	$56.9

Population Survey of Bald Eagles in Prince William Sound, Alaska

Project Number: 95029

Project Leaders: Philip F. Schempf

Lead Agency: U.S. Fish and Wildlife Service

Cost of Project: $41.4K

Project Start-up/Completion Dates: 4/95-12/95

Project Duration: 1 year (to be repeated in 2000)

Geographic Area: Prince William Sound

Contact Person: Philip F. Schempf
U.S. Fish and Wildlife Service
3000 Vintage Blvd. Suite 240
Juneau, AK 99801-7100
(907) 586-7243
(907) 786-7378 fax

B. Introduction

Bald eagles were directly impacted by the Exxon Valdez Oil Spill (EVOS). Productivity of PWS bald eagles was greatly reduced during the breeding season following the spill, but returned to normal levels the next year. Population surveys did not indicate any significant difference in eagle numbers among surveys conducted in 1982 prior to the spill and in 1989-91 after the spill. Populations of herring, pink salmon and marine invertebrates, however, were also impacted by the spill and have not recovered. These species are key prey for bald eagles, and reductions in their availability to bald eagles may be adversely impacting eagle productivity and numbers. Populations of other small forage fishes that have not been studied (sand lance, eulachon, etc.) may also have been reduced by the spill, further reducing prey available to eagles. This project will re-survey the population of bald eagles in Prince William Sound (PWS) and compare the 1995 population with populations in prior years to determine if reductions in prey availability have reduced the number of eagles in PWS. The Trustees funded identical population surveys in 1989-91.

C. Need for the Project

Bald eagles were studied intensively for two years following the spill and at a reduced level for a third year (1991). Impacts to eagle prey were not evident until after work on eagles was concluded. Eagles are slow to mature and have a long life span. We believe that eagles in Alaska may not enter the breeding population until they are at least 6-8 years old, and eagles are known to live up to at least 28 years. The young that should have been produced in 1989 would just be maturing and few would be entering the breeding population this soon. However, a reduction in numbers of breeding adults would be cause for concern. Loss of breeding adults erodes future productivity potential and exacerbates the effects of reduced productivity. Such losses would require a decade or more for recovery once the debilitating factors were corrected. This survey will help to confirm the recovery of bald eagles and alleviate concern created by the suspected reduction in prey availability.

D. Project Design

1. Objectives:

a. Determine bald eagle population size in PWS in 1995.

b. Compare the 1995 population with populations in 1982 and 1989-91.

c. Confirm that the population is following the increasing trajectory modeled based on previous survey data.

2. Methods:

Stratified random plots will be flown by fixed wing aircraft using standard survey protocol (See Hodges, J. I., Jr., J. G. King, and R. Davies. 1984. Bald eagle breeding population survey of coastal British Columbia. J. Wildl. Manage. 48(3):993-998. and Bowman, T. D., P. F. Schempf, and J. A. Bernatowicz. 1993. Effects of the *Exxon Valdez* oil spill on bald eagles. Final rep., *Exxon Valdez* Oil Spill Trustees Council, Anchorage, Alas. 141pp.) Island shorelines within the study area will be censused. The area, plots and shorelines surveyed and censused will be the same as in 1989-91. Differences between years will be compared using a T-test.

3. Schedule:

The survey will be flown in early May, 1995. A final survey report will be completed by December 31, 1995.

4. Technical Support:

None required.

5. Location:

The survey will be conducted in Prince William Sound, based from Cordova.

E. Project Implementation

The most appropriate entity to implement this project is the U. S. Fish and Wildlife Service, MBM-Raptors, 3000 Vintage Blvd., Suite 240, Juneau, AK 99801-7100. The Service has specific management authority for bald eagles under the Bald Eagle Protection Act of 1940, as amended. The Service conducted the previous surveys on PWS eagles immediately after the spill and has the technical ability, logistic capability and specific field experience to conduct the study.

F. Coordination of Integrated Research Effort

Data collected during the population survey will supplement the proposed productivity surveys for bald eagles. Data may corroborate findings of studies on prey species and will contribute to an understanding of ecosystem changes in Prince William Sound.

G. Public Process

The public will be involved through proposal and report document reviews. Results will be presented at Trustee Council meetings and at other scientific forums.

H. Personnel Qualifications

1. **Project Leader**--Philip F. Schempf

   Philip F. Schempf conducted initial 3 year assessment of the effects of the EVOS on bald eagles. Project leader for the U. S. Fish and Wildlife Service, Migratory Bird Management-Raptors, since 1980. Extensive experience with bald eagle surveys and population studies for the past 14 years, including trapping and handling eagles, aerial surveys and satellite telemetry.

2. **Pilot/Biologist**--John I. Hodges

   John Hodges conducted the previous population surveys within PWS and throughout the bald eagle's range from British Columbia to the Aleutian Islands. Has worked extensively with bald eagles and has degrees in wildlife biology and statistics.

I. Budget

Personnel		16.0
Travel		5.3
Contractual		18.0
Commodities		5.3
Equipment		0.0
Capital		0.0
Subtotal		44.6
General Administration	3.7	
Total	48.3	

Productivity Survey of Bald Eagles in Prince William Sound, Alaska

Project Number: 95030

Project Leaders: Philip F. Schempf

Lead Agency: U.S. Fish and Wildlife Service

Cost of Project: $75.0K

Project Start-up/Completion Dates: 5/95-12/95

Project Duration: 1 year (to be repeated in 2000)

Geographic Area: Prince William Sound

Contact Person:

Philip F. Schempf
U. S. Fish and Wildlife Service
Migratory Bird Management-Raptors
3000 Vintage Blvd., Suite 240
Juneau, AK 99801-7100
(907) 586-7243
(907) 786-7378 fax
R7JMB@mail.fws.gov E-mail

B. Introduction

Bald eagles were directly impacted by the Exxon Valdez Oil Spill (EVOS). Productivity of Prince William Sound (PWS) bald eagles was greatly reduced during the breeding season following the spill, but returned to normal levels the next year. Populations of herring, pink salmon and marine invertebrates, however, were also impacted by the spill and have not recovered. These species are key prey for bald eagles and reductions in their availability to bald eagles may be adversely impacting eagle productivity. Populations of other small forage fishes that have not been studied (sand lance, eulachon, etc.) may also have been reduced by the spill, further reducing prey available to eagles. This project would re-survey nest occupancy and productivity of bald eagles in PWS and contrast the results with productivity parameters found to be "normal" in studies of coastal Alaska eagle populations. The Trustees funded identical productivity surveys in 1989-91.

C. Need for the Project

Bald eagles were studied intensively for two years following the spill and at a reduced level for a third year (1991). Impacts to eagle prey were not evident until after work on eagles was concluded. Low prey availability would likely be manifested in poor productivity. Bald eagle populations are resistant to the effects of short term low productivity. Continued low productivity, however, will eventually result in the long term reduction of bald eagle numbers. A productivity survey will determine the current level of productivity. This information is necessary to evaluate whether bald eagle populations injured by the spill are recovering as predicted based on population modeling.

D. Project Design

1. Objectives:

a. Determine bald eagle productivity in PWS in 1995.

b. Compare 1995 and 1990 productivity in PWS with productivity in other coastal Alaska populations.

c. Determine whether productivity is within normal bounds.

2. Methods:

Standard nest productivity protocol will be followed (See Bowman, T. D., P. F. Schempf, and J. A. Bernatowicz. 1993. Effects of the *Exxon Valdez* oil spill on bald eagles. Final rep., *Exxon Valdez* Oil Spill Trustees Council, Anchorage, Alas. 141pp.) Nests within the survey area will be located by helicopter in mid May and nest occupancy will be recorded. The area will be re-surveyed in the third week of July to determine the number of successful nests, the number of young produced and the age distribution of the young. These data will be compared with the same data from PWS in 1990 and from survey results from southeastern Alaska to determine if they fall within the expected range of nest occupancy and productivity for healthy coastal Alaska bald eagle populations.

3. Schedule:

The initial survey will be flown in mid May, 1995, and the second survey will be flown in the third week of July. A final survey report will be completed by December 31, 1995.

4. Technical Support:

None required.

5. Location:

The survey will be conducted in Prince William Sound, based from Cordova, AK.

E. Project Implementation

The most appropriate entity to implement the project is the U. S. Fish and Wildlife Service, Migratory Bird Management-Raptors, 3000 Vintage Blvd., Suite 240, Juneau, AK 99801-7100. The Service has specific management authority for bald eagles under the Bald Eagle Protection Act of 1940, as amended. The Service conducted the previous surveys on PWS eagles immediately after the spill and has the technical ability, logistic capability and specific field experience to conduct the study.

F. Coordination of Integrated Research Effort

Data collected by this project may corroborate findings of studies on prey species of bald eagles and will contribute to understanding of ecosystem changes in Prince William Sound.

G. Public Process

The public will be involved through proposal and report document reviews. Results will be presented at Trustee Council meetings as well as at other scientific forums.

H. Personnel Qualifications

1. **Project Leader**--Philip F. Schempf

   Philip F. Schempf conducted initial 3 year assessment of the effects of the EVOS on bald eagles. Project leader for the U. S. Fish and Wildlife Service, Migratory Bird Management-Raptors, since 1980. Extensive experience with bald eagle surveys and population studies for the past 14 years, including trapping and handling eagles, aerial surveys and satellite telemetry.

I. Budget

Personnel	15.0
Travel	8.5
Contractual	52.0
Commodities	0.5
Equipment	0.0
Capital	0.0
Subtotal	76.0
General Administration	5.9
Total	81.9

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Reproductive Success as a Factor Affecting Recovery of Marbled Murrelets in Prince William Sound, Alaska

Project Number: 95031

Principal Investigator: Katherine J. Kuletz

Lead Agency: U. S. Fish and Wildlife Service

Cost of Project: \$398.0K (includes \$55K for write-up in FY96)

Project Startup/ Completion Dates: 10/94 - 3/96

Project Duration: 3 years[a]

Geographic Area: Prince William Sound

Contact Person: Katherine J. Kuletz
Migratory Bird Management
U.S. Fish and Wildlife Service
1011 E. Tudor
Anchorage, Alaska 99503
(907)-786-3453

[a] Useful results can be obtained in 1 year. A 3-year project is recommended to assess interannual variation in murrelet reproduction relative to forage fish availability.

B. Introduction

Marbled murrelets (*Brachyramphus marmoratus*) are the most abundant seabird in Prince William Sound (PWS) in the summer, and their population has declined significantly since the early 1970's. Although murrelets suffered high mortality in the *Exxon Valdez* oil spill, the spill cannot account for the 65% reduction in numbers observed in post-spill years. There has been no significant increase in the PWS murrelet population since 1989. The goal of this project is to determine if low reproductive success is limiting the recovery of marbled murrelets in Prince William Sound, and if so, if food limitation or predation are responsible. This project is a continuation of previous restoration studies funded by the Trustee Council, wherein nesting habitat and foraging patterns of murrelets were investigated.

C. Need For The Project:

In other areas of its range, marbled murrelet populations have declined primarily due to the loss of old-growth forest nesting habitat. However, a comparatively small proportion of potential nesting habitat has been harvested in PWS. Concurrent with murrelet population declines, populations of other apex predators that eat small schooling fish have also declined in PWS. During the breeding season murrelets depend on forage fish such as sand lance, capelin, juvenile herring and juvenile pollock. Thus, one explanation for the decline of the PWS murrelet population is that food is limiting recovery by affecting murrelet reproductive success.

Murrelet reproduction may be limited by food if adults can not provide sufficient quantity or quality of prey to their chicks. Additionally, nest habitat or adult foraging patterns may affect the vulnerability of chicks to predation. Depredation has been a common source of nest failure for the few murrelet nests in PWS that have been monitored. This project is a multi-year study with the overall objective to determine if food availability or predation is limiting the recovery of the PWS murrelet population. This hypothesis will be investigated by comparing annual differences in murrelet reproductive parameters to relative prey abundance in PWS. In 1995 we will determine if there is evidence of food limitation by assessing chick provisioning rates and reproductive success.

This project will use two approaches to monitor murrelet productivity in PWS: i) observations of individual radio-tagged murrelets and their nesting success and ii) at-sea surveys to assess juvenile/adult ratios at selected sites.

If food is a limiting factor, management efforts can be directed at the forage fish population of PWS. As the most abundant apex predator in the PWS marine ecosystem, the murrelet is an important indicator of the health of the marine environment. Furthermore, information on the foraging ecology of the marbled murrelet can contribute to the development of PWS ecosystem trophic models. Our results will compliment studies of forage fish abundance and distribution in relation to oceanographic characteristics.

D. Project Design

1. Objectives:

- o Determine the reproductive success of radio-tagged murrelets and the effects of predation and adult foraging patterns.
- o Determine if predation rates on chicks are influenced by the foraging patterns of the adults.
- o Develop an index of reproductive success by surveying for juveniles at-sea, in the early post-fledging period.

2. Methods

Thirty radio-tagged birds will be used to locate nest sites. Nest status will be determined periodically by observers using night scopes or by video cameras equipped with remote sensors. Number and timing of visits by radio-tagged adults to their chicks will be monitored using Data Collection Computers (DCCs) and hand-held receivers. Prey types and predation of adults on the nest, eggs and chicks will be determined by direct observation or video. Information on the foraging patterns of these radio-tagged adults will be collected by the same researchers contracted to capture and radio-tag the murrelets.

We will continue our efforts to develop an index of reproductive success that can be used to estimate annual murrelet production for a relatively large area. Surveys to determine the distribution and abundance of juvenile murrelets will be conducted from 25 ft. vessels using USFWS protocol. Complete shoreline surveys and randomly selected offshore transect routes will be surveyed in five areas of PWS. June surveys will be conducted to assess the adult population during the incubation phase of murrelet breeding. Follow-up surveys will be conducted at the same locations between late July and mid August, when murrelet fledglings are on the water. The ratio of juveniles to adults will be determined relative to the June adult counts and the late summer adult counts. The absolute number of juveniles will be used to assess variability among areas and years. A better understanding of juvenile dispersal is necessary to interpret at-sea surveys. Dispersal patterns of juveniles will be investigated by marking accessible chicks that are near fledging age with radio tags or dye, and following them after fledging.

We will use non-parametric tests to examine the relationships between reproductive success, predation rates and chick feeding patterns at individual nests, as nest sample size will be small (estimated 10-15 nests). On a larger scale, we will examine the relationship between murrelet productivity and forage fish abundance as determined by the forage fish study. Information on the prey used by murrelets will be provided by the BAA study on food web relationships of PWS. Vegetation and landscape data will be collected by FWS at the murrelet nests to expand the database on nesting habitat.

3. Schedules

Oct-May	Contracting, hiring, procurement
May-Aug	Field work
Sept-Nov	Data analysis
Dec-Jan	Report writing
Jan 1995	Draft Report
March 1995	Final Report

4. Technical Support:

This study will require FWS Geographic Information System mapping support. Ancillary prey samples we obtain (fish brought to chicks or otoliths found in chick feces) will require lab analysis.

5. Location:

The primary study sites will be areas where murrelets have been successfully captured or are known to nest. These sites may include Eaglek Bay, Unakwik Inlet, Naked Island, Knight Island and Port Nellie Juan. Potential sites may also be selected from areas where other seabird or forage fish studies will be conducted. Because murrelets forage over large areas, the study area will include all of PWS.

E. Project Implementation

The Migratory Bird Management Division of the U. S. Fish and Wildlife Service has conducted studies on the marbled murrelet in PWS since 1989, and has the technical expertise and logistical support required to complete this project. The FWS has located more murrelet nest sites than any other murrelet project to date. The FWS has trust responsibility for murrelets and all other seabirds as designated in the Migratory Bird Treaty Act of 1918.

F. Coordination of Integrated Research Effort

This project is one of several proposals to investigate whether food availability is limiting the recovery of injured species that prey on forage fish. It will share logistical support and data on prey with the pigeon guillemot and kittiwake studies. This study will complement and benefit from other proposed studies: NBS's (puffin diet, PWS food web), NOAA's (forage fish, prey energetics).

G. Public Process

The public will be invited to comment on this project if it becomes part of the FY95 work plan. If funded, results will be presented at Trustee Council-sponsored workshops each winter.

H. Personnel Qualifications

Project Leader: Kathy Kuletz

Kathy Kuletz received her B.S. degree in biology from the California Polytechnic State University, San Luis Obispo, and her M.S. degree in Ecology and Evolutionary Biology from the University of California, Irvine, in 1974 and 1983, respectively. Her thesis, based on research done at Naked Island, PWS, was on foraging and reproductive success of pigeon guillemots. Ms. Kuletz has worked in Alaska since 1976 for Dames and Moore Consulting, LGL Alaska Research and the U.S. Fish and Wildlife Service. Since 1989 she has been P.I. for the marbled murrelet damage assessment study and the restoration studies. She has been active in the development of the Pacific Seabird Group protocols for murrelet surveys and nest site sampling.

Biologist: Dennis Marks

Dennis Marks completed his B.S. degree in biology at the University of California, Irvine, and M.S. degree in biology at the University of Oregon Institute of Marine Biology, in 1979 and 1986, respectively. His M.S. research was on the feeding ecology of bottom fish. He has been part of the marbled murrelet restoration studies since 1990.

Biologist: Nancy Naslund

Nancy Naslund received her B.A. degree in biology and her M.S. degree in marine biology from the University of California, Santa Cruz, in 1985 and 1993, respectively. Ms. Naslund's M.S. thesis research was on the breeding biology of marbled murrelets in California. Ms. Naslund has studied avian reproductive ecology, habitat use, and distribution, and has been with the murrelet restoration project since 1991. She is currently chair of the Pacific Seabird Group Marbled Murrelet Technical Committee.

Pertinent reports and publications of project personnel:

Kuletz, K.J. 1994. Marbled murrelet abundance and breeding activity at Naked Island, Prince William Sound, and Kachemak Bay, Alaska, before and after the *Exxon Valdez* oil spill. In J. Rice and B. Wright [eds], Proceedings of the *Exxon Valdez* Oil Spill Symposium, 1993. Amer. Fish. Soc.

_____, D.K. Marks, N.L. Naslund, and M.B. Cody. 1994. Marbled murrelet activity in four forest types at Naked Island, Prince William Sound, Alaska. In S.G. Sealy and S.K. Nelson [eds], Proceedings of the Pacific Seabird Group Marbled Murrelet Symposium, 1993. Northwestern Naturalist.

_____, D.K. Marks, N.L. Naslund, N. Stevens, and M.B. Cody. In review. Inland habitat suitability for the marbled murrelet in southcentral Alaska. In C.J. Ralph, G.L. Hunt, Jr., J.F. Piatt, and M. Raphael [eds], Conservation assessment for the marbled murrelet, U.S.D.A. Forest Service.

Marks, D.K., K.J. Kuletz, and N.L. Naslund. 1994. Marbled murrelet surveys in Prince William Sound, Alaska: surveying for murrelet nesting habitat in remote areas. In S.G. Sealy and S.K. Nelson [eds], Proceedings of the Pacific Seabird Group Marbled Murrelet Symposium, 1993. Northwestern Naturalist.

Marks, D.K., and N.L. Naslund. In press. Sharp-shinned Hawk preys on a marbled murrelet nesting in old-growth forest. Wilson Bull.

Naslund, N.L., K.J. Kuletz, M.B. Cody, and D.K. Marks. 1994. Tree and habitat characteristics and status of fourteen marbled murrelet tree nests in Alaska. In S.G. Sealy and S.K. Nelson [eds], Proceedings of the Pacific Seabird Group Marbled Murrelet Symposium, 1993. Northwestern Naturalist.

Naslund, N.L. 1994. Why do marbled murrelets attend old-growth forest nesting areas year-round? Auk 110:594-602.

_____, and B.P. O'Donnell. In review. Patterns of daily variation of inland activity patterns of marbled murrelets. In C.J. Ralph, G.L. Hunt, Jr., J.F. Piatt, and M. Raphael [eds], Conservation assessment for the marbled murrelet, U.S.D.A. Forest Service.

I. Budget ($K)

Personnel	$136.0
Travel	10.0
Contractual	180.0
Commodities	10.0
Equipment	29.0
Capital Outlay	0.0
Sub-total	$365.0
General Admin.	33.0
Total	$398.0

Kittiwakes as Indicators of Forage Fish Availability

Project Number: 95033

Project Leader: David B. Irons

Lead Agency: U.S. Fish and Wildlife Service

Cost of Project: $181.6K

Project Start-up/Completion Dates: 10/94-3/96

Project Duration: Five years, depending on frequency and duration of forage fish project.

Geographic Area: Prince William Sound and Gulf of Alaska

Contact Person: David Irons
U.S. Fish and Wildlife Service
1011 E. Tudor Rd.
Anchorage, AK 99503
(907) 786-3681 or 786-3376

B. Introduction

Populations of several species of marine birds and mammals that prey on forage fish have declined in Prince William Sound (PWS) since 1972. Conversely, populations of most species that feed on benthic invertebrates have not declined. Marbled murrelets, pigeon guillemots, arctic terns, black-legged kittiwakes, glaucous-winged gulls and puffins (Klosiewski and Laing, ms) and harbor seals (Kathy Frost, pers. comm.) feed on schooling forage fish, and have declined by more than 50%. Harlequin ducks, goldeneyes, black oystercatchers (Klosiewski and Laing, ms) and sea otters (Irons et al. 1988, Burns, ms) feed on benthic invertebrates and have not declined throughout PWS, although some species were affected by the *Exxon Valdez* oil spill (Klosiewski and Laing, ms; Burns, ms). This pattern of fish-eating species declining and benthic invertebrate-eating species not declining suggests that important forage fish populations may have declined in PWS in the past 20 years. There are no population trend data on forage fish in PWS to support or refute this hypothesis.

If fish-eating marine bird and mammal populations that were injured by the *Exxon Valdez* oil spill (i.e., common murre, marbled murrelet, pigeon guillemot, and harbor seal) are limited by food, recovery of these populations is not possible. Therefore, an important question concerning the recovery of these injured species is: Are their populations limited by food? The goal of this study is to evaluate the relative availability of food for kittiwake populations in PWS, which serve as an indicator of other seabird species. This study, in conjunction with the forage fish study, will provide data to answer the question: Is food limiting the recovery of injured species' populations?

The Trustee Council funded a kittiwake damage assessment study in 1989. The study found that reproductive success of kittiwakes was damaged by the oil spill (Irons 1994). Prior to and after the spill the U. S. Fish and Wildlife Service (USFWS) monitored kittiwake population size and reproductive success in PWS. The USFWS study (Irons 1994) demonstrated that reproductive success of kittiwakes in PWS has not recovered since the EVOS and worsened in 1992 and 1993. Data from USFWS monitoring also suggested that food availability to kittiwakes nesting in PWS may have decreased (Irons, 1994). The USFWS monitoring will continue and the proposed study will complement the monitoring.

C. Need for the Project

The common murre, marbled murrelet, pigeon guillemot, and harbor seal are injured species that eat forage fish. A major question concerning the recovery of these injured species is: Are their populations limited by food?

To answer the question of food limitation for seabirds, the best species to study are those that occur throughout PWS, and for which data on foraging and breeding parameters can easily be collected. In PWS, kittiwakes are well suited to address the food limitation question. Several parameters of kittiwake foraging and breeding indicate physiological stress caused by limited food (Irons, 1992). There are 24 colonies of kittiwakes spread throughout PWS, and because kittiwakes are colonial cliff-nesters their productivity and brood size can be obtained for all colonies fairly easily. Other breeding and feeding parameters are also inexpensive and easy to record. Also, there are ten years of population size and productivity data for kittiwakes in PWS that can be used for comparison.

Because kittiwakes prey on similar forage fish species as marbled murrelets, pigeon guillemots, and murres, they act as indicator species of the availability of prey such as juvenile herring, sand lance, and various osmerids (smelts). However, because kittiwakes are surface feeders, a diving species such as the pigeon guillemot should also be studied.

The USFWS will continue to monitor kittiwake colony size and productivity in PWS. The project proposed here will expand on this basic monitoring by providing reasons for the continuing failure of kittiwakes to reproduce since the EVOS. Information about the availability and distribution of forage fishes in PWS generated by this project will also be useful for understanding food web relationships of other bird species that were injured by the EVOS, and the entire PWS ecosystem.

D. Project Design

1. Objectives:

a. Determine relative food availability to kittiwakes by

1. Monitoring reproductive parameters, including egg laying date, clutch size, hatching success, growth rates, fledging success, brood size at fledging and overall productivity.

2. Monitoring diets and foraging parameters such as: foraging trip length, foraging trip distance, foraging areas, chick provisioning rates, species and size of prey consumed.

3. Monitoring survival rates of adults.

2. Methods

Twenty-four kittiwake colonies in PWS and three colonies in the northern Gulf of Alaska will be monitored for productivity and brood size at fledging. Clutch size will be monitored at 10 to 12 colonies in PWS. Hatching success, chick growth rates, fledging success, and diets will be monitored at four to six colonies in PWS. All parameters will be measured at two or three colonies in PWS.

Methods for measuring reproductive parameters and foraging of kittiwakes are described in Irons (1992). All methods have been tried and were successful in one or more other studies on kittiwakes. Productivity will be determined for entire colonies in PWS and study plots at colonies outside PWS. Productivity will be determined by counting the numbers of nests in June and the number of pre-fledging chicks in August and calculating an average number of chicks per nest. Egg laying dates, clutch sizes, hatching success, chick growth rates, provisioning rates and fledging success will be determined for nests in study plots at colonies. Foraging trip length will be measured using radio-tagged birds and data collection computers to monitor their foraging trips. Foraging trip distance and foraging areas will be determined by locating foraging radio-tagged birds with boats and planes in conjunction with the marbled murrelet project.

3. Schedule

October-May	Prepare for field season
June-August	Field work
Sept.-Nov.	Data analysis
Dec.-Jan.	Report Writing
January 1995	Draft Report
March 1995	Final Report

4. Technical Support:

This project will require technical support for analysis of diet samples and GIS analysis.

6. Location:

Kittiwakes will be monitored throughout Prince William Sound at 24 kittiwake colonies and in the northern Gulf of Alaska at the Wooded, Chiswell and Barren islands in conjunction with the proposed puffin project.

6. Literature Cited

Burn, D. M. ms. Boat-based population surveys of sea otters (*Enhydra lutris*) in Prince William Sound, in response to the *Exxon Valdez* oil spill. NRDA Marine Mammal Study Number 6. U.S. Fish and Wildl. Serv., Anchorage, AK.

Irons, D.B. 1992. Aspects of foraging behavior and reproductive biology of the black-legged kittiwake. Unpublished Ph.D. Dissertation.

Irons, D.B. 1994. Size and productivity of black-legged kittiwake colonies in Prince William Sound, Alaska before and after the T/V *Exxon Valdez* oil spill. NRDA Bird Study Number x. Unpubl. Rep., U.S. Fish and Wildl. Serv., Anchorage, AK. xx pp

Irons, D. B., D. R. Nysewander, and J. L. Trapp. 1988. Prince William Sound sea otter distribution. Unpubl. Rep., U.S. Fish and Wildl. Serv., Anchorage, Ak 31 pp.

Klosiewski, S. P., and K. K. Laing. ms. Marine bird populations of Prince William Sound, Alaska, before and after the *Exxon Valdez* oil spill. NRDA Bird Study Number 2. Unpubl. Rep., U.S. Fish and Wildl. Serv., Anchorage, Alas. 85 pp.

E. Project Implementation

The U. S. Fish and Wildlife Service is the most appropriate entity to conduct this project. The National Biological Survey will be responsible for the data collection at the Wooded, Chiswell and Barren islands, which will occur in conjunction with the puffin project.

The U.S. Fish and Wildlife Service has the technical expertise to conduct this study. Other similar projects have been conducted by the USFWS on kittiwakes in Prince William Sound for several years. Successful methods have been established to collect and analyze data. The USFWS has trust responsibility for kittiwakes and all other seabirds as designated in the Migratory Bird Treaty Act of 1918.

F. Coordination of Integrated Research Effort

This project will collaborate with several other projects that will investigate whether food availability is limiting the recovery of injured species that prey on forage fish. Proposals on this topic will be submitted by several agencies and private groups. The agencies include NOAA, NBS, ADF&G, and USFWS. There will also be proposals concerning prey energetics, which was advertised as a NOAA broad agency announcement. This study meshes especially closely with NOAA's forage fish study, NBS's puffin and murre studies, the food web study, with the BAA topic of energetics of prey, and with other FWS studies on murrelets and pigeon guillemots. The forage fish project will provide data on the abundance of forage fish in areas where kittiwakes, puffins, pigeon guillemots and murrelets feed. The energetics study will provide data on the value of various prey species to kittiwakes and other fish eating seabirds. This suite of bird studies along with the forage fish study should be successful in determining if food, predation, oil toxicity or a combination of these factors are limiting the recovery of injured species.

G. Public Process

The public will be invited to comment on this project if it becomes part of the FY95 work plan. If funded, results will be presented at Trustee Council-sponsored workshops each winter.

H. Personnel Qualifications

Project Leader: David Irons

David Irons received his PH.D. in 1992 from the University of California (Irvine) and his M.S. in 1982 from Oregon State University. For his Ph.D. dissertation, David studied the factors affecting the reproductive success of black-legged kittiwakes in PWS. For his M.S. thesis he studied the foraging behavior of glaucous-winged gulls in relation to the presence of sea otters. He conducted marine bird and sea otter studies in PWS in 1984 and 1985. He has been studying kittiwakes in PWS for 11 years. Recently, he has overseen several seabird projects including a marine bird and sea otter study in PWS and Cook Inlet, seabird monitoring on Little Diomede Island, and a study of the cost of reproduction in kittiwakes. David has authored several reports and publications on seabirds and has made several presentations at scientific conferences on seabirds.

Pertinent reports and publications:

Irons, D.B. 1994. Size and productivity of black-legged kittiwake colonies in Prince William Sound, Alaska before and after the T/V *Exxon Valdez* oil spill. Unpubl. rept., U. S. Fish and Wildlife Service, Migratory Bird Management, Anchorage.

Hatch, S.A., G.V. Bryd, D.B. Irons, and G.L. Hunt. 1993. Status and ecology of kittiwakes in the North Pacific Ocean. Pages 140-153 *in* K. Vermeer, K.T. Briggs, K.H. Morgan, D. Siegel-Causey (eds), The status, ecology, and conservation of marine birds of the North Pacific. Can. Wildl. Serv. Spec. Publ., Ottawa, Canada.

Irons, D.B. 1992. Aspects of the foraging behavior and reproductive success of the Black-legged Kittiwake. Unpublished Ph.D. dissertation. U. of California, Irvine.

Vermeer, K., and D.B. Irons. 1991. The Glaucous-winged Gull on the Pacific Coast of North America. Acta 20th Congressus Internationalis Ornithologici:2378-2383.

Irons, D.B., R.G. Anthony, and J.A. Estes. 1986. Foraging strategies of Glaucous-winged Gulls in a rocky intertidal community. Ecology 67:1460-1474.

Hogan, M.E. and D.B. Irons. 1986. Waterbirds and marine mammals. *in* M.J. Hameedi and D.G. Shaw (eds), Environmental management of Port Valdez, Alaska: scientific basis and practical results. Springer-Verlag, New York.

I. FY95 Budget ($K)

	Requested	Base Funds
Personnel	$ 96.0	30.0
Travel	6.0	4.0
Contractual	30.0	0.0
Commodities	15.0	10.0
Equipment	35.0	45.0
Capital Outlay	0.0	0.0
Subtotal	$182.0	89.0
General Admin.	16.5	
Total	$198.5	89.0

Project #95038

RESTORATION PROJECT

SYMPOSIUM ON SEABIRD RESTORATION

Project Leader [interim]	Craig S. Harrison
Lead Organization:	Pacific Seabird Group
Cost of Project:	$77,000
Start-up date:	Within 1 month of contract award
Completion date:	December 1995
Project Duration:	One year only (possible additional work in one subsequent year)
Geographic Area:	No field work
Contact Person:	Craig S. Harrison Vice Chair for Conservation Pacific Seabird Group 4001 North Ninth St. #1801 Arlington, VA 22203 (202) 778-2240

#95038

Introduction. The Trustee Council has struggled for the past five years with determining the most efficacious means to restore seabird populations that were damaged by the oil spill. The Pacific Seabird Group (PSG) proposes to host a symposium in Alaska during September or October 1995 to discuss the science of seabird restoration. PSG would invite and sponsor knowledgeable scientists from around the world to discuss the benefits and costs of every technique to restore seabirds that has been used.

The affected seabird species include common murres, marbled murrelets, Kittlitz's murrelets, pigeon guillemots, tufted puffins, cormorants, black oystercatchers, black-legged kittiwakes and ancient murrelets. Some of these species suffered severe losses in the spill, but little work has been done to restore their populations.

Need for Project. The symposium will provide state and federal trustees with a realistic approach to the most effective means of restoring Alaska's seabird colonies. PSG has been involved with the EVOS restoration process since the beginning, and we believe this symposium would assist the Trustee Council with seabird restoration.

Project Design.

1. Objectives. (1) Identify and evaluate the techniques that can be used to restore seabird populations injured by oil spills; (2) gather knowledgeable scientists from throughout the world to attend and participate in discussions.

2. Methods. (1) Identify suitable scientists; (2) inquire as to their availability and need for travel funds; (3) develop a symposium format that will concentrate on discussion and practical experiences. Formal paper sessions will be included, but the focus will be on discussions to identify the most efficacious restoration methods; (4) Minutes of the meeting and general conclusions will be available. A synthesis of the discussions and papers could be published, but is not included in this proposal.

3. Schedule.

Activity	Month
Contract Award	0
Work Begins	1
Scientists identified and invited	3
Planning completed	5
Draft Report	October 1995
Final Report	December 1995

The draft report can be available for public comment if the Trustee Council believes that this would be necessary.

#95038

4. Technical Support. None.

5. Location. Kodiak or Anchorage, after discussions with the Trustee Council.

Project Implementation. PSG should undertake this project. PSG is an international organization that was founded in 1972 to promote knowledge, study and conservation of Pacific seabirds. PSG draws its members from the entire Pacific Basin, and includes biologists who have research interests in Pacific seabirds, state and federal officials who manage seabird refuges and individuals with interests in marine conservation. PSG has hosted symposia on the biology and management of virtually every seabird species affected by the Exxon Valdez oil spill, and has sponsored symposia on the effects of the spill on seabirds. PSG is uniquely qualified to implement this project.

Coordination. This project can be integrated with all on-going seabird restoration projects.

Personnel Qualifications. PSG had only about two weeks between receipt of the information to propose projects and the June 15, 1994 deadline. For this reason, PSG is unable to identify sub-contractors at this time but intends to sub-contract most of this work to highly qualified seabird biologists.

Budget.

Sub-contract(s)	$30,000
Travel and meeting site	30,000
Commodities (supplies, telephone, etc.)	2,000
General administration/overhead	15,000
Total	$77,000

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Common Murre Population Monitoring Closeout

Project 95039 (closeout)

Project Leader: Dave Roseneau

Lead Agency: U.S. Fish and Wildlife Service

Cost of Project: $30.5K

Project Start-up/Completion Dates: 10/1/94 - 03/31/95

Project Duration: N/A

Geographic Area: N/A

Contact Person: Catherine Berg
U.S. Fish and Wildlife Service
1011 E. Tudor Rd.
Anchorage, AK 99503
(907) 786-3598

B. Introduction

This project is the closeout of 94039 - Common Murre Population Monitoring. The purpose of the project was to monitor trends in numbers, productivity, and phenology of common murres at colonies in the Barren Islands that were affected by the spill

C. Need for the Project

Not applicable.

D. Project Design

1. Objectives:

The purpose is to analyze 1994 project data and prepare a final report. The report will be prepared for the peer-review process and presentation to the Trustee Council.

2. Methods

Not applicable.

3. Schedule

October - December: Data analysis
December - January: Report writing
February 15: Draft report
March 31: Final report

4. Technical Support:

Not applicable.

6. Location:

Report preparation will occur at Alaska Maritime National Wildlife Refuge Headquarters in Homer, Alaska.

E. Project Implementation

The USFWS is the most appropriate entity to analyze the data and write the report.

F. Coordination of Integrated Research Effort

Not applicable.

G. Public Process

This project was reviewed by the public as part of the FY94 Work Plan.

H. Personnel Qualifications

Not applicable.

I. Budget ($K)

Personnel	$25.2
Travel	0.5
Contractual	0.0
Commodities	1.0
Equipment	0.0
Capital Outlay	0.0
Subtotal	$26.7
General Admin.	3.8
Total	$30.5

J. Literature Cited

Not applicable.

Common Murre Productivity Monitoring

Project Number: 95039

Project Leader: David G. Roseneau

Lead agency: U.S. Fish and Wildlife Service

Cost of Project: FY95 $163.7K; FY96 $138.5K[1]

Project Start-up/Completion Dates: 2/95-4/96

Project Duration: Three years (FY95-FY97)

Geographic Area: East Amatuli Island and East Amatuli Light Rock, Barren Islands

Contact Person: David G. Roseneau or G. Vernon Byrd
Alaska Maritime National Wildlife Refuge
2355 Kachemak Bay Dr. (Suite 101)
Homer, Alaska 99603-8021
907/235-6546

B. Introduction

Common murres *(Uria aalge)* are the injured resource addressed by this project. Both documented and estimated losses of murres were higher than losses suffered by any other avian species following the 24 March 1989 *T/V Exxon Valdez* oil spill (e.g., Piatt and Lensink 1989, Piatt *et al.* 1990, ECI 1991). The Barren Islands contained one of the largest nesting concentrations of these diving fish-eating seabirds in the path of the oil (USFWS 1990).

The proposed FY95 common murre restoration monitoring project focuses on obtaining detailed data on the productivity and nesting chronology of murres in the Barren Islands, a location recently proposed as the key restoration monitoring site for obtaining this information (EVOSTC 1994). Implementing the project will provide one year of the multi-year data set required to determine whether common murres are recovering from the *Exxon Valdez* oil spill (see EVOSTC 1994, page A-13).
The FY95 work is related to several previous Trustee Council projects including damage assessment studies of common murres during 1989-1991 (Bird Study No. 3; e.g., Nysewander *et al.* 1993), and a murre restoration monitoring studies in 1992 (Restoration Project No. 11; Dragoo *et al.* 1993), 1993 (Project 93049, Roseneau *et al.* 1994) and 1994 (Project 94039, currently underway). These projects were designed to collect detailed

[1]Includes costs of writing reports. FY96 costs assume that productivity studies will be combined with population census work.

information on numbers, productivity, and nesting chronology at the injured Barren Islands colonies. The proposed FY95 work is a continuation of the 1993-1994 studies; however, it is specifically designed to monitor only productivity and timing of nesting events. Monitoring of population size will be deferred until 1996. This approach follows the proposed Recovery Monitoring Strategy formulated during the 13-15 April 1994 workshop (EVOSTC 1994).

C. Need for the Project

This project is the first part of a potential three to four year-long restoration monitoring program designed to collect additional detailed information on the productivity of injured common murres in the Barren Islands. These productivity data are needed to help determine the recovery status of this injured resource. The FY95 work will provide critical information on numbers of fledged chicks per nest site, timing of nesting events (e.g., egg-laying and hatching dates), and attendance of adults that will be combined with similar data collected during 1993 and 1994. This information will be used in conjunction with at least two (possibly three) more years of data collected during 1996-1997 (possibly 1998) to determine whether reproductive timing and success are within normal ranges, based on prespill data and information from other nesting colonies located outside the spill zone. At least five years of data are required to allow for natural variation.

The draft Recovery Monitoring Strategy suggests that productivity studies for murres should be conducted for four years starting in FY95 (EVOSTC 1994). However, because detailed productivity information will be available from the FY93 and FY94 studies, two years of work after FY95 will produce a five-year data set that should be sufficient to determine whether production and breeding schedules are within normal ranges for Gulf of Alaska colonies.

Both the injured resource and the public will benefit from the proposed project. Common murres will benefit because 1995 productivity data will help resource managers and the Trustee Council determine whether murres are recovering or whether other measures need to be taken to ensure full recovery of this injured species to pre-spill levels. For example, computer simulation models developed for the Trustee Council that estimate recovery rates for murre populations (Heinemann 1993) can utilize the 1995 productivity data to more accurately predict rates of recovery for this injured resource. The general public will benefit because they will have access to new information on the status of the avian species that suffered the greatest known direct mortality from floating oil. Private sector businesses offering sight-seeing and birding tours to the Barren Islands and other Gulf of Alaska colonies will benefit because they will have new information on the status of the injured species that will help them plan trips, prepare lectures, and be of interest to their clientele.

D. Project Design

1. Objectives:

a. Monitor the recovery of Barren Island murres by collecting data on reproductive timing and success and determining whether these biological variables fall within normal bounds.

2. Methods:

This project will collect high quality information for determining whether murre productivity and timing of nesting events are within normal ranges. Funds will be conserved by focusing efforts at East Amatuli Island. Both East Amatuli and Nord islands were included in the 1993 and 1994 studies, but Nord Island is difficult to access, and including Nord Island increases the cost of the study by at least $60K.[2] In 1993, differences in productivity values and timing of nesting events between murres nesting on East Amatuli and Nord islands were not significant (Roseneau *et al.* 1994). We therefore proposed to limit monitoring efforts to East Amatuli Island and Light Rock, with the exception of placing time-lapse cameras on Nord Island to collect attendance and chronology data.

The objective of the draft Recovery Monitoring Strategy for common murres is to monitor productivity in the Barren Islands for a few more years to ensure that it remains within normal bounds (EVOSTC 1994). Data collected at East Amatuli Island and Light Rock in FY95, when combined with information from 1993-1994 and additional work there in 1996-1997, will produce a five year data set that should be sufficient to meet this goal.

The methods employed during the FY93 and FY94 DOI-FWS Barren Islands common murre restoration studies (Projects 93049 and 94039) will be used to collect FY95 productivity data. These methods are based on standard refuge and seabird colony protocols. Data will be collected from at least 10 productivity plots, including 9 on East Amatuli Island and 1 on Light Rock. These plots, first established in 1993, contain about 250 nest sites and sample a variety of nesting habitats (Roseneau *et al.* 1994). Data will also be collected from at least two new plots that will be set up on East Amatuli Island during FY94. The new plots, located in a different sector of the colony, will contain about 20-30 nest sites each.

[2]Camp sites are not available on Nord Island, and crews must camp on nearby Ushagat Island. Because of strong tidal rips and swells backed by westerly winds, the crossing between Ushagat and Nord islands requires, particularly in the late season (August-September), the use of a large, contract vessel.

Observations will encompass the time from before eggs are laid until chick-fledging peaks. Each plot will be visited every three to four days, weather permitting, and observations will be made with the aid of high quality binoculars and spotting scopes. Data collected during the visits will provide information on productivity (numbers of eggs laid and hatched and chicks fledged per plot, per pair, and per total number of adults). These data will also be used to determine timing of nesting events (first egg-laying dates, and mean and median laying, hatching, and fledging dates).

Information on any factors or events that might adversely affect murre productivity will be collected (e.g., avian predation events, adverse weather conditions, charter boat activities, aircraft overflights). During predation and other disturbance episodes, large numbers of birds often flush from the nesting cliffs. Efforts will be made to quantify both numbers of flushing individuals and numbers of incubating or brooding birds remaining on the nesting ledges during and after these types of events. During flushing events, special care will also be taken to look for falling eggs or chicks.

Two time-lapse cameras will be set up at the East Amatuli Island productivity plots to record attendance of adults during the breeding season. These attendance data will be supplemented with regular counts of adults on the study plots (i.e., counts made during visits to collect productivity data). Two additional cameras will be set up to obtain similar attendance information at the Nord Island productivity plots for comparison with East Amatuli Island data and data collected in previous years.
Because sea surface temperature (SST) can influence timing of nesting events at murre colonies (Birkhead and Harris 1985), water temperatures will be taken on a regular basis at several locations near East Amatuli Island with a datalogger device and pre-calibrated hand-held thermometers. Broader-scale breeding season SST data will be obtained via AVHR satellite imagery from the Geophysical Institute at the University of Alaska-Fairbanks for the 1989-1994 breeding seasons. Barren Islands SST information will also be obtained from other sources (e.g., published literature; T. Royer, University of Alaska-Fairbanks; NOAA buoy and declassified U.S. Navy data, if available). All efforts to obtain SST data will be coordinated with principal investigators of other agencies and organizations working on Trustee Council projects (University of Alaska Institute of Marine Science, Prince William Sound Science Center, and NOAA researchers).

When time allows during the productivity study, eight special multi-count plots at East Amatuli Island and Light Rock will be counted several times during appropriate times of day and periods of the nesting cycle (i.e., between 1100-2000 hrs in the late incubation - late chick-rearing period). These small-scale counts, which can be made at no extra cost to the project, will provide a small, but valuable amount of "off-year" information that can be integrated with large-scale population census data that are currently scheduled to be collected every third year beginning in FY96 (see EVOSTC 1994, pages A-13 and A-14).

3. Schedule:

Jan-Mar 95	Recruit seasonal employees.
Apr-Jun 95	Field preparations.
Jun-Sep 95	Field work
Sep-Dec 95	Data Analysis
Jan-Mar 96	Report Writing
March 96	Submit Draft Report

4. Technical Support:

None. However, some technical support may be required at a later date to help interpret satellite imagery of sea surface temperatures.

5. Location:

East Amatuli island in the Barren Islands, about 75 km south-southwest of Homer, between the Kenai Peninsula and the Kodiak Archipelago. The study will be staged from Homer.

E. Project Implementation

The U.S. Fish and Wildlife Service is the most appropriate entity to implement this project. The Barren Islands are part of the Alaska Maritime National Wildlife Refuge (AMNWR), and the AMNWR office in Homer has an experienced research team that has the technical capabilities needed to successfully carry out this project. The Barren Island murre colonies are particularly dangerous, difficult places to work. Nesting cliffs are located in areas where strong tidal currents and rips develop on a regular basis (1.5-2.5 m-high standing waves and currents exceeding 5-6 kts are common). Productivity plots are only accessible with the aid of boats, and use of running-line mooring systems capable of withstanding 6-9 m seas during storms and technical rock climbing equipment. The proposed project leader (D.G. Roseneau) and field team leader (A.B. Kettle) have the training, experience, and technical knowledge necessary to safely work at remote locations in these situations and conditions. AMNWR staff assigned to this project have a combined total of 12 seasons experience working at these rugged Gulf of Alaska murre colonies and over 40 years combined expertise conducting similar types of seabird studies. This level of knowledge of both the biology of the birds and study area conditions will make it easy to efficiently plan and implement this study.

F. Coordination of Integrated Research Effort

The FY95 common murre monitoring study is a complete, stand-alone project that is directly related to FY93 and FY 94 Barren Islands murre work. However, it is also part of a larger, integrated ecosystem oriented package of bird and marine mammal restoration projects designed to address the information needs of the Trustee Council. The FY95 work will be coordinated with several studies listed in the package, if they are funded. Projects most likely to produce information relevant to the Barren Islands murre productivity work that have been tentatively selected for coordination efforts include proposed investigations of murre foraging areas, food web relationships, foraging efficiencies at food patches, forage fish assessment, and fisheries oceanography.

The project will also be coordinated with other FWS and National Biological Survey seabird monitoring work in the Gulf of Alaska and elsewhere (e.g., Bering Sea). Data collection and analysis methods will be reviewed to ensure that data can be compared between studies. Efforts will be made to share personnel and equipment whenever possible.

G. Public Process

The draft work plan describing the FY95 study will be available for public review at the AMNWR office in Homer Alaska and at the USFWS Regional Office in Anchorage. Letters have been sent to the communities of Port Graham and Nanwalek describing the proposed study and offering to present information from this work and previous restoration projects during late fall 1994 - early winter 1995. Efforts will be made to encourage people living in oil spill communities to apply for any positions that may be available. The results of the study will be available to the public in Homer and Anchorage, and information from these studies will be presented to the public during Trustee Council sponsored workshops during 1994-1995.

H. Personnel Qualifications

1. Project Leader - David G. Roseneau

David Roseneau received his B.S. degree in wildlife management and M.S. degree in biology from the University of Alaska - Fairbanks in 1967 and 1972, respectively. His thesis research was on the numbers and distribution of gyrfalcons, *Falco rusticolus* on the Seward Peninsula, Alaska. He joined the U.S. Fish and Wildlife Service in January 1993 and was project leader of common murre restoration monitoring Project No. 93049 in the Barren Islands in 1993. Mr. Roseneau is also project leader of the 1994 Barren Islands common murre restoration monitoring study (Project 94039). Prior to 1993, he was a consulting biologist for 20 years, and he has conducted and managed marine bird, raptor, and large mammal projects in Alaska and Canada for government agencies and private-sector clients. Mr. Roseneau has been involved in several large-scale murre *(Uria* spp.) population monitoring projects. During 1976-1983, as co-principal investigator of NOAA/OCSEAP Research Unit 460, he conducted monitoring studies of murres and black-legged kittiwakes *(Rissa tridactyla)* at capes Lisburne, Lewis, and Thompson in the Chukchi Sea, and St. Lawrence, St. Matthew, and Hall islands in the Bering Sea. He also studied auklets *(Aethia* spp.) at St. Lawrence and St. Matthew islands, and participated in murre and kittiwake projects at Bluff in Norton Sound. In 1984-1986, he participated in follow-up studies of murres and kittiwakes in the northeastern Chukchi Sea, and during 1987-1988 and 1991-1992, he helped conduct additional murre and kittiwake work at capes Lisburne and Thompson, and at Chamisso and Puffin islands. Mr. Roseneau is experienced in collecting and analyzing data on numbers, productivity, and food habits of seabirds; relating trends in numbers and productivity to changes in food webs and environmental parameters (e.g., air and sea temperatures, current patterns); and assessing potential impacts of petroleum exploration and development on nesting and foraging marine birds. He has broad knowledge of rock climbing techniques and has operated inflatable rafts and other outboard-powered boats in the Bering, Chukchi, and Beaufort seas and on various Alaskan rivers in excess of 2,800 hrs. Mr. Roseneau has also accrued several hundred additional hours operating time in small boats and larger, more powerful vessels (e.g. 25 ft, 300-400 hp HydroSports and Boston Whalers) in Kachemak Bay, Prince William Sound, and Kenai Peninsula and Barren Island waters [before starting work in the Barrens Islands in 1993, he spent several weeks camping and boating in the Barren Islands in 1965 and discovered the fork-tailed storm-petrel *(Oceanodroma furcata)* colony on East Amatuli Island. During his career, Mr. Roseneau has authored and co-authored over 65 reports and publications, including 22 on Alaskan seabirds.

Selected Seabird Publications

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

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

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

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

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

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

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

1215.

2. Field Team Leader - Arthur B. Kettle

Arthur Kettle received his B.A. degree in Human Ecology from the College of the Atlantic in 1984. He has participated in several large-scale seabird projects at remote locations. He joined the U.S. Fish and Wildlife Service in May 1993, and is currently the field team leader for common murre restoration monitoring Project No. 94039 in the Barren Islands. In that capacity, Mr. Kettle is responsible for logistics at the Amatuli Cove and Ushagat Island camps. He is also responsible for ensuring that the study design is followed at both locations.. Mr. Kettle was in charge of the East Amatuli Island camp during common murre restoration monitoring Project No. 93049 in 1993. During that study, his broad knowledge of boat-mooring systems and technical rock climbing techniques allowed him to safely collect productivity and chronology data from a series of study plots he established on East Amatuli Island (a difficult technical task not accomplished during any previous pre- or postspill study). He also censused birds at East Amatuli Island and East Amatuli Light Rock in 1993. Mr. Kettle counted these murre colonies and collected productivity data on Light Rock during Exxon-sponsored University of Washington Barren Islands studies in 1990-1992. Besides his murre work, he also participated in large-scale University of Washington studies of magellanic penguins in Argentina in 1987-1991, and tufted puffins and fork-tailed storm-petrels in the Barren Islands during 1990-1992. Mr. Kettle has over 15 years experience safely operating small boats in both north Atlantic and Pacific ocean waters. By September 1994, he will have completed his fifth consecutive field season operating outboard-powered inflatable and ridged-hulled craft in the Barren Islands.

Selected Publications

Boersma, P.D., J.K. Parrish, and A.B. Kettle. 1993. Common murre abundance, phenology, and productivity on the Barren Islands, Alaska: The *Exxon Valdez* oil spill and long-term environmental change. In BOOK TITLE, ASTM STP 1219._. (eds.); American Society for Testing and Materials, Philadelphia; 1993.

I. Budget

Personnel	99.6
Travel	30.3
Contractual	2.0
Commodoties	10.8
Equipment	6.0
Capital	0.0
Subtotal	148.7
General Admin.	15.0
Total	163.7

J. Literature Cited

Birkhead, T. R. and M.P. Harris. 1985. Ecological adaptations for breeding in the Atlantic alcidae. Pp. 205-231 *in* The Atlantic Alcidae (D. Nettleship and T.R. Birkhead, eds.). Academic Press, London. 574 pp.

Dragoo, D.E., G. V. Byrd, D.G. Roseneau, D.A. Dewhurst, J.A. Cooper, and J.H. McCarthy. 1993. Effects of the *T/V Exxon Valdez* oil spill on murres: A perspective from observations at breeding colonies four years after the spill. Final rept., Restoration Proj. No. 11, U.S. Fish Wildl. Serv., Homer, AK.

Ecological Consulting, Inc. 1991. Assessment of direct seabird mortality in Prince William Sound and the western Gulf of Alaska resulting from the *Exxon Valdez* oil spill. Unpubl. rept. by Ecol. Consulting, Inc., Portland, OR. 153 pp.

EVOSTC (*Exxon Valdez* Oil Spill Trustee Council). 1994. Invitation to submit Restoration Projects for Fiscal Year 1995. *Exxon Valdez* Oil Spill Trustee Council, Anchorage, AK. 38 pp. + appendices.

Heinemann, D. 1993. How long to recovery for murre populations, and will some colonies fail to make the comeback? Pp. 139-141 *in Exxon Valdez* Oil Spill Symposium Abstract Book (February 2-5, 1993). Exxon Valdez Oil Spill Trustee Council, Anchorage, AK. 356 pp.

Nysewander, D., C.H. Dippel, G.V. Byrd, and E.P. Knudtson. 1993. Effects of the *T/V Exxon Valdez* oil spill on murres: A perspective from observations at breeding colonies. Bird Study No. 3. Final rept., U.S. Fish Wildl. Serv., Homer, AK. 40 pp.

Piatt, J. F., and C. J. Lensink. 1989. *Exxon Valdez* toll of marine birds. Nature 342:865-866.

_____, _____, W. Butler, M. Kendziorek, and D. R. Nysewander. 1990. Immediate impact of the *Exxon Valdez* oil spill on marine birds. Auk 107:387-397.

Roseneau, D.G., A.B. Kettle, and G.V. Byrd. 1994. Population and productivity monitoring studies of murres at Barren Islands colonies five years after the *T/V Exxon Valdez* oil spill. Restoration Project No. 93049. *In Preparation*. Annu. rept. by the U.S. Fish Wildl. Serv., Homer, AK.

USFWS (U.S. Fish and Wildlife Service). 1990. Catalog of Alaskan seabird colonies computer archives. U.S. Fish and Wildl. Serv., Migratory Bird Management, Anchorage, Alaska.

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Closeout: Introduced Predator Removal from Islands

Project Number: 95041-A

Project Leader: Edgar Bailey

Lead Agency: U.S. Fish and Wildlife Service

Cost of Project: $20.4K

Project Start-up/Completion Dates: 10/1/94 - 03/31/95

Project Duration: N/A

Geographic Area: N/A

Contact Person: Catherine Berg
U.S. Fish and Wildlife Service
1011 E. Tudor Rd.
Anchorage, AK 99503
(907) 786-3598

B. Introduction

This project is the closeout of 94041 - Introduced Predator Removal from Islands. The purpose of the project was to restore natove bird populations, particularly those injured by the spill, by removing introduced predators.

C. Need for the Project

Not applicable.

D. Project Design

1. Objectives:

The purpose is to analyze 1994 project data and prepare a final report. The report will be prepared for the peer-review process and presentation to the Trustee Council.

2. Methods

Not applicable.

3. Schedule

October - December: Data analysis
December - January: Report writing
February 15: Draft report
March 31: Final report

4. Technical Support:

Not applicable.

6. Location:

Report preparation will occur at Alaska Maritime National Wildlife Refuge Headquarters in Homer, Alaska.

E. Project Implementation

The USFWS is the most appropriate entity to analyze the data and write the report.

F. Coordination of Integrated Research Effort

Not applicable.

G. Public Process

This project was reviewed by the public as part of the FY94 Work Plan.

H. Personnel Qualifications

Not applicable.

I. Budget ($K)

Personnel	$16.0
Travel	1.0
Contractual	0.0
Commodities	1.0
Equipment	0.0
Capital Outlay	0.0
Subtotal	$18.0
General Admin.	2.4
Total	$20.4

J. Literature Cited

Not applicable.

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Introduced Predator Removal from Islands: Follow-up Surveys

Project Number: 95041-B

Project Leaders: Edgar P. Bailey and G. Vernon Byrd

Lead Agency: U.S. Fish and Wildlife Service

Cost of Project: 44.0 K

Project Start-up/Completion Dates: Feb 1995/Apr 1996

Project Duration: 1 year

Geographic Area: Field work will occur at Simeonof and Chernabura islands in the Shumagin Islands, western Gulf of Alaska, and reports will be written at the DOI-FWS Alaska Maritime National Wildlife Refuge office in Homer, Alaska.

Contact Person: G. Vernon Byrd
Alaska Maritime National Wildlife Refuge
2355 Kachemak Bay Drive, Suite 101
Homer, AK 99603
(907) 235-6546.

B. Introduction

In 1994, the Trustee Council funded a project (No. 94041) to restore populations of injured black oystercatchers (*Haematopus bachmani*) and pigeon guillemots (*Cepphus columba*) by removing introduced arctic foxes (*Alopex lagopus*) from Simeonof and Chernabura islands in the Shumagin group, western Gulf of Alaska. It will be necessary to survey these islands in 1995 to eradicate remaining foxes or to determine that none remain. In addition, surveys of oystercatchers, guillemots and other seabirds will be conducted to determine whether their populations are beginning to increase following fox removal.

C. Need for the Project

Few options are available for direct restoration of black oystercatcher and pigeon guillemot populations injured by the oil spill, but it is possible to take action to cause populations to expand at the western edge of the area affected by oil by removing introduced foxes from islands where they have kept numbers of oystercatchers, guillemots, and other populations of seabirds depressed. Fox removal efforts began at Simeonof and Chernabura islands in 1994, and it will be necessary to return to the islands in 1995 to verify that no foxes remain. Following a winter with no foxes present, evidence like lack of fresh tracks and scat, and grown-over fox trails may be used to determine if foxes remain.

D. Project Design

1. Objectives:

a. Determine that arctic foxes have been eradicated from Simeonof and Chernabura islands.

b. Document increases in black oystercatcher and pigeon guillemot populations at Simeonof and Chernabura islands as a result of elimination of introduced foxes.

2. Methods:

a. Fox Surveys.--Crews will check beaches, trails, and creek banks for signs of foxes on Simeonof and Chernabura islands. If it is determined that foxes remain, trapping according to methods used in 1994 will be used to remove remaining foxes.

b. Oystercatcher and Guillemot Surveys.--As in 1994, oystercatchers will be monitored by surveying beaches on foot and from a small inflatable boat operated within 30 m of the shoreline. Guillemots will be counted from a small inflatable boat during nearshore surveys of island perimeters. Surveys will be conducted at Simeonof, Chernabura, and the three control islands surveyed in 1994 (Bird, Atkins, and Herendeen). All surveys would be conducted during the early incubation period of each species. At least 3 surveys will be made of each island to provide a basis for examining variation among counts.

3. Schedule:

Mar 95	Complete study plan, procure equipment, and select temporary field personnel
Apr 95	Continue procurement of equipment and supplies
May 95	Organize and pack supplies, and train field personnel
Jun 95	Establish camps on Simeonof and Chernabura islands to check for signs of foxes and to survey populations of oystercatchers and guillemots at these two islands and the "control" islands (Bird, Atkins, and Herendeen).
Jul 95	Leave Shumagin Islands and return to Homer

Aug 95 Clean and store equipment, begin report

Sep-Oct 95 Analyze data and write draft report

Nov 95 Submit revised report

4. Technical Support:

None required

5. Location:

The project will occur in the Shumagin Islands. The nearest community is Sand Point, about 80 miles away.

E. Project Implementation

The DOI-Fish and Wildlife Service is the most appropriate entity to conduct this project because this is a followup to the project began in 1994. The same people that conducted the 1994 program would be best suited because of their local knowledge of the project sites, experience in evaluating the success of fox removal efforts, knowledge of locations of bird study plots, and familiarity with the 1994 data for comparisons. Furthermore, the restoration sites are on the Alaska Maritime National Wildlife Refuge, and the staff of that agency is in the best position to insure that the information gained is incorporated into the long-term refuge management program.

F. Coordination of Integrated Research Effort

This is a direct restoration project.

G. Public Process

Public review of this project will occur through the normal Trustee Council process. No additional formal public review will be sought. The local government at Sand Point will be kept informed about the project.

H. Personnel Qualifications

1. Project Manager-G. Vernon Byrd

G. Vernon Byrd received a B.S. degree in wildlife management from the Univ. of Georgia in 1968, did post-graduate studies in wildlife biology at the Univ. of Alaska in 1975, and completed a M.S. degree in wildlife resources management (with an emphasis in applied statistics) from the Univ. of Idaho in 1989. Mr. Byrd has worked for the U.S. Fish and Wildlife Service for over 20 years, focusing on studies of marine birds in Alaska and Hawaii. His major interests have centered around monitoring long-term trends in seabird populations and the impacts of introduced animals on native bird populations. He has written over 50 scientific papers and 50 U.S. Fish and Wildlife Service reports on field studies, and he has presented more than 15 papers at scientific meetings. Mr. Byrd currently serves as supervisory wildlife biologist at the Alaska Maritime National Wildlife Refuge, the premier area for seabirds in the national public land system.

Recent Related Publications

Byrd, G.V., E.C. Murphy, G.W. Kaiser, A.J. Kondratyev, and Y.V. Shibaev. 1993. Status and ecology of offshore fish-feeding alcids (murres and puffins) in the North Pacific. Pages 176-186 in Vermeer, K., K.T. Briggs, K.H. Morgan, and D. Siegel-Causey (eds.). *The status, ecology, and conservation of marine birds of the North Pacific.* Can. Wildl. Serv. Spec. Publ., Ottawa.

Byrd, G.V., J.L. Trapp, and C. Fred Zeillemaker. *in press.* Removal of introduced foxes: A case study in restoration of native birds. Transactions of the 59th N. Am. Wildl. and Natur. Res. Conf., Anchorage, Alaska. Wildl. Manage. Institute, Washington, D.C.

2. **Project Leader**-Edgar P. Bailey

Edgar P. Bailey obtained a B.S. degree in biology from the Univ. of Redlands, California, and spent an additional 3 years at Utah State Univ. receiving a M.S. degree in wildlife biology in 1963. He has worked for Federal resource agencies for over 30 years. Mr. Bailey came to Alaska 25 years ago as assistant manager for the former Aleutian Islands National Wildlife Refuge, and during this period he has been continuously involved with marine birds and mammals, specializing on adverse effects of alien species on island biodiversity and particularly the need to remove introduced foxes from refuge islands. He has published more than 20 papers in various journals and has written numerous unpublished reports. He has thousands of hours of experience operating small boats primarily in southcentral and southwestern Alaska, and has been involved in removing foxes from 10 islands.

Recent Related Publications

Bailey, E.P. 1993. Introduction of foxes on Alaskan islands--history, effects on avifauna, and eradication. U.S. Dept. of the Interior, Fish and Wildl. Serv. Res. Publ. 193.

Bailey, E.P. and G.W. Kaiser. 1993. Impacts of introduced predators on nesting seabirds in the northeast Pacific. Pages 218-226 in Vermeer, K., K.T. Briggs, K.H. Morgan, and D. Siegel-Causey (eds.). *The status, ecology, and conservation of marine birds of the North Pacific.* Can. Wildl. Serv. Spec. Publ., Ottawa.

I. Budget

Personnel	26.0
Travel	12.5
Contractual	0.0
Commodities	5.0
Equipment	3.5
Capital	0.0
Subtotal	47.0
General Administration	3.9
Total	50.9

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FIVE-YEAR PLAN TO REMOVE PREDATORS FROM SEABIRD COLONIES

Project Number: 95042

Project Leader Craig S. Harrison

Lead Organization: Pacific Seabird Group

Cost of Project: $75,000

Start-up date: Within 1 month of contract award

Completion date: Within 11 months of contract award

Project Duration: One year only

Geographic Area: No field work

Contact Person: Craig S. Harrison
Vice Chair for Conservation
Pacific Seabird Group
4001 North Ninth St. #1801
Arlington, VA 22203
(202) 778-2240

Introduction. This project will produce a practicable five-year plan whereby all introduced foxes, rats, ground squirrels and other alien mammals that have reduced nesting habitat at present and former seabird colonies in Alaska will be identified and recommendations will be made for their removal. We will produce a colony catalog on CD-ROM as well as hard copy of colonies where alien mammals should be removed. The five-year plan will identify cost-effective method(s) of removing alien mammals and establish a milestone and activity time line whereby removal from all islands can be accomplished within five years. The five-year plan will identify any needed regulatory activities (such as licensing or permitting the use of M-44's and 1080) and propose a strategy by which such approvals can be obtained.

During the past two years, the Pacific Seabird Group has asked the U.S. Fish & Wildlife Service either to fund this project itself, or to ask the EVOS Trustee Council to fund it. To the best of our knowledge, FWS has never asked the Trustee Council to fund this work, although the Trustee Council funded a pilot project to remove predators from two islands during FY94 (Project 94041).

The seabird species affected by this project include common murres, marbled murrelets, Kittlitz' murrelets, pigeon guillemots, tufted puffins, black oystercatchers, cormorants, black-legged kittiwakes and ancient murrelets. Some of these species suffered severe losses in the spill, but little work has been done to restore their populations. While most of the islands are outside of the Trustee Council's definition of spill area, all of the bird species killed in the spill are migratory. Common murres throughout their range in the Gulf of Alaska and the Aleutian Islands are probably genetically linked. Banding studies of alcids indicate that substantial numbers of young birds prospect for breeding sites long distances from their natal colony, such as the distance from the Aleutians to Prince William Sound. Colonies outside the Trustee Council's definition of the oil spill area are a source of birds that can and will recolonize damaged colonies. NOAA's proposed natural resource damage assessment rules (January 1994) allow for restoration of resources beyond the oil spill area when such resources have been damaged.

Need for Project. The five-year plan will provide state and federal trustees with a realistic approach to restoring Alaska's seabird colonies. Because biologists have eliminated predators from some breeding islands, we can estimate the increase in the population of seabirds that has occurred once predators such as rats and foxes have been removed. After Kaligagan Island was stocked with foxes in 1921, its seabird population plunged so low that the renowned Alaska naturalist Olaus Murie recommended that it continue as a fox farm. In the 1980s, after foxes had died out, Kaligagan had 125,000 burrowing seabirds.[1/] FWS biologists have described dramatic increases in bird populations after foxes were removed from Nizki-Alaid Island in the western Aleutians.[2/] They found particularly impressive increases for loons, pelagic cormorant, Aleutian green-winged teal, common eider, glaucous-winged gull and tufted puffin. At a 600 hectare island off Newfoundland, twelve foxes consumed 31,000 Leach's storm-petrels in one breeding season.[3/] Alien predators obviously can devastate seabird colonies.

Arctic fox, red fox (introduced for commercial ranching) or rats occur on dozens of islands in the Alaska Maritime National Wildlife Refuge. We cannot estimate with any precision the increase in population if the island ecosystems in the Alaska Maritime National Wildlife Refuge were restored to their natural, predator-free condition. We believe that increases per island would range from 10,000 to 150,000 birds. It is possible that a few decades following predator removal a colony of one million or more birds might be reestablished. Accordingly, alien predators on the Alaska Maritime National Wildlife Refuge depress seabird populations in the order of one to ten Exxon Valdez oil spills.

The Trustee Council should plan for compensatory restoration in breeding areas outside

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[1/] Nyswander et al. 1982. Marine bird and mammal survey of the eastern Aleutian Islands, summers of 1980-81. FWS report.

[2/] Byrd and Bailey, Response of Aleutian Birds to Removal of Introduced Fox. Alaska Bird Conference (November 1991).

[3/] Skepkovych. 1986. A predatory behavior and impact of red foxes (Vulpes vulpes) on the seabird colonies of Baccalieu Island, Newfoundland. M.S. Thesis, Memorial University of Newfoundland, St. Johns.

of the spill area. This project will provide a framework for large-scale, cost-effective compensatory restoration.

Project Design. 1. Objectives. (1) identify all present and former seabird colonies that are limited by alien mammals; (2) propose a method to remove each alien population of mammals from the colony in conjunction with the Alaska Maritime National Wildlife Refuge; (3) develop a five-year plan whereby all such populations could be removed.

2. Methods. (1) literature search and consultations with federal, state and other natural resource managers to identify all islands with introduced predators; (2) consult with FWS, ADF&G, USDA Animal Damage Control, and predator removal experts abroad to identify the most efficacious removal techniques.

3. Schedule.

Activity	Month
Contract Award	0
Work Begins	1
Literature search completed	3
Agency/experts contacts completed	5
Draft Report for comment	8
Final Report	11

The draft report can be available for public comment if the Trustee Council believes that this would be necessary.

4. Technical Support. PSG will need access to the FWS colony catalog data base.

5. Location. Juneau, Anchorage, Homer, Aleutian Islands.

Project Implementation. For over two years, PSG has urged FWS to undertake this project. PSG is prepared to facilitate this project by functioning as the lead organization.

PSG is an international organization that was founded in 1972 to promote knowledge, study and conservation of Pacific seabirds. PSG draws its members from the entire Pacific Basin, and includes biologists who have research interests in Pacific seabirds, state and federal officials who manage seabird refuges and individuals with interests in marine conservation. PSG has hosted symposia on the biology and management of virtually every seabird species affected by the Exxon Valdez oil spill, and has sponsored symposia on the effects of the spill on seabirds. As such, PSG is uniquely qualified to implement this project.

Coordination. This project can be integrated with project No. 94041 that removes predators from two colonies. Moreover, if the Trustee Council were to fund predator removal from additional colonies during FY95 (as PSG would urge it to do), this project would be integrated with any such project(s).

Personnel Qualifications. PSG had only about two weeks between receipt of the information to propose projects and the June 15, 1994 deadline. For this reason, PSG is unable to identify sub-contractors at this time but intends to sub-contract most of this work to highly qualified seabird biologists.

FY95 Budget.

Sub-contract(s)	$50,000
Travel	8,000
Commodities (supplies, telephone, etc)	2,000
General administration/overhead	15,000
Total	**$75,000**

Cordova Cutthroat Trout Habitat Rehabilitation

Project Number: 95043-A

Project Leader: Dave Schmid, Cordova Ranger District USFS

Lead Agency: U.S. Forest Service

Project Cost: $22,690

Project Startup/Completion Dates: October 1994/September 1995

Project Duration: 1994-1995

Geographic Area: Streams in Eyak Lake basin and in logged areas near Cordova.
Contact Person: Dave Schmid. P.O. Box 280. Cordova, AK 99574, 424-7661.

B. Introduction

In recent years there has been increasing concern over the cutthroat trout (Oncorhynchus clarki) populations in the Prince William Sound area. Studies by the Alaska Department of Fish and Game show that cutthroat trout were adversely affected by the Exxon Valdez oil spill (Hepler et al. 1993). Areas in Prince William Sound have been closed to cutthroat fishing, and reduced limits and size restrictions have been imposed in the remaining areas. In addition, road construction and other development around Eyak Lake, near Cordova, has eliminated cutthroat spawning habitat. Recent timber harvesting east of Cordova could possibly have adverse effects on cutthroat habitat, although no assessment has yet been made.

The Cordova Ranger District proposes to work with the City of Cordova, the State of Alaska, and the Eyak Corporation, to identify degraded cutthroat habitat and develop a restoration or enhancement program. Although the areas identified so far are not on Forest Service land, adjacent Forest Service lands or recreation sites could be affected. In addition, if cutthroat populations in Eyak Lake and other areas are restored, there would be less fishing pressure on some of the small cutthroat stocks in streams on Forest Service lands.

The initial role of the Forest Service would be to take the lead in contacting the other groups and developing a memorandum of understanding. If the groups agree to undertake a cutthroat habitat restoration program, the Forest Service could help identify the work that needs to be done, develop proposals, obtain permits, and work on the environmental analysis.

Once the work is identified, additional funding will be needed to carry out the projects, most likely in FY 1996. The landowners should be responsible for hiring the crews to work on their lands. This will help ensure that members of the local community are hired. The role of the Forest Service at this point would be to provide some technical assistance, if needed, and to evaluate the work that has been done.

C. Need for the Project

Historically Eyak Lake supported a good cutthroat sportfishery with estimated harvests ranging from 90 to 833 during the period from 1977 to 1989 (Whitmore et al. 1991). The loss of spawning habitat from the construction of roads, a water treatment plant, and housing seems to have adversely affected the population, however. Although there is only anecdotal information and limited data from a study in 1991 by ADF&G, it appears that the population has declined dramatically.

In the areas east of Cordova where timber harvesting has occurred, there is little or no information as to whether cutthroat habitat has been affected. These areas do surround several lakes which have cutthroat and include the streams where cutthroat spawning would take place.

In both cases there is a need to determine what damage has been done, what potential problems exist, and how to remedy the situation. In some of the logged areas, for example, all that may be needed could be the rehabilitation of the roads to halt sedimentation of the streams. Around Eyak Lake it may be necessary to construct additional spawning area or reset culverts so they do not block cutthroat migration. Most of all, it is important to identify the problems that exist so measures can be taken before the cutthroat populations are further impacted.

Speaking in more general terms, there are a number of other reasons for preserving or enhancing the cutthroat populations in the Cordova area. Although the Cordova area was not in the direct path of the oil spill, the study by ADF&G found that cutthroat trout can stray considerable distances (Hepler et al. 1993). Thus, it is possible that Cordova stocks have been affected. This study also suggests that the effects of the oil spill may have spread into unoiled areas in 1990, affecting the growth of Dolly Varden char. While no adverse affects were noted for cutthroat in unoiled areas, there could still be residual effects that have gone undetected.

There are also some genetic concerns that need to be addressed. Since Prince William Sound is the northern limit of the cutthroat trout's range, there may be unique genetic stocks which have adapted to the extreme conditions here. The local populations should be protected until genetic studies have been conducted.

Cutthroat trout also provide a popular sportfishery in the spring and early summer before the salmon runs begin, especially for flyfishermen. As tourism increases, and especially if the Copper River Highway is completed, fishing pressure will increase in the Cordova area. It will be important to maintain or enhance the fish populations to preserve the recreational experience and the economic benefits derived from sportfishing, as well as the biological vitality of the stocks.

Literature Cited

Hepler, K.R., P.A. Hanson, and D.R. Bernard. 1993. Impact of oil spilled from the Exxon Valdez on survival and growth of Dolly Varden and cutthroat trout in Prince William Sound, Alaska. Unpublished report. 32 pp.

Whitmore, C., D. Vincent-Lang, and K.R. Hepler. 1991. Annual management report for the Prince William Sound management area. Alaska Department of Fish and Game Sportfish Division Region II. 168 pp.

D. Project Design

1. Objectives

The main objective for FY 1995 would be to identify habitat restoration opportunities in the

Cordova area. This would require coordination and cooperation among the City of Cordova, the Eyak Corporation, the State of Alaska, and the U.S. Forest Service since these entities are the principal landowners in the area. Once the opportunities are identified, the groups would need to develop a memorandum of understanding to determine the responsibilities each group will have for implementing the restoration work. The actual project work would be funded separately for FY 1996.

2. Methods

The Cordova Ranger District would take the lead in arranging and facilitating meetings with these groups and other interested parties. If there is sufficient interest and agreement, the preliminary surveys and assessments would then be carried out, preferably with representatives from all of the groups. However, the Alaska Department of Fish and Game and the U.S. Forest Service would be expected to provide technical expertise as to how to conduct the surveys and the rehabilitation work. A project work plan would then be submitted to the parties for approval.

The surveys and assessments would require a three-person crew for two months. Each of the streams in developed or altered areas would need to be surveyed. Special attention would be given to road crossings and other areas where erosion or migration barriers would be likely to occur. As the crews walk the streams, the amount of spawning and rearing area would need to be recorded, problem areas would be identified, and restoration prescriptions or enhancement opportunities would be noted.

3. Schedule

October 1994 - February 1995: Develop memorandum and commitment of personnel for preliminary surveys.

May - June 1995: Conduct surveys to assess project needs. Prepare project work plan.

July 1995: Decision on project plan.

4. Technical Support

Technical expertise on the rehabilitation of logging roads, tree planting and other silvicultural practices, and hydrology may be needed to carry out the surveys and assessments. There are qualified Forest Service personnel that could perform some of this work, but other parties may also have qualified personnel. Selection of the assessment team will need to be developed during the meetings.

5. Location

The proposed project area would include the Eyak Lake watershed near Cordova (Cordova C-5 quadrangle, T15S, R1W and R2W) and the logged areas approximately 13 miles east of Cordova (Cordova C-4 quadrangle, T15S, R1W) around Lake Elsner and several other small lakes.

E. Project Implementation

The Cordova Ranger District could arrange the meetings and discussions, but after that the duties would be shared by all of the aforementioned parties. The main part of the habitat survey work and the identification of restoration and enhancement opportunities could be carried out by the Forest Service, since the agency has experience in this area. However, it would be best if all of the parties involved could provide as much input as possible. The actual implementation of the restoration work would be carried out by contractors, employees of the Eyak Corporation, or other personnel.

F. Coordination of Integrated Research Effort

N/A

G. Public Process

This proposal does not require documentation under NEPA.

H. Personnel Qualifications

David Schmid is the program manager and a fisheries biologist for the Cordova Ranger District. He has a B.S. degree in resource management from the University of Wisconsin, Stevens Point. He worked on the Glacier Ranger District for four years as a fisheries technician and two years as a fisheries biologist, during which time he managed the fisheries program and oversaw the construction of several fish ladders and other major construction projects. Since 1990 he has been the program manager on the Cordova Ranger District.

Ken Hodges is a fisheries biologist on the Cordova Ranger District. He has a B.S. degree in fisheries from Humboldt State University. Before coming to the District in 1989, he had worked as a seasonal employee for the Oregon Dept. of Fish and Wildlife and conducted a one-year study on steelhead genetics in Northern California. In Cordova he has worked as a fisheries technician and now as a biologist.

I. Budget

1. Personnel

	Days	Rate	Cost
David Schmid GS-11	15	213	3,195
Ken Hodges GS-9	20	171	3,420
GS-07	45	145	6,525
GS-03 (2)	40 (2)	75	6,000
Total			19,140

2. Travel		
Vehicle costs		750
3. Contractual services	N/A	
4. Commodities	N/A	
5. Equipment		800
6. Capital outlay	N/A	
7. General administration		2,000
Total		22,690

Cutthroat Trout and Dolly Varden Rehabilitation in Western Prince William Sound

Project Number: 95043-B

Project Type: Restoration

Name of Sub-Project Leader: Kate Wedemeyer

Lead Agency: USFS, Glacier Ranger District

Cooperating Agency: None

Cost of Sub-Project: $137.4 K

Project Startup Date: March 95 Duration: 4 years

Geographic Area: Prince William Sound

Project Leader, Glacier Ranger District, Chugach National Forest Kate Wedemeyer, Fisheries Biologist

Lead Agency

Project Manager

A. Introduction

Although cutthroat trout (Oncorhynchus clarki) and Dolly Varden (Salvelinus malma) overwinter and spawn in freshwater, these fish use nearshore and estuarine habitat for feeding throughout their lives. The highest concentrations of petroleum hydrocarbon metabolites in bile of all fish sampled in 1989 were found in Dolly Varden. The larger cutthroat trout also showed higher levels of mortality in oiled than in unoiled areas.

Tagging studies demonstrated that the annual mortality of adult Dolly Varden in oiled areas was 32 percent greater than in unoiled areas. In 1989-1990, there was 57 percent greater mortality, and in 1990-1991, a 65 percent greater mortality, in oiled streams versus unoiled streams.

Cutthroat trout growth rates in oiled areas were 68 percent in 19891990 and 71 percent in 1990-1991 of those in unoiled areas. Although concentrations of bile hydrocarbons were greatly reduced in 1990 and 1991, indicating less exposure to oil, it is unclear why differences persist in survival rates between oiled and unoiled streams.

Prince William Sound (PWS) is the northern extent of the range of cutthroat trout. The cutthroat stocks known to exist within PWS are few in number, rarely number more than 1,000 individuals, and are geographically isolated from each other. Of 143 streams surveyed for spawning salmon in PWS in 1989, only 10 contained anadromous cutthroat trout. These fish have a limited home range and do not migrate over great expanses of water. These small populations are vulnerable to exploitation and habitat alterations. Dolly Varden and cutthroat trout in oiled areas may have sustained a sublethal injury (slower growth in oiled areas). Scientists cannot estimate a recovery time without further study.

A combination of habitat improvements and decreased harvests could increase overall survival of those stocks impacted by the oil spill. By decreasing mortality in the freshwater phases of the life cycle, habitat improvements in the freshwater environments can mitigate the increased mortality experienced in the nearshore and estuarine habitats. As the principal land manager in Prince William Sound, the US Forest Service will undertake habitat improvements in the freshwater habitats of Dolly Varden and cutthroat trout. ADF&G has promulgated regulations and emergency closings which increase survival by a decreased harvest of Dolly Varden during spawning periods and eliminating the harvest of cutthroat trout in the oiled areas of Prince William Sound.

B. Project Description

1. Resources and/or Associated Services:

Cutthroat trout and Dolly Varden will primarily benefit. Sport fishing for these species will improve.

2. Objectives:

The objectives are to restore, improve, and enhance cutthroat trout and Dolly Varden rearing and spawning habitat in PWS.

3. Methods:

Field surveys in 1994 will test for presence\absence and further evaluate the proposed structures at each site in order to write the NEPA documents. The interim report will consist of copies of NEPA documents prepared at that date. Habitat improvements will be constructed in 1995. Pre-monitoring will also occur in 1995.

This project entails the use of some or all of the approved instream habitat techniques, including: channel blocks, boulder placement, cover logs and root wads, tree cover, bank cribs with cover logs, logs and bank shelters, single-wing and double wing deflectors, deflectors and cover logs, channel constrictors, cross logs and revetments, wedge dams, and K dams.

Channel Blocks:

Channel blocks consolidate braided channels into a single, deeper channel and, subsequently, create additional fish holding habitat. These structures may also be used to maintain stream meanders where flood flows have eroded a channel through the meander. These structures hold normal or moderately high flows in the meander channels, but still allow flood waters to overflow in the blocked channels. They can also collect gravels suitable for spawning.

Boulder Placement:

Boulders provide overhead cover and resting areas. Added depth is also created by scouring as a result of reduced channel capacity and increased velocity.

Cover Logs and Rootwads:

These structures provide overhead cover in sections of stream where existing water depth may be adequate but cover is lacking.

Tree Covers:

Trees placed in proper locations provide excellent overhead cover and an ideal substrate for aquatic organisms. In addition, trees serve as deflectors which constrict wide, shallow channels and increase stream velocity. This results in sediment flushing and the creation of deeper scour pools and pockets of spawning substrate.

Bank Cribs with Cover Logs:

These structures protect unstable banks, while at the same time providing excellent overhead cover for fish.

Log and Bank Shelters:

Log and bank shelters provide overhead cover. Some streambank protection is also provided, although less than with cribs. Brush and other woody material attached to the platforms provide additional benefit by harboring insects and other fish food organisms.

Single-Wing Deflectors:

These structures constrict and divert water flow so that stream meanders and pools and pockets of spawning gravel are formed by scouring and relocation of fine sediment and gravel.

Double-Wing Deflectors:

Double-wing deflectors create midchannel pools through scouring action in shallow sections of streams.

Deflectors and Cover Logs:

Deflector and cover logs are similar to a single-wing deflectors. Cover logs ensure bank stability where suitable boulders, tree stumps, or stable banks are lacking.

Channel Constrictors:

These structures serve as modified deflectors designed to create overhead cover similar to that provided by undercut banks.

Cross Log and Revetment:

Cross log and revetments create scour pools by the action of water pouring over or under cross logs. Revetment logs create overhead cover and protect the bank at the same time.

Wedge Dam and K Dam:

These structures create pools or deeper water through scouring action in shallow sections of stream. In continuous, steep gradients, the short, upstream break in gradient also provides resting and spawning area, often holding more fish than the deeper pool below. The quiet water above the structure and the edges of the pool below also act as a trap for spawning gravel and organic material used as food by stream invertebrates .

Gabions:

Where proper size rocks are available, gabions can be used in lieu of logs for structure designs such as deflectors, dams, and bank abutments.

Brush Bundles:

Brush bundles can be used to provide fish hiding cover in a stream or lake which can decrease competition for space with more aggressive species. Bundles create visual obstructions, reducing interspecific competitive interactions, allowing more fish to inhabit preferred habitats.

4. Alternatives

In addition to the present proposal, alternatives considered to mitigate effects on cutthroat trout and Dolly Varden included: decreasing fishing mortality, transplanting cutthroat trout and Dolly Varden char from healthy populations, starting new cutthroat trout and Dolly

Varden populations, and redirecting sport fisheries by planting other species in barriered lakes. These alternatives were dropped from further consideration for reasons described below.

Decrease fishing mortality

Decreasing fishing mortality, especially during the vulnerable spawning seasons, can increase the overall survival of cutthroat and Dolly Varden trout. The most effective method of changing fishing mortality is through controlling fishing seasons, bag limits and areas. This alternative is not available to the principle land manager, the US Forest Service under the present management authorities but is being implemented by ADF&G. Harvest regulation for sport and commercial fishing is managed by the Alaska Department of Fish and Game. ADF&G has promulgated regulations and emergency closings which increase survival by a decreased harvest of Dolly Varden during spawning periods and eliminating the harvest of cutthroat trout in the oiled areas of Prince William Sound.

Transplant cutthroat trout and Dolly Varden char from healthy populations

Populations sustaining higher mortalities or decreased reproductive success due to hydrocarbon metabolites could be supplemented by trout from other healthy populations. Because no genetic evaluations of stock separation among the populations in Prince William Sound have been undertaken, and because little information is known of immigration between geographic areas, there is little basis for evaluating whether a potential donor stock is available.

Start new cutthroat trout and Dolly Varden populations

New populations established in presently uninhabited locations could increase the effective population size of the cutthroat trout and Dolly Varden meta-populations in Prince William Sound. Because competitive abilities of these two species is low compared to other salmonids, this would need to be habitats in which pacific salmon are at low abundance or absent. At this time, no areas have been identified in which to start new populations. Due to lack of information on present stocks, there is little basis for selecting either parent stocks or appropriate locations for stocking.

Redirect sport fisheries by planting other species in barriered lakes

Harvest mortality on cutthroat and Dolly Varden trout could be decreased by substituting other sport fishing opportunities. New fishable populations of trout such as rainbow or grayling could decrease fishing pressure on cutthroat and Dolly Varden trout. These would have to be planted in lakes in which they will not cause harm to other species, such as barren or barriered lakes. Because rainbow trout and grayling are not endemic to Prince William Sound, it is likely that they will have limited survival ability. Monitoring of rainbow planted Granite Bay Lake, western PWS in 1990 by ADF&G will give further information relevant to their ability to survive in Prince William Sound and to substitute for cutthroat trout and Dolly Varden sport fisheries.

5. Location

All sites are located in Prince William Sound. Potential improvements which will be further investigated include:

Otter Creek and Lake, Bay of Isles, Knight Island

Otter Creek is the site of a fish pass which is being modified to improve passage for pinks and cutthroat (project 94139). The value of brush bundles for hiding cover, structures to collect spawning gravel and brush cover structures in the steeper area with larger substrate will be investigated.

Cowpen Lake, Unakwik Inlet

The emphasis at this lake will be cover structures in the inlet and outlet stream to provide additional cover and spawning gravel for cutthroat trout competing with coho salmon. Structures to collect spawning gravel and create resting pools with hiding cover are planned for the inlet stream. Cover in the form of increased pool size and hiding areas made of brush bundles are being considered in the upper end of the outlet stream which flows intermittently in dry periods trapping cutthroat trout and Dolly Varden in pools.

Gumboot Lakes, Eshamy Bay

The creek, also called Gunboat Creek, is located in a muskeg flat on the northeastern shore of the lake. The channel has two small faces which impede fish passage upstream. Potential enhancements include blasting two pools in the lower gradient boulder/bedrock section to lower the gradient and provide pools and placing five brush bundles in the upper section.

Billy's Hole, Long Bay (Northern PWS near Columbia Bay)

A short, wide and shallow channel connects a small lake to the larger 80 acre lake. Small structures to provide cover would be provided in this short connecting stream. Trout habitat can potentially be improved by constructing cover structures in a large semi-braided inlet channel.

Sockeye Creek and Lake, Bay of Isles, Knight Island

The major western inlet will be considered for large structures to stabilize gravel in the high gradient section and brush bundles will be considered for the lower gradient areas where no salmon spawning is occurring. Large woody debris may be placed in the upper end of the southeast tributary of the lake to stabilize gravel. Implementation of the project on this site must await confirmation that moneys can legally be spent by the Forest Service on private lands.

Unnamed lake in Heather Inlet, Columbia Bay

This site is an alternate site that will be considered if approval to expend money on private lands is delayed. Structures designed to create pool habitat for cutthroat trout in the shallow, low gradient inlet stream are being considered. Possible modification of barriers in the outlet stream will be evaluated .

6. Benefits

By increasing habitat and survival in the freshwater phases of the life cycle, habitat improvements in the freshwater environments can mitigate the possible mortality cutthroat and Dolly Varden experienced in the nearshore and estuarine habitats. Cutthroat trout and Dolly Varden will primarily benefit. Sport fishing for these species will improve.

7. Technical Support

The Forest Service hydrologist will be requested to review the suitability of the proposed structures for the hydrological regime of each stream.

8. Contracts

A contract for a boat will be required if the schedule for boats operated by the Glacier Ranger District prevents their use for this project. Where possible, this will be combined with other projects such as fish pass modifications at Shrode and Otter Creeks.

9. Mitigation Measures

Work in the streams will be conducted within timing windows to protect eggs in substrates and spawning adults. Structures will be designed to blend with the natural environment in the Wilderness Study Area.

10. Bibliography

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C. Schedules and Planning:

Because approval and funding of projects were delayed, the anticipated schedule listed in the proposal (Table 1) must change. The National Environmental Policy Act (NEPA) requires that actions affecting resources on the National Forest be analyzed for their potential effects on the environment prior to implementation of the project .

The original timeline scheduled the EA's to be completed between 10/93 and 1/94. Prior to 10/93 all the instream field reconnaissance had not been completed. The funding and the opportunity to complete the field work were not available during the fall and winter of 1993. Without site specific stream habitat information the EA cannot be completed.

Construction of habitat improvements in 1994 was predicated on completion of NEPA documents prior to planning for the 1994 summer field season. Since potential effects of construction of instream structures are to be mitigated by limiting these activities to timing windows outside those periods in which spawning adults or eggs are present in the streams, streams with both spring and fall spawning species may have severely constricted windows limited to two to four weeks in May and June.

The Forest Service initiated public scoping in January 1994. Habitat surveys must precede the EA decisions. These surveys would be completed during the 1994 field season (5/94-10/94). After the surveys are complete the EA's can be completed for public review and a decision made. Instream enhancement activities could then be allowed, depending on the decision that is made. These enhancements would most likely be constructed in May and June, 1995, to meet the narrow construction time window allowed for instream habitat improvements. The attached budget reflects the changes requested to complete the project in 1995.

Table 1: Anticipated schedule of events for proposed projects. Time periods listed in brackets are the time period projected in the original proposal.

Activity	Time Period
Habitat surveys	05/94 - 11 /94 (02/94 - 07/94
Stream monitoring	05/94 - 05/95 (02/94 - 06/94)
NEPA scoping & writing	01/94 - 12/94 (10/93 - 01/94)
Project construction	05/95 - 07/95 (05/94 - 07/94)
Estimate fish abundance & distribution	08/95 - 11 /96 (08/94 -11/94)
Analyze data, write project report	12/94 - 04/95, 12/95 - 04/96 (10/94 - 04/95)
Submit annual project report	04/95 ,04/96 (04/95)

D. Environmental Compliance/Permit/Coordination Status

EA's will be required with information specific to each project. EA's must be reviewed for compliance with Coastal Zone Management regulations by the State of Alaska. Projects in eastern Prince William Sound may require review at the District level while projects in the Wilderness Study Area in western Prince William Sound require extensive review at the District, Forest and Regional levels of the Forest Service. These projects also require coordination with the land owners and are as follows.

Title 16 compliance is needed for activities on private lands. Cooperative agreements with the land owners will specify the need for them to apply for Title 16 permits.

Table 2: Land ownership and Wilderness status of proposed sites, and NEPA documentation required for proposed projects.

Project Location	Land Owner	NEPA
Otter Creek and Lake	USFS land, within Wilderness Study Area	EA
Cowpen Lake	USFS land, within Wilderness Study Area	EA
Gumboot Creek and Lakes	USFS land, within Wilderness Study Area	EA
Billy's Hole Lake	USFS land, within Wilderness Study Area	EA
Sockeye Creek and Lake	CAC land, within Wilderness Study Area	EA
Columbia Bay	USFS land, within Wilderness Study Area	EA

Performance Monitoring

The distribution of cutthroat trout and Dolly Varden will be monitored in the study areas and a report will be submitted to the Trustees.

Monitoring originally proposed for this project included estimating numbers of trout in the Lake basins and in nearby streams which contain cutthroat and Dolly Varden to provide a reference to untreated control sites and to normal year to year variability. We propose to limit that monitoring to fish numbers at the sites before and after construction of habitat enhancements.

F. Personnel Qualifications

The project leader, Kate Wedemeyer, is the District Fisheries Biologist for the Glacier Ranger District which encompasses most of the western Prince William Sound streams being considered for habitat enhancement. Kate has completed Masters of Science degrees in Fisheries Science and Natural Resource Management.

She has worked extensively in fish habitat enhancement in the Tongass and Chugach National Forests of Alaska since 1988. She has attended training sessions by two nationally recognized experts on instream habitat structures. She has designed and installed approximately 20 such structures.

Fisheries technicians for the project will be selected on the basis of their experience in stream habitat enhancements and stream survey techniques.

G. FY95 Budget ($K)

The attached budget reflects changes in schedule described above.

Personnel			82.9
Resources Staff Officer, GS ll	4.0 mo	13.2	
Fisheries Biologist, GS 11	7.5 mo	33.8	
Fisheries Biologist detailer, GS 9	3.0 mo	15.5	
Fisheries Tech, GS 8	3.5 mo	1.2	
Fisheries Tech, GS 7	3.5 mo	9.2	
Commodities			16.8
Field food @ $20/day x 120 days		2.4	
Safety equipment		1.0	
Sampling and monitoring equipment		0.8	
Construction supplies		4.3	
Field gear and camping supplies		3.0	
Equipment maintenance		1.0	
Fuel		0.8	
Hand tools		3.5	
Equipment			13.8
Boat Rental		7.5	
Vehicle		1.5	
Photo		0.9	
Seasonal housing		2.0	
Boat maintenance		1 .9	
Contract			6.0
Air charter @ $400/hr x 11		4.4	
Train		1.6	
Administration			17.9
TOTAL FY 95			137.4

In situ Formation and Ecotoxicity of Hydrocarbon Degradation Products Produced by ultramicrobacteria.

Investigators: D. K. Button, PI
L. Pinto
B. R. Robertson

Project Number: 95044

Agency. Institute of Marine Science, University of Alaska, Fairbanks Ak.

Cost. $118,470/a

Duration: First of five years

Area: Prince William Sound

Contact: D. K. Button
Institute of Marine Science
University of Alaska Fairbanks
Fairbanks AK, 99775
(907) 474-7708

A. INTRODUCTION.

Marine bacteria are abundant throughout the oceans. Their biomass is about equal to that of other organisms in the oceans combined (1). Abundance and small size gives a large surface area for the collection of organic compounds. These compounds are i) remineralized to support primary productivity, ii) reorganized into new organic compounds, or iii) passed to bacterivores and on up the food chain to an extent that rivals primary productivity by phytoplankton.

Most **marine bacteria are poorly understood** because they are too small to be seen by conventional microscopes. Adapted to growth in dilute media, they fail to grow on conventional recipes so that focus has been on large but rare forms that are particularly fast-growing in the laboratory. Most measurements of hydrocarbon oxidizing bacterial populations related to the *Exxon Valdez* oil spill include only those which will attain large populations in conventional laboratory culture, while most activity is associated with the smaller forms (2).

New ways to evaluate the mostly undescribed but more typical marine bacteria include phylogenetics (3), flow cytometry (4), and extinction culture (5). Their growth rates in situ can be measured by dilution culture (6). According to phylogenetics, these oligotrophs may be in either of two kingdoms, the Eubacteria and the Archaea. All other organisms are in the third. Most with Eubacterial DNA belong to members of new and yet undescribed genera. A few of these super-small organisms have now been cultivated (7-10). To date none of the Archaea have been isolated. However their 16S rRNA sequences indicate particular importance in extreme environments such as Antarctica (3) and Prince William Sound where abundances exceed 105 organisms per ml (in preparation).

Ecosystem function is probably most closely tied to water chemistry. The biomass of marine organisms is clearly controlled by major nutrients, and most of these are liberated from organics by bacteria. Other interspecies interactions and chemically mediated responses may be even more important but more difficult to observe. Ecosystems have been relatively stable over eons at a state far from thermodynamic equilibrium. One explanation of this highly improbable behavior is that organisms learned from their mistakes that harmonious coexistence is preferable to exclusionary competition. This learned behavior is then shared among contemporary species much as strategies for assembling antibiotic resistance mechanisms is shared. Because bacteria are prone to sharing genestocks with dissimilar organisms, they may have additional importance to ecosystem function as mediators of information. This information is used in part to maintain ecosystem balance.

Ecotoxicity of aromatic hydrocarbons is connected to their physical properties. Hydrophobicity drives them into the phospholipid envelopes of bacteria where oxidases therein cleave the rings to form hydrophilic carbonyls. Less than half of these intramembrane products continue on into the organism for further oxidation. Most escape to the environment. Because active transport is now required for reprocessing these products have very long half-lives, sometimes of the order of centuries (11). Metabolic product stability exceeds that of hydrocarbons in seawater (12) so that a mechanism exists for long-term accumulation of these carbonyl products in the environment.

Like the oxidation products of DDT, it is mostly the products of oxidation that are responsible for hydrocarbon toxicity (13). The toxicity of crude oil increases following partial processing by microorganisms (14), and Alyeska consultants found that ballast water treatment pond effluent remained inhibitory after the volatile hydrocarbons had been removed. In higher unlike the dioxygenase systems of hydrocarbon degrading bacteria (16). Suspected compounds are somewhat uncommon moderate chain-length organic acids with additional functional groups. Important members still lack published mass spectra.

Following the discovery that large amounts of oxidation products are released by the microbial metabolism of hydrocarbons by conventionally-isolated bacteria (12,17), new techniques were developed for the cultivation of what is believed to be the more typical marine bacteria present as discussed above. The first of these isolated, *Oligobacterium* RB 1, is of record small size, only 0.06 um3 in volume. This organism, randomly selected from Resurrection Bay seawater, will grow on a large number of substrates including toluene (8,9). Like conventional isolates, it produces large amounts of these oxidation products of metabolism. Moreover mixed cultures from the ballast water treatment pond in Port Valdez liberate these products as well. It is our goal to understand the behavior of typical marine bacteria in general with particular reference to general ecosystem function. In this project we propose to focus on metabolism of anthropogenic hydrocarbons by these organisms in an effort to predict how the system, including higher organisms might respond to chronic pollution. Related programs are funded at a modest level by the US Environmental Protection Agency Office of Exploratory Research and By Ocean Sciences at the National Science Foundation (See References).

B. NEED

Dissolved hydrocarbons appear to remain in the marine environment for hundreds of years. Those that are microbially oxidized liberate products of metabolism that are toxic. Similar toxic products of metabolism probably enter the marine system by incomplete treatment of ballast water. However precise chemical characterization of these compounds has not yet been performed and specific toxicological studies are therefore absent. While Prince William Sound is subject to hydrocarbon input from various sources, detailed studies of hydrocarbon bioconversion, and particularly the potential effects of those bioconversion products on other organisms, are absent. Most studies are restricted to observation of short-term death rates following exposure to weathered crude oil. However these LD 50's overlook the effect of irritants on indigenous species. Studies here represent a more general approach with attention to the molecular mechanisms involved. While some studies of the populations involved in hydrocarbon degradation and toxic product production exist, the vast majority of the responsible organisms are eliminated from consideration by the methods used. The proposed program will provide a modern account of Prince William Sound Microbiology with particular emphasis on hydrocarbon degrading ultramicrobacteria, and evaluate the roles of these organisms in i) recycling organic carbon to higher organisms, and ii) converting influent hydrocarbons to toxic compounds.

D. PROJECT DESIGN

1. OBJECTIVES

a. Provide contemporary measurements of hydrocarbon concentrations in Prince William Sound,

b. Determine the fraction of total PWS bacteria that are capable of oxidizing hydrocarbons.

c. Test random extinction-culture isolates of indigenous bacteria for inducibliity toward hydrocarbons.

d. Identify the products of metabolism of aromatic hydrocarbons on representative cultures.

e. Identify the toxicological mechanisms of specific ring-cleavage products produced.

2. METHODS

a. Hydrocarbon concentrations are obtained by purge and strip techniques (2).

b. The fraction of bacteria with constitutive ability to oxidize hydrocarbons is observed by autoradiography (18) with total populations characterized by high resolution flow cytometry (4).

c. Random marine bacteria are selected by extinction culture (6). Their ability to metabolize hydrocarbons is evaluated, following exposure to ug/liter inducing concentrations of hydrocarbons (12), by collection of the products of metabolism from radiolabeled hydrocarbons(19).

d. Products of metabolism of aromatic hydrocarbons by these cultures are initially located by the affinity of those products for acidic aqueous media (12). Detailed characterization is by derivatization within the aqueous phase, solvent-extraction, fractionation on silica gel columns, and analysis of the resulting fractions by gas chromatography for evaluation of the total compounds present, and by mass spectrometry for chemical identification (methods now under development).

e. The offending compounds will be examined by published methods for cytotoxicity (20), and teratogenicity (21), for their influence on sensitive enzymatic processes by newly developed enzymatic procedures, for their influence on species interactions by success in interspecies competition in nutrient-limited experiments and chemotaic avoidance behaviors.

3. SCHEDULE

	Year 1	Year 2	Year 3	Year 4
Year 5				
Hydrocarbon measurements	-----	-----	-----	------
Total and hydrocarbon oxidizer populations	-----	-----	-----	
Obtain extinction culture isolates	-----	-----		
Develop extinction culture isolates	------------	------------	------------	
Examine for hydrocarbon oxidizing capacity	------------	------------	------------	
Identify ring cleavage products of metabolism	----------	----------		
Evaluate toxicity of biooxidation products			------------	------------------
Data synthesis				-----

4. TECHNICAL SUPPORT

Project investigators are competent in all proposed aspects except toxicity which will be done in collaboration with colleagues (see below).

5. LOCATION

Cruise locations will include Prince William Sound near currently-contaminated beaches and in Port Valdez where discharge of the offending compounds is suspected.

E. IMPLEMENTATION.

The project should be implemented at the Institute of Marine Science, through the School of Fisheries and Ocean Sciences because it is uniquely capable of doing so. **Unique capabilities** include:

1. Capabilities for cultivating ultramicrobacteria (5,7,9,10)

2. Availability of flow cytometry with sufficient sensitivity for enumerating, sizing, biochemically analyzing, and physically sorting marine bacteria (4,22,23).

3. Capabilities of characterizing hydrocarbon oxidizing ultramicrobacteria, previously unknown and unrecognized in oil-contaminated sediments, as a major player in beach restoration (2).

Other relevant **areas of special expertise** include:

1. An understanding of hydrocarbon bioconversion kinetics (24,25), i.e. how bioconversion rates respond to hydrocarbon concentrations from both theoretical and experimental aspects.

2. An understanding of flow cytometry from both theoretical and experimental aspects. This allows, for example use of light scatter theory to size marine bacteria including those so small that they have previously been ignored, and to account for differences in shape and refractive index, as well as size on the signal produced from seawater samples (26).

3. Familiarity with the concentrations and disposition of dissolved hydrocarbons produced from the *Exxon Valdez* oil spill, and expected decomposition rates through direct measurements (2). This was first reported in our discovery of monoterpenes as a normal hydrocarbon constituent of Prince William Sound (27).

4. Familiarity with the types of compounds expected to be produced by the metabolism of anthropogenic hydrocarbons through laboratory experiments (12) and an ongoing program for their identification and quantification.

5. An understanding of how oil-phase hydrocarbons coat gravel, and how this coating extracts dissolved hydrocarbons passing through them (Alaska Science and Technology final report and in preparation).

6. Equipment purchased and a developing program for the characterization of newly isolated hydrocarbon-oxidizing ultramicrobacteria from patterns generated on state-of-the-art two-dimensional electrophoresis.

7. Some understanding of thermodynamics of whole biological systems which allows consideration of ecosystem interactions, now sometimes called "global physiology" (28).

8. Familiarity with the mechanisms of active transport, and have proposed a new one (vectorial partitioning)(29) for the sequestering of hydrocarbons to accompany the three known forms.

9. Ability to evaluate *in situ* hydrocarbon oxidation rates following the development of sensitive new methods (19).

F. COORDINATION.

The project will stand alone. Experts in this laboratory include B. R. Robertson, a microbiologist with exceptional skills in flow cytometry, and Dr. Luis Pinto, a geochemist with skills in the quantitative analysis of the organic compounds in seawater.

We also work closely with colleagues in a number of areas. Collaborators include:

1. Professor Fritz Juttner in Zurich Switzerland who has modern electrospray mass spectrometry and is helping us with the identification of the metabolic products from hydrocarbons.

2. Professor Thomas Schmidt at the University of Michigan who is helping us with the phylogenetic characterization of our newly isolated hydrocarbon-oxidizing ultramicrobacteria, and also producing oligonucleotide probes for their *in situ* quantifications.

3. Professor Harold Steen at the University of Oslo who is helping with the design of the next generation of flow cytometers.

4. Professor Arthur Koch at Indiana University who is helping with light scatter theory for quantifying microbial biomass by flow cytometry from light scatter.

5. Dr. Ya Chen at the University of Wisconsin who has provided cryogenic scanning electron micrographs in stereo of the newly isolated hydrocarbon-oxidizing ultramicrobacteria from Prince William Sound.

6. Professor Staffan Kjelleberg of the University of New South Whales who is helping with the identification of the transport proteins which interface hydrocarbon-oxidizing oligobacteria with their environment.

7. Professor Pham Quang, a theoretical statistician at UAF, who is helping with the design and interpretation of experiments on microbial viability.

8. Professor David Ross, a toxicologist at the University of Colorado, has examined the structures of likely compounds that ultramicrobacteria produce from aromatic hydrocarbons, and has offered to collaborate in toxicity testing.

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concentrationdependent kinetics of toluene oxidation in some North American estuaries. Limnol. Oceanogr. 31:101-111. 12. **Robertson, B. R., and D. K. Button.** 1987. Toluene induction and uptake kinetics and their inclusion in the specific-affinity relationship for describing rates of hydrocarbon metabolism. Appl. Environ. Microbiol. 53:2193-2205.
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H. FY95 BUDGET($K)

D. K. Button PI, 1 mo	$8.0
L. Pinto, co-PI, 11, mo	31.0
B. Robertson, co-PI 3 mo	14.0
Benefits	16.0
Ship time (Little Dipper)	2.1
Flow cytometry	5.0
Isotopes and chemicals	2.0
Travel	4.0
Direct Costs	82.1
Indirect Costs	36.4
Total	**$118.5K**

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Green Island Intertidal Restoration Monitoring.

Project Number: 95045

CO-PRINCIPAL INVESTIGATORS:	Dr. Glenn Juday and Nora Foster	
LEAD AGENCY:	University of Alaska Fairbanks	
COST	FFY 1995	$113,414 start-up phase
	FFY 1996	$112,955 continuation
	FFY 1997	$116,664 continuation
PROJECT START-UP/COMPLETION	February, 1995 - June, 1997	
PROJECT DURATION	3 years overall	
GEOGRAPHIC AREA	Prince William Sound	
CONTACT PERSON	Dr. Glenn Juday	

B. INTRODUCTION

We propose the first year of a three year effort to update and expand a project to monitor natural recovery of biological diversity and community structure in intertidal and shoreline ecosystems of outer Prince William Sound affected by the *Exxon Valdez* oil spill. In 1986 we began a project to document the biological diversity features of Green Island. In late March 1989 oil from the *Exxon Valdez* arrived at Green Island. In August 1989 we established intertidal and shoreline monitoring transects in 3 locations at Green and Little Green Island that had received heavy, moderate, and light oiling. The plots were remeasured in June 1990, and two publications resulted (Juday and Foster 1990, 1991). Funding and support came from the University of Alaska and USDA Forest Service PNW Research Station. No money from the *Exxon Valdez* process was obtained to support the Green Island project. The study has been halted for lack of funding since. With this project we propose to continue our monitoring at Green Island and Little Green Island, and add a control (unoiled) site to be established at Hinchinbrook Island. This project will:

1. Update and analyze changes in abundance of intertidal organisms on the transects since 1989-90;
2. Determine overall changes in species richness since 1989/1986;
3. Document growth and community structure of *Fucus* that have recruited since 1989;
4. Compare community structure and species richness of the oiled sites with non-oiled sites to be established.

This project will provide a basis for determining the rate and degree of recovery from the spill in a representative heavily affected area, continue and update documentation of a site studied before the spill and now dedicated to long-term research and monitoring use, and generate reports, data bases, scientific literature, and public information.

C. NEED FOR THE PROJECT

Intertidal organisms are listed as one of the biological resources not recovering from the spill. Monitoring natural recovery has been identified as one of the primary restoration strategies for intertidal organisms, along with conducting research to find out why these resources are not recovering. While the lower and to some extent the middle intertidal zone are recovering, injury persists in the upper intertidal zone. In a previous paper on our Green Island study (Juday and Foster 1990) we proposed a conceptual scheme and explanation for why oil damage should be expected to be most severe at the upper intertidal level. We also suggested in that change to community structure was one of the major effects of the spill in our study area (Juday and Foster 1991).

This proposed project will identify the pattern and rate of natural recovery on sites of different oiling severity and especially the *continuing* effects of the disruption cause by the spill - how community structure and composition has changed. A unique element of this proposed project is that we carried out taxonomic surveys in 1986 before the spill and thus we have some idea of how our site has been affected by the spill in particular. We also have voucher specimens, quantitative data, and photo documentation of intertidal sites matched to beach transects above with derived index values for the amount of oiling from 1989 and 1990. These are particularly valuable data sets given the importance of the time dimension in recovery processes. Any totally new studies begun now, no matter how well planned, would have to ignore or infer the previous condition of the community, making meaningful comparison difficult.

D. PROJECT DESIGN

1. Objectives

There are three main elements to successful data collection in a biotic monitoring project:

1) establishing high-resolution spatial control in order to be able to relocate individual small areas and organisms,

2) positively identifying species to ensure that changes seen between monitoring dates are properly assigned among species, and

3) quantifying the abundance of species.

To date our Green Island project has concentrated on tasks 1 and 2; we propose to expand that work at Green Island and establish an unoiled control site on Hinchinbrook Island. We have been impressed with the dynamic forces in the surf zone and have already experienced a significant loss of our permanent plot markers. Rehabilitation of markers is an important continuing task.

To accomplish our objectives we have identified 4 project tasks.

1. Update beach and intertidal transects. We propose to monitor our original transects in field season 1995, and thus be able to report results based on a comparison with 1989

and 1990 data. We will establish spatial control on the study locations and intensive study locations will be grided.

2. Expand the area of coverage and obtain and unoiled control site. A gap in our existing data base is the lack of an unoiled control site that matches the characteristics of our study area. We have identified a suitable area on Hinchinbrook Island and propose to establish a replicate monitoring installation early on in the project. We also are convinced of the need to expand the size of the plots we are monitoring to collect more data for the field effort and to overcome a large natural variability term.

3. Complete a biosystematic survey, species lists, and design a protocol to resample with the same intensity for the future. A master species list is a cumulative product, but we believe it is necessary to design a species diversity sampling protocol that can be repeated at intervals with some confidence of comparability.

4. Investigate winter and spring conditions. We have observed already the dramatic differences between summer and winter beach conditions. We believe that fall/winter site visits are necessary to observe and document some of the forces and immediate effects of winter storms.

Our three working hypotheses at this point are:

1. Mussels and other bivalves formerly restricted to crevice refuges on Green Island will successfully colonize exposed habitats, reducing the abundance of formerly dominant primary producers.

2. Simultaneous mass mortality disrupted the natural patch dynamic regime of disturbance in rocky intertidal habitats and is leading to a uniform, locally less diverse community structure in the area affected by the *Exxon Valdez* spill.

3. Opportunistic green filamentous algae will occupy growing space released by delayed mortality of the pre-spill organisms. To the degree that the green algae persist in local habitat patches in the 1993-1996 time period they are indicators of continuing, local chronic oil injury.

2. Methods:

In 1989 at each site we established horizontal beach transects to map the extent and distribution of oil. Mapping extended from about MHHW (or 3 m above tidal datum) inland to the line of alder shrubs. Patches of oil along the beach larger than 30 cm along either axis were mapped in their entirety. The extent of oil coverage along the beach was mapped in percent cover classes. In the intertidal zone, we established 3 parallel transects oriented perpendicular to the shoreline. Along each transect line we established plots of 0.5 m x 0.5 m at vertical intervals of 1.0 m to determine the condition of marine organisms and communities. We photographed the intertidal plots and took notes and made collections of the plants and animals present, and noted the oiling condition. We made cover and abundance measurements from 8" x 10" black and white prints of the photos. Both the horizontal and vertical transects were permanently marked. During an extreme high tide stage we observed patches of oil or tar that were stranded on the lower beach to determine the potential for oil remobilization.

We will follow the methods of Jones et al. (1980) for monitoring rocky intertidal sites. We will obtain quantitative measures of cover/abundance through direct observation and sequential photography. We will expand the coverage of plots in our existing transects to an area that will allow characterization of the entire community and statistically valid estimation of the abundance of special species.

Special target species will be closely monitored within the transects and surrounding area because of their known important ecological roles elsewhere. A working list will be developed early in the project and adjusted as results dictate. Candidate species include the following:

> The surfgrass *Phyllospadix serrulatus*, blue mussel *Mytilus edulis*, and brown rockweed *Fucus garderni*, three of the species that appear to have sustained the heaviest damage from the oil spill in our area.
>
> The seastars *Pisaster ochracea* and *Evasterias troschelli*. The first is one of the most conspicuous animals along much of the Pacific coast intertidal zone where it has a major effect through predation (Paine 1974) on barnacles, snails, limpets, and chitons.
>
> The snails *Nucella lamellosa* and *N. lima*, and the nudibranch *Onchidoris bilamellata*. The first species is a regulator of marine community structure (e.g. Spight 1982).
>
> The grazers *Strongylocentrotus droebachiensis* and *Katherina tunicata*. The second species is a significant herbivore in the region (Himmelman 1978).

3. Schedule: Start project in February 1995 to prepare for 1995 field season. Visit site in spring low tide sequence to rehabilitate plot markers. Sample during summer low tide series and establish control site. Visit and assess site during fall/winter low tides. Recruit graduate student for fall 1995. Prepare first year report on 6-year (1989-95) changes. Coordinate with other restoration projects in winter 1995-96 and modify plans. First year report in June 1996. Continue study in 1996 and 1997 seasons. Plan for permanent archiving of database and long-term future study at appropriate intervals.

4. Technical Support: University of Alaska Museum facilities (reference collection and archiving), computer mapping and access to previous Green Island study database, rock drill, taxonomic expertise in nearshore benthic organisms, statistical and ecological consulting.

5. Location: Green Island, Little Green Island, and north Montague Island

E. PROJECT IMPLEMENTATION

Because of the continuing nature of the project which would build upon a previous effort, the University of Alaska team that conducted the original study and which has the database and knows the study locations should implement the project. In addition Nora Foster is the taxonomic expert for aquatic and marine invertebrates in the state of Alaska.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

We propose to develop cooperation with the Institute of Marine Science at the University of Alaska Fairbanks including through support of a graduate thesis project. We plan to coordinate our study with others taking place at Green Island, especially studies of sea otter population changes. Taxonomic samples will be archived in the University of Alaska Museum for permanent referencing.

G. PUBLIC PROCESS

Both our previous publications on oil spill effects at Green Island were published in an outlet with wide circulation among both Alaska resource managers, scientists, and the interested public. A third article in this series will be prepared. Opportunities for training and education during the project will be taken. Local charter or tour operators will be solicited for contractual travel and local naturalists will be contacted for possible involvement in reestablishing and maintaining the monitoring project, especially for the time beyond the end of the 3-year proposal.

H. PERSONNEL QUALIFICATIONS

Nora Rakestraw Foster
2998 Gold Hill Road
Fairbanks, Alaska 99709

PRESENT POSITION:
Coordinator, Aquatic Collection, University of Alaska Museum

EDUCATION:

1965-1967	Michigan Technological University
1969	B.S. Biological Sciences, University of Alaska
1979	M.S. Biological Oceanography, University of Alaska Thesis: A Synopsis of the Marine Prosobranch Gastropod and Bivalve Mollusks in Alaskan Waters

EMPLOYMENT:

1972-1975	Laboratory Assistant, Institute of Marine Science, University of Alaska
1978-1981	Laboratory Assistant, Seward Marine Station, Institute of Marine Science, University of Alaska
1981-1983	Laboratory Assistant, Aquatic Collection, University of Alaska Museum
1983-present	Coordinator, Aquatic Collection, University of Alaska Museum

MEMBERSHIPS:

American Association for the Advancement of Science
American Malacological Union
Association for Women in Science
Association of Systematics Collections
Society for the Preservation of Natural History Collections
Western Society of Malacologists
International Bryozoology Association

REPORTS:

Foster, N.R. 1986. Green Island Research Natural Area, intertidal survey. Unpublished report to the U.S. Forest Service, Institute of Northern Forestry, Fairbanks, Alaska.
Foster, N.R. 1987. Gambier Bay Research Natural Area, intertidal survey. Unpublished report to the U.S. Forest Service, Institute of Northern Forestry, Fairbanks, Alaska.

ABSTRACTS:

Foster, N.R. 1991. Green Island Research Natural Area, long-term monitoring in the intertidal zone. Workshop Proceedings, Research in the 1990's for Prince William Sound and the Copper

River Delta. Cordova, Alaska.

Foster, N.R. 1991. Bivalves from Prince William Sound, Alaska. Western Society of Malacologists Annual Report, Volume 23.

Naidu, A.S., H.M. Feder and N.R. Foster. 1991. Temporal changes in the abundance of the clam *Macoma balthica* on an intertidal mudflat in Port Valdez, Alaska. 21st Arctic Workshop, Fairbanks, Alaska.

PUBLICATIONS:

Lee, R.S. and N.R. Foster. 1985. A distributional list with range extensions of the Marine Opisthobranch Gastropods of Alaska. Veliger 24(2):440-448.

Foster, N.R. 1987. *Hermaea vancouverensis* O'Donoghue, 1924, from Kodiak Island and Unga Island, Alaska. Veliger 30(1):98.

Foster, N.R. 1987. Range extension for *Doridella steinbergae* (Lance, 1962) to Prince William Sound, Alaska. Veliger 30(1):97-98.

Juday, G.P. and N. Foster. 1990. A preliminary look at effects of the *Exxon Valdez* oil spill on Green Island Research Natural Area. Agroborealis 22(1):10-17.

Foster, N.R. 1990. Mollusc collections at the University of Alaska Museum. The Festivus 22(9):102.

Foster, N.R. and M.P. Hare. 1990. Cephalopod remains from a Cuvier's Beaked Whale (*Ziphius cavirostris*) stranded in Kodiak, Alaska. Northwestern Naturalist 71:49-51.

Juday, G.P. and N.R. Foster. 1991. A return to Green Island. Agroborealis 23(1):26-28.

Foster, N.R. 1991. Intertidal bivalves: A guide to common marine bivalves of Alaska. University of Alaska Press. 152 pp.

SELECTED FIELD EXPERIENCE:

Jul 1975	Intertidal survey - Port Valdez
Feb 1983	R/V Alpha Helix cruise - Prince William Sound and Port Valdez
May 1984	Intertidal and nearshore collecting - Kasitsna Bay, Cook Inlet
Mar 1986	R/V Alpha Helix cruise - Gulf of Alaska and Prince William Sound
May 1986	Intertidal and nearshore collecting - Kodiak Island
Jul 1986	Intertidal survey - Green Island, Prince William Sound
Jun 1987	Intertidal survey - Gambier Bay, Admiralty Island
Aug 1989	Intertidal survey - Green Island, Prince William Sound
Sep 1991	Northeastern Chukchi Sea - Sampling for a fisheries oceanography study

Name: **Glenn Patrick Juday**

Rank **Associate Professor of Forest Ecology**: Date of Appointment 07/01/87

Education: **B.S. summa cum laude**, 1972, Forest Management, Purdue University, West Lafayette, IN.
Ph.D., 1976, Plant Ecology, Oregon State University, Corvallis, OR
Dissertation topic: The Location, Composition and Structure of Old-Growth Forests of the Oregon Coast Range.

Post-Doctoral Fellowship in Environmental Affairs, 1976-1977, (Rockefeller Foundation) Oregon State University; Executive Chairman of the Oregon Natural Area Preserves Advisory Committee.

Field of Specialization and Areas of Interest

Analysis of landscape-level processes responsible for natural diversity
Long-term environmental monitoring
Structure of old-growth forest ecosystems
Definition and identification of elements of natural diversity
Natural area protection and management

Selected Research Reports and Papers

Juday, Glenn Patrick, and Nora Foster. 1991. A Return to Green Island. Agroborealis 23(1): 26-28.

Juday, Glenn Patrick. 1991. Ten Years of Successional Change on the Hugh Miller Inlet Plots, Glacier Bay National Park. Contract Report to Alaska Region, National Park Service, # CA-9700-0-9011. 35 p. plus 18 numbered figs., 5 appendices.

Juday, Glenn Patrick, and Nora Foster. 1990. A Preliminary Look at Effects of the Exxon Valdez Oil Spill on Green Island Research Natural Area. Agroborealis 22(1): 10-17.

Alaback, Paul B.; Juday, Glenn Patrick. 1989. Structure and Composition of Low Elevation Old-Growth Forests In Research Natural Areas of Southeast Alaska. Natural Areas Journal 9(1): 27-39.

Juday, Glenn Patrick. 1987. Selecting Natural Areas for Geological Features: A Rationale and Examples from Alaska. Natural Areas Journal 7(4) p 137-156.

Consulting and other non-university activity

President and Past-president, Natural Areas Association, 1988, 1989 (International professional organization based in U.S. of 2,200+ people working to identify, study, protect, and manage natural areas and significant features of natural diversity).

Principal author, Research Natural Area element of Chugach National Forest Plan 1980-1981. Plan proposes 9 new Research Natural Areas designed to represent major elements of natural diversity including marine-related features and species.

Principal author, Research Natural Area element of Tongass National Forest Plan Update, 1988-1989. Plan proposes over 22 new Research Natural Areas designed to represent major elements of natural diversity, and special area designation for over 20 other areas. Several areas incorporated into new wilderness and LUD II areas established by Congress in October 1989.

Consultant to National Park Service advising and helping to launch the Resource Inventory and Monitoring initiative at both Alaska Region and national level, 1988-1990.

Consultant to various agencies on response measures to the Exxon Valdez oil spill, 1989-1994. Advised Forest Service on specific measures appropriate to Green Island Research Natural Area.

I. BUDGET

CO-PIs	work mo.	cost
Ecologist	1.5	$15,109
Taxonomic specialist	1.5	$7,376
FIELD & LAB ASSISTANTS		
Field crew/GIS leader	4	$13,818
Field crew	4	$6,286
Graduate Student (1)	2	$14,400
TRAVEL-LOGISTICS		$10,000
SUPPLIES		$2,000
EQUIPMENT		$12,000
Overhead @ 47% [a]		$32,425
Year 1 total		$113,414

YEAR 2

CO-PIs	work mo.	cost
Ecologist	1.5	$15,562
Taxonomic specialist	1.5	$7,597
FIELD & LAB ASSISTANTS		
Field crew/GIS leader	4	$14,233
Field crew	4	$6,286
Graduate Student (1)	2	$14,400
TRAVEL-LOGISTICS		$11,000
SUPPLIES		$3,000
EQUIPMENT		$7,000
Overhead @ 47% [a]		$33,877

Year 2 total	$112;955

YEAR 3

CO-PIs	work mo.	cost
Ecologist	1.5	$16,029
Taxonomic specialist	1.5	$7,825
FIELD & LAB ASSISTANTS		
Field crew/GIS leader	4	$14,660
Field crew	4	$6,286
Graduate Student (1)		$14,400
TRAVEL-LOGISTICS		$10,000
SUPPLIES		$2,000
EQUIPMENT		$12,000
Overhead @ 47% [a]		$33,464
Year 3 total		$116,664

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Investigation of the long-term record in tree rings of climatic features that control key ecosystem variables related to recovery in the spill-affected area

Project Number: 95046

CO-PRINCIPAL INVESTIGATORS:	Dr Gordon Jacoby and Dr. Glenn Juday
LEAD AGENCY:	Columbia University University of Alaska Fairbanks
COST	FFY 1995 $153,620 pilot phase FFY 1996 $166,302 continuation FFY 1997 $174,586 continuation
PROJECT START-UP/COMPLETION	February, 1995 - June, 1997
PROJECT DURATION	1 year pilot study, probable 3 years overall
GEOGRAPHIC AREA	Prince William Sound, Kenai Peninsula, Kodiak Is.
CONTACT PERSON	Dr. Glenn Juday

B. INTRODUCTION

We propose to sample tree-rings from a variety of sites in the spill-affected area to develop a long-term master chronology and proxy record of climatic conditions over the last 2 to 4 centuries. This project will calibrate tree growth compared to instrument-based climate records during the 20th century in order to determine the climatic sensitivity of the trees, and then extend the inferred climate record back in time as far as tree-ring records will permit. Climatic/oceanographic features can control populations of a variety of injured resources either directly or through their control of ecosystem variability. Studies of climatic/oceanographic variability have been identified as a high priority restoration research item. Long-term climate changes and/or cycles are potential explanations or additional factors that may be preventing the recovery of injured resources. Instrument-based climate records are limited in time in the spill-affected area, and the long-term perspective that tree-ring

Tree-rings, when properly sampled, measured, and interpreted, have proven to be useful and reliable indicators of climatic events. Different trees growing on different sites respond to a variety of factors in the environment. Trees on some sites slow their growth when summers are cold or accelerate growth when conditions are wet, for example. As a result, the long time series available from tree-ring records are an especially valuable source of information on long-term environmental change. In addition, individual trees damaged by unrecorded natural disasters (volcanoes, heavy snow loads, droughts, abnormal short-term weather events, or insect attacks) produce thin tree-rings that can pinpoint these events. Whole stands of trees integrate and then record growing conditions over whole regions.

This project will provide a basis for determining whether natural climate cycles or trends are responsible for preventing the recovery from the spill, expand coverage of tree-ring work in a potentially climate-sensitive area, and generate reports, data bases, scientific literature, and public information.

C. NEED FOR PROJECT

Several of the injured resources that are not recovering are higher trophic level animals that are highly dependent of the fluctuating larger ecosystem of the spill-affected area. Climatic and oceanographic conditions can both augment and limit the productivity of this system, and the resulting ecosystem conditions may largely explain the status of injured resources. Studies and monitoring in the spill-affected area greatly benefit from a long time perspective, but few techniques are available to investigate the past. Tree-ring research is one of the best-established tools of investigating the past and this project can draw upon an emerging picture of the eastern Pacific climate system from other tree-ring studies in western North America. The forests of Prince William Sound are the northernmost expression of the coastal forest of western North America, and they are sustained in their extreme northern location to a great degree by advected heat from the North Pacific/Gulf of Alaska system. When that system changes in state it should be reflected in the growth of trees. The forests of Kodiak Island are the westernmost extent of the coastal forest and grow under a rigorous limitation by summer temperature, although a general treeline advance is continuing along the western margin of the coastal forest limits.

D. PROJECT DESIGN

1. Objectives:

1. Develop a master chronology of climate response as reflected in tree-ring width and density correlated to the instrument-based record of the 20th century.

2. Identify the sensitivity of ring-widths and densities to key ecosystem-forcing properties of climate and ocean state in the spill-affected area.

3. Collect samples of ring-width series across the spill-affected area on sites that are sensitive to summer temperature, precipitation, and other factors.

4. Identify any unusual ring signatures that indicate volcanic events, extreme weather

events, etc.

5. Develop a high-resolution proxy climate record for the 18th and 19th centuries, and if possible for the 16th and 17th centuries.

6. Integrate the proxy record into models of the larger spill area ecosystem.

2. Methods:

Tree-ring analysis methods are fairly well established and involve cross-dating to assure precision of ring series, transformation of raw ring-width chronologies to unitless standardized ring width indices through user-specified function fitting, theoretically based and empirical application of spline and filter functions, and residual transformation.

1. Identify growth-sensitive sites in forests of the spill area and the particular factors of climate that tree-rings are responding to on such sites.

2. Correlate degree of sensitivity to master chronologies for all strongly correlated climatic/oceanographic parameters during instrumented period.

3. Extend record of proxy climate back by obtaining high-resolution tree-ring samples from Prince William Sound, Kenai Peninsula, and Kodiak Island. Attempt a 400-year chronology.

4. Provide input to ecosystem assessment team on pattern, trend, and periodicity of climatic/ocean state conditions. Formulate input into ecosystem model.

3. Schedule: Start project in February 1995 to prepare for 1995 field season by examining climate models and collecting instrument-based climate records. Visit low-elevation forest sampling sites in PWS in early summer 1995. Sample and revisit reference stands during July and August 1995. Visit high elevation treeline sites and take cores in PWS in July and August 1995. Prepare data and determine potential of different growth sensitive tree-ring sampling sites in fall 1995. Coordinate with other restoration projects in winter 1995-96 and modify plans. First year report in June 1996. Continue study in 1996 and 1997 seasons and expand to Kenai and Kodiak. Plan for permanent archiving of database.

4. Technical Support: (described under Project Implementation)

5. Location:
1995 - Prince William Sound (possible other coastal forest locations for background

sampling).
1996 - Expanded PWS sampling on best sites, Kenai Peninsula.
1997 - Kodiak Is. and final sampling in other localities.

E. PROJECT IMPLEMENTATION

The conduct of this restoration project requires the combination of state-of-the art tree-ring analysis facilities, knowledge of the potential forest sampling base in the spill-affected area, and availability for involvement and interaction with ecosystem research teams in Alaska. A collaborative partnership recently established between the Tree-Ring Laboratory (TRL) at Lamont-Doherty Earth Observatory (LEDO) and the University of Alaska Fairbanks (UAF) Agricultural and Forestry Experiment Station (AFES) has the unique capabilities required.

TRL at LEDO)has 3 computerized (Macintosh) measuring machines of its own design. The UAF AFES) recently acquired all the components for a similar measurement system and is being assisted by LDEO in making the system operational and compatible by the fall of 1994. These machines measure to an order of magnitude more precisely (.001) than commercially available units. For data analysis AFES has a newly acquired Macintosh Power PC 7100. AFES has one Zeiss binocularscope for ring boundary sighting; TRL has several microscopes, with one equipped for photomicrographs. TRL has fully operational x-ray and densiometric analysis systems, including a new high capacity image analysis system.

There are shop facilities for preparing specimens for ring-width or densiometric analysis at both LEDO and AFES. TRL has humidity-controlled storage rooms set up for preserving specimens. AFES is attempting to build an Alaska tree-ring archive for permanent archiving of Alaska specimens. TRL offices and labs occupy all of one building at LDEO. In addition, TRL has the use of support facilities at LDEO, machine and wood shops, libraries, etc. TRL has its own library of specialized computer programs for the reduction and analysis of tree-ring data. AFES has a data base on several large, precisely mapped forest reference stands in Prince William Sound and potential areas of similar vegetation with different climate in southeast Alaska that are permanently marked. These reference stands could serve as permanent sample/future monitoring sites.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

Once the master chronologies and tree-ring sensitivities have been established, a close collaboration will be formed with ecosystem-level integrated programs such as the Sound Ecosystem Assessment (SEA). Input will be provided for ecosystem modeling efforts. Based on past patterns of climate-forcing as revealed in the tree-ring record, a projection of future probabilities will be attempted that should serve as an indication of restoration outlook for dependent injured resources.

G. PUBLIC PROCESS

We will investigate the possibility of sampling disks on harvested private land through voluntary cooperation with land owners. A general interest article will be prepared. Opportunities for training (graduate student) and involving local residents in the selection of sampling sites will be investigated. Local charter or tour operators will be solicited for contractual travel and local naturalists will be contacted for possible involvement in reestablishing and maintaining the long-term forest reference stands, especially for the time beyond the end of the 3-year proposal.

H. PERSONNEL QUALIFICATIONS

Gordon C. Jacoby
Senior Research Scientist
Tree-Ring Laboratory
Lamont-Doherty Earth Observatory of Columbia University
Palisades, New York 10964
914-365-8517
FAX 914-365-3046

Born:	14 August 1934, Fitchburg, Massachusetts
Military:	U.S. Marines, 1953-1956, Tank Driver
Education:	Ph.D. in Hydrogeology, Columbia University, 1971
Professional Experience:	Senior Research Scientist, Lamont-Doherty Geological Observatory of Columbia University (LDGO), 1987-present Research Scientist, LDGO, 1984-1987 Research Associate, LDGO, 1975-1984 Research Hydrogeologist, Institute of Geophysics and Planetary Physics University of California at Los Angeles, 1971-1975 Visiting Professor, Department of Earth Sciences, Dartmouth College, Hanover, New Hampshire, winter term, 1973
Tree-Ring Experience:	Founded and have been chief scientist at the Tree-Ring Laboratory at Lamont- Doherty Geological Observatory since 1975
Scientific Organizations:	International Union of Forestry Research Organizations Leader of Tree-Ring Analysis Group 1988-1990 National Research Council Member of Committee on Opportunities in Hydrological Sciences 1989-1990 American Association for the Advancement of Science American Geophysical Union

Tree-Ring Society

Meetings: International Meeting on Stable Isotopes in Tree-Ring Research 22-25 May 1979, New Paltz, New York
Convener and Editor of proceedings volume

International Symposium on Ecological Aspects of Tree-Ring Analysis 17-21 August 1987, Tarrytown, New York
Chairman of Organizing Committee and Compiler of proceedings volume

SELECTED PUBLICATIONS OF G.C. JACOBY, 1988-1992

Jacoby, G.C., P.R. Sheppard and K.E. Sieh. 1988. Irregular recurrence of large earthquakes along the San Andreas fault: evidence from trees, Science 241, pp. 196-199.

Cook, E.R., M.A. Kablack and G.C. Jacoby. 1988. The 1986 drought in the southeastern United States: How rare an event was it? Journ of Geophysical Res. v. 93, n. D11. pp. 14, 257-260.

Sheppard, P.R. and G.C. Jacoby. 1989. Application of tree-ring analysis to paleoseismology: two case studies. Geology 17:226-229.

Jacoby, G.C. and R. D'Arrigo. 1989. Reconstructed Northern Hemisphere annual temperature since 1671 based on high-latitude tree-ring data from North America. Climate Change 14:39-59.

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D'Arrigo, R.D. and G.C. Jacoby. 1990. Reconstructed Arctic annual temperature variations for recent centuries based on high-latitude Scandinavian and North American tree-ring data (abst.) EOS Trans. AGU, v. 71, n. 43, p. 1246.

Boninsegna, J.A., J. Keegan, G.C. Jacoby, R.D. A'rrigo and R.L. Holmes. 1990. Dendrochronological studies in Tierra del Fuego, Argentina, Quaternary of South America and Antarctic Peninsula, v. 7, pp. 305-326.

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D'Arrigo, R.D. and G.C. Jacoby. 1991. A thousand-year record of northwestern New Mexico winter precipitation reconstructed from tree rings and its relation to El Niño and the southern oscillation, Holocene, 1(2):95-101.

Thetford, R.D., R.D. D'Arrigo and G.C. Jacoby. 1991. An image analysis system for determining densitometric and ring-width time series, Canadian Journal of Forest Research 21(1):1544-1549.

D'Arrigo, R.D. and G.C. Jacoby. 1991. Dendroclimatic evidence from northern North America, in Climate Since A.D. 1500, Bradley, R.S. and P.D. Jones, eds., Routledge, London, pp. 296-311.

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Jacoby, G.C., P.L. Williams and B.M. Buckley. 1992. Tree-ring correlation between prehistoric landslides and abrupt tectonic events in Seattle, Washington. Science 258:1621-1623.

D'Arrigo, R.D., G.C. Jacoby and E.R. Cook. 1992. Impact of recent North Atlantic anomalies on surrounding land areas based on dendroclimatic evidence. Geography Res. Letters, 19, 23, pp. 2321-2324.

D'Arrigo, R.D., G.C. Jacoby and R.M. Free. 1992. Tree-ring width and maximum latewood density at the North American tree line: parameters of climatic change. Can. Jour. of For. Res. 22(9):1290-1296.

Name: **Glenn Patrick Juday**

Rank **Associate Professor of Forest Ecology**: Date of Appointment 07/01/87

Education: **B.S. summa cum laude**, 1972, Forest Management, Purdue University,
West Lafayette, IN.
Ph.D., 1976, Plant Ecology, Oregon State University, Corvallis, OR
Dissertation topic: The Location, Composition and Structure of Old-Growth Forests of the Oregon Coast Range.

Post-Doctoral Fellowship in Environmental Affairs, 1976-1977, (Rockefeller Foundation) Oregon State University; Executive Chairman of the Oregon Natural Area Preserves Advisory Committee.

Field of Specialization and Areas of Interest

Analysis of landscape-level processes responsible for natural diversity
Long-term environmental monitoring
Structure of old-growth forest ecosystems
Definition and identification of elements of natural diversity
Natural area protection and management

Selected Research Reports and Papers

Alaback, Paul B.; Juday, Glenn Patrick. 1989. Structure and Composition of Low Elevation Old-Growth Forests In Research Natural Areas of Southeast Alaska. Natural Areas Journal 9(1): 27-39.

Juday, Glenn Patrick. 1988. Old-Growth Forests and Natural Areas: An Introduction. Natural Areas Journal 8(1) p 3-6.

Juday, Glenn Patrick. 1991. Ten Years of Successional Change on the Hugh Miller Inlet Plots, Glacier Bay National Park. Contract Report to Alaska Region, National Park Service, # CA-9700-0-9011. 35 p. plus 18 numbered figs., 5 appendices.

Publications In Progress

Juday, Glenn Patrick. (in prep.). Age structure and development of an old-growth white spruce forest in the Bonanza Creek LTER. [Intended submission - Canadian Journal of Forest Research].

I. BUDGET

		FFY 1995	FFY 1996	FFY 1997
1. Personnel (inclu Indirect)				
	G. Jacoby	$38,212	$39,846	$42,850
	Other TRL	$30,042	$32,294	$34,535
	G. Juday	$19,747	$22,004	$23,697
	Other AFES	$18,619	$21,158	$22,004
	Grad student	$16,500	$17,500	$18,500
2. Travel (inclu Indirect)		$19,000	$23,000	$22,000
3. Contractual		$2,000	$3,000	$4,000
4.Commodts.		$3,500	$4,500	$3,000
5. Equipment		$6,000	$3,000	$4,000
6. Capital outlay		$0	$0	$0
7. General administration		$0	$0	$0
TOTAL		$153,620	$166,302	$174,586

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RECEIVED
JUN 15 1994
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

Project #
95047

1508 W 43rd #7
Anch, AK 99503
6/15/94

My proposal for the actual restoration of the Prince Willaim Sound would be to extacte the perimary eleiment within the Turnagain Arm an to seal the migrating contamination in place, seperating the contamination from the water colum.

Now I don't Cotton to the idea of the presumptuous an there schematice in Sam-mon habitat restoratign of Prince Willaim Sound, when they having a felonious postion of assessment to grants.

The above proposal being a cost plus project not unlike the pipe line it self, will also pay dividends.

Please see copyright filed TXu 545 416 and other documents plus attcements

signed Charles E. McKee
6/15/94

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Historical Analysis of Sockeye Salmon Growth Among Populations Affected by Overescapement

Project number: 995048

Principal Investigators Dr. Gregory T. Ruggerone, NRC
Dr. Donald E. Rogers, FRI-UW

Lead Organization Natural Resources Consultants, Inc.

Cost of Project **FY 95** $85.0K
FY 96 $11.0K
FY 97 $11.0K

Project Startup/Completion October 1994/ December 1997

Project Duration 3 years

Geographical Areas Kenai River, Akalura Lake, Red Lake, Coghill Lake, Chignik Lake, Kasilof River, Crescent River, Wood River Lakes

Contact Person Dr. Gregory T. Ruggerone
Natural Resources Consultants, Inc.
4055 21st Avenue West, Suite 200
Seattle, Washington 98199
(206) 285-3480

INTRODUCTION

The Exxon Valdez Oil Spill Trustee Council (EVOSTC) has identified several sockeye salmon stocks that are not recovering from the overescapement caused by the *Exxon Valdez* oil spill. Injured sockeye salmon stocks include sockeye from the Kenai River in Upper Cook Inlet, and Akalura Lake and Red Lake on Kodiak Island. Additionally, the EVOSTC is funding a restoration project on Coghill Lake near Prince William Sound (lake fertilization to enhance growth), although the declining sockeye runs have not been linked to the oil spill. Although the EVOSTC did not list Chignik Lake as a potentially injured lake, Chignik Lake received more than twice its escapement goal as a result of the oil spill in 1989. Monitoring of Chignik Lake in relation to the overescapement has not been conducted.

Overescapement of sockeye salmon to these lake systems is believed to have led to exceptionally high densities of salmon in the lakes, which in turn has caused reduced growth. Schmidt et al. (1993) suggested that small sockeye fry in the fall cause exceptionally high mortality during winter, a period when sockeye salmon may lose 10% body weight because few or no prey are available (Ruggerone 1993).

Presently, the EVOSTC and the Alaska Department of Fish and Game (ADF&G) are monitoring fry abundance and size in the Kenai River system and smolt abundance and size in Akalura Lake and Red Lake. However, monitoring of sockeye smolt lengths in these systems began only recently. Few years of data are available for comparison before and after the overescapement. Thus, the effect of overescapement on salmon growth is difficult to evaluate. Furthermore, growth of sockeye smolts migrating through oiled waters, especially in Prince William Sound, may have been reduced. This effect has been documented for pink salmon (Willette et al. 1993). To our knowledge, the early marine growth of sockeye salmon from the areas affected by the *Exxon Valdez* oil spill has not been examined.

Scale measurements offer a relatively inexpensive means to evaluate the effect of overescapement in freshwater and oil in the marine environment on sockeye salmon growth. Scale measurements can also be used to inexpensively evaluate the recovery of the sockeye populations. Sockeye salmon scales are correlated with fish length and have been used to describe sockeye salmon growth in lakes (Zimmermann 1991, Bumgarner 1993, Ruggerone 1994) and the ocean (Rogers and Ruggerone 1993).

The objectives of the proposed project are to:

1. measure annual growth zones of sockeye salmon before, during, and after the oil spill from systems affected by the oil spill (Kenai River system, Akalura Lake, Red Lake, Coghill Lake, Chignik Lake) with sockeye growth from systems less affected by the oil spill (Kasilof River, Crescent Lake, Black Lake, and the Wood River Lake system),

2. compare trends in annual growth zone measurements of sockeye from systems affected by overescapement or oil in the marine environment with that of systems not affected,

3. determine the relative magnitude of reduced sockeye growth in freshwater or first year at sea as a result of overescapement or the presence of oil in the marine environment and evaluate the recovery of sockeye growth in years subsequent to the spill.

NEED FOR THE PROJECT

The declining sockeye runs to the Kenai River, Red Lake, and Akalura Lake are believed to be related to reduced growth caused by overescapement. The effect of large escapement in Chignik Lake has not been evaluated. Additionally, the effect on growth of Coghill Lake sockeye migrating through oil-contaminated waters in Prince William Sound has not been evaluated, although Willette (1993) demonstrated that growth of pink salmon in Prince William Sound was reduced.

Efforts to monitor the size of sockeye salmon smolts emigrating from these lakes began only recently and few data are available for comparison prior to the oil spill (D. Waltemyer, ADF&G, pers. comm.). In order to document the magnitude of the effects and the recovery of salmon in these areas, measurements prior to the spill, during the spill, and subsequent to the spill are needed. Scale measurements, which are an index of salmon growth, offer an inexpensive means to monitor the recovery of sockeye salmon in these affected areas. Furthermore, detailed analyses of freshwater and marine growth of sockeye from oil-affected and unaffected stocks over the past 20 years could help identify non-spill factors influencing growth and production (see Rogers and Ruggerone 1993). Thus, the use of scale measurements of a variety of sockeye stocks will enable us to distinguish effects of the oil spill from other environmental factors.

PROJECT DESIGN

Adult sockeye salmon scales would be obtained from ADF&G for each of the populations described above. ADF&G collects these scales as part of their normal management activities. Scales are available back to at least 1970 for sockeye stocks in the Kenai River, Kasilof River, Red Lake, and Coghill Lake stocks (D. Waltemyer, B. Barrett, ADF&G, pers. comm.). Akalura scales are available back to at least 1985. Scales for Chignik Lake, Black Lake, and Wood River Lakes sockeye stocks are available back to 1920; these scales have already been measured through 1990. Thus, scales measurements need be updated for these only stocks.

At least 100 scales from the dominant age group of each stock will be measured for each year. This sample size was determined to be adequate by Zimmermann (1991). The scales will be measured by the Optical Pattern Recognition System (OPRS) at Dr. Donald E. Rogers' laboratory at the University of Washington. The scale measurement methodology will follow that described by Zimmermann (1991), who was a graduate student supervised by Dr. Rogers and Dr. Ruggerone.

Annual frequency distributions of scale measurements will be plotted and analyzed for normality. Skewness of the frequency distributions may indicate size-biased mortality, which may indicate the effect of predation on smaller individuals. Trends in scale growth measurements will be analyzed within and among sockeye stocks in relation to the overescapement and oil spill events.

Scales available through 1995 will be measured, analyzed, and reported during FY95. Scales collected during 1995 represent the last progeny of the 1989 brood year. Scale collected during 1996 and 1997 represent progeny of sockeye spawning after the spill. Thus, we recommend two additional years of investigation (FY96, FY97) to examine the recovery of the sockeye stocks. These two years of investigation would be conducted at a much lower cost.

PROJECT IMPLEMENTATION

The project will be conducted by Dr. Gregory T. Ruggerone, Natural Resources Consultants, and Dr. Donald E. Rogers, Fisheries Research Institute, University of Washington. Both Ruggerone and Rogers have extensive first-hand experience with interpretations of scale measurements and have published numerous papers involving sockeye salmon scales. This team offers excellent qualifications and has available the needed equipment to conduct the investigation.

COORDINATION OF INTEGRATED RESEARCH EFFORT

The ADF&G will provide sockeye scales for each of the stocks described above. These scales were collected as part of the ADF&G's routine management activities. Sockeye scales from Chignik Lake and the Wood River system have already been measured and transferred to a computer database for return years 1950 to 1990. Thus, scale measurements for these stocks need only to be updated.

PUBLIC PROCESS

Results of the investigation can be presented in public forums, as needed.

PERSONNEL QUALIFICATIONS

Dr. Gregory T. Ruggerone will supervise the scale measurement process and conduct the data analysis. He has extensive experience with scale aging and measurement techniques. In 1981, he assisted the stock identification program by scale pattern analysis in the Upper Cook Inlet Management Area. In 1984 and 1985, he performed scale measurements of adult Chignik sockeye salmon for stock management applications (Conrad and Ruggerone 1984). He guided graduate students at the University of Washington in major studies involving life history interpretations from sockeye salmon scales collected from the Wood River Lakes and Chignik Lakes (Zimmermann 1991, Bumgarner 1993, Ruggerone 1994). Recently he used scale measurements to assess density-dependent growth of Bristol Bay sockeye salmon in the Pacific Ocean (Ruggerone and Rogers 1993).

Dr. Donald E. Rogers, University of Washington, will assist with project coordination and the interpretation of sockeye salmon growth measurements. Dr. Rogers has over 30 years experience with sockeye salmon in Alaska. He has been the chairperson for four graduate students whose theses were based on scale measurements. Dr. Rogers maintains an Optical Pattern Recognition System in his lab.

REFERENCES

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Conrad, R.H., and G.T. Ruggerone. 1985. Stock composition of the 1984 sockeye salmon run to the Chignik Lakes estimated using scale patterns and linear discriminant functions. Alaska Dept. Fish and Game Technical Report No. 151. 43 pp.

ɜrs, D.E., and G.T. Ruggerone. 1993. Factors affecting the marine growth of Bristol Bay sockeye salmon. Fisheries Research. 18: 89-103.

Ruggerone, G.T. 1992. Winter ecology of sockeye salmon in the Chignik Lakes, Alaska. FRI-UW-9214. University of Washington, Seattle. 33 pp.

Ruggerone, G.T. 1994. Investigations of salmon populations, hydrology, and limnology of the Chignik Lakes, Alaska, during 1993. Prepared for the Chignik Regional Aquaculture Association by Natural Resources Consultants, Inc. 111 pp.

Willette, M. 1993. Impacts of the *Exxon Valdez* oil spill on migration, growth, and survival of pink salmon in Prince William Sound. Pp. 112-114 in *Exxon Valdez* Oil Spill Symposium. Anchorage, Alaska.

Zimmermann, M. 1991. Trends in the freshwater growth of sockeye salmon from the Wood River Lakes and Nushagak Bay, Alaska. M.S. Thesis. University of Washington, Seattle.

BUDGET

31 October 1994 to 30 September 1995

Personnel	Cost
G. Ruggerone, NRC	
3 months	$38,250
D. Rogers, FRI	
0.5 months	$6,000
Technician	
10 months	$37,850
Misc. supplies	$500
Travel	2,400
Total	$85,000

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Independent Review of Salmon Restoration and Monitoring Projects

Project Number: 95049

Principal Investigators Dr. Gregory T. Ruggerone, NRC
Dr. Donald E. Rogers, FRI-UW

Lead Organization Natural Resources Consultants, Inc.

Cost of Project FY 95 $31.9K

Project Startup/Completion October 1994/ September 1995

Project Duration 1 year

Geographical Area Kenai River, Kodiak Island, Coghill Lake

Contact Person Dr. Gregory T. Ruggerone
Natural Resources Consultants
4055 21st Avenue West, Suite 200
Seattle, Washington 98199
(206) 285-3480

INTRODUCTION

The Exxon Valdez Oil Spill Trustee Council (EVOSTC) has funded and will continue to fund numerous monitoring and restoration projects related to the *Exxon Valdez* Oil Spill. These projects have been conducted by personnel with excellent qualifications. However, good science is incomplete without thorough, independent review. Independent review of monitoring and restoration projects is needed to maximize the benefit of the projects and to minimize costs.

The purpose of this proposal is to offer the expertise of Natural Resources Consultants (NRC) and associates for the review and evaluation of salmon monitoring and restoration projects.

PROJECT DESIGN

The review and evaluation process would focus on the methodology and sampling design of the study in relation to the stated objectives, statistical procedures used in the analyses, interpretation of the results, and identification of assumptions used in the investigation. The evaluation will include recommendations for the reviewed investigation as well as recommendations for future studies. All comments will be made with a thorough discussion of the issue. The goal of the review process will be to improve the investigation in order to better meet the goals of the EVOSTC. The schedule of the review process would be determined by the availability of draft reports.

PROJECT IMPLEMENTATION

NRC offers the expertise of three scientists who have extensive experience with salmon management, salmon ecology, habitat restoration, and limnological issues in Alaska. These scientists are Dr. Gregory T. Ruggerone, former project leader of FRI's Alaska Salmon Program, Dr. Donald E. Rogers, Research Professor at the University of Washington's Fisheries Research Institute (FRI), and Dr. F. Joan Hardy, who has conducted limnological and lake fertilization projects related to salmon enhancement in Alaska and British Columbia. These scientists are intimately familiar with monitoring and restoration projects of the type planned by the EVOSTC and could provide valuable insight to the studies

Projects that these scientist could evaluate include:

- Coghill Lake Sockeye Salmon Restoration
- Kenai River Sockeye Salmon Restoration
- Sockeye Salmon Overescapement
- Coded Wire Tag Recoveries from Pink Salmon in Prince William Sound
- Coded Wire Tagging of Wild Pinks for Stock Identification
- Forage Fish Study in Prince William Sound

COORDINATION OF INTEGRATED RESEARCH EFFORT

Drs. Ruggerone, Rogers, and Hardy frequently interact with agencies such as the Alaska Department of Fish and Game, who has conducted many of the monitoring and restoration projects. Drs. Ruggerone and Rogers have a long working relationship with ADF&G and have also been asked by various clients to critically evaluate reports by the department. Our working relationship with ADF&G would facilitate the exchange of information needed to conduct reviews of their work.

PUBLIC PROCESS

Results of the investigation can be presented in public forums, as needed.

PERSONNEL QUALIFICATIONS

Dr. Gregory T. Ruggerone has conducted salmon projects in Alaska during the past 15 years, including areas such as Upper Cook Inlet, Kodiak, Chignik, Bristol Bay, and coastal and offshore areas of the Gulf of Alaska. During the 1984-1993, he was Project Leader of the Alaska Salmon Program at the Fisheries Research Institute, University of Washington. He designed, directed, and conducted salmon studies at the Chignik Research Station where his research goal was to determine factors influencing salmon survival, monitor salmon populations and their prey, develop techniques to improve harvest management, define escapement goals, and identify habitat restoration projects. Dr. Ruggerone has refereed numerous salmon studies for scientific journals, including *Canadian Journal of Fisheries and Aquatic Sciences, North American Journal of Fisheries Management, Transactions of the American Fisheries Society, Aquatic Living Resources, and Fishery Bulletin.* He has published over 10 investigations in peer-reviewed journals and over 40 technical reports involving salmon ecology, predator-prey interactions, salmon management, limnology, and habitat. Dr. Ruggerone is presently the Northwest District Director of the American Institute of Fisheries Research Biologists.

Dr. Donald E. Rogers, Research Professor at the Fisheries Research Institute, has conducted salmon studies in Alaska since 1958. During his 35 years of field research in Alaska, Dr. Rogers has investigated nearly all aspects of salmon life history and management. He developed an extensive monitoring program of sockeye salmon lakes in the Bristol Bay in an effort to determine factors influencing salmon survival and to develop salmon escapement goals. He conducted one of the first major lake fertilization projects in Alaska in an effort to enhance sockeye growth and survival. He has chaired the graduate committees of over 15 graduate students. Dr. Rogers is considered to be one of the most knowledgeable scientists on salmon management and biology issues in Alaska and is frequently requested by ADF&G or other groups to provide expert opinions on salmon related issues.

Dr. F. Joan Hardy has over 15 years experience as a limnologist and aquatic toxicologist. During 1975 to 1980, she participated in one of the first large-scale lake fertilization studies in Alaska. Following her doctoral program at Fisheries Research Institute, University of Washington, Dr. Hardy received a two year NSERC fellowship with the Fisheries and Oceans Canada to conduct limnological studies involving the fertilization of sockeye salmon lakes. She was a Research Scientist with Canada's National Hydrology Research Institute and conducted additional limnological studies there. She assisted with the development of a limnological monitoring program for the Quinault Indian Tribe's sockeye lake and recently developed the aquatic plant management program for the State of Washington. She is presently investigating toxic cyanobacteria (bluegreen algae) in western Washington lakes.

BUDGET[1]

31 October 1994 to 30 September 1995

Personnel	Cost
G. Ruggerone, NRC 1.0 months	$12,750
D. Rogers, FRI 0.75 months	$9,562
F.J. Hardy 0.75 months	$9,562
Travel (Anchorage)	______
Total	$31,874

1 The above budget was generated for the review of the Coghill Lake Sockeye Salmon Restoration project, the Kenai River Sockeye Salmon Restoration project, and the Sockeye Salmon Overescapement project. Budgets for other projects would be provided as needed.

A Test of Sonar Accuracy in Estimating Escapement of Sockeye Salmon

Project number: 95050

Principal Investigators Dr. Gregory T. Ruggerone, NRC
Dr. Donald E. Rogers, FRI-UW

Lead Organization Natural Resources Consultants, Inc.

Cost of Project	FY 95	$79,290
	FY 96	$78,030
	FY 97	$78,030

Project Startup/Completion May 1995/ December 1997

Project Duration 3 years

Geographical Area Wood River and Kenai River, Alaska

Contact Person Dr. Gregory T. Ruggerone
Natural Resources Consultants, Inc.
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(206) 285-3480

INTRODUCTION

Knowledge of salmon spawning density is paramount to conservation management of salmon runs in Alaska. Spawning density and the timing of the spawning escapement are primary factors that harvest managers can control during a fishery. Proper management of the spawning escapement is needed not only to perpetuate the salmon run but also to maximize the sustainable harvest of the run (Ricker 1954).

The Exxon Valdez Oil Spill Trustee Council (EVOSTC) has identified Kenai River sockeye salmon as a biological resource that is not recovering from the 1989 *Exxon Valdez* oil spill. The primary reason for the declining run to Kenai River is the large escapement resulting from the closure of the drift gillnet fishery after oil contaminated the fishing grounds (Schmidt et al. 1993). The overescapement in 1989 was the third consecutive large escapement to the Kenai River. The first excessive escapement resulted from the *Glacier Bay* oil spill in 1987.

A primary issue surrounding the overescapement of salmon to the Kenai River is whether the sonar counters undercount sockeye salmon. The accuracy of the sonar counters was initially contested during the 1987 *Glacier Bay* oil spill trial and is an issue in the *Exxon Valdez* oil spill trial.

Natural Resources Consultants and its associate Dr. Donald E. Rogers, University of Washington, have provided evidence that adult salmon sonar counters underestimate salmon escapement in Upper Cook Inlet based on information about their performance in Bristol Bay. In brief, sonar estimates of sockeye, pink, chinook, and chum salmon abundance in the Nushagak River, Bristol Bay, were less than expected based on comparisons with visual counts from towers and aerial surveys during an eight-year period. The sonar estimates of salmon abundance averaged 24% less than visual counts, but this error increased to 55% during years of large escapement. The greater undercounting error by sonar during large salmon escapements was predicted by John Suomola, an acoustic engineer at the Massachusetts Institute of Technology, because sonar may not discriminate between individual fish at high densities. Additional evidence that sonar is undercounting in Upper Cook Inlet is the fact that harvest rates for UCI sockeye salmon are high relative to other major sockeye salmon systems, even though sockeye runs to the Susitna River are frequently managed as "weak" and the Kenai and Kasilof rivers include glacial lakes that are generally less productive than relatively clear water lakes, such as Becharof and Chignik. Underestimation of sockeye escapement could explain the unexpectedly high harvest rates in the UCI management area. Finally, aerial counts of salmon, which are known to be biased low, are not that much lower than total sonar counts in the Kenai and Kasilof river systems. In 1988 and 1975, the peak spawning count for seven index streams (primarily aerial counts) in the Kasilof drainage actually exceeded the sonar count for the system even though the peak counts did not cover all spawning areas and no attempt was made to expand the index counts. The Alaska Department of Fish and Game discarded the sonar estimate in favor of the index count in 1988.

The issue of sonar undercounting reached a peak in December 1993 when the ADF&G's sonar expert Paul Skvorc announced that sonar undercounted salmon abundance. Problems with sonar include high frequency which limits the ability of sonar to detect salmon, changing attenuation with conductivity of the water, and automation of the sonar counting procedure (Skvorc, pers. comm.). The accuracy of sonar continues to be debated among ADF&G personnel.

Although sonar has been used to count salmon in Alaska since at least 1978, no experiments have been designed to field test sonar using visual observations other than the Nushagak River analysis described above. The Kenai River appears to have received more salmon than counted by the sonar. The accuracy of sonar needs to be determined in order to help restore and monitor the declining sockeye runs to the Kenai River and to help manage the sockeye salmon runs in Upper Cook Inlet and other parts of Alaska. The proposed project will develop a correction factor that could be applied to historical sonar counts of adult salmon in the Kenai River and other rivers in Upper Cook Inlet. Thus, the proposed project will be beneficial both to conservation of injured resources and to fishermen injured by the reduced salmon harvests. The EVOSTC has identified the need to improve abundance estimation techniques and has funded genetic stock identification and coded wire tag studies. The proposed study would enhance the value of these funded studies.

The objectives of the proposed project are to:

1. test the accuracy of sonar on a seasonal and daily basis,

2. determine whether sonar counts are linearly or curvilinearly related to salmon abundance,

3. compare automatic counts made by the Bendix sonar with acoustic marks made on a chart recorder,

4. develop a correction factor that could be applied to Bendix sonar counters in the Kenai River and other rivers in Alaska.

NEED FOR THE PROJECT

The declining sockeye runs to the Kenai River are believed to be related to overescapement in 1987, 1988, and 1989. ADF&G estimates of escapement were based on sonar, which may be undercounting the escapement. Thus, escapement of sockeye salmon to the Kenai River, Kasilof River, Susitna River, and Crescent River in the Upper Cook Inlet Management Area may actually be much greater than previously estimated by the ADF&G. Given the curvilinear relationship between actual escapement and sonar estimated escapement in the Nushagak River, the actual escapement to the Kenai River during 1987-1989 could be 70% more than the estimate made by sonar.

In order to evaluate the effect of overescapement on sockeye production in the Kenai River, it is imperative to determine the accuracy of the escapement enumeration procedure. Surprisingly, no studies have been designed to field test sonar estimates of migrating adult salmon. Evaluation of sonar by comparing visual and sonar counts over the course of the sockeye spawning migration is needed not only to evaluate overescapement in the Kenai River but also to evaluate sonar counts in all areas of Alaska where sonar is used as the primary enumeration process.

Results of the sonar test at Wood River could be used to correct sonar counting errors in the Kenai. Because Wood River is considered an ideal location for deployment of sonar (A. Menin, pers. comm.), any error discovered at Wood River is likely to be equal to or less than that at glacial rivers such as the Kenai. Thus, correction factors at Wood River could be used to provide a minimum correction factor to historical sonar data in the Kenai River and other rivers in Upper Cook Inlet where sonar has been deployed. Results of this study would help resolve some of the questions related to the dispute over sonar accuracy.

PROJECT DESIGN

We propose to test the accuracy of Bendix sonar by comparing sonar with visual tower counts of sockeye salmon. The tower count method is considered to be one of the most accurate methods for enumerating salmon (Cousens et al. 1982). Comparison of tower and sonar counts will determine whether sonar undercounts salmon and whether sonar undercounting is greater when large numbers of salmon are migrating, as indicated in the Nushagak River.

The investigation will occur in Wood River near Bristol Bay during 15 June to 20 July 1995. Wood River is a good location to test sonar because (1) the ADF&G has a long history of enumerating sockeye salmon in Wood River from a tower, (2) the spawning escapement to Wood River (1 million fish) is similar to the Kenai River (750,000 fish), (3) Wood and Kenai rivers are similar in size, (4) large numbers of salmon may migrate upriver in a short time period, and (5) Wood River is an ideal location for sonar (A. Menin, pers. comm.). Thus, the test will occur during ideal conditions, thereby allowing a test of sonar accuracy without complicating factors such as channel morphology.

The enumeration of sockeye salmon by sonar will be conducted without knowledge of daily or cumulative tower counts of sockeye salmon. Furthermore, visual observations of sockeye salmon in Wood River will not be used by the sonar crew to calibrate sonar. Wood River will be treated as if it were a glacial river similar to the Kenai River. The blind test approach is essential to objective testing of sonar accuracy.

A chart recorder will be used to record potential fish targets. These charts will be analyzed post-season to determine whether potential sonar counting error was caused by the automatic counting procedure of the Bendix equipment or by the sonar itself. Presently, sonar crews in Upper Cook Inlet rely on the automated counting procedure rather than interpretations of chart recordings. Additionally, conductivity of Wood River will be measured on a daily basis because conductivity may influence sonar accuracy. A video camera equipped with a polarizing filter will be used to document the methodology and to photograph the migration density of sockeye salmon during peak escapement periods.

Sonar methodology will be the same as that used on the Kenai River. Al Menin, who developed the Bendix sonar and who oversees ADF&G sonar operations throughout Alaska, will assist with sonar set up, calibration, and operation. Additionally, a staff member of the statewide Sonar and Technical Services Unit will assist with the operation of the sonar to insure that the project is conducted to ADF&G specifications (D. Eggers, Chief Scientist, ADF&G, pers. comm.).

Hourly escapement data from tower observations at Wood River will be obtained from the ADF&G after field observations have been completed. Hourly, daily, and seasonal tower counts will be compared to sonar counts. The project should be conducted for three years in order to fully evaluate potential error in total annual escapement.

PROJECT IMPLEMENTATION

The project will be conducted by Dr. Greg Ruggerone, Natural Resources Consultants, Dr. Donald E. Rogers, Fisheries Research Institute, University of Washington, and Al Menin who developed the Bendix sonar. This team brings a strong background in salmon escapement techniques, salmon ecology, hydroacoustic applications, field investigations, and knowledge of the proposed test site.

COORDINATION OF INTEGRATED RESEARCH EFFORT

The ADF&G has two Bendix sonar units available for this project (Skvorc, ADF&G, pers. comm.) and has approved the use of the equipment for the project (Doug Eggers, Chief Fisheries Scientist, ADF&G, pers. comm.). Al Menin, who developed the Bendix sonar and inspects the operation of Bendix sonar by the ADF&G, will assist with the setup, calibration, and general operation of the sonar. Additionally, a staff member of the statewide Sonar and Technical Services Unit will assist with the operation of the sonar to insure that the project is conducted to ADF&G specifications (D. Eggers, Chief Scientist, ADF&G, pers. comm.). The sonar crew will stay at the University of Washington's field station (operated by Dr. Rogers) at the outlet of Lake Aleknagik, approximately five miles from the likely sonar site. Boats and supplies will be provided through the field station.

PUBLIC PROCESS

Results of the investigation can be presented in public forums, as needed.

PERSONNEL QUALIFICATIONS

Dr. Gregory T. Ruggerone will conduct and oversee sonar operations at Wood River. Dr. Ruggerone has used sonar to estimate salmon abundance in the Columbia River and anchovy abundance in the ocean near southern California. He has observed sonar operations at Kenai, Kasilof, and Crescent rivers in Upper Cook Inlet and Chignik River. He published a paper, which involved sonar estimates of salmon abundance, in the *North American Journal of Fisheries Management.* Dr. Ruggerone has conducted field studies at Wood River and other areas of Alaska over the past 15 years.

Dr. Donald E. Rogers will assist with project implementation at Wood River and will oversee data analysis and report preparation. Dr. Rogers has conducted field studies at Wood River since 1958. His Ph.D. dissertation involved sonar and townet operations to estimate juvenile salmon abundance in the Wood River Lakes. Dr. Rogers assembled the ADF&G escapement data for the Nushagak River and provided the first comparison of sonar salmon counts with visual counts.

Mr. Al Menin will assist with sonar set up, calibration, and operation at Wood River. Mr. Menin developed the Bendix sonar and presently oversees the operation of Bendix sonar throughout Alaska.

REFERENCES

Cousens, N.B. et al. 1982. A review of salmon escapement techniques. Can. Tech. Rept. Fish. Aq. Sci. No. 1108.

Ricker, W.E. 1954. Stock and recruitment. J. Fish. Res. Bd. Can. 11:559-623.

Schmidt, D. et al. 1993. Overescapement impacts of Kenai River sockeye salmon. Pp. 132-134 in *Exxon Valdez* Oil Spill Symposium. Anchorage, Alaska.

BUDGET

31 October 1994 to 30 September 1995

Personnel	Cost
G. Ruggerone, NRC 3.0 months	$38,250
D. Rogers, FRI 0.5 months	5,080
A. Menin 5 days	3,600
Technicians (2) 1.3 months	7,000
Food, lodging, boats, fuel	15,500
Travel	7,800
Equipment	
oscilloscope	600
chart recorder rental	800
transducer stand	360
kerosene heater	300
Total	$79,290

Large-Scale Coded Wire Tagging of Prince William Sound Herring

Project Number: 95051

Principal Investigators

Jeffrey A. June, NRC
Dr. Gregort T. Ruggerone, NRC
Guy Thornburgh, NMT
Dr. Gary Morishima

Lead Organization

Natural Resources Consultants, Inc.

Cost of Project

FY 95	$190,575
FY 96	$512,500
FY 97	$143,075

Project Startup/Completion January 1995/ December 1997

Project Duration 3 years

Geographical Areas Prince William Sound

Contact Person

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INTRODUCTION

The Exxon Valdez Oil Spill Trustee Council (EVOSTC) has identified several fish stocks that are not recovering from the effects caused by the *Exxon Valdez* Oil Spill. Prince William Sound herring is one of these stocks. Population biomass has unexpectedly declined from over 130,000 tons in 1992 to about 7,000 tons in 1994 due mainly to the demise of a particularly strong 1988 year class of herring that was anticipated to support large harvests and future year classes through spawning escapement.

The 1993 herring run to Prince William Sound was approximately 100,000 tons below expected abundance resulting in severe commercial fishing restrictions. Returning fish were observed to have VHS disease and were in a weakened state with unusual behavior. In 1994, the herring run further declined to less than 7,000 tons below the 8,400 ton minimum required to allow any commercial fishing and fish were again found with evidence of VHS disease.

The current level of biomass and age composition of the population indicates the 1996 commercial fishery may have to be curtailed and future commercial fisheries harvests will likely be reduced compared harvests of the past five to eight years. Herring stocks and fisheries in other areas of Alaska appear to remain healthy and some are continuing to expand.

Numerous theories have been proposed to explain the decline in Prince William Sound herring stocks including long-term effects of the Exxon Valdez oil spill, limitations on food supply, competition with pink salmon hatchery releases, and effects of the VHS disease. Oil spill effects studies have shown the possibility that egg, larvae, and juvenile herring were, and may continue to be, affected by the presence of oil. Genetic damage, reduced immune response, and possible lowered reproductive capacity are but a few of the potential oil spill related effects that are likely to have been felt by the 1988, 1989 and possibly later year classes of herring in Prince William Sound. Chronic low-level oil contamination may be further affecting recent year classes.

Critical to the study of Prince William Sound herring stock recovery is accurate determination of population size, differential growth, disease occurrence and mortality between oiled and un-oiled areas, and migration of potentially genetically damaged fish from affected areas to unaffected areas. ADF&G currently relies mainly on inseason aerial surveys and test fisheries and post-season on spawner deposition and age-structured modeling to determine the size of the returning herring population in Prince William Sound. These same techniques combined with samples of fish from the commercial fishery provide information on the age composition, size and weight at age, fecundity, and location of spawning deposition. ADF&G is aware these stock assessment tools are subject to error which may vary from year to year depending on stock size, level of commercial fishery, and environmental conditions. Not enough is known about the physical and biological factors that determine early life survival or those that control adult maturation and spawning. For example, the 1988 year class appeared particularly strong in 1992 as four year-old fish and then unexpectedly declined drastically at age five and further at age six in stark contrast to the population dynamics of similar strong year classes in the recent past which persisted in the population through age seven.

Currently ADF&G places it greatest reliance on spawner deposition surveys to provide a means of back-calculating the spawning biomass of herring each year. When combined with the commercial harvest, this estimate provides the overall annual run size and allows calculation of exploitation rates, and inputs into the age-structured stock assessment model to predict next year's run size and possible commercial harvest. The accuracy of these population estimates drives the predictive process. Skip-spawners (herring that return but may not spawn), the spread of the geographical location of spawning, and the distribution of the commercial fleet all may affect the accuracy of these estimates.

Large-scale coded wire tagging would provide an additional useful tool to estimate population size while providing important additional information on growth, health, fecundity, and migration patterns of herring.

The objectives of the proposed project are to:

1) develop a large-scale coded wire tag release and recapture program for herring in PWS

2) create a coded wire tag return database that would be available to researchers working in Prince William Sound and other areas,

3) assist researchers in analyzing coded wire tag returns to answer specific questions for research and management.

NEED FOR THE PROJECT

The declining herring stock in Prince William Sound is creating an economic hardship for commercial fishers and the communities that depend on the harvest of this resource. Herring is an important food source throughout all stages of its life history for many other important species in Prince William Sound. Reduction in the stock size of herring may inhibit the recovery of other fish, birds, and marine mammals.

ADF&G budget constraints do not allow the initial capital outlay for development of such a project. However, once in place with equipment purchased, technicians trained, and databases developed, ADF&G may be able to continue a large scale herring tagging program beyond the end of the proposed project period.

..OJECT DESIGN

Experts from Natural Resources Consultants and Northwest Marine Technology along with support from ADF&G will develop a coded-wire tagging program for Prince William Sound. Historical harvest and spawning patterns will be reviewed, fishers and processors will be contacted, researchers and fishery managers will be interviewed, and a detailed tag release and recovery plan developed.

Recently developed statistical procedures using marked-tag recovery techniques on large-sized fish populations require far fewer tag releases and recoveries than the traditional Petersen estimates (see attached description). We anticipate that four Mark-4 tagging units would be purchased (or borrowed from ADF&G salmon tagging programs). Northwest Marine Technology has achieved tagging rates from 800 to 1,000 herring per hour with the Mark-4 units in the North Atlantic. The units would be completely self-contained and portable. They could be used together on a tagging vessel or spread separately throughout the Prince William Sound area.

Live herring for tagging will be obtained from test fishery purse seiners, chartered commercial seiners prior to and after fishery openings (or during the entire 1995 season when no commercial fishery is expected), and from pound herring prior to release. The latter source would provide evidence of the relative survival rate of herring used in the pound fishery which could result in management allowing an expansion of this fishery. Assuming that each Mark-4 tagging unit was kept busy for a conservative ten hours per day over a ten day period each season, it is not unreasonable to estimate that up to 300,000 herring could be tagged and released each season. Using recently developed large population mark and recapture population estimate techniques, as few as 60,000 tagged fish may need to be released to get a reasonably accurate estimate of the population size (see attached articles).

Herring are processed at approximately four locations in Prince William Sound each year. Processing lines would have NMT large volume detection units installed. These units have been proven in other large-scale fisheries such as North Atlantic herring. They detect coded wire tags under a continuous flow of fish and divert a "batch" of fish that are then further scanned for tags with a smaller volume automatic detector or by use of a hand-held detector. The four detection units proposed for the study should be able to scan a majority of the herring processed in Prince William Sound each year for coded wire tags. In 1995, the project will focus on maximizing tag releases. In 1996 and 1997, the project will focus on both tag releases and recoveries.

A computer tag release and recovery database will be developed by the team using input from ADF&G, NMFS, and researchers active in Prince William Sound and other areas where the data may have application. Additionally, tag data use support services will be offered to all interested researchers and managers. These support services will include specific sample design, access and instruction in the use of the database, and a dial-in computer bulletin board format for information on tagging data availability and downloading protocols. At the termination of the three year project all tagging equipment and the coded wire tag database will be supplied to ADF&G for continued operation.

PROJECT IMPLEMENTATION

The project will be conducted by Natural Resources Consultants and Northwest Marine Technology. Mr. Jeffrey A. June and Mr. Guy Thornburgh will develop the tag release, recovery, and tag reading program in conjunction with the representatives from the ADF&G.

Dr. Greg Ruggerone, Dr. Gary Morishima, and Mr. Jeffrey June will work with Dr. Fritz Funk, Mr. Hal Geiger and Ms. Evelyn Biggs of ADF&G to develop the coded wire tag database structure and outside research and management information support.

COORDINATION OF INTEGRATED RESEARCH EFFORT

The project team will integrate the project design, tag release, tag recovery, and database utilization with any other relevant ongoing or planned projects in the area. The team will assist other researchers and fishery managers in integrating the information collect in the herring coded wire tagging project into their studies and make available the herring coded wire database to all interested users. In addition to studies directed at herring, the coded wire tag program could be useful in a variety of other studies ongoing in Prince William Sound. For example, coded wire tags from herring could even be hand-scanned for in fish, mammal, and bird stomach or scat studies to provide additional information on feeding habits.

PUBLIC PROCESS

Results of the investigation can be presented in public forums and publications as needed. The herring coded wire tag database will be public information.

PERSONNEL QUALIFICATIONS

Mr. Jeffrey A. June and Dr. Gregory T. Ruggerone have experience undertaking a number of tag recovery projects using a variety of tagging methods, development of tag return databases, and analyses. Mr. Guy Thornburgh and the staff of Northwest Marine Technology have extensive experience in the design of the equipment and methods for large-scale coded wire tagging programs. They have assisted in the development of nearly all the coded wire tag programs in the Pacific Northwest, Alaska, and other regions of the United States. Dr. Gary Morishima has been involved in the development and maintenance of the Pacific Salmon Commission's coded wire tag database. He provides assistance to a variety of users of salmon coded wire tag data.

BUDGET
(Approximate Estimate)

January 1995 to December 1997

	YEAR			
Personnel	1	2	3	TOTAL
Principal Professionals 1,920 hrs @ $75/hr	$57,600	$43,200	$43,200	$144,000
Technicians 2,880 hrs @ $22.50/hr	$16,200	$24,300	$24,300	$64,800
ADF&G Support Labor 800 hrs @ $45/hr	$14,400	$10,800	$10,800	$36,000
Tag Readers/Data Entry 450 hrs @ $18/hr	$0	$6,075	$2,025	$8,100

Personnel Subtotal $252,900

Equipment				
Mark-4 Tagging Machines 4 @ $13,000/unit	$52,000	$0	$0	$52,000
High-Vol. Detection Devices 4 @ $90,000/unit	$0	$360,000	$0	$360,000
Tag and Scan Equip Setup	$4,000	$3,000	$3,000	$10,000
Tag Readers 3@ $4,500/unit	$0	$6,750	$6,750	$13,500
Computer Bulletin Board Equip.	$0	$6,500	$0	$6,500
Misc.	$2,500	$1,250	$1,250	$5,000
	Equipment Subtotal		$447,000	
Vessel Charter				
One Purse Seine Vessel 15dy @ $2,500/d	$37,125	$37,125	$37,125	$112,500
Travel/Per Diem/Shipping	$6,750	$13,500	$13,500	$33,750
GRAND TOTAL	**$190,575**	**$512,500**	**$143,075**	**$846,150**

Community Involvement and Use of Traditional Knowledge

Project Number: 95052

Project Leaders: Judith E. Bittner/ Douglas R. Reger

Lead Agency: Department of Natural Resources, Unknown Contractor

Cooperating Agencies: Alaska Department of Fish and Game
U.S. Forest Service
Department of the Interior
Department of Commerce

Project Cost: FY95- $230.6; FY96- $300.0 (estimated)

Project Start up: December, 1994; Continuing

Project Duration: 5 years (estimated)

Geographic Areas: Oil Spill Area Wide

Contact Persons: Judith E. Bittner/ Douglas R. Reger
Office of History and Archaeology
Alaska Division of Parks and Outdoor Recreation
Anchorage, AK 99510-7001
(907) 762-2622

B. Introduction

The Exxon Valdez Oil Spill in 1989 caused severe disruption of the lives and perceptions of many spill area inhabitants and communities about their surrounding environment. Scientific studies have occurred throughout the spill area with researchers mostly based in agencies or institutions in Anchorage, Fairbanks, or outside Alaska. Data is collected under research strategies dictated by generalized knowledge of local environments but with little detailed historical knowledge. That lack of knowledge frequently diminishes application of results to specific local needs. It intensifies the frustration of local subsistence users and sense of loss of their historic lifestyle.

Traditional knowledge is used for this project to describe personal observations by people living in the spill area and knowledge which has passed from generation to generation by members of communities who share a common cultural heritage. This project intends to develop a multicultural partnership between the people of the oil spill region and scientific investigators carrying out detailed studies of the ecosystem of the region.

One Elder of the village of Tatitlek was noted as saying that while he was flying to Tatitlek from Chenega Bay that he could see the bottom in places where it had not been evident before and he wondered what effect this obvious lack of plankton would have on the salmon runs. He made this observation in 1992 and again in 1994. Another example of local knowledge based on observations of past local conditions was recognition of the lack of herring spawn on seaweed in Tatitlek Narrows which is gathered each year by the local people. Herring spawn is an important part of the spring diet and valued delicacy of Tatitlek people. This is the type of traditional knowledge that would be valuable in understanding the long term effects of the Exxon Valdez Oil Spill.

C. Need for Project

Researchers have recognized that local residents have traditional knowledge that could help them answer questions they have not been able to answer through conventional scientific means. For example, people living in the spill area have detailed knowledge about condition of resources, including seals, eel grass beds, archaeological sites, etc., which can significantly add to data of scientific studies and enhance application of results. Local people have stated their desire to add local knowledge for the benefit of researchers and be involved in all stages of projects. Presently there is no mechanism to bring the two groups together to share their knowledge. The project will initiate a mechanism and protocol for accomplishing those goals. Much of the documented damage and related research has been in the Prince William Sound and Outer Kenai Peninsula areas and the initial phase of this project will focus there. Successful implementation of the FY95 program will be followed by expansion to other communities, especially the Kodiak area, where scientific research and traditional knowledge can compliment each other.

D. Project Design

1. Objectives

The objective of the project will be to aid science project researchers to involve the local people into their studies either by making use of unique local knowledge, incorporating research aims which are locally important, and facilitating feed back of study results to the appropriate study area residents.

2. Methods

In each of three pilot communities a local person will coordinate efforts of knowledgeable local people, arrange local support and equipment for scientific investigators and communicate back to the local community the information and findings generated by scientific investigations in the local area. The local coordinators will be selected based on their knowledge of local natural and cultural resources. They will receive a part-time salary and will be selected and paid by the contracted area wide coordinator. The area wide coordinator will be selected by evaluation of proposals solicited by RFP and appraised by a panel of agency resource specialists.

This project will be structured on the stewardship concept with a contracted spill area wide coordinator who works with local community coordinators to assure comparability of aims, policy and procedures between the local programs. The first year of the project will involve three communities, to refine the process and provide a pilot program to be expanded to other communities in subsequent years. A listing of all scientific studies funded by the Trustees during FY95 in the area of each village will be compiled. Also a list of local knowledgeable people and people able to provide support on contract will be assembled by the local coordinator. That list will be provided to the overall coordinator who will provide it to researchers. The local coordinators will also be responsible for compiling information and sources of additional local information about spill affected resources other than just the resources subject to current scientific research. That will allow local residents to help identify important research questions related to the spill.

Reimbursement of local participants will be arranged if applicable, between the local participants and scientists conducting studies in the area. The local coordinator will act only as a facilitator to help investigators find locally knowledgeable informants and operators equipped for support services if required.

A contracting officer representative will assist the contractor to comply with agency contracting requirements and act as liaison between the agency and the contractor.

Local coordinators will be selected and brought into Anchorage to attend a meeting tentatively scheduled for January 1995 to share findings of various scientific projects. Immediately prior to or after the general meeting, local coordinators will meet to plan implementation of the Community Knowledge Transfer project in the selected communities.

Proposals submitted in response to the Request for Proposals will detail how the local coordinators will function, which communities will support the program and a sample of how lists of client scientists and similar lists of local resource people will be maintained. The proposals will be reviewed by a committee of agency specialists including scientists familiar with investigations in the spill area of the different resources and an individual representing local interests. The kinds of data the project should cover are for example, fish, sea mammals, birds, intertidal habitat, and archaeological sites which are among the many studies being proposed for FY95. Proposals will be submitted in the format of detailed work plans including a narrative describing the program proposed and details of the proposed budget.

3. Schedule

Project Proposal published
in Public Review Document......................August, 1994

Trustee Project Approval....................November 1, 1994

RFP Published..............................November 15, 1994
30 day response to RFP

Proposals evaluated and contractor selected........................December 15, 1994

Oil Spill Science Meeting
/Training for Local Coordinators............January 15, 1995
(Optional, time permitting)

Study lists to communities.................February 15, 1995

Local lists to researchers....................March 15, 1995

Project Status Report to Trustees...............July 1, 1995

Final Project Report......................September 30, 1995

4. Technical Support

No technical support will be necessary for the project as it is a coordination project between local people and projects each with its own technical support requirements.

5. Location

This project is located in the Prince William Sound and Lower Cook Inlet areas. The communities proposed are Tatitlek, Chenega Bay, and Port Graham.

E. Project Implementation

This project should be implemented under contract with a group or individual experienced in coordinating studies in the rural communities of the oil spill area. The contractor should have training in social sciences and experience in cultural anthropology or sociology. The contractor should also be familiar with traditional environmental knowledge.

F. Coordination of Integrated Research Effort

This is a coordination project rather than a research project and as such is directly aimed at integrating research studies with local informants and resource users.

G. Public Process

The public will be involved with this project from the initial review and acceptance of the proposal to the Trustees to the recruitment and use of local volunteers in communities.

H. Personnel Qualifications

The personnel qualifications of the contractor and local coordinators will need to emphasize more practical experience and local knowledge than formal training. The area wide coordinator will be expected to have some formal training in the social sciences.

I. Budget

Personnel	55.0
Travel	18.0
Contractual	139.5
Commodities	0.0
Equipment	0.0
Capital Outlay	0.0
SubTotal	212.5
General Administration	18.1
Total	230.6

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Project 95053

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL

FORMAT FOR IDEAS FOR RESTORATION PROJECTS

Title of Project: Cordova's Mini Imaginarium

Justification: Service and education -- To understand the impacts of the EXXON VALDEZ oil spill and ongoing activities to restore the damage.

Description of Project: (e.g. goals(s), objectives, location, rationale and technical approach)

Everyone loves "hands-on" experiences. The best possible way to help someone learn is to provide them with an experience they can see, hear, smell and feel. The oil spill had a tremendous impact upon Prince William Sound and its communities. A mini-imaginarium in Cordova would provide the perfect means to help residents and visitors, young and old, learn more about the Sound and the impacts of the oil spill.

The mini-imaginarium would be modelled after the very successful Anchorage Imaginarium. Realistic displays and hands-on activities exploring our abundant and diverse wildlife, varied habitats, oil spills and other hazarouds waste problems, impacts, response mechanisms, clean-up technology, energy conservation, among others, would be exhibited.

The project would be completed over a period of two years. The first year would be dedicated to planning which would include building plans and renovations. The second year would be dedicated to creating exhibits and interpretive displays, acquiring educational materials and hiring and training staff.

The mini-imaginarium, potentially located on the docks of Cordova next to the Prince William Sound Science Center, would be a first-rate creative learning environment providing valuable experiences in oil-related areas, encouraging a better understanding of Prince William Sound and promoting educated decision-making for all ages.

Estimated Duration of Project: Two years for planning and set-up; ongoing support will be sought from other funding sources.

Estimated Cost per Year: $62,589 each year

Other Comments: A cooperative agreement is being established with the U.S. Forest Service, Chugach Ranger District, acknowledging 1) the need for an imaginarium/environmental education center, and 2) the willingness of both parties to work together to fulfill this need. Negotiations are underway for the use of a Forest Service warehouse as the basic structure.

More detailed information is available from the Science Center's Education Coordinator, Beth Trowbridge.

95053

Name, Address, Telephone:

Dr. G.L. Thomas, Director
Beth Trowbridge, Education Coordinator
Prince William Sound Science Center
P.O. Box 705
Cordova, AK 99574
(907) 424-5800 — FAX 424-5820

Oil spill restoration is a public process. Your ideas and suggestions will not be proprietary, and you will not be given any exclusive right or privilege to them.

Montague Riparian Rehabilitation Monitoring Program

Project #95054

Project Leader: Ken Hodges

Project Manager: Dave Schmid

Lead Agency: U.S. Forest Service, Cordova Ranger District

Cost: $42,725

Starting Date, FY 95: July 1995, completion September 1995

Project Duration: Annual inspections 1995-97

Project Location: Various clearcut areas, Montague Island

Contact Person: Ken Hodges, Cordova Ranger District, P.O. Box 280, Cordova, AK 99574. 424-7661.

B. Introduction

In FY 1994 the Cordova Ranger District received funding to construct 25-30 structures in streams flowing through clearcut areas on Montague Island. The reasons for building these structures are to improve fish spawning and rearing habitat, prevent erosion, and help restore the natural flows and stream features that existed before the logging. The 1994 work also includes the improvement of 20 acres of riparian vegetation.

In FY 1995 the District proposes to monitor and evaluate these structures to ensure that they are functioning as intended, repair any damages that may have occurred, and assess the changes in the aquatic habitat, stream channels, and substrates. The riparian vegetation work will also be monitored and assessed.

C. Need for Project

While instream structures have been used successfully in the Pacific Northwest and in some of the smaller streams on the Cordova Ranger District, this will be the first time such structures have been placed on Montague Island. Because of the climate and topography, the streams on the west side of the island are subject to intense flows. Although we feel confident that the structures will hold up to the flows, the extreme conditions may have some unforeseen effects. This project is also somewhat experimental because it is being carried out in a remote area by a small crew using hand tools. Most other restoration work has involved heavy equipment where road access has been available.

We will need to evaluate the structures to document their performance and determine whether they are an effective method of rehabilitating streams in this area. If the structures prove to be successful, as we believe they will, the same methods could be used to treat streams in other logged areas on Montague Island. The scope of the present structure work has been limited mainly to Hanning Creek, but there are several other streams which could benefit from this type of activity if it proves successful.

This work might also prove effective in other logged areas in Prince William Sound. The Port Fidalgo area, for example, also has steep slopes, high rainfall, and streams with highly variable flows. The findings of the monitoring of the Montague Island work could be applicable to Port Fidalgo if restoration work is required there. The monitoring could also demonstrate that a small crew using hand tools in a remote area can be effective.

D. Project Design

1. Objectives

One objective of this study is to determine the changes in channel structure, fish habitat, and substrate at each of the structure sites and in an untreated area downstream from where the structures are placed. Another objective is to assess the riparian vegetation work by determining the survival rate of planted seedlings and the effectiveness of the tree thinning.

2. Methods

Changes in the stream channels will be evaluated by mapping the structure sites before and after construction. Pools, riffles, backwater and other features will be mapped. The depths and substrate sizes in each of these areas will also be recorded. Fish habitat, such as spawning and rearing area will be assessed. Downstream from the general area where the structures are to be built, a 100-yard segment will be mapped to assess the cumulative effects of the structures upstream.

The effectiveness of the structures can then be assessed in several ways. Since some of the structures are meant to re-create pool and backwater areas which were lost due to the effects of the logging, their success can be measured by the increase in these features. The increase in fish habitat is also easily measured. Other structures are meant to disperse energy and help moderate flows. This can be assessed indirectly by changes in substrate sizes or the formation of bars and other depositional features.

To assess the effectiveness of the tree planting, the main objective would be to determine the percentage of seedling survival. The roots and crowns can also be examined to assess growth and health. Competition from other species, such as alder and salmonberry should be assessed as well. The effectiveness of thinning is more difficult to quantify. Generally, however, such factors as growth, sunburnt stems, and windthrow should be noted so that a general assessment of the work can be made.

Monitoring should continue at least through 1997, although some of the workload should decrease after the first year. Because of the high flows, most of the effects of the structures should be apparent after several periods of high water. The success of the vegetation work will take much longer to fully assess, however.

3. Schedule

Monitoring of the structures during the first year should be done at high and low flows. Monitoring of the vegetation work can be done later in the summer after a season of growing.

April 1995: Prepare equipment, personnel, and other preliminary work.

May 1995: Monitoring of structures at high flow. Map stream channel effects at all structures and area below structures.

Mid-July: Low flow monitoring. Map stream channel effects at all structures and area downstream from structures. Assess use of fish habitat.

Early September: Monitor use of spawning areas and other fish habitat. Assess vegetation.

Late September: Input and analyze information, complete reports.

4. Technical Support

All work can be carried out by Forest Service personnel. No outside technical support is needed. A silviculturist will be needed to help with the assessment of the vegetation work. A GIS specialist will be used for entering the information into the GIS system.

5. Location

Hanning Creek (ADF&G stream # 710) Blying Sound D-1,2 quadrangle, R10E, T3S, section 2 SE 1/4; Swamp Creek (ADF&G # 739) Seward A-1 quadrangle, R12E, T1N, section 11, SE 1/4 and section 12, SW 1/4; and ADF&G streams 734, 735, 736, Seward A-2 quadrangle, R12E, T1S, section 4 NE 1/4 and section 33 SW 1/4.

E. Project Implementation

To be carried out by the Cordova Ranger District USFS.

F. Coordination of Integrated Research Effort

N/A

G. Public Process

The activity in this proposal does not require further public involvement or NEPA work since it is only the monitoring of a project which has already gone through the NEPA process.

H. Personnel Qualifications

David Schmid is the program manager and a fisheries biologist for the Cordova Ranger District. He has a B.S. degree in resource management from the University of Wisconsin, Stevens Point. He worked on the Glacier Ranger District for four years as a fisheries technician and two years as a fisheries biologist, during which time he managed the fisheries program and oversaw the construction of several fish ladders and other major construction projects. Since 1990 he has been the program manager on the Cordova Ranger District.

Ken Hodges is a fisheries biologist on the Cordova Ranger District. He has a B.S. degree in fisheries from Humboldt State University. Before coming to the District in 1989, he had worked as a seasonal employee for the Oregon Dept. of Fish and Wildlife and conducted a one-year study on steelhead genetics in Northern California. In Cordova he has worked as a fisheries technician and now as a biologist.

Kevin Buckley is a fisheries technician with the Cordova Ranger District. He has a B.S. in watershed management from the University of Wisconsin, Stevens Point. He has worked previously with the Forest Service on the Willowa-Whitman National Forest doing stream rehabilitation work and timber sale planning.

I. Budget

1. Personnel

Name	Days	Rate	Cost
Dave Schmid GS-11	20	213	4,260
Silviculturist GS-11	20	210	4,200
Ken Hodges GS-09	45	171	7,695
GIS tech. GS-07	20	142	2,840
Kevin Buckley GS-05	45	94	4,230
GS-03 (2)	40 (2)	75	6,000
Total			29,225

2. Transportation			
Three RT flights DH Beaver	12 hrs	350/hr	4,200
3. Contractual Services	N/A		
4. Commodities			
Field per diem	120 person days	15/p/day	1,800
5. Equipment			3,500
6. Capital Outlay	N/A		
7. General Administration			4,000
Total			42,725

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Prehistoric Ecological Baseline for Prince William Sound

Project Number 95055

PROJECT LEADER: Linda Finn Yarborough

LEAD AGENCY: USDA Forest Service

COST OF PROJECT: **$241,300** (FY95 = **$149,600;** FY96 = **$91,700)**

PROJECT START-UP/COMPLETION DATES:
Start-up Approximately March 1, 1995
Completion Approximately January 31, 1996

PROJECT DURATION: One year, additional years dependent upon information needs.

GEOGRAPHIC AREA: Prince William Sound

CONTACT PERSON: Linda Finn Yarborough
USDA Forest Service
Chugach National Forest
3301 C Street, Suite 300
Anchorage, AK 99503-3998
(907) 271-2511

Preface

The mosaic of contemporary ecosystems in Prince William Sound are subject to intensive study by specialists from a variety of specialties. These ecosystems represent a biological snapshot in time - only one condition among many over the past 10 millennia. Most restoration projects are providing information only on the present condition, the latest manifestation of a changing ecosystem mosaic. *The ecosystems which found root at the end of the Pleistocene and the beginning of the Holocene have changed over time to their present states, and will continue to change in the future.* To more adequately understand the present ecosystems and to better forecast the future condition the changes in the ecosystem over the past several thousand years needs to be more fully studied.

Prehistoric Ecological Baseline for Prince William Sound

B. INTRODUCTION

The proposed project is a multidisciplinary endeavor to acquire ecological information from the past, using information gathered on biological species, on geomorphologic structures, and on archaeological remains. Information on climactic changes, species types and distributions, the effects of glaciation and tectonic events, and the role of humans as part of the ecosystems will be gathered and correlated. *The goal is to establish an ecosystem baseline of the Prince William Sound, on decadal and millennial time scales, which will be usable by researchers into rates and degrees of contemporary species recovery, and which will be extendible to (or provide the basis for additional work considering) other areas affected by the EVOS.* The project could address potentially each of the injured biological resources, but will concentrate on those represented in archaeological contexts in Prince William Sound. Specifically addressed will be nonrecovering resources such as clams and mussels, harbor seals, salmon, and sea otter. Additional information may address various seabirds, killer whales, and animals not categorized as injured by the EVOS. The results will also address archaeological resources and subsistence uses.

C. NEED FOR THE PROJECT

Over time, Prince William Sound has developed productive and biologically diverse ecosystems, supporting plant and animal species, as well as the people who depended on them. This information may be used by researchers of the contemporary ecosystems to assess where contemporary population numbers and distributions fit within long-term trends. *This, in turn, would provide additional information to managers about expected recovery times, especially if climate and other factors are determined to be important indicators of cyclical fluctuations in biological resources. It may provide great insight into natural causes that may be limiting recovery.* The role of humans in the ecosystem of Prince William Sound is important because people have utilized a broad spectrum of resources throughout much of the Holocene. Archaeological sites function as preservers and concentrations of biological data. The archaeological context provides the link between temporal and geographic distribution for ecological data. This information is only available through geomorphological, paleobiological, and archaeological study.

The proposed project should be considered a pilot study. The project will include a synthesis of findings and results, and will assess the need for additional information in consultation with other researchers and representatives from the Trustee Council. The project will allow adaptive modification of methods and questions in view of results and EVOS restoration management needs for long-term research on ecosystem processes.

D. PROJECT DESIGN

1. Objectives:

- Review archaeological, geomorphological, climatological, and paleobiological information available for Prince William Sound;

- Contact interested public groups, communities, and individuals to encourage participation in project planning, design, implementation, and review.

- Conduct coordinated and integrated fieldwork to gather appropriate data from sufficient sources to produce a base for a paleoecological model for Prince William Sound.

- Complete analyses of literature review and gathered data, and produce a report for the Trustee Council on findings and recommendations. This document will be of professional scientific standard.

- Complete and make public a summary of research and findings. This document will be less technical, geared to the general public, and will be used to solicit public input on process, methods, findings and conclusions.

2. Methods:

- Archaeology: Review of literature and existing collections of faunal material, and correlation with cultural and temporal indicators will provide a guide to where additional materials may be needed through controlled excavations at site(s) within Prince William Sound. Samples of soils, animal bones, shells, pollen, and other organics from existing collections and selected archaeological sites will be used to conduct radiocarbon, stable isotope, and other analyses for paleoecological reconstructions.

- Geomorphology: Review of existing literature on the geomorphology of Prince William Sound (especially glacial history, sea level changes, and tectonic displacement) will provide a guide to where additional data may be needed through field observations and sampling. Geologic mapping and geomorphological studies will be used to develop a model of landform transformation and sea level/landform relationships for the Holocene. This will be used to identify possible early habitat for specific species/species groups and for human occupation.

- Paleoclimatology: Review of existing literature on pollen, diatom and other sedimentological studies and other climatic indicators for Prince William Sound will provide guidance to where additional field samples are needed to best tie together the archaeological and geomorphological data. Coring of selected bogs and/or lakes will provide additional samples that will be used to accomplish that objective.

- Overall: The archaeologists, geomorphologists, paleoclimatologists, and other specialists will work as an integrated team, using known archaeological sites as a focus for information gathering. Standard procedures established for Arctic and Subarctic regions will be used for all studies. The facilities and expertise of the USDA Forest Service (Chugach National Forest) and the University of Alaska Fairbanks will be used collaboratively - with public involvement - to accomplish the stated objectives.

3. Schedule:

- Pre-field activities (public contacts, literature reviews, collection identification and permitting): Winter/Early Spring, 1995.
- Field activities (archaeological excavations, geomorphological studies, pollen and other sample gathering): May through September, 1995.
- Data compilation and analysis (collaborative mapping, radiocarbon, pollen, O_{18}, and other analyses): September through November, 1995.
- Final Technical Report for Trustee Council: By April 15, 1996.
- Final Public document: By April 15, 1996.

4. Technical Support:

- Special analyses: Radiocarbon analyses will be conducted by Beta Analytic or Washington State University Radiocarbon Laboratory. Geologic and pollen analysis will be conducted by the University of Alaska. Other specialized analyses will be conducted in accordance with the project team specialists' established procedures.
- Transportation: Pre-field investigations will determine the number and locations of data gathering sites. An analyses will be conducted once the locations are selected to determine the most cost effective mode of transportation and field support, whether a float-plane or boat based operation.

5. Location:

- Specific sites will be selected in the pre-field phase, but it is anticipated that three general areas will be selected for field investigations: one in the Western, one in the Eastern, and one in the Southern parts of the Sound. Tatitlek, Cordova, Chenega Village, Valdez, and Whittier will be contacted during planning and after the fieldwork is completed.

E. PROJECT IMPLEMENTATION

The proposed project is envisioned as a collaborative effort between agencies, universities, and the public sector. The project requires a high level of expertise in a number of disciplines, expertise that is available through Alaska-based institutions. It may be possible to offer the project through a competitive contract process. Since the locations for the projects are likely to be on State or Federal lands, projects would require monitoring and permitting through the land managers. Cooperative projects with Native organizations are possible and will be pursued in the planning stages of the project.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

The project implementation, analyses, and reporting will be conducted collaboratively by team specialists. In addition, information sharing with biologists with specialties in contemporary species will be integrated into the project from the beginning through reporting. Fieldwork will be coordinated as much as possible with other projects efficiently use transportation, supplies, and information distribution systems. Projects which will be coordinated with include the archaeological site stewardship and monitoring project (lead agency:ADNR). The methodology and information will be compatible with that of other funded projects, such as that of D.Schell and T.Kline (UAF) dealing with modern food web dynamics and ecosystem changes.

G. PUBLIC PROCESS

Relationships with the communities of Prince William Sound are being strengthened through the effort to integrate community traditional knowledge into the scientific investigations of the restoration effort. This is being enhanced through community outreach. This provides at least two avenues through which to ensure early and close coordination with local communities. Project proposals will be distributed to regional and village Native corporations, Tribal governments, non-profit Native corporations, city governments, university specialists, and other interested persons. Public meetings will be conducted at selected communities to explain the results of the project if communities request.

H. PERSONNEL QUALIFICATIONS

Mary Edwards, Ph.D.
- Associate Professor, Departments of Geology and Biology, University of Alaska Fairbanks

Bruce Finney, Ph.D.
- Assistant Professor, Institute of Marine Science, University of Alaska Fairbanks

Daniel Mann, Ph.D.
- Geologist US Geological Survey, Branch of Alaskan Geology; Geologist, Bureau of Land Management; Affiliate Assistant Professor, Geology and Geophysics Department, University of Alaska Fairbanks; Alaska Quaternary Center

Linda Finn Yarborough, M.S.
- Assistant Forest Archaeologist, Chugach National Forest
- Ph.D. candidate, University of Wisconsin, Madison

I. Budget - FY95 and FY96

Personnel

USFS

(Co-PI, GS-11, $3.5/mo X 4 mo. = $14.0)
(GS-7, $2.6/mo. x 3 mo. = $7.8)
(GS-5, $2.2/mo. x 2 mo. = $4.4)
FY95= **19.2**; FY96= **7.0** USFS Total = **$26.2**

UAF

(Co-PI, Institute of Marine Science, $7.1/mo x 2 mo. = $14.1)
(Co-PI, Department of Geology, $7.6/mo x 1 mo. = $7.6)
(CO-PI, Alaska Quaternary Center, $6.7/mo x 3 mo. = $20.2)
(Technician, $4.6/mo. x 12 mo. = $55.1)
(Student, $1.1/mo. x 12 mo. = $13.6)
(Tuition for Student, $5.1)

FY95= **56.7**; FY96= **59.0** UAF Total = **$115.7**

Total Personnel $141.9

Travel

9 RT Fairbanks-Anchorage (fieldwork and EVOS workshops)	**$2.7**
Per diem and field related	**$7.0**
Float Plane Charter	**$10.2**

FY95 = **18.2**; FY96 = **1.7** **Total Travel = $19.9**

Contractual Services

Radiocarbon dating (40 samples, $400 ea.)	**$16.0**
Mass spectrometer analysis (400 samples, $5 ea.)	**$2.0**
Communications	**$1.0**
Publication printing	**$1.0**

FY95 = **10.0**; FY96 = **10.0** **Total Contractual = $20.0**

Commodities

Field Supplies	**$2.0**
Laboratory Supplies	**$3.0**
Mass spectrometer supplies (glassware, tubing, etc.)	**$3.0**

FY95 = **6.0**; FY96 = **2.0** **Total Commodities = $8.0**

Equipment

Microscope	**$16.0**
Cluster gauge for mass spectrometer	**$2.5**
Baratron mamometer (2) for mass spectometry	**$1.5**

Total Equipment (FY95) $20.0

	FY 95	FY 96	Total
Direct Costs	130.1	79.7	209.8
Indirect Costs *(Direct x 15%)*	19.5	12.0	31.5
	Total Cost Estimate for Project:		***$241.3***

A System for Monitoring The Visual Sensitivity of Prince William Sound For Commercial Marine-based Tourism

Principal Investigator: **Dr. Patrick Reed**

Lead Agency: **USDA Forest Service**

Project # 95056

Cost of Project: **FY95 $264.7K**
FY96 $159.8K
Total $424.5K

Project Start-up/Completion Dates: **October 1, 1994 to May 30, 1996**

Project Duration: **20 Months**

Geographic Area: **Greater Prince William Sound**

Contact Person: **Dr. Patrick Reed**
Chugach National Forest
3301 C Street, Suite 300
Anchorage, Alaska 99501
907-271-2813

INTRODUCTION

Alaska's Prince William Sound is a nationally and internationally renown tourism destination in addition to being a playground for local Alaskans. Despite the Sound's obvious tourism and recreation value there has been remarkably little attention paid to enhancing federal and state agency capability to routinely assess, manage, and monitor its scenic resources as well as respond to critical environmental emergencies. The 1989 *Exxon Valdez* oil spill illustrated the general inability to rapidly assess the extent of visual impacts and evaluate alternative measures to mitigate those impacts.

Focusing on the economically important commercial marine-based tourism (including cruise ship, state ferry, and tour boat passengers), this one and one-half-year project would make quick and significant progress towards correcting this situation. ***Together, the project's seven stand-alone products would create an interactive geographic information system (GIS) monitoring tool permitting federal and state decision makers and land managers to both enhance and protect Prince William Sound's economically important commercial marine-based tourism industry.***

The basic process developed through this process could later be adapted to address small craft recreation use of the Sound, or included into this project with additional funding. In addition, while this project would meet the assessment and monitoring needs for oil spill planning, it would be equally useful for other land management activities with potential visual impacts, such as timber harvesting, mining, and other construction.

NEED FOR THE PROJECT

Commercial marine-based tourism, or tourism associated with cruise ships, state ferries, and tour boats, represents a major segment of Alaska's tourism industry. In 1993, more than 250,000 visitors entered Alaska enter via cruise ships alone, representing about one-fourth of all total passengers entering Alaska (Alaska Division of Tourism 1993a). This segment of Alaskan tourism showed the largest percent increase in volume from 1992, up some 17 percent. Cruise ship tourists traveling through the Prince William Sound spent more than $54 million instate in 1993, roughly one-half of the total instate cruise ship passenger expenditures (Alaska Division of Tourism 1993b) . Three or more new cruise ships are currently under construction and planned to enter service in the Sound within the next few years.

Commercial marine-based tourists are potentially sensitive to adverse visual impacts to Prince William Sound, including potential marine oil spills. A 1992 national visitor study revealed that commercial marine-based tourists reported (1) scenic beauty as the number-one reason for visiting the Chugach National Forest and (2) quality of scenery was the most important general site attribute of the Forest (USDA Forest Service 1993).

Currently, there is an only a basic inventory system in place for monitoring and assessing the visual sensitivity of Prince William Sound for commercial marine-based tourists. In addition, there is insufficient existing methodology for integrating those data in order to model the expected the extent of adverse visual impacts, including potential marine oil spills. As a result, with respect to commercial marine-based tourism there is no ability to monitor the changing condition of Prince William Sound nor to evaluate alternative response measures to mitigate a potential marine oil spill emergency (such as requesting re-routing of cruise ships for a specified period of time).

This project would provide land managers and decision makers with an important tool to more quickly and effectively manage Prince William Sound resources so as to better ensure high quality visual experiences for commercial marine-based tourists. The project would permit improved capabilities to assess, monitor, and model a variety of changing conditions, adverse impacts, and mitigation measures. For example, the system would be capable of addressing the visual impacts of timber and mining activities, construction, and additional marine-based tourism volume as well as oil spills. The system would be able to identify and prioritize locations where to begin or to concentrate response activities.

PROJECT DESIGN

<u>Objectives</u>

The objectives of the proposed project are as follows:

1. ***Develop an analytical system capable of monitoring and assessing the visual sensitivity of the entire Prince William Sound with respect to commercial marine-based tourism, or cruise ship, state ferry, and tour boat passengers.***

2. ***Develop an analytical system capable of real-time modeling of (1) the probable number, and (2) associated economic impacts, of commercial marine-based tourists exposed to potential oil spills.***

3. ***Develop an analytical system capable of identifying optimal responses to visual impacts in Prince William Sound, whether for emergencies such oil spills or for routine but potentially controversial project planning.***

Methods

Methodologically, the objectives of the proposed study would be met through the concurrent completion of seven separate but related tasks. While Tasks 1 through 5 could each produce a useful tourism management tool, the combination of all task outputs would permit heretofore impossible monitoring of the visual and economic impacts to commercial marine-based tourism in Prince William Sound. The seven tasks are as follows:

1. ***Inventory the existing inherent scenic attractiveness of the Prince William Sound, including physiological, biological, and cultural features.***

Task 1 would be achieved through the application of state-of-the art USDA Forest Service "scenery management system." The new inventory would augment or replace the current inventory of the coastline of Prince William Sound in order to better identify those areas which have outstanding vistas of natural scenery, unique natural features (such as glaciers), wildlife habitat or populations and historically significant sites. Task 1 output would be a GIS map layer and associated database capable of showing the location of outstanding scenic attractiveness for commercial marine-based tourism.

2. ***Estimate the total and spatial and temporal distribution of commercial marine-based tourism volume for cruise ships, state ferries, and tour boats as a function of number, size and type of vessels.***

Task 2 would be achieved through (a) literature review and records and data archival and (b) personal contact with commercial marine-based tourism operators in Prince William Sound. Task 2 output would be a GIS map layer and associated database capable of showing density of commercial marine-based tourism volume by cruise ships, state ferries, and tour boats (individually or combined).

3. ***Estimate the proportion of commercial marine-based tourism volume sensitive to visual conditions as a function of tourist attitude, information and physical capability.***

Task 3 would be achieved through social survey of commercial marine-based tourists on representative sample of vessel types, routes, and seasons. Task 3 output would be a GIS map layer and associated database capable of showing viewer sensitivity of commercial marine-based tourists as they are likely to vary by cruise ship, state ferry, and tour boat (individually or combined).

4. ***Estimate the effect of oil spills on the economic expenditures of commercial marine-based tourists and willingness-to-pay for trips.***

Task 4 also would be achieved through social survey of commercial marine-based tourists on representative sample of vessel types, routes, and seasons. Task 4 output would be a GIS map layer and associated database capable of showing economic
value of viewing of commercial marine-based tourism by cruise ships, state ferries, and tour boats (individually or combined).

5. ***Estimate the "seen areas" as a function of viewer distance and duration of view (from typical vessel routes and speeds), and seasonal atmospheric and air-quality conditions.***

Task 5 viewer distance and duration information would be achieved through (a) literature review and records and data archival and (b) personal contact with commercial marine-based tourism operators in Prince William Sound. Atmospheric information to be achieved from literature and records review. Task 5 output would be a GIS map layer and associated database capable of showing seen areas by cruise ships, state ferries, and tour boats (individually or combined).

6. ***Combine Task 1, 2, 3 and 5 outputs to develop a GIS-based, probability model to evaluate the existing (and potential) visual sensitivity of Prince William Sound with respect to marine-based tourism.***

Task 6 would be achieved through construction of a mathematical algorithm which is a function of density, proportion, and seen area parameters. Task 6 output would be (a) a GIS map layer and associated database capable of showing existing visual sensitivity by cruise ships, state ferries, and tour boats (individually or combined) and (b) an algorithm capable of real-time modeling of the number and attitudes of commercial marine-based tourists that would view the progress and impacts of potential oil spills.

In addition, the output would be able to produce an optimal solution for minimizing the probability of commercial marine-based tourists be exposed to oil spill (or other land management activity) evidence.

7. ***Combine Task 4 and 6 outputs to develop a GIS-based, probability model to evaluate the existing (and potential) economic value of Prince William Sound scenery with respect to commercial marine-based tourism and potential oil-spills.***

Task 7 would be achieved through construction of a mathematical algorithm which is a function of visual sensitivity and economic parameters. Task 7 output would be (a) a GIS map layer and associated database capable of showing existing economic value by cruise ships, state ferries, and tour boats (individually or combined) and (b) an algorithm capable of real-time modeling of the economic "impact" of commercial marine-based tourists that would view the progress and impacts of potential oil spills.

Schedule

The proposed project would be completed within fiscal years 1995 and 1996--assuming that Tasks 1 to 7 could be initiated relatively concurrently. The following briefly summarizes the proposed schedule:

Fiscal Year 1995:

Oct - Jan Finalize project task planning, construct, advertise, bid, and award contract.

Feb - Sep Complete concurrent literature review, records and data archival, mapping, and ground truthing for Tasks 1 to 5. Conduct passenger surveys for Tasks 3 and 4. Develop prototype models for Tasks 6 and 7.

Fiscal Year 1996:

Oct - Nov Complete construction and testing of computer models for integrating Task 1 to 5 data.

Dec - Feb Complete analysis of Task 1 to 5 data and preparation of draft final report by contractors.

Mar Review and comments on draft final report.

Apr - May Maps, computer programs, and final reports completed.

Technical Support

In order to complete the project technical support in the following areas would be required:

1. Visual resource assessment: Knowledge and skills in the application of state-of-the-art USDA Forest Service scenery management system.

2. GIS data input and map creation: Knowledge and skills in the creation and application of GIS data layers.

3. Economic research: Knowledge and skills in the application and interpretation of contingent

valuation recreation research.

4. Computer modeling: Knowledge and skills in programming GIS software for the integration of data to create analytic and predictive computer models.

5. Manuscript preparation: Knowledge and skills in the technical writing and publication preparation.

Location

The contracted services and overall administration of the seven project tasks would be directed from Anchorage. The actual field work for Tasks 1 to 5 would be completed within the Sound. Task 1 would require some ground truthing of locations of significant physiological, biological and cultural features within the Sound. Tasks 3 and 4 would require the on-site interviewing of cruise ship, state ferry, and tour boat passengers at randomly selected points in time and location within the Sound. Tasks 6 and 7 would be completed at the location of the contractor responsible for computer mapping and modeling.

PROJECT IMPLEMENTATION

Prince William Sound lies within the administrative jurisdiction of the USDA Forest Service's Chugach National Forest headquartered in Anchorage. Given forest management activities projected for the Chugach National Forest in fiscal year 1995, a significant portion, if not all, of the project should be go through the competitive procurement process. Specifically, the previously identified technical support is required in all seven tasks under the direction of key Forest Service personnel.

COORDINATION OF INTEGRATED RESEARCH EFFORT

The proposed project is not directly related to other ongoing projects proposed for 1995. However, the system to be produced would benefit other federal and state agencies which administer public lands within Prince William Sound, including the National Park Service, the Alaska Division of Parks and Outdoor Recreation.

PUBLIC PROCESS

Opportunities for federal, state, and public review and comments of the project could be achieved through informational workshops conducted prior to the previously outlined dates. Commercial marine-based tourists would be surveyed in Tasks 3 and 4 regarding their attitudes and perceptions of marine oil spills. Overall, the implementation of the project would not directly effect the activities of the public within Prince William Sound.

PERSONNEL QUALIFICATIONS

The following personnel with unique and capable knowledge, skills, and abilities, would be the principal Chugach National Forest personnel involved in various phases of the design and implementation of the proposed study:

Dr. Patrick Reed: Social Scientist. PhD, Recreation Resources. National and international experience in recreation visitor surveys; principal investigator visual and economic impact analysis of energy projects surrounding Theodore Roosevelt NP; and author of more than 20 recreation and wilderness management papers.

Dr. Zane Cornett: Manager of Resource Information. PhD, Watershed Management. Forest GIS coordinator and former consultant in national RARE II national forest roadless area analysis.

Stephen Hennig: Landscape Architect. MLA, Landscape Architecture. Forest planning and project-level visual resource assessment and simulations, and 17 years experience with recreation management in Prince William Sound.

Glenn Stubbs: Outdoor Recreation Planner. MS, Forestry. Forest recreation management experience with Recreation Opportunity Spectrum and social carrying capacity, and familiarity with current federal and state recreation planning interests in Prince William Sound.

Additional non-USDA Forest Service personnel could be added as identified and available, such as specialists from the University of Alaska, Anchorage.

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DOC. #950615019

PROJECT 95057

SFOS 94-157

947

PROPOSAL

RECEIVED
JUN 15 1994
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

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

FROM: Institute of Marine Science
School of Fisheries and Ocean Sciences
P.O. Box 757220
University of Alaska Fairbanks
Fairbanks, AK 99775-7220

TITLE: Movement of larval and juvenile fishes within Prince William Sound

PRINCIPAL INVESTIGATORS: Brenda L. Norcross
Assistant Professor
SS# 355-42-8879

NEW/CONTINUING: New

DURATION: 1 Year

PROPOSED START DATE: 1 November 1994

AMOUNT REQUESTED: $300,000

for 5-16 94
Brenda L. Norcross /Date
Principal Investigator
(907)474-7990

5/16/94
Joan Osterkamp /Date
Executive Officer
School of Fisheries and Ocean Sciences

5/17/94
A. V. Tyler /Date
Associate Dean
School of Fisheries and Ocean Sciences

16 May 94
Donald M. Schell /Date
Director
Institute of Marine Science

5/20/94
Ted DeLaca /Date
Director, Office of Arctic Research
University of Alaska Fairbanks

May 1994

PROJECT 95057

Title: Movement of larval and juvenile fishes within Prince William Sound

Project Leader: Brenda L. Norcross

Lead Agency: University of Alaska Fairbanks

Cooperating Agencies: ADF&G, PWSSC, NMFS, NBS

Cost of Project, FY95: $300,000
$300,000 estimated cost of completion

Project Startup Date: 1 November 1994

Completion Date: 30 October 1997
for sample processing, data analysis and reporting

Geographic Area: Prince William Sound

Contact Person:
Brenda L. Norcross
Institute of Marine Science
University of Alaska Fairbanks
Fairbanks, Alaska 99775-7220
(907)474-7990

B. INTRODUCTION

Prior to the Exxon Valdez oil spill, there had been no baseline studies conducted to document presence, absence, distribution or abundance of larval or juvenile fishes in Prince William Sound (PWS). As a result of research conducted following the oil spill in 1989 several important issues regarding the fate of larvae and juveniles have arisen. McGurk et al. (1990) note that future research on early life history should be designed and conducted in order to answer questions related to fisheries ecology and management. An ecosystem approach addresses questions about fishes such as predator/prey relationships, physical processes affecting natal habitat, environmental factors controlling recruitment, the relationship between transport of larvae and surface and subsurface currents in the sound, and location and condition of juveniles in the winter. This study proposes to fill the gap between SEA and the Forage Fish and Seabird and Mammal studies by following patches of herring and other larval fishes on transit through PWS to identify areas of aggregation used as juvenile nurseries.

Forage fishes (herring, pollock, sandlance, capelin, northern smoothtongue) are the target species of this study. These species are important food for marine birds and mammals which are listed as not recovering. Additionally Pacific herring is 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. In addition to low returns, herring have been plagued with VHS, a viral disease which contributed to sound-wide failure of the herring fishery in both 1993 and 1994.

C. NEED FOR PROJECT

Knowledge of dispersal of the larval stages of fishes is a significant gap in understanding the life history of forage fishes. Dispersal of herring and pollock larvae in 1989 indicated that larvae move from northeast to southwest through the sound with the current, analogous to the path followed by the oil following the *Exxon Valdez* oil spill. This suggests that larvae may exit PWS and recruit as juveniles to areas downstream, i.e., Kenai Peninsula and Kodiak Island. One year of well-designed fisheries and physical oceanographic studies are needed to confirm this. Knowledge of the movement of larvae through the sound can be used to identify areas where juveniles aggregate, both within and outside the sound. After year one, these results will be used to efficiently design sampling in key areas important for rearing juvenile fishes.

An ecosystem approach is needed now because lack of such an approach immediately following the oil spill is causing interpretation of some of the previous data to be questioned. A conclusion of the 1989 larval fish study was that movement of larvae is related to current patterns in PWS, but flow patterns are more intricate than indicated by the pathway taken by the *Exxon Valdez* oil. Peer reviewers of papers submitted based on those results (Norcross and Frandsen, in review; Norcross et al., in review) questioned the interpretation of winds and currents acting in the same way on oil slicks and larvae in the water column because comprehensive associated oceanographic data were lacking. Additionally, larval herring collected in oiled areas of PWS following the *Exxon Valdez* oil spill which experienced morphological and cytogenetic damage (Norcross et al., in review) are being questioned. Unfortunately, the relationship between damaged herring and spilled oil cannot be directly made because, without the supporting oceanographic data, we can only infer but not prove the larvae moved through oiled areas. Peer reviewers have cited these as "interesting observations...tempting to make the association ...cannot be justified because we do not know which larvae may or may not have been exposed to oil...situation is compounded by the lack of baseline data." (N. Moir, CJFAS, Jan. 1994).

Currents in PWS may create differential affects on larvae depending upon their spawning location (McGurk et al. 1990). If larvae from the southern spawning grounds disperse at a faster rate than larvae from northern spawning grounds, that may indicate habitat for juveniles is concentrated in the northern half of the sound (McGurk et al. 1990). Using a coordinated oceanographic-based ecosystem approach we intend to determine what percentage of larvae may be transported out of the sound. The amount and timing of wind and buoyancy-driven flushing of the upper layers of PWS during April and May will have a significant effect on larvae. When the sound is acting like a "river" larvae may quickly be passed through the sound resulting in nursery areas downstream in locations as far as the Kenai Peninsula. When the sound is acting like a "lake" larvae may be retained in the sound and thus be dependent upon food available within the sound. By learning where the larvae are transported, we can determine the location of nursery grounds and use that information to efficiently design future studies.

D. PROJECT DESCRIPTION

1. Objectives

The overall objective of this project is to understand the distribution and abundance and the resulting interannual variability in successful year classes of fishes in PWS. This can be accomplished by examining the fish in the context of their total environment including the meteorology and oceanography driving the system and the biology of the lower trophic levels which act as food for fish larvae. The larval fish aspect of the ecosystem study will achieve the following objectives:

1) To identify and count all larval fishes collected.

2) To determine the relationship between observed distribution of fish larvae and broad scale oceanographic patterns.

3) To use patches of herring larvae as markers and follow them from beach deposition throughout their passage within PWS.

4) To determine if local oceanography differentially affects herring larvae spawned at separate locations.

5) To project the locations of nearshore nursery areas for age-0 fishes from the movement of the larvae coupled with the oceanographic conditions.

2. Methods

The logistics of this project will be in cooperation with the other components of the proposed ecosystem study, therefore specific needs for vessels are not included here. The assumption is that there will be a vessel available with capabilities for towing a Tucker trawl (1 m^2 plankton net) and that the vessel will concurrently be used by this fisheries oceanography project and the physical oceanography project.

Herring was the third most abundant larval fish collected in PWS in 1989, but it is the only one which we can identify its spawning areas. Therefore, herring larvae will be used as markers and their movement will be followed throughout the sound. Immediately following deposition of herring eggs in April 1995 two patches of larvae will be tracked. These two patches of herring which originate in different areas of the sound will be followed to determine the effect of local oceanography on recruitment success. Comparisons of herring from two different areas will reveal if local oceanography affects survival of larvae from separate locations disparately. A major spawning site in the northeast portion of the sound and one near Hinchinbrook Entrance or Montague Strait will be identified and herring larvae from those key sites will be followed as they move through the sound. Sample locations will initially be based on ADF&G overflights to identify spawn deposition.

Patches of larvae will be identified and sampled on a scale of daily to weekly or longer, dependent upon weather conditions and speed of patch movement. Sampling of two separate patches of larvae will be coordinated so that they are not sampled simultaneously and the same boat is used for all sampling. One or more drogues (in component of Physical Oceanography - 94320-M) will be released into each patch as transport away from the beach begins. Current speed and direction will be measured using an Acoustic Doppler Current Profiler (Physical Oceanography - 94320-M). Sampling for larvae will continue through July, thus encompassing the season of larval herring, pollock and capelin growth and movement through the sound.

To relate the observed distribution of larvae to broad scale oceanographic patterns of flow, sampling transects will be in line with the water flow. Each sampling day a transect will be run from outside the trailing edge of the patch, through the patch, to outside the leading edge. The trailing edge of transects on successive days will overlap the leading edge of the transect the day before. Net sampling in conjunction with drogues will be used to define the 2-dimensional size (long axis) of the patch. A minimum of five stations will be sampled per day, two outside and three inside the patch. As patches of larvae disperse with time and become larger, more stations will be sampled per day. Estimating the latitudinal extent of the patch will be dependent upon sophisticated hydroacoustic methods (Nearshore Fish - 94320-N). Net tows will be used in conjunction with hydroacoustic methods to determine the vertical distribution of the target species. Net tows will also be used to groundtruth the hydroacoustic data by providing species composition, relative abundance and size data as all larvae will be identified and counted.

PROJECT 95057

Sampling for larval fishes will be done with a 1 m^2 Tucker trawl with 505μ mesh nets. Except for those tows used to determine vertical distribution of larvae for use with the hydroacoustics, all samples will be oblique tows covering the upper 50 m of the water column because 95% of larvae captured in May and June 1989 were in that depth range (Norcross and Frandsen, in review). Sampling for older juvenile fishes will require a different net to be designed, tentatively it is planned to be a small mesh seine and will be coordinated with the Nearshore (94320-N) component.

As larvae metamorphose into juveniles, they are expected to move into nearshore nursery areas. An advantage of following a patch of larvae is to use the patch to locate nursery areas. Juvenile fishes will be sampled with nets and hydroacoustics (Nearshore Fish 94320-N) in nursery areas along with concurrent oceanographic measurements of temperature and salinity with a CTD and water movement with an ADCP (Physical Oceanography 94320-M). 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 fishes. Characterization of juvenile habitat coupled with transport results can be used to project locations of nursery areas for forage fishes around and outside of the sound. These areas can then be investigated later in the season by the Forage Fish project and by the Nearshore Fish (94320-N) project to determine which locations produce the most successful recruitment.

Fish will be separated from zooplankton and rough sorted to family groups by undergraduate students at UAF. Fish will be identified to species in Fairbanks by Michele Frandsen who is skilled in the identification of PWS fish larvae having ID'd all the larval fish collected in PWS in 1989. The standard length of all fish will be measured using a Wild MZ3 dissecting microscope and image analysis system (Bioquant) interfaced to a computerize data base (RBase). This process simultaneously enumerates the larvae as the length data are stored.

Length will be measured for a subsample of individuals of each fish species. The precise age of a larva, in days, combined with hydrographic data can provide estimates of advection rates. Age of herring larvae can be determined in days and growth can be estimated following the methods of McGurk (1984). Growth rates between sites and among years will be compared using an ANOVA. Because aging of daily growth rings in larval herring is time consuming it will only be employed on a small subsample of herring collected. For a larger percentage of herring larvae, we will employ a method of morphological staging (Humphrey et al. unpub. MS). There is an overlap of size between substages, giving information concerning development of larvae along with size frequency. These data can expand the information gained from the smaller subsample of larvae which were aged.

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.

All larval and juvenile fishes will be counted and measured. Distribution and abundance of each species of forage fish will be analyzed in relation to the oceanographic parameters and transport of larvae will be determined. From that, an estimate of retention of larvae within the sound will be made.

3. SCHEDULES

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

January - March 1995
Stage for FY95 field season.

April - August 1995
Field work in Prince William Sound, begin sorting and identification of larvae.

August - September 1995
Continue sorting and identifying larvae. Preliminary analysis of data.

For FY 1996, a continuation of this project will be requested to complete the workup of larvae and analysis of data. Only minimal field sampling will be required in 1996 because results of 1995 will be used to predict where the patch should move where the juvenile nursery areas should be.

4. TECHNICAL SUPPORT

This project requires strong supporting projects from the Prince William Sound Science Center (Physical Oceanography - 94320-M and Nearshore Fish 94320-N), Alaska Department of Fish and Game Spawn Deposition Study and ADF&G Juvenile Herring (new proposal). A subcontract to 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.

5. LOCATION

Sampling will take place in Prince William Sound. If there is significant transport of herring larvae out of the sound, it will be necessary to follow them along the Kenai Peninsula.

E. PROJECT IMPLEMENTATION

The lead agency on this project is proposed to be the University of Alaska Fairbanks because Brenda L. Norcross at UAF has the expertise to sample, identify and analyze larval fishes from Prince William Sound. She was the PI on a related project in PWS in 1989 and is familiar with the sampling techniques and the sample area. Having analyzed the previous data, she will use that information to design the study plan for the proposed study.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

The proposed study is coordinated with 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 (94320-M) and Nearshore Fish (94320-N) projects through shared data and resources and integrated sampling plans. This study will use results generated by Zooplankton in the Ecosystem (94320-H), Phytoplankton and Nutrients (94320-G), Avian Predation on Herring Spawn (94320-Q) projects and the VHS study which was initiated in April 1994 on an emergency basis. This proposed study will contribute nursery area information to the newly proposed Juvenile Herring study and. The information gained from this proposed study will contribute to the PWS Herring Recruitment Model (new proposal). It will also be coordinated with the ongoing herring spawn deposition studies funded by ADF&G and will be integrated with the newly proposed Food Limitation of Seabirds (NBS), Forage Fish (NMFS) and Marine Mammals (ADF&G) studies. As part of this proposed project, Dr. Norcross will work directly with the PI's from the other project to integrate her results into their research.

G. PUBLIC PROCESS

The results of this research will be presented at public workshops, forums and seminars, including presentation to the local communities, e.g. Cordova.

PERSONNEL QUALIFICATIONS

Brenda L. Norcross, Principal Investigator, will supervise all work. Dr. Norcross is an Assistant Professor and Fisheries Oceanographer at the University of Alaska Fairbanks. She was PI on the Injury to Larval Fish Study in 1989. She has conducted other research on transport of larval fish in the Middle Atlantic Bight and Chesapeake Bay and sampled larval fishes across the North Pacific from Seward, AK to Honolulu, HI. She is the author of several peer reviewed papers on the distribution and transport of larval fishes.

Michele Frandsen who is skilled in the identification of PWS fish larvae having ID'd all the larval fish collected in PWS in 1989.

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PROJECT 95057

NORCROSS - SEA

BUDGET
1 October 94 - 30 September 95

SALARIES AND BENEFITS

Wages	*Mos.*	*OT Hrs. (Field)**	*Rate*		
Norcross, B.	4.50		$27.38	$21,352	
Technician	4.75	352	$16.51	$22,308	
Technician	7.00	352	$15.33	$26,691	
Technician	4.00		$10.70	$7,417	
M. S. Student	15.00		$10.50	$13,647	
Undergraduate Student	6.00	528	$6.28	$10,416	
Undergraduate Student	6.00	528	$6.28	$10,416	
Undergraduate Student	6.00	528	$6.28	$10,416	
Undergraduate Student	6.00		$6.28	$5,442	
Leave Accrual					
Norcross, B.				$4,292	
Technician				$2,908	
Technician				$3,980	
Technician				$1,587	
M. S. Student				$0	
Undergraduate Student				$0	
Undergraduate Student				$0	
Undergraduate Student				$0	
Undergraduate Student				$0	
Benefits					
Norcross, B.				$7,514	
Technician				$6,715	
Technician				$9,189	
Technician				$3,665	
M. S. Student				$0	
Undergraduate Student				$0	
Undergraduate Student				$0	
Undergraduate Student				$0	
Undergraduate Student				$0	
TOTAL SALARIES AND BENEFITS					$167,955

PROJECT 95057

NORCROSS - SEA

TRAVEL		
9 R/T Fairbanks-Cordova @$500/trip	$4,500	
Per diem @$80/person/day - 40 days, 3 people	$9,600	
R/T Fairbanks-Anchorage	$300	
Per diem @$170/person/day - 10 days, 1 person	$1,700	
R/T Fairbanks - New York	$750	
Per diem @$178/person/day - 1 day, 1 person	$1,246	
R/T Fairbanks-Shanghai	$1,500	
Per diem @$176/person/day - 10 days, 1 person	$1,760	
TOTAL TRAVEL		$21,356
SERVICES		
Communications (phone, FAX, photocopy)	$1,500	
Report preparation	$2,000	
Air freight Fairbanks-Cordova @$0.50/lb	$1,000	
Air freight Cordova-Fairbanks @$0.50/lb	$4,000	
Air freight Cordova-Seward @$0.50/lb	$500	
Presentation preparation (photo processing, etc.)	$2,500	
Consultant Services (JoEllen Hose)	$5,000	
TOTAL SERVICES		$16,500
SUPPLIES		
Office supplies (floppy disks, paper, etc.)	$1,033	
Jars (100 cases @$75/case)	$7,500	
Formalin (25 gal. @$40/gal)	$1,000	
Isopropyl Alcohol (4 drums @$450/drum)	$1,800	
Vials (6 cases @$250/case)	$1,500	
Replacement nets (various)	$1,500	
Flowmeters (6@$670)	$4,020	
Messengers (10 @$50 each)	$500	
Weights (3 sets @$92)	$276	
Tripper mechanisms (3 @$400 each)	$1,200	
Software (GIS Graphics)	$3,000	
TOTAL SUPPLIES		$23,329
EQUIPMENT		
Computer	$4,500	
Printer	$3,300	
Workstation (SUN Clone)	$8,000	
TOTAL EQUIPMENT		$15,800
TUITION		
2 Semesters @$2,530	$5,060	
TOTAL TUITION		$5,060
TOTAL DIRECT COSTS		$250,000
INDIRECT COSTS (20% Total Direct Costs)		$50,000
TOTAL FUNDING REQUIRED		$300,000

*Based on 44 hours of overtime per week in the field.

PROJECT 95057

BUDGET FY95

Personnel	164,290
Travel	16,556
Contractual	16,500
Commodities	22,594
Equipment	15,000
Capital Outlay	0
Tuition	5,060
Subtotal	240,000
Indirect (20% Total Project Costs)	60,000
Total	$300,000

Restoration Assistance to Private Landowners

Project Number: 95058

Project Coordinators: Ken Holbrook, U.S. Forest Service
Mark Kuwada, Alaska Dept. Fish and Game

Lead Agencies: U.S. Forest Service
Alaska Dept. Fish and Game

Project Cost: $415.7K

Project Startup Date: October 1, 1994

Project Completion Date: September 30, 1995

Project Duration: 1 year; additional duration TBD

Geographic Area: Prince William Sound, Gulf of Alaska

Contact: Ken Holbrook
U.S. Forest Service
Calais Bldg.
Anchorage, AK Phone: 271-3839

Mark Kuwada
Alaska Dept. Fish and Game
333 Raspberry Rd.
Anchorage, AK 99518-1599 Phone: 267-2277

Introduction

The project is proposed to take advantage of opportunities to enhance or restore injured species habitats or service values on private lands throughout the oil spill area. This differs from the Comprehensive Habitat Protection Process by focusing on site-specific mitigation and enhancement opportunities that can be implemented in conjunction with on-going development activities.

Injured resources and services that will potentially benefit from this project include: harlequin duck, marbled murrelet, pink salmon, sockeye salmon, Dolly Varden, cutthroat trout, river otter, sea otter, harbor seal, bald eagle, recreation, Wilderness, archeological resources, and subsistence.

Need for the Project

The project will provide information and assistance to private landowners who wish to minimize the impacts of their on-going and proposed activities on injured resources and services. Too often, impacts occur because landowners and development contractors lack an awareness of resource sensitivities during pre-project planning. This is especially true of many spill-injured resources and services that are not specifically protected by law but, nevertheless, are important elements of a healthy and diverse ecosystem. Moreover, these resources may need additional levels of protection during their recovery period. The project will attempt to make development and restoration objectives compatible so that land use activities do not impede natural recovery. Enhancement activities may even accelerate the rate and degree of recovery for some resources and services.

Project Design

1. **Objectives**

   a. Conduct an initial survey of normal agency responsibilites as they relate to on-going development activities that affect injured resources/services;

   b. Identify critical requirements needed to support key habitats of injured resources or services;

   c. Survey appropriate mitigation measures and best management practices that could be applied to the types of development that are presently occurring on private lands;

   d. Enter into discussions/negotiations with private landowners to review development plans, discuss restoration options, and develop specific project proposals or funding requests;

   e. Develop an annual report of various enhancement/restoration options for the Trustee Council to implement, as appropriate;

   f. Prepare short and long-term maintanence and management plans (or agreements) for all Trustee Council-sponsored projects; and

   g. Develop a bibiliography of best management practices, mitigation, and enhancement techniques for restoring injured resources/services that can be integrated with the Exxon Valdez Information Management System.

2. **Methods**

In addition to educating landowners on ways to protect injured resources and services, four different approaches are planned: enhancement, mitigation, reclamation/revegetation, and monitoring/research. Examples are provided below.

a. Enhancement projects - increasing fish production by constructing fish passes, spawning channels, rearing areas and overwintering sites; developing coastal wetlands with impoundments; increasing bird production by constructing nesting boxes or islands; installing recreational use amenities including trails and other access-related improvements as a result of Trustee Council acquisitions.

b. Mitigation projects - increasing stream buffers; modifying timber slash removal techniques; providing wildlife corridors; maintaining adequate wildlife cover; removing debris dams; modifying the design or areal scope of development, timing and siting of support facilities to minimize impacts to critical life stages and key habitats.

c. Reclamation/rehabilitation projects - modifying planting techniques or plant species to accelerate revegetation; tree planting to accelerate forest maturity; removing or repairing perched culverts; removing, stabilizing or revegetating discontinued logging roads.

d. Monitoring/research projects - evaluating the effectiveness of various mitigation techniques; inventorying injured species habitats; assessing habitat quality as a function of on-going development activities.

3. **Schedule**

October 1, 1994 - June 1, 1995: Project planning, includes a survey of agency responsibilities and development recommendations, best management practices and current mitigation techniques, key habitat and use requirements for injured resources and services. Meetings with private landowners to develop restoration options. Presentation of restoration options to the Trustee Council. Preparation of NEPA documents for public review and Record of Decision, as appropriate.

June 1 - September 30, 1995: Field inspections of potential project sites. Monitoring of construction or development activities to achieve restoration objectives. Continued meetings with landowners to identify additional opportunities for restoration. Preparation of project summary report for Trustee Council.

4. **Technical Support**

Technical support will be needed in the fields of forest ecology and management, project permitting, fisheries biology, wildlife conservation, mapping and GIS.

5. **Location**

The project will initially focus on locations where development activities are occurring, or are planned to occur, throughout the oil spill area.

Project Implementation

The project will be conducted as a cooperative effort between the U.S. Forest Service and the Alaska Department of Fish and Game. Each agency has extensive experience in permitting timber harvests, mining and other development projects on state and federal lands; both agencies have worked together to design and implement restoration and enhancement projects for fish and wildlife.

Coordination of Integrated Research Effort

As noted, the project will be a coordinated effort between the U.S. Forest Service and the Alaska Department of Fish and Game. In addition, the project will utilize data and expertise from the Trustee Council's Habitat Work Group and produce a bibliography that can be integrated into the Exxon Valdez Information Management System.

Public Process

Private landowners will be encouraged to participate in the project. In addition, the public will have a number of opportunities to comment on various restoration options throughout the NEPA process.

Personnel Qualifications

Mark Kuwada - Habitat Biologist with the Alaska Department of Fish and Game for 14 years. Extensive experience in coordinating departmental policy and mitigating major project impacts: Federal OCS Oil and Gas Leasing Program; Susitna Hydroelectric Project; Bradley Lake Hydroelectric Project; Diamond Chuitna Coal Project. ADF&G Response Coordinator, Exxon Valdez oil spill.

Ken Holbrook - Fisheries Biologist and Forest District Ranger for 20 years. Extensive experience in fisheries/wildlife management, enhancement and restoration. Supervised the design and construction of hundreds of fish stream improvements, fish passes, and other habitat protection projects on Forest Service lands. District Ranger in Yakutat; fisheries biologist in Cordova.

FY95 Budget($K)

Personnel:	230.0
Travel:	18.0
Contractual:	90.1
Commodities:	13.5
Equipment:	17.0
Capital Outlay:	0.0
Subtotal:	368.6
General Admin.:	47.1
Project Total:	415.7

Full-time Equivalents (FTE) = 3.3

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Spruce Bark Beetle Infestation Impacts on Injured Fish and Wildlife Species of the Exxon Valdez Oil Spill

Project Number: 95060

Lead Agencies: Alaska Department of Fish and Game
U.S. Forest Service-State and Private Forestry

Project Cost: TBD

Initiation Date: October 1, 1994

Completion Date: December 31, 1995

Project Duration: 1 Year; Additional duration TBD

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

Contact: Steve Albert
Alaska Dept. Fish & Game
333 Raspberry Road
Anchorage, AK 99518
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Ed Holsten
U.S. Forest Service-State & Private Forestry
Calais Building
Anchorage, AK
Phone: 271-2573

Introduction

Spruce bark beetles (SBB) are infesting white, Lutz, and sitka spruce trees within the range of fish and wildlife species injured by the Exxon Valdez Oil Spill (EVOS). There is only minimal knowledge of the geographic extent, intensity, or effects of the role of mature spruce trees as habitat for injured species, and the geographic extent, intensity, or effects of the SBB infestation on injured fish and wildlife species and their habitats. Decreases in essential habitats resulting from bark beetle infestations would further stress these populations and prevent population recovery or lead to further population declines.

Injured resources that will benefit from this project include : marbled murrelet, harlequin duck, pink salmon, sockeye salmon, Dolly Varden, cutthroat trout, river otter, bald eagle, and the forest ecosystem upon which they depend and with which they interact.

Need for the Project

This project will provide information describing the geographic extent of spruce bark beetle infestation within the range of habitats previously demonstrated to be important to the EVOS species. The project will identify specific critical habitats for each applicable injured species and evaluate impacts to these critical habitats resulting from SBB infestations.

Project Design

1. **Objectives**

   A. Determine the role of the spruce forest as habitat for each of the injured species.

   B. Evaluate whether the current and potential level of spruce bark beetle infestation within the EVOS area is impacting injured species habitats.

   C. Increase existing knowledge levels of SBB infestation impacts on injured fish and wildlife species through intensive literature searches of automated databases, contacts with governmental agencies at the state, provincial, and federal levels in Canada and the U.S.

   D. Increase public awareness of current and potential impacts of SBB infestations on injured species habitats through multi-media presentations.

   E. Enhance the capability of Alaskan biologists, foresters, and land managers to access information and communicate with professional counterparts throughout Alaska and in other states and provinces.

2. **Conceptual Study Methods and General Tasks**

   A. Identify critical habitat requirements of each injured species

      1. Review existing studies and conduct intensive literature review to supplement with additional information
      2. Interview principal investigators for each species
      3. Compile existing databases (e.g., Anadromous Stream Atlas) for spill area
      4. Based upon 1-3 above, characterize and map critical habitat for each injured species in GIS

   B. Identify the historic, current, and potential geographic distribution of spruce bark beetle infestations

      1. Conduct an intensive review of historical literature

2. Compile and reconcile all existing GIS-based maps and databases
3. Evaluate potential infestation areas using USFS Spruce Beetle Expert software
4. Cooperate directly with USFS and DNR/DOF entomologists in achieving 1-5
5. Based upon 1-4 above, produce GIS map layers depicting the distribution of historic, current, and future beetle infestation ranges

C. Define the degree of overlap between the geographic distribution of critical habitat for each injured species and the historic, current, and potential ranges of SBB infestation.

1. Using GIS analytical techniques, overlay the bark beetle infestation ranges with the critical habitat maps for each species
2. Evaluate the degree of overlap by species and geographic region

D. Identify primary and secondary effects of SBB infestations on the landscape

1. Conduct a thorough literature review
2. Based upon the critical habitat characteristics compiled in A.4, describe changes in infested stands that might affect injured species

    a. Evaluate changes via appropriate field methods (plots, transects, evaluations of adjoining uninfested stands)
    b. Evaluate appropriate characteristics of comparably infested stands
3. Cooperate with USFS and DOF entomologists and silviculturalists as well as appropriate agency personnel in other states and Canadian provinces
4. Based upon 1-3, describe the impacts of spruce bark beetle infestations on the critical habitat components of injured species

E. Evaluate whether the results of D.4 are significant by species and by region

F. If the results from section E above, or a portion thereof, are affirmative, determine appropriate responses
1. Identify plausible habitat management responses to ameliorate infestation impacts
2. Compare the impacts to critical habitats of injured species resulting from "no management action" strategy with the suite of management responses developed in F.1 above
3. Recommend appropriate habitat management responses by species by region
4. Identify knowledge gaps.

G. Develop recommendations to aid EVOS Trustee Council habitat acquisition process

H. Produce a multi-media presentation specifically designed for public use that will increase public awareness of current and potential impacts of SBB infestations on injured species habitats

I. As the majority of bark beetle impact information is not contained in the conventional literature, establish an INTERNET discussion group for biologists, foresters, entomologists, land managers, and other interested parties. This forum will provide an opportunity for free exchange of technical literature and habitat management information, encourage the influx of new problem-solving techniques, and will improve our limited abilities to readily communicate with other professionals due to travel constraints. Naturally, this forum could also be available to public users or public interest groups.

3. Schedule

A. October 1, 1994 - December 31, 1994

* Project planning and mobilization of GIS
* Initiate literature reviews
* Initiate planning for multi-media presentation
* Public meeting
* Identify and map critical habitats
* Complete establishing INTERNET discussion forum

B. January 1, 1995 - March 30, 1995

* Mapping ranges of SBB infestations
* Compare SBB infestation ranges with critical habitats
* Initiate field analyses

C. April 1, 1995 - June 30, 1995

* Complete production of multi-media presentation
* Continue field analyses
* Develop recommendations
* Completion of annotated bibliography database
* Analysis of mapped information
* Evaluate effects of SBB infestation and impacts analysis
* Develop recommendations for habitat acquisition process

D. July 1, 1995 - September 30, 1995

* Complete field analyses

E. October 1, 1995 - December 31, 1995

* Complete writing final project report
* Assemble project components for submission
* Public meeting to review project results

4. Technical Support

The following areas of technical support will be needed and utilized to accomplish this project:

* GIS
* Cartography
* Forest Ecology
* Fisheries Biology
* Wildlife Biology
* Professional Library Services
* Multimedia Production

5. Location

The project will include all of Prince William Sound, the area east of Cordova to the Copper River, the Kenai Peninsula, western Cook Inlet to Cape Douglas, and the Kodiak Archipelago.

6. Deliverable Products

1. Detailed written analysis of 2.A-G above
2. GIS map atlas and database
3. Multi-media presentation for use describing spruce bark beetle infestation management problem in the spill area
4. Annotated bibliography of all pertinent literature compiled in an electronic and paper format
5. An INTERNET mailing list (BBS) specifically designed for spruce bark beetle management problems that will link agencies and interest groups with biologists and foresters and others with expertise and experience with common management problems

Coordination of Integrated Research Effort

The project will be a cooperative effort between the Alaska Department of Fish and Game (ADF&G) and the U.S. Forest Service - State and Private Forestry (S&P). Other cooperators include the Alaska Department of Natural Resources, Division of Forestry (DOF), Division of Parks and Outdoor Recreation (DPOR), and the U.S. Fish and Wildlife Service (FWS). The project will utilize data and mapped products compiled by the Habitat Work Group and work completed by species principal investigators. All computerized products resulting from this project will be produced in a format that will allow easy integration into the Exxon Valdez Information Management System.

Project Implementation

This project will be conducted as a cooperative effort between the Alaska Department of Fish and Game and the U.S. Forest Service-State and Private Forestry. Actual day-to-day project management responsibility will be designated to the ADF&G. S&P has the longest experience and greatest expertise in spruce bark beetle biology, distribution, and management in Alaska. The same is true for the ADF&G with respect to all injured species except for marbled murrelets and bald eagles. In addition, the department has played an active role in bark beetle management planning with the USFS and the DOF.

Public Process

The project will sponsor public meetings periodically throughout the project study to update the public on the project's progress. Public meetings will be held in localities throughout the spill area.

Personnel Qualifications

Steve Albert - Habitat Biologist with the Alaska Department of Fish and Game for 13 years. Has represented fish and wildlife interests on various spruce bark beetle management planning efforts and was given a national award for his work on the Cooper Landing Cooperative Project. Extensive experience in modeling wildlife habitat characteristics; timber harvesting-fish and wildlife relationships; forest ecology; inter-agency coordination.

Ed Holsten - Forest Entomologist with the U.S. Forest Service - State and Private Forestry for more than 20 years. Dr. Holsten is one of the leading authorities on spruce bark beetle biology. He has had extensive experience studying the geographic distribution of bark beetle infestations in Alaska and has completed several bark beetle research studies.

Budget

River Otter Recovery Monitoring

Project Number: 95062

Project Leader:

Lead Agency:

Cost:

Project Start-up Date: Feb.1, 1995

Project Completion Date: Sept. 30, 1995

Project Duration: 1 year

Geographic Location: Northern Knight Island and Esther Passage, PWS

Contact Person:

INTRODUCTION

River otters (Lutra canadensis) suffered direct mortality during the Exxon Valdez oil spill. A river otter damage assessment study in PWS conducted during 1989-92 documented subsequent long-term sublethal effects. No monitoring was done during 1993 or 1994, and therefore, recovery status is unknown. Monitoring of latrine sites that was begun during the damage assessment study will be continued for one additional year to establish an index of otter abundance that can be used to help assess recovery.

Signs of injury included changes in home range size, habitat use, and latrine abandonment. Home ranges of otters from oiled areas were twice as large as those from unoiled areas. Otters from oiled areas selected habitat differently. Latrine sites which are an index to abundance, were abandoned more often in 1991 in oiled than in unoiled areas, suggesting there may have been a delayed response in river otter populations from exposure to crude oil. Differences in rates of fecal deposition between oiled and unoiled latrine sites in Herring Bay suggested otters used heavily-oiled areas less often.

Effects from exposure to crude oil were also indicated in blood and fecal samples. Increased levels of haptoglobins and interleukin were found in the blood of live-captured otters from oiled areas as compared to unoiled areas one and two years after the spill. Elevated levels of these blood values indicate trauma and a weakened immune system. Male river otter in 1990 had significantly lower body mass in oiled areas. By summer 1990, there were significant declines in the number of species in otter diets in oiled areas. Relative abundance of prey remains in otter feces showed strong differences between oiled and unoiled areas.

NEED FOR THE PROJECT

Restoration objective for river otter is a return to prespill habitat use, food habits, and physiological indices. Primary strategy for achieving this objective is to rely on natural recovery, to monitor that recovery, and to protect otters and their habitats. This project will provide the population monitoring information called for in the restoration strategy. It will also provide information essential for assessing the need for additional otter protection. Current trapping seasons in the oiled area may be curtailed or closed if the population is not recovering.

PROJECT DESIGN

River otter latrine sites are activity centers that provide the opportunity to monitor population trends and provide insights into the lower trophic levels that support otters. Once established by otters, sites are seldom abandoned unless significant changes occur in otter density or habitat. In 1991, latrine sites in areas within the path of the spill were abandoned at nearly four times the rate documented in unoiled areas. During the previous damage assessment study, intensive study areas were established in oiled and unoiled otter habitat. All latrine sites that were found in the two intensive study areas are available for continue examination in this study. Use of these sites by otters in 1990 and 1991 is documented and will provide the base for quantifying differences in otter use. Use will be compared in the oiled and unoiled study areas, and changes over time since the oil spill will be determined. Monitoring of latrine use will provide information on population trends within both study areas. The population trend within the oiled study area can be used as an indicator of the status of otter populations in other areas impacted by the spill. Trend data from the unoiled area will be necessary to separate the effects of weather from residual impacts of oil on population trends.

Objectives

Objectives are to: (1) determine the annual level of latrine site use by river otters in the northern Knight Island study area and compare that use with data from the Esther Passage study area; and (2) monitor the annual harvest with emphasis on harvest size and the presence or absence of subadult animals from area impacted by the spill.

Methods

Methodology for cleaning otter scats and for determining latrine site abandonment will follow those used previously in the river otter damage assessment study. The same intensive study areas will be monitored. Field investigations of approximately two weeks each will occur in early June and September. During June, latrine site use or non-use will be determined and scats will be cleaned from the site. In early September, use or non-use will be determined.

Areas used as latrine sites are readily recognizable and have been identified in previous research. In addition to fecal droppings, otters keep the trails and a core area free of non-woody vegetation and light litter fall from the forest canopy. By summer, a lack of continued use will produce regrowth of vegetation and many small branches laying in formerly cleared areas. Also, lack of use will mean no scats will be deposited after the cleaning in early June. The trend in latrine site use will be determined and used as an indicator of the trend in otter population.

Trappers are required to bring river otter pelts to Alaska Department of Fish and Game for harvest sealing. Department fur sealing records for Game Management Unit 6 will be reviewed. Hide measurements may provide data on reproductive success. If sample size is adequate, it may be possible to identify subadults and evaluate recruitment into the population.

Schedule

This project will be conducted only during 1995.

Feb. 1	Equipment and materials purchase. Initiate vessel charters and hiring of personnel.
June 1-14	First field trip; visit latrine sites to clear scats and determine use or non-use.
June 15-30	Field and harvest data analysis.
Sept.1-14	Second field trip; visit latrine sites to determine use or non-use.
Sept.15-30	Final report production.

Technical Support

No technical support required.

Location

Project study areas are northern Knight Island and Esther Passage.

PROJECT IMPLEMENTATION

Project should be done through competitive contract.

COORDINATION OF INTEGRATED RESEARCH EFFORT PUBLIC PROCESS

Results will be discussed with Fish and Game Advisory Committees in Cordova and Valdez. Any recommendations for otter trapping season changes will be published by the Alaska Board of Game and discussed at one of their scheduled meetings.

PERSONNEL QUALIFICATIONS

Personnel will be determined by competitive contract process.

BUDGET

100	Personnel	\$32.9
200	Travel	\$3.1
300	Contractual Services	\$20.0
	Administration	\$
400	Commodities	\$5.0
500	Equipment/capital	\$4.0
	TOTAL	\$65.0

Monitoring, Habitat Use, and Trophic Interactions of Harbor Seals in Prince William Sound, Alaska.

Project Number: 95064

Principal Investigator: Kathryn J. Frost

Lead Agency: Alaska Department of Fish and Game, Division of Wildlife Conservation

Cost of Project (for FY 95/future years, including reports, if known):
FY95: $309.4
FY96: $302.0
FY97: $ 98.6

Project Start-up: 10/94 **Completion Dates:** 9/97

Project Duration: 3 years (2 field + analysis and report)

Geographic Area: Prince William Sound

Contact Person: Kathryn J. Frost
Alaska Department of Fish and Game
1300 College Road, Fairbanks, AK 99709-6009
Phone (907) 456-5156 Fax (907) 452-6410

B. Introduction

Project Overview: This restoration monitoring and research proposal is written in collaboration with the interdisciplinary and integrative MARINE MAMMAL ECOSYSTEM program submission to the EVOS Trustee Council. Harbor seals are a non-recovering biological resource whose status affects subsistence uses and commercial fishing, both services which were negatively impacted by the EVOS. As outlined under the broad program direction, the goals of the combined collaborative MARINE MAMMAL ECOSYSTEM projects are to investigate, in an ecosystem context, the reasons for the long-term decline in harbor seals and their lack of recovery following the EVOS. In particular this project will focus on four questions which have been identified as the most likely explanation for the failure of harbor seals to recover following the EVOS: Is it food? Is it predation? Is it human impact? Is it disease?

Background: Harbor seals (Phoca vitulina) occur year-round in Prince William Sound (PWS), where they pup, breed, molt, and feed. During extensive surveys of PWS in 1991-1993, 2,500-2,900 harbor seals were counted on haulouts. Another 1,700 were counted in the Copper River Delta and Orca Inlet. From 1984-1988, harbor seal numbers at trend count sites in PWS declined by over 40% due to unknown causes. In 1989, the decline was exacerbated in oiled areas by the Exxon Valdez oil spill (EVOS). More than 300 seals (36% of the seals in oiled areas) were estimated to have died in PWS because of the spill. Inhalation of light aromatic compounds, which caused brain damage that led to drowning, was the most likely cause of death. During molting-period surveys in 1993, there were 51% fewer seals at oiled trend count sites than there were in 1988, compared to 11% fewer at unoiled sites. For all PWS trend sites combined, there were 27% fewer seals in 1993 than in 1988, and 57% fewer than in 1984. The reasons for the ongoing decline, and the lack of recovery from the EVOS, are unknown.

Harbor seals are an important subsistence resource. In 1985-1988, they made up 13%-27% of the subsistence foods harvested in Tatitlek and Chenega Bay. Since the EVOS, the number of seals harvested by subsistence hunters in PWS has declined by over 60%. Harbor seals interact with and are incidentally killed in commercial fisheries. Like all marine mammals, they have federal protection under the Marine Mammal Protection Act (MMPA). Because of the ongoing decline, they are currently being considered for listing as depleted under the MMPA. It is essential that current population data be available, as well as information about what may be causing the decline, so that inappropriate restrictions on human activities are not implemented.

Project Description: This project is a continuation and redirection of a harbor seal restoration study that his been conducted by ADF&G since 1992. The ongoing study has consisted primarily of recovery monitoring and satellite tagging of seals to determine their movements, use of haulouts, and diving and haulout behavior in PWS. The proposed 1995-1997 study will build upon previous research findings and incorporate new components to address high-priority issues regarding harbor seal recovery.

The ADF&G study will have five key components: 1) **Restoration Monitoring** - Harbor seal numbers will be monitored during pupping and molting periods at 25 trend count sites in PWS to determine whether or not recovery is occurring; 2) **Habitat Use** - Seals will be instrumented with satellite tags (PTTS) in 1995 and 1996 to investigate habitat use, movements, and diving and haulout behavior; 3) **Trophic Interactions** - Fatty acids in blood and blubber of harbor seals and in prey species will be compared and relative frequencies matched to provide an indication of diet and to elucidate food webs in PWS; 4) **Demographic Modeling** - The effects of killer whale predation, subsistence harvest, and other mortality on the harbor seal population in PWS will be modelled in order to evaluate whether any of these factors may be inhibiting recovery; and 5) **Disease and Genetics** - Blood serum samples will be analyzed for phocine distemper, herpes virus, and other diseases that could cause health problems in the seal population. Skin samples will be used for genetic analysis to determine the relationships of PWS harbor seals to those in other parts of Alaska.

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

Because of the ongoing decline in harbor seal abundance, which was exacerbated by the EVOS, it is particularly important to understand what factors are limiting the harbor seal population. Because of the ongoing decline and the lack of recovery in the oiled areas, we cannot assume that the number of seals in oiled areas will stabilize and/or return naturally to pre-spill levels. It is necessary both to continue monitoring population trends and to identify and appropriately manage areas or resources of biological significance in order to augment recovery in any way possible. Native residents of PWS utilize harbor seals extensively as a source of food, and have noted the scarcity of seals and the impact this has had on subsistence hunting. Commercial fisheries in PWS may face more restrictive measures regarding incidental take of harbor seals unless something can be done to understand and reverse the population decline.

The ongoing declines of harbor seals began over two decades ago in the northern Gulf of Alaska and at least a decade ago in PWS. Although periodic surveys have documented these downward trends, they have done nothing to elucidate the cause of the declines. Unless research is specifically designed and conducted to investigate the factors limiting harbor seals, it is likely that little progress will be made in understanding the decline. Similar declines have occurred in Steller sea lions (Eumetopias jubatus), also for unknown reasons. For both of these species, it has been suggested that changing prey availability may be responsible. This is a difficult but important topic to investigate. It will require a multidisciplinary approach that incorporates an understanding of harbor seal behavior, habitat use, and energetics with data about the distribution, abundance and biology of prey species and predators.

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

1. **Objectives.** The objectives of this study are:

a) Monitoring: 1) continue monitoring harbor seal population trends in PWS during pupping and molting in 1995 and 1996; 2) recommend a monitoring schedule for 1997 and beyond; 3) evaluate whether seal numbers are continuing to decline, have stabilized, or are recovering to pre-spill levels.

b) Habitat Use: 1) describe hauling out and diving behavior, and by inference, feeding behavior of satellite-tagged seals in PWS; and 2) describe the use of and movements between haulouts and feeding areas.

c) Trophic Interactions: 1) determine individual, seasonal, and interannual differences in fatty acid composition of lipid stores in harbor seals from PWS; 2) assess variation in the fatty acid composition of prey species; 3) statistically determine prey items in harbor seal diets using analyses of fatty acid signatures; and 4) evaluate the relative contribution of each prey type to the overall diet using measured fat content of the prey.

d) Demographic Modelling: 1) model the effects of killer whale predation, the subsistence harvest, and incidental take by fisheries on the harbor seal population; and 2) evaluate how these factors may impact recovery from the EVOS.

e) Disease and Genetics: 1) conduct viral screening to determine whether disease may be causing or aggravating the harbor seal decline; 2) conduct genetic analysis to determine whether PWS harbor seals constitute a genetically distinct population.

2. Methods. We are proposing two years of field study (1995 and 1996) with final data analysis and reporting to take place in year three (1997). Findings from this study will be evaluated annually and modifications in study approach will be recommended in order to incorporate recent findings from this and other PWS ecosystem studies. In addition to the five components outlined in this project description, questions about health and condition, stable isotope analyses, predation by killer whales, and prey availability will be addressed by other studies included in the MARINE MAMMAL ECOSYSTEM package.

a) Monitoring: Harbor seal abundance will be monitored by flying aerial surveys during pupping (June) and molting (late August; September). A fixed-wing aircraft will be used to fly a survey of 25 trend count sites at an altitude of 700 ft. These 25 sites have been used by ADF&G for PWS harbor seal trend counts since 1983, including NRDA and Restoration studies in 1989-1994. Replicate counts will be made at each site in allow statistical analysis of trend. Methodology and observers will be the same as in 1989-1991.

b) Habitat Use: Satellite-linked time-depth recorders (PTTs) will be attached to 12 seals per year at locations chosen for their proximity to forage fish and oceanographic stations sampled as part of other PWS ecosystem studies. Seals will be caught by entanglement in nets placed near haulouts and PTTs will be glued to their backs with epoxy resin. Each PTT will transmit signals to polar-orbiting satellites whenever the seal is hauled out or when it surfaces for a sufficient time. Sensor information will indicate when the animal is hauled out, and how deep and for how long it dives. PTTs will be shed during the annual molt in July-August.

c) Trophic Interactions: Blubber samples will be taken from seals by biopsy and blood will be collected from extradural vein. Samples will be collected from all seals that are caught during tagging operations. Prey species will also be analyzed. During year one, approximately 10 species that are known to be prey of harbor seals in PWS will be sampled during two seasons. For each species, 8 individuals of the size range consumed by seals will be be collected and analyzed for total fat and protein content and fatty acid composition. During year two, prey species determined to be most important in the diet will be examined in more detail. Samples will be obtained from herring and forage fish projects.

Fatty acid methyl esters will be extracted from seal blubber and prey and analyzed using temperature programmed gas liquid chromatography. Approximately 70 fatty acids and isomers can be separated and quantified in most marine lipids. Fatty acids will be used to evaluate food webs in two ways. The array of fatty acids in seal tissues will be statistically compared to fatty acids in prey species in order to quantify the relative contribution of each prey item to the overall diet. In addition, single unusual or unique components will be used to trace a specific prey. Data will be analyzed using a multivariate model called a tree regression analysis which has recently been applied and modified for fatty acid signature analysis.

d) Demographic Modeling: A demographic model will be developed to examine the effects of predation, harvest, and incidental take on the harbor seal population in PWS. The model will use life table data from PWS harbor seals collected by ADF&G in the 1970s. Data on the subsistence harvest will be provided by ADF&G's Division of Subsistence, obtained in cooperation with subsistence hunters from Chenega Bay, Tatitlek, and Cordova. Information on killer whale predation will be obtained from the proposed NMML/NMFS study on Effects of Killer Whale Predation on Injured Resources, as well as from other pertinent studies. Data on incidental take in fisheries will be obtained from NMFS.

e) Disease and Genetics: Viral swabs, blood serum, and skin samples will be collected from seals caught during tagging. Disease assays from swabs or serum will be conducted by a variety of laboratories specializing in these assays. Genetics analyses will be conducted by NMFS/SWFSC.

3. Schedule.

This project will be conducted during 1995 and 1996, with either a recommendation for additional field studies or submission of a final report in 1997. Aerial surveys will be conducted during 7-14 days in June and August/September. Satellite tagging, and associated sampling for lipid and stable isotope analyses, genetics, and disease work will take place during late April/May and/or September. PTTs must be ordered by January of each year. Satellite data acquisition costs must be encumbered in February. Data are received monthly and preliminary analyses will begin as soon as diskettes are received. Final analyses cannot be completed until the PTTs have ceased to function. A report of field activites will be submitted in letter form within 30 days following any field activity. The principal investigator will participate in planning workshops, as scheduled by the Trustee Council, and be prepared to present findings of this study. An annual progress report will be submitted by 15 April of each year. A final report will be submitted by 30 September 1997. Results will be prepared for publication in peer-reviewed journals.

4. Technical Support.

Computer programming and biometric support will be provided by project personnel at ADF&G Fairbanks. Laboratory analyses of lipids, blood, and genetics samples and viral screening are budgeted for as part of this study but will be done by agencies or institutions other than ADF&G.

5. Location.

Aerial surveys will be conducted of 25 established trend count sites in PWS. Seal tagging and sampling will also take place in PWS. Tagging locations will be coordinated with forage fish and oceanographic studies.

E. Project Implementation — Who Should Implement the Project. This study will be conducted by ADF&G, Division of Wildlife Conservation. ADF&G personnel have over 20 years of experience conducting harbor seal research in PWS, including trend count surveys and studies of natural history and diet. ADF&G has conducted all previous harbor seal NRDA and Restoration Monitoring and Research studies (1989-1994). Project personnel have developed the methodology for trend count surveys and for catching and tagging seals in PWS. ADF&G works closely with the National Marine Mammal Laboratory/NMFS which is the agency responsible for managing harbor seals.

F. Coordination of Integrated Research Effort. This project is a multidisciplinary, interagency undertaking. Surveys and satellite tagging will be conducted by ADF&G. Lipid analyses and interpretation will be conducted at Dalhousie University. Blood chemistry analyses will be coordinated by UAF. Genetics samples will be analyzed at SWFSC/ NMFS. Demographic modelling will be done by personnel at NMML/NMFS.

This project is part of an integrated MARINE MAMMAL ECOSYSTEM package. Studies in this package include this project (Harbor Seal Monitoring, Habitat Use, and Trophic Interactions); Harbor Seal Condition and Health Status (UAF); Effects of Killer

Whale Predation on Recovery Rates of Injured Resources (NMML); and Confirming Food Web Dependencies in the PWS Ecosystem Using Stable Isotope Tracers (UAF). In addition, this study will be closely integrated with Herring (ADF&G) and Oceanographic (UAF) studies being submitted under the SEA plan and with the Forage Fish study being developed by NMFS to investigate food availability to pelagic predators. Prey samples obtained by Herring and Forage Fish studies will be analyzed as part of this study. Species to be analyzed will be chosen based on their collective importance to harbor seals, seabirds, and killer whales. Modelling efforts will incorporate and build on the results of a restoration study being conducted by the ADF&G Division of Subsistence entitled Harbor Seal and Sea Otter Recovery.

ADF&G is conducting studies of harbor seals in southeast Alaska and near Kodiak with funding from NOAA/NMFS. Those studies contain similar components to the PWS study and are closely coordinated to ensure that data are collected and analyzed in a similar manner. This will faciliate comparisons of data from declining populations (PWS and Kodiak) and healthy populations (southeast Alaska) of harbor seals.

G. **Public Process.** Information from the harbor seal study has been presented at oil spill symposia, conferences, and in the published literature. Project personnel have and will continue to participate and report study results at planning workshops that scientists and the public attend. Information is provided to personnel from the University of Alaska Sea Grant Program and ADF&G Division of Subsistence for use in meetings and discussions with subsistence hunters in PWS. The Principal Investigator has and will continue to talk with representatives of the public, including those from the tourism industry, fisheries, conservation groups, and subsistence comunities. ADF&G marine mammals staff regularly attend meetings with various public groups to inform them about status, important conservation issues, and key research needs for harbor seals.

H. **Personnel Qualifications**. Kathryn Frost has conducted research on marine mammals in Alaska since 1975. She has undertaken extensive research on natural history and ecology of seals, including aerial and photographic surveys; studies of food habits and trophic interactions; and studies of habitat use using satellite tags. She has conducted extensive aerial surveys of harbor seals in PWS and boat-based observations and sampling of harbor seals as part of NRDA studies following the EVOS. She has conducted satellite tagging studies of harbor seals in PWS from 1991 through 1994.

Lloyd Lowry is the Marine Mammals Coordinator for the State of Alaska. He has conducted research on marine mammals in Alaska since 1975, including studies of the natural history, ecology, distribution, abundance, and food habits of seals. He has participated in all NRDA and Restoration studies on harbor seals, including the development of methodology to catch and attach satellite tags to harbor seals. He has been responsible for project coordination and management of state and federally funded research projects, and is familiar with the federal marine mammal permit system.

Ron DeLong is an Analyst Programmer for ADF&G. He has developed custom software for the analysis of location and dive data from satellite-tagged seals. He was responsible for programming a PC-compatible Geographic Information System (PC Arc Info and Arc View) that is used in presenting seal location and movements information. Mr. DeLong is also accomplished in seal catching and tagging techniques.

Jay Ver Hoef is a Biometrician for ADF&G. He has been responsible for statistical analysis of all harbor data during NRDA and Restoration studies. He has participated in field work in PWS and is familiar with seal catching and tagging techniques.

Dr. Sara Iverson is an Assistant Professor at the University of Dalhousie. She is currently conducting research at Sable Island, Nova Scotia, on the lipid metabolism of seals and the use of fatty acids to determine marine food webs. She received her PhD in nutritional sciences, conducting studies of the energetics of reproduction and fatty acid metabolism in seals. She developed procedures for analysis of lipids in milk, blubber and tissues of pinnipeds. Dr. Iverson has published extensively on these subjects.

I. Budget

	FY95		FY96		FY97
	94 Rpt	New	95 Rpt	New	Report
1. **Personnel**	72.7	42.5	75.0	42.5	81.1
2. **Travel**	4.0	7.6	4.1	7.6	2.0
3. **Contractual Services**	17.0	106.1	13.0	100.5	113.5
4. **Commodities**	2.7	55.4	2.5	55.4	2.5
5. **Equipment**	1.4		1.4		
6. **Capital Outlay**					
SUBTOTAL	97.8	211.6	96.0	206.0	98.6
7. **General administration**					
TOTAL					

PWSAC Pink Salmon Fry Mortality

Project Number: 95065

Project Leader: Jeff Olsen, PWSAC Operations Manager

Lead Agency: AK. Dept. of Fish and Game (ADF&G)

Cost of Project, FY95: $52.5; **FY96** $53.0

Start/Completion: January, 1995 - September, 1995

Project Duration: 0.75 yr.

Geographic Area: Prince William Sound

Contact Person: Jeff Olsen, Operations Manager
PWSAC, P.O. Box 1110, Cordova, AK 99574
(907) 424-7511

B. Introduction

Pink salmon hatcheries operated by the Prince William Sound Aquaculture Corporation annually release approximately 400 million pink salmon fry from three hatcheries located in the northern, northwestern, and southwestern corners of Prince William Sound. Since the **EVOS**, PWSAC has observed unusual mortality in second and third generation of the odd year cycle pink salmon that returned through oil in 1989. Abnormally high pink salmon fry mortality (5% - 15%) occurred at Cannery Creek Hatchery in 1992 just prior to and after salt water entry. In 1994, similar mortality occurred at both AFK Hatchery (18%) and again at Cannery Creek Hatchery (7%).

C. Need for Project

This project will determine the cause of mortality and provide recommendations for reducing mortality and restoring the pink salmon production to its pre-spill level.

D. Project Design Objectives, Methods, Schedule and Location

1. Objectives

These will be detailed and forwarded to the EVOS Office.

2. Methods

3. Schedule

4. Technical support

The PWSAC salmon program receives technical support from permitting agencies, University of Alaska Fairbanks, University of Alaska Juneau, and PWS Science Center. The ADF&G pathology lab, genetics lab, and coded wire tag lab are among specific expertise areas overseeing the hatchery salmon program.

5. Location

This project will take place in PWS at the Armin F Koernig Hatchery on Evans Island, the Wally Noerenberg Hatchery on Esther Island, and the Cannery Creek Hatchery in Unakwik Inlet.

E. Project Implementation

PWSAC will implement the project in conjunction with ADF&G as the lead agency.

F. Coordination of Integrated Research Effort

G. Public Process

PWSAC is a regional salmon enhancement association comprised of representatives from commercial, sport, subsistence, personal use fishermen, native representatives from villages in PWS and the Copper River region, representatives of the fish processing industry and representatives of the communities in PWS. The PWSAC Board of Directors gave high priority to research objectives that addressed the current decline in the PWS pink salmon runs and emphasized the need to include hatchery pink salmon fry releases as part of the larger SEA ecosystem study.

H. Personnel Qualifications

Jeffrey B. Olsen

Work Experience

1989-Date: Operations manager for PWSAC. Oversee operations of five salmon hatcheries producing five species of Pacific salmon. Work with the PWSAC and regional planning groups to develop fish production goals. Responsible for achievement of hatchery production objectives. Work with the ADF&G and other state and federal agencies to assure the PWSAC enhancement program is in compliance with regulation and required permits. Work with hatchery staff, fish culture industry, ADF&G, and scientific community to develop research goals for enhancement program. Oversee the budgets of five hatcheries totaling over $4.0 million.

1988-1989: WNH hatchery manager, PWSAC. Oversee operations of PWSAC's largest salmon hatchery. Responsible for production of four species of Pacific salmon.

1986-1988: WNH hatchery assistant manager, PWSAC.

1982-1986: AFK hatchery fish culturist and assistant manager, PWSAC.

Education

1977-1981: Univ. of Washington., B.S. Degree in Fisheries Science

I. Budget FY95

100	Personnel	$2.0
200	Travel	$2.0
300	Contractual Services	$42.0
	Administration	$2.5
400	Commodities	$2.0
500	Equipment	$2.0
	TOTAL	$52.5

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Kenai River System and sockeye salmon: how overescapement affects the salmon population - an information pamphlet.

Project Identification Number: [illegible] 95067

Lead Agency: USDA Forest Service

Cooperating Agencies:

Cost of Project, FY95: $23,449

Cost of Project, FY96: TBD

Project Startup Date: 3/31/95

Duration: 5/95

Geographic Area: Kenai River, Cook Inlet

INTRODUCTION:

This general restoration project would prodruce a single page, trifolded brochure to describe three primary elements of the Kenai River sockeye salmon: 1) sockeye salmon life history (a diagram), 2) zooplankton life history (including how different species are more susceptible to predation by salmon fry and smolt), and 3) sockeye salmon overescapement and its consequences. The brochure can also be used to describe Trustee Ccouncil projects for Kenai River sockeye salmon, i.e. plankton studies and fish tagging.

PROJECT DESCRIPTION

Current predictions suggest that the adult sockeye salmon population returning to the Kenai River System will be greatly decreased in 1995 and 1996. At this time it is uncertain what actions will be necessary to protect the returning adults, but it is likely that commercial and sport fishing harvests and fishing time will be restricted. In 1992, the Russian River Campground hosted approximately 80,000 campers. Most of these visitors were fishing for sockeye salmon, and many were nonresident anglers. An information brochure would be very helpful for public relations.

1. Resources and/or Associate Services:

Sockeye salmon sport fishing in the Kenai River.

2. Objectives:

The primary objective of these brochures would be to reduce further injury to the sport fishers by promoting understanding of the consequences of the overescapements that occurred in 1987,1988, and 1989.

3. Methods:

A total of 50,000 single page, folded twice on semi-glossy paper brochures will be distributed to the public in 1995 and 1996. The brochure will define overescapement and describe how it has affected Kenai River salmon. Information gained from 1994 smolt outmigration suggests that the effects of the overescapement are diminishing, and the brochure can help alleviate public concern over the duration of the effects.

U.S. Forest Service staff will draft the text for the brochure and finalize the document after a technical review from other State and Federal agency experts. The layout, and any artwork can also be completed by USFS staff.

4. Location:

Primary production will occur in Anchorage, although review and/or printing may occur outside of Anchorage. Distribution sites could include: Begich-Boggs Visitor Center (Portage); Russian River Campground; Kenai National Wildlife Refuge; ADF&G offices; and potentially tour companies serving the Kenai River and Lake areas or located near the Kenai River.

5. Technical Support:

Prduction will be done by a Graphic Artist with computer layout and artwork skills. Technical review will be performed by ADF&G fisheries biologists familiar with the Kenai River sockeye salmon.

6. Contracts:

Printing can be contracted through a competitive bidding process.

SCHEDULES:

The schedule for this project can easily be moved forward if needed (for example, if ADF&G would like to incorporate the brochure into the regulations document).

a) The draft text and mock-up of artwork (photos and/or drawings) would be completed by March 31, 1995. (Beginning in early March.)

b) a technical review would be completed during April.

c) the brochure would be printed and distributed to appropriate agencies or organizations in May.

d) If needed, an additional printing of the brochure April in 1996.

EXISTING AGENCY PROGRAM:

The Chugach National Forest has won several rewards in recent years for public information brochures.

This project will include interagency review between USFS, USFWS and ADF&G. These agencies are likely to be the primary distribution centers. ADF&G expertise will be sought during the technical review of the brochure.

The Trustee Council may choose to add a section to the brochure which would describe the projects that are being conducted to monitor recovery and increase management capabilities.

ENVIRONMENTAL COMPLIANCE/PERMIT/COORDINATION STATUS

None required.

PERFORMANCE MONITORING

Not applicable.

BUDGET ($K)

	Total
Personnel	$5,000
Travel	$200
Contractual	$15,200
Commodities	$200
Equipment	$0
Capital Outlay	$0
Sub-total	$21,500
General Administration	$1,949
Project Total	$23,449
NEPA Compliance	$0

Restoration of Salmon Stocks of Special Importance to Native Cultures

Project Number: 95069

Project Leader: Mark Willette (ADF&G), TBD (US Forest Service)

Lead Agency: Alaska Dept. of Fish and Game, U. S. Forest Service co-leads

Cost of Project (FY95): $500 K

Project Start-Up: Nov. 1994 **Completion Date:** Sept. 1995

Project Duration: Two years

Geographic Area: Prince William Sound, Lower Kenai Peninsula, Kodiak

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

Mr. Raymond Thompson
U.S. Forest Service
3301 C Street, Suite 300
Anchorage, AK 99503
Phone: 907-271-2536

B. Introduction: Pink salmon primarily spawn intertidally in Prince William Sound and to varying degrees throughout their Northern Gulf of Alaska range. Consequently eggs and pre-emergent fry were exposed to oil while they incubated in intertidal gravel following the Exxon Valdez oil spill (EVOS). Significant injuries were documented at the time which ultimately resulted in fewer adult returns to oiled streams, but there also appears to have been heritable genetic damage as well which roughly makes successful spawning twice as unlikely (up to 40% for some streams) for returning adults. The Alaska Department of Fish and Game and the United States Forest Service conducted stream rehabilitation surveys (93063) in order to determine which methods of habitat or stock manipulation would be appropriate for particular streams. From these developed project 94139, Salmon Instream Habitat and Stock Restoration which began to implement the findings of 94063. While restoration of impacted stocks and sport and commercial fishing services were considered, subsistence uses of particular stocks were not given major consideration. The currently proposed project is designed to identify stocks of particular interest to subsistence users and, where needed, apply appropriate instream habitat and stock restoration techniques using native skilled craftsmen and laborers to the extent possible under the guidance of USFS and ADF&G biologists. As well as instream techniques, incubation of stocks at hatcheries to improve egg to fry survival and other hatchery involvement will be among techniques considered.

C. Need for the Project: Many subsistence foods were impacted by the EVOS and users have been forced to substitute subsistence caught foods with commercially obtained processed foods. While some resources are recovering, use of subsistence foods has not returned to a pre-spill level and will not until subsistence resources have returned to pre-spill and appear to be free from tainting by petroleum hydrocarbons. In order to return to a more traditional lifestyle, native users have suggested a need to restore and enhance stocks of salmon returning to streams of particular interest to them. Because this is a need expressed by them and the stocks provided subsistence foods directly to them, they are interested in participating in the efforts to restore these stocks.

D. Project Design:

1. **Objectives:** Restore and enhance salmon stocks identified by native users as depressed and of value to their subsistence life style. A target of approximately eight stocks are to be affected by this project in 1995.

2. **Methods:** Appropriate specific techniques are dependent upon methods deemed most likely to succeed and cost effective for particular streams. The restoration options include but are not limited to egg incubation boxes, fish barrier bypasses, spawning channels, incubation of eggs and early juvenile rearing at hatcheries with planting of juveniles in the stream of origin, capture of emergent fry at streams and short term rearing in netpens off the stream mouths. Cost benefit ratios have been conducted somewhat differently by USFS and ADF&G in the past. These methods will be modified to include subsistence values.

3. Schedule:

	Date	Action
a.	Nov. 1994	Request list of candidate streams from native subsistence users.
b.	Dec. 1994	Assess appropriate restoration/enhancement techniques for up to eight streams/stocks. Begin NEPA process for those streams with known appropriate techniques.
c.	May 1995	Complete NEPA for streams with known appropriate restoration/enhancements. Initiate requests for proposals for restoration/enhancement of these streams/stocks
d.	June 1995	Award contracts for restoration/enhancement.
e.	July-Sept. 1995	Obtain permits, conduct restoration/enhancement actions.
f.	Jan.-Sept. 1995	Conduct surveys of streams where appropriate restoration/enhancement techniques have not been determined.
g.	Oct. 1995	Initiate NEPA for streams surveyed in 1995.
h.	Dec. 1995	Complete NEPA. Initiate requests for proposals for restoration/enhancement of these streams/stocks.
I.	Jan. 1996	Award contracts for restoration/enhancement.
j.	Feb.-May 1996	Obtain permits.
k.	June-Sept. 1996	Conduct restoration/enhancement actions.
l.	1996-1998	Evaluate success of project.

4. Technical Support: None anticipated at this time.

5. Location: Prince William Sound, Lower Kenai Peninsula, Kodiak

E. Project Implementation: ADF&G and US Forest Service will seek candidate streams, assess the appropriateness of techniques, conduct RFP's, award contracts and assess the success of the project at individual streams. ADF&G and US Forest Service may conduct surveys of streams for which appropriate restoration/enhancement techniques have not been previously determined or these agencies may contract out this work. NEPA compliance will be conducted by ADF&G and US Forest Service. Contracts will be awarded for actual restoration/enhancement actions. It is expected that native organizations will be employed for instream habitat manipulation and private non-profit corporations will provide any hatchery services required.

F. Coordination of Integrated Research Effort: This project will be coordinated with other 1995 pink salmon and subsistence projects.

G. Public Process: The nomination of candidate streams will be obtained through public solicitation. It is anticipated that each part of this project for individual streams will require environmental assessments (EA) which involves public review. Solicitations will be made from the public to actually perform the identified restoration/enhancement actions.

This project was originally conceived by Stephen and Monica Riedel who obtained the support of the Native Village of Eyak. Their original proposal was focused on egg incubation boxes which have been shown to be effective under certain circumstances. Nevertheless, it is the experience of both USFS and ADF&G that different stream conditions warrant different restoration/enhancement techniques, and that determination of the most appropriate method should be made on a stream by stream basis.

H. Personnel Qualifications: Area and regional ADF&G and USFS biologists (specific staff to be determined) with many years of stream habitat manipulation and fish culture experience will solicit and evaluate stream nominations and contractors.

I. FFY 1995 Budget ($K):

	USFS	ADF&G	TOTAL
Personnel	75.0	75.0	150.0
Travel	8.0	8.0	16.0
Contracts	200.0	200.0	400.0
Commodities	20.0	20.0	40.0
Equipment	8.0	8.0	16.0
Subtotal	311.0	311.0	622.0
General Administration	25.3	25.3	50.6
Project Total	336.3	336.3	672.6
NEPA Compliance	16.0	16.0	32.0

Monitoring nearshore fish species for persistence of oil exposure and ecotoxicological effects

Project Number: 9507*/*

Principal Investigator:	Tracy K. Collier, Ph.D.
Co-principal investigator:	Sin-Lam Chan, Ph.D.
Co-principal investigator:	Tom Hom, M.Sc.
Co-principal investigator:	Donald W. Brown, M.Sc.
Co-principal investigator:	John E. Stein, Ph.D.
Co-principal investigator:	Mark S. Myers, M.Sc.
Co-principal investigator:	Lyndal Johnson, B.Sc.
Co-principal investigator:	Margaret M. Krahn, Ph.D.
Co-principal investigator:	Usha Varanasi, Ph.D.

Lead Agency: National Oceanic and Atmospheric Administration

Cost of Project: FY95 $225K
FY96 $185K

Project Start-up: April, 1995

Project Completion: February, 1997

Project duration: 2 years

Geographic area: Prince William Sound and nearshore habitat along the Alaskan and Kenai Peninsulas

Contact person: Dr. Tracy Collier
NOAA, NMFS
2725 Montlake Blvd. E.
Seattle, WA 98112
(206)860-3312

B. Introduction:

There has been persistent oil exposure of the nearshore subtidal habitat, and this project proposes to continue recovery monitoring of the benthic fishes of this ecosystem component, together with making a final effort to ascertain any biological dysfunctions resulting from persistent exposure. The results from this study will 1) delineate the geographic areas where subtidal oil contamination is continuing; 2) allow a determination of the rate of recovery, if any, for those areas which were still showing persistent exposure into 1992 and 1993; 3) allow a determination of ecotoxicological effects in the benthic fish compartment of the Prince William Sound and Kenai/Alaskan Peninsula nearshore habitat. The need for incorporation of this compartment into the ecosystem studies of Prince William Sound have been clearly stated in the Implementation Management Structure workshops in Anchorage, and in the Cordova planning and review workshop for the Sound Ecosystem Assessment proposal. Portions of this type of study have been previously funded by the NRDA and Restoration programs, under Fish/Shellfish 24b and 24, Subtidal 7, and Subtidal 1. Funding was stopped after the 1991 and 1993 collections, but analyses of the final collections made under these projects have shown a continuation of exposure at some sites both inside and outside the Sound.

C. Need for the Project:

There has been extensive and continuing exposure of nearshore subtidal fish species to oil in and around Prince William Sound following the EVOS, as documented in Progress Reports and the Final Report from F/S 24 (1989 and 1990), ST 7 (1991), and ST 1 (1993). Biological exposure, while generally decreasing with time in species examined in these studies, could nevertheless still be documented in 1991 and 1993. There are some data to suggest that oil has moved from intertidal areas to deeper sediments, due to wind and wave action, and also perhaps due to some cleanup procedures. However, sampling of subtidal sediments in 1993 and 1994 failed to show any detectable hydrocarbons derived from the EXXON Valdez. Biological monitoring, however, allows for integration of overall contamination of a geographic area and thus may be a more sensitive measure of subtidal contamination. Because of the ecological importance of the benthic community to ecosystem modeling efforts, the rates and extent of natural recovery of these species need to be determined. In addition, it is critical to determine if the demonstrated persistent exposure of this community has resulted in any biological dysfunction that may impact the ecosystem as a whole.

C. Project Design

1. Objectives

1) Collect three flatfish species (rock sole, flathead sole, and yellowfin sole) from six sites inside Prince William Sound in May and June of 1995 and four to six sites along the Kenai and Alaska Peninsulas in May and June of 1996, at depths from 10-30 meters.

2) Analyze liver samples for levels and/or activities of cytochrome P450 1A (CYP1A) and bile samples for levels of fluorescent aromatic compounds (FACs) in order to determine oil exposure and biochemical effects in the collected animals.

3) Analyze liver samples for evidence of DNA damage

4) Assess histopathological alterations in several tissues, including liver, kidney, gonad, and gill.

5) Assess reproductive function in males and females (primary target species is yellowfin sole), utilizing histopathological methods, levels of circulating sex hormones, and appropriate biomarkers of reproductive function.

6) Measure levels of petroleum-derived compounds in stomach contents of collected animals.

7) Provide synthesis reports in February of 1996 and 1997 detailing levels of oil exposure and associated ecotoxicological effects in benthic fish species from Prince William Sound (1996) and the nearshore habitats of the Kenai and Alaska Peninsulas (1997).

2. Methods

Methods are as described in previous detailed study plans and final and progress reports, and in previous peer-reviewed publications. Summaries of these methods and appropriate citations can be found in:

Collier, T.K., C.A. Krone, M.M. Krahn, J.E. Stein, S.-L. Chan, and U. Varanasi. (1994). Petroleum exposure and associated biochemical effects in fish following the EXXON Valdez oil spill 1. 1989-1991. Submitted to Trans. Am. Fish. Soc.

Collier, T.K., M.M. Krahn, C.A. Krone, L.L. Johnson, M.S. Myers, S.-L. Chan, and U. Varanasi. (1993). Oil exposure and effects in subtidal fish following the EXXON Valdez oil spill. In: Proceedings 1993 International Oil Spill Conference pp 301-305.

3. Schedule

January, 1995	Contract for vessel support
March, 1995 especially from	Solicit public input concerning sites and additional target species, subsistence consumer
April/May, 1995	Finalize cruise plans and schedule
May/June, 1995	Field collections in Prince William Sound
June-October, 1995	Analysis of collected samples
September, 1995	Submission of report detailing samples and species collected
January, 1996	Submission of draft synthesis report
January, 1995	Contract for vessel support for year 2
February, 1996	Submission of final synthesis report covering Prince William Sound collections and results
March, 1996	Solicit public input concerning sites and additional target species to be sampled outside Prince William Sound, especially from subsistence consumers
April/May, 1996	Finalize cruise plans and schedule
May/June, 1996	Field collections along Kenai and Alaskan Peninsulas
June-October, 1996	Analysis of collected samples
September, 1996	Submission of report detailing samples and species collected
January, 1997	Submission of draft synthesis report
February, 1996	Submission of final synthesis report for Kenai/Alaskan Peninsula sites

4. Technical Support

The Environmental Conservation Division has most of the required equipment and facilities for performing this project. The only anticipated costs are for vessel support each year and nets to be purchased in the first year. The ECD has in-house facilities and personnel to carry out the field sampling and sample handling, all biochemical and chemical analyses, data compilation and analysis, and sample and data archival.

5. Location

The proposed project will be undertaken at several sites in Prince William Sound and along the Kenai and Alaskan Peninsulas. Possible sites within Prince William Sound include Olsen Bay, Snug Harbor, Sleepy Bay, and Squirrel Bay. Outside the Sound, sites may include Tonsina Bay, Hallo Bay, Resurrection Bay, and sites on Kodiak Island. To the extent that there is a desire on the part of native Alaskans to have additional sites sampled, attempts will be made within the budget confines to accommodate these requests.

E. PROJECT IMPLEMENTATION

It is proposed that this project be implemented by the Environmental Conservation Division (ECD) of the Northwest Fisheries Science Center of NOAA, NMFS. This group has been the lead agency on several similar projects in the past, and has all requisite technical expertise and equipment. This project is proposing to use state-of-the art techniques for determining oil exposure and determining ecotoxicological impacts of such exposure in nearshore subtidal species. These techniques have been largely developed, or optimized for use on oil-exposed organisms, by researchers in the ECD. The Division has demonstrated its ability to provide sound chemical, biochemical, and biological data on a timely basis, both under the NRDA process and for the Subsistence Science Project, following the EVOS. Moreover, this Division has considerable experience with sampling in and around Prince William Sound, and knowledge of the distribution of the species of interest. To our knowledge there are no other groups with the combination of chemical, biochemical, and biological expertise sufficient to conduct an ecotoxicological study of this magnitude in Alaskan waters.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

The results from this project will be integrated into the overall ecosystem studies of Prince William Sound that will be conducted in FY95 and FY96. It is anticipated that an evaluation of any continuing ecotoxicological impacts in the nearshore benthic habitat will be available for the proposed annual ecosystem workshops, provisionally scheduled for winter 1995/1996 and 1996/1997. As appropriate, platforms and sampling gear will be shared with other projects that will be in the field at the same time as proposed in this study.

G. PUBLIC PROCESS

There will be defined periods where formal public notification will be made requesting review of proposed work plans, including sites and species to be sampled. The investigators on this project will be available to present results at public meetings and will participate in workshops to the extent that budget allows.

H. PERSONNEL QUALIFICATIONS

Detailed CVs of key project personnel have been previously submitted in the Detailed Study Plans for F/S 24, ST 1, and ST 7, and updated CVs are being prepared and will be submitted.

I. BUDGET

FY 95 (estimate)

Personnel	125.0K
Travel	7.0K
Contractual	25.0K
Commodities	33.0K
Equipment	15.0K
Capital outlay	0.0K
General Administration	20.5K
TOTAL	225.0K

NEPA Compliance Cost: 0.0K

Total for FY95 $220K

Impact of Killer Whale Predation on Harbor Seals in Prince William Sound

Project Number: 95073

Project Leader: Marilyn E. Dahlheim, Ph.D.

Lead Agency: NOAA, Alaska Fisheries Science Center National Marine Mammal Laboratory
Seattle, Washington 98115

4. **Cost of Project:** FY95: $103.7K
FY96: $243.1K
FY97: $173.3K

5. **Project Dates:** Start-up: 5/95; Completion: 10/97

6. **Project Duration:** 3 years (2 field + analysis and report).

7. **Geographic Area:** Prince William Sound, Alaska

8. **Contact Person:**
Dr. Marilyn E. Dahlheim
Alaska Fisheries Science Center
National Marine Mammal Laboratory
7600 Sand Point Way NE
Seattle, Washington 98115
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B. Introduction

Killer whales are classified as top predators of the marine ecosystem with diets that vary regionally and seasonally. Two life-history patterns, involving two forms of killer whales termed resident and transient, have been suggested for the whales occupying the waters of Puget Sound, Washington and British Columbia. One of the criterion used to differentiate the two forms is diet. Resident whales are thought to feed primarily on fish whereas transients are thought to feed primarily on marine mammals. Both forms of killer whales have been described from Prince William Sound. In Prince William Sound, predation by killer whales occurs on at least three injured resources: harbor seals, salmon, and herring. To predict the relative impact that killer whale predation may have on these injured resources, the level of predation and the relative proportion of each species consumed by killer whales must be quantified.

Current information on the dietary habits of killer whales are based on 1) observations of feeding events, and/or 2) stomach content analyses from stranded animals. Although both methods of determining food habits of killer whales are valid, each approach has significant limitations. Observations of feeding events may only represent the localized distribution of prey in an area. In many cases target prey consumed by the whales may be hard to determine. Since killer whales rarely strand, few stomach contents have been examined. Stomach contents represent a one time and fairly recent feeding event or series of events and this could misrepresent the relative contribution of the prey item found in the stomach. Other problems associated with stomach content analysis are that the stomach contents may either represent something that the prey has eaten or a by-catch from an attempt to capture other prey.

The objective of the proposed project is to investigate the potential impact of killer whale predation on Prince William Sound harbor seal populations. We will collect biopsy samples from 40 killer whales from each of two putative populations (suspected resident and transient whale populations) from Prince William Sound. Killer whale skin and blubber samples will be examined through stable isotope and fatty acid analyses to determine the fraction of the Prince William Sound killer whale population that predates on marine mammals versus fish. In addition to obtaining dietary preferences of killer whales through biopsy sampling, our investigations will also include studies to determine population energetics of killer whales. Researchers working with killer whales and harbor seals will collaborate (INTEGRATIVE MARINE MAMMAL ECOSYSTEM PROGRAM), to construct a model of killer whale predation on Prince William Sound harbor seal populations.

C. Need for Project

The effect of predation on the recovery rates of injured resources has been defined as a priority research issue by the EVOS Trustee Council. Information gathered during the killer whale study will be integrated with other studies (MARINE MAMMAL ECOSYSTEM PACKAGE) to provide a greater understanding of ecosystem processes in Prince William Sound and will enable us to predict the relative impact of whale predation on harbor seals. Additional insights regarding the relative impact of killer whale predation on herring and salmon will also be obtained during the course of these studies.

D. Project Design

1. Objectives:

1) Determine short-term and long-term diets of Prince William Sound killer whales.

2) Compare dietary preferences of transient and resident killer whales in Prince William Sound.

3) Determine the potential impact that killer whale predation may have on Prince William Sound harbor seals and other injured resources, as appropriate.

2. Methods: Killer whale tissue samples will be collected using a biopsy dart. We plan to use an air pistol powered by a CO_2 cartridge. We chose the CO_2 system because it allows the force of impact to be more precisely controlled. The dart size is 6mm by 25mm (diameter x depth) and the airgun dart is plastic to reduce the weight (less than 10 g) and improve flotation. The dart is collected free floating after sampling.

Samples will be subjected to stable isotope ratio analysis, fatty acid signatures and fatty acid isotope ratio analysis. Stable isotopes analysis has become a powerful tool in the studies of marine food webs. The ratio of heavy to light isotopes in a sample varies between organisms. An organism has an average of 1-2 ppt (parts per thousand) difference than it prey for carbon and 2-5 ppt for nitrogen. Using both carbon and nitrogen increases the resolution of the analysis. It may also be possible to rule out the presence of a certain species.

Analysis of fatty acid composition can be done from various tissues of an animal to determine the presence of fatty acids that are unique to potential prey. The lipids of the prey are hydrolyzed in the stomach and small intestine into fatty acids as well as glycerol and monoglyceride. Fatty acids remain intact during digestion. Therefore comparisons of the fatty acid composition of potential prey with blubber of the predator makes it possible to determine which prey was consumed. Many fatty acids can be attributed to a single phylogenetic group or species from a specific community. However, it may not always be possible to assign a species on the basis of one or two free-fatty acids. Thus it is necessary to consider an array of fatty acids present and then match the pattern present in the tissue with the pattern in the potential prey. This technique has the added advantage of enabling an assessment of the relative contribution of different prey types. Therefore, the presence of certain fatty acids can act as trophodynamic tracers. Analysis of carbon and nitrogen stable isotopes of a fatty acid will decrease noise and increase resolution in prey determination.

Longer term estimates of diet are required to more fully address food web dynamics. Although killer whales are considered top predators (defined as a species that is not eaten by any other species in the food web), this information alone does not allow for quantitative analysis or comparisons to be made between or within food webs. It is necessary to determine how many trophic levels or successive energy transfers occur between basal and top level species. This has important implications for the flow of energy and material through the ecosystem. The trophic level at which a predator feeds will determine the relative efficiency of that consumer and dictate much about the life history patterns and demographics of those animals. Further, the trophic level may change spatially as well as temporally, which affects the dynamics of resource utilization as well as the potential for concentration of environmental pollutants. Prey species consumed by predators may be the same over the course of the year, but could in fact represent different trophic levels depending upon the time of year and environmental conditions.

Trophic level can be determined on the basis of the isotopic analysis of the ratio of heavy to light nitrogen $^{15}N/^{13}N$, in the blubber and skin. Animals average from 3 to 5 parts per thousand (ppt) heavier in dietary nitrogen. In terms of food webs, nitrogen isotope values increase 10-15 ppt in many food webs due to the presence of 3-5 successive trophic transfers. Each transfer increases the ^{15}N content by 3-4 ppt. Comparison of stable isotope ratios of tissue samples of predators (e.g., killer whales) with those of potential prey (e.g., harbor seals, salmon, herring, etc.) makes it possible to determine the diet of a species, as well as the trophic level at which they are feeding.

Of equal importance to the work being conducted on stable isotope and fatty acid analysis, we also propose to study foraging strategies and population energetics of killer whales. Information pertinent to these studies will be collected during field work and with captive killer whales. These data, in conjunction with the results obtained from analyses of skin and blubber samples, will be an integral part of a model we are developing to determine the impact of predation by whales on seals as well as other injured resources.

3. Schedule: This study will be conducted during 1995 and 1996, with either a recommendation for additional field studies or submission of a final report in 1997. The field season will operate from July to September each year. Data analysis will occur between October 1995 and February 1996. An annual report (summarizing 1995 research) will be submitted in April 1996 and in April 1997 (summarizing 1996 research). A final report will be submitted by 30 September 1997. Results will be prepared for publication in peer-reviewed journals.

4. Technical support: Technical support will be provided by the research/administration staff of the Alaska Fisheries Science Center, National Marine Fisheries Service, National Marine Mammal Laboratory, Seattle, Washington. Laboratory analyses of killer whale tissues will be done by agencies or institutions other than NMFS/NMML. Research staff at Sea World (California and Florida) will assist with studies on captive killer whales.

5. Location. Field work conducted under this project will be restricted to Prince William Sound.

E. Project Implementation. This study will be coordinated by staff at the National Marine Mammal Laboratory. NMML personnel have over 20 years experience conducting killer whale research in Alaska. NMML has designed and coordinated all previous killer whale NRDA and restoration monitoring and research studies (1989-91 and 1993). NMML will work closely with Alaska Department of Fish and Game biologists, scientists conducting laboratory studies on stable isotope and fatty acid analyses, biologists conducting captive killer whale studies, and other Principal Investigators, as appropriate.

F. Coordination of Integrated Research Effort. This project is part of an integrated MARINE MAMMAL ECOSYSTEM package and as such is multi-disciplinary and would involve the collaborative efforts of many Federal and State Agencies, and includes the participation of Universities and private individuals. An integrated approach is absolutely critical to the overall success of this project and mandatory to obtain the desired results of this work. Studies in this package include this project (Impact of killer whale predation on harbor seals); Harbor Seal Monitoring, Habitat Use, and Trophic Interactions (ADF&G); Harbor Seal Condition and Health Status (UAF); and Confirming Food Web Dependencies in the PWS Ecosystem Using Stable Isotope Tracers (UAF). In addition, this study will be closely integrated with Herring (ADF&G) and Oceanographic (UAF) studies being submitted under the SEA plan and with the

Forage Fish study being developed.

G. Public Process. We encourage public participation at all levels of this scientific research (workshops, meetings, document reviews, etc.). The Principal Investigator of this Project has attended all scheduled meetings/workshops and has presented all available information pertaining to the whale studies to the general public at these symposia, conferences, and in the published literature. Numerous reports of our research efforts on killer whales are available through the Oil Spill Public Information Office. The Principal Investigator has and will continue to talk with representatives of the public, which have and will include those from tourism, industry, fisheries, and conservation groups.

H. Personnel Qualifications. Dr. Marilyn E. Dahlheim is recognized worldwide for her expertise on killer whales. Dr. Dahlheim has been the Principal Investigator of the EVOS damage assessment and recovery research on killer whales since 1989 and has successfully managed all aspects of these investigations. Her involvement with Prince William Sound killer whales began in 1985 (killer whale/blackcod fisheries interactions), however, she has been conducting killer whale research throughout Alaskan waters since 1978. In addition to her work on killer whales, Dr. Dahlheim has made significant contributions to the biology of gray whales, Alaskan humpback whales, and Alaskan harbor porpoise. Dr. Dahlheim has published extensively on cetacean biology; of which 20 manuscripts have been published on killer whales. Dr. Dahlheim will coordinated various experts relating to topics in the proposed project. These include fatty acid sampling, isotope sampling, modeling, and energetic studies of killer whales.

I. Budget**	**FY95**	**FY96**	**FY97 ***
Personnel	$18.0K	$24.0K	$16.0K
Travel	6.0K	9.0K	3.0K
Contractual Services	50.0K	171.0K	120.0K
Commodities	23.5K	23.5K	23.5K
Equipment	0.0	0.0	0.0
Capital Outlay	0.0	0.0	0.0
General Administration	6.2K	15.6K	10.8K
Total	$103.7K	$243.1K	$173.3K

*If a third year field season is needed (required if 80 samples not collected), an additional $99.5K would be requested for FY97 for field studies.

**If the killer whale/harbor seal predation project is merged with the killer whale monitoring project proposed by NMML, a significant cost savings would result. The proposed budget for the killer whale monitoring project is $99.5K for FY95; $29.0K for FY96; $99.5K for FY97, and $29.0K for FY98. The proposed FY95 budget for this project (if no monitoring occurs) is $99.5K (FY95); $229.5K (FY96); and $164.5K for FY 97 (assuming no field work is required). If field work is required in FY97, an additional $99.5K would be needed. If the two projects are combined, $99.5K would be saved both in FY95 and in FY97 if field work associated with the predation project was still warranted (i.e., adequate sampling not accomplished). If the projects are combined over the next three years and a third field season is required on the predation project, the costs would be as follows: FY95 = $99.5K; FY96 = $258.5K; FY97 = $264.0K, and FY98 = $29.0K.

Herring Reproductive Impairment[1]

Project Number: 95074

Project Leaders: Stanley Rice, National Marine Fisheries Service
Mark G. Carls, National Marine Fisheries Service

Lead Agency: National Marine Fisheries Service

Cooperating Agency: State of Alaska
Department of Fish and Game
Division of Commercial Fisheries

Project Cost: FY95 $234.8K
FY96 $119.2K

Start Date: February 1, 1995
Finish Date: March 1, 1997[2]

Geographic Area of Project: Prince William Sound and Auke Bay Laboratory
Juneau, Alaska

Agency project manager: Bruce Wright
National Marine Fisheries Service
Office of Oil Spill Damage Assessment and Restoration
P. O. Box 210029
Auke Bay, AK 99821
907-789-6600

B. INTRODUCTION

Herring stock in Prince William Sound (PWS) may have been reproductively impaired by the 1989 Exxon Valdez oil spill, and it is feared that continuing long-lasting effects could hamper restoration of the stocks that have crashed since the spill. Most or all of the life stages of herring may have been exposed to oil after the 1989 *Exxon Valdez* oil spill in PWS. Significant histopathological damage was observed in adults collected in oiled areas in 1989 and 1990 (ADF&G), and over 40% of the spawning areas were oiled (ADF&G). Exposure of herring

[1]NOAA component

[2]Phase two of a three year project.

eggs to petroleum hydrocarbon concentrations frequently results in abnormal larvae with poor survival potential. In the pectoral fins of herring embryos exposed to oil, anaphase aberrations was elevated, giving some credence to the hypothesis that long term genetic damage was possible to the germ line. Because year-class strength is heavily influenced by survival of herring larvae, contamination of pre-spawn adults, eggs, or larvae by petroleum hydrocarbons may have an adverse impact on herring populations. Long term effects are possible and unknown.

The primary goal of the study is to determine if herring reproduction can be impaired by exposure to oil; a combination of controlled laboratory exposures and viability measurements from herring in the field will be used. In year one (FY 94), our goal was to determine if exposure of pre-spawning adults to oil would result in genetically impaired larvae with reduced survival potential. In year two (FY 95), the laboratory oil exposures will be extended to eggs and larvae, with similar measurements of genetically impaired larvae. This will allow direct comparison of impacts between adult, egg, and larval stages. Data will be used to infer what the relative effects the *Exxon Valdez* oil spill were on adult and early life stages of herring in PWS. In addition, a field component of the study will measure the current status of herring reproduction at several locations in PWS by age class. Spawn from these herring will be returned to the lab and incubated in a stable and common environment for determination of hatching success and abnormality rates for each age class and spawning location.

The field component in FY 95 will be integrated with the two other herring components -- the age/weight/length analyses by ADF&G, and the disease sampling by ADF&G or independent contractor. All of the samples for each component will come from the same group of fish sampled at a spawning site.

C. NEED FOR THE PROJECT

Five years after the *Exxon Valdez* oil spill, questions concerning the impact of oil persist, as well as questions about the recovery potential of herring. There is evidence that exposure to oil may have caused long term genetic damage in herring; this issue has been identified as a critical by the *Exxon Valdez* Oil Spill Trustee Council. In years after the spill, recruitment to the fishable stock has been unexpectedly low, and disease incidence has been unexpectedly high. Of principal concern is whether the herring population is reproductively impaired as a result of exposure to oil. Evaluation of the extent of reproductive impairment should be possible from the results of this study. If impairment has occurred, adjustment in the management of the herring fishery in PWS may be necessary.

D. PROJECT DESIGN

1. <u>Objectives</u>

a. Determine if exposure of herring eggs and larvae causes genetic injury. This is a continuation of the three year research proposal initially funded in 1994. From estimates of somatic genetic damage, we will infer the possibility that exposure of herring to oil can cause genetic damage that is transmissible to subsequent generations. It is not practical to measure germ line damage directly in the laboratory because it is not possible to rear herring from eggs to maturity. In 1994, oil was exposed to pre- spawning adults and genetic aberrations in eggs and larvae were measured. In 1995, oil will be exposed to eggs and larvae, and genetic aberrations will be measured. Aberration rates will be compared across exposure doses and life stage exposed.

b. Survey herring in PWS for reproductive impairment by measuring larval viability by location and age class. Herring reproduction may be impaired as a result of past oil exposures at one or more life stages. In 1995, we will measure herring reproduction success from several age classes collected from several sites in PWS. Some of the age classes were exposed to oil, but post 1990 year classes were not. Spawn will be returned to the lab and reared until hatch to determine larval viability and abnormality rates.

2. Methods

a. Adult herring will be artificially spawned onto glass slides (identified by fish) or substrate contaminated with oil. Eggs will be exposed to two types of treatments - oil in water (as in FY94) and to oil contaminated substrate. One series of treatments will consist of four oil doses plus a control. For larval exposures, eggs will be incubated in clean water, and resultant larvae will be exposed to a series of doses. Chromosomal aberration rates will be the primary measurement. The number of mitoses per fin and chromosomal (anaphase) aberrations will be assessed from subsets of larvae at the point of yolk resorption. Data will also be collected to determine graded severity indices (morphological defects), condition of interphase cells, and number of degenerating cells. Several secondary parameters will be observed periodically to determine fertility, hatching, death, and larval viability. Genetic observations will be completed after preservation.

b. Herring will be collected from multiple locations throughout PWS, aged, and crossed. Additional herring will be similarly crossed from a control location, Sitka Sound. The goal is to obtain 25 fish from each age class at each location. The eggs will be incubated in individual containers at the Auke Bay Laboratory (ABL) until hatch. Larval viability will be judged at hatch for each female, age class, and location. Hatch timing, percent fertile, morphological abnormalities, and egg survival will also be recorded. Researchers from ABL will work closely with ADF&G to collect fish; age, length, weight, and VHN samples can be collected at the same time, thus integrating state and federal research objectives.

3. Schedule

1994 brood year: finish analyses and reports. Mar 1995
1995 Brood year:

1. reproductive impairment survey in PWS: Feb - Jun 1995
2. Laboratory exposures: Jan - Jun 1995

3. Chemical and contract analyses: Jul - Nov 1995
4. Data analysis and final report: Dec 95-Apr 96

4. Technical support

All egg and larval culturing and chemical analyses will be conducted at ABL. Chemists at ABL will participate in oil dosing and analysis. Computer services, data archiving, and GIS mapping are all services available in-house at the Auke Bay Laboratory. Herring researchers at ABL will work closely with ADF&G to obtain herring and spawn in PWS, so that age, length, weight, and disease sampling are all from the same spawning sites. We will ask ADF&G to age all of the adult herring spawned. Analysis of genetic aberrations will be contracted out.

5. Location

Herring impairment samples will be collected in PWS and at Sitka (control site). All lab exposures and rearing will be at ABL.

E. PROJECT IMPLEMENTATION

Project would be implemented by NOAA/NMFS/Auke Bay Laboratory with interagency cooperation with ADF&G and the SEA plan. Researchers at the Auke Bay Laboratory are uniquely suited to complete this project because of their expertise and knowledge in culture and maintenance of adult, egg, and larval herring, their history of oil related research (including herring), continuity of similar research completed in 1994, and hydrocarbon analytical facilities.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project is an integral component of the suite of herring studies in the SEA plan. Reproductive impairment sample collection will be integrated with herring disease and spawn deposition research.

G. PUBLIC PROCESS

When available, data will be presented in a public forum.

H. PERSONNEL QUALIFICATIONS

GS-14 Physiologist - Stanley D. Rice

Received BA (1966) and MA (1968) in Biology from Chico State University, and PhD (1971) in Comparative Physiology from Kent State University. Employed at Auke Bay Fisheries Laboratory since 1971 as a research physiologist, task leader and Habitat Program Manager since 1986. Rice has researched oil effects problems since 1971, and has published over 70 papers, including over 50 on oil effects. Studies have ranged from field to lab tests, behavioral to physiological to biochemical studies, from salmonids to invertebrates to larvae to meiofauna. Rice has conducted and managed soft funded projects since 1974, including the Auke Bay Laboratory *Exxon Valdez* damage assessment studies since 1989. Activities since the oil spill have included leadership and management of up to 10 damage assessment projects, field work in PWS, direct research effort in some studies, establishment of state of the art chemistry labs and analyses in response to the spill, quality assurance procedures in biological-chemical-statistical analyses, establishment of hydrocarbon database management, servicing principal investigators and program managers in NOAA and other agencies with reviews and interpretations, provided direct input into agency decisions, interacted with other agencies in various ways (logistics coordination, critique experimental designs, interpret observations, etc.).

GS-12 Fishery Biologist - Mark G. Carls

Received BA (1975) in Biology from Gustavus Adolphus College, St. Peter, MN, and MS (1978) in Biological Oceanography from Dalhousie University, Halifax, Nova Scotia. Mark has been employed at the Auke Bay Fisheries Laboratory since 1979. His principal involvement has been in research of petroleum hydrocarbon toxicology to marine fish and invertebrates, including egg, larval, and adult life stages. Mark has published 12 papers, and has 5 *Exxon Valdez* damage assessment papers pending publication. Since 1989, he has been involved as a principal investigator and co-investigator on several studies resulting from the *Exxon Valdez* oil spill.

I. BUDGET

A. Project - $234.8K (FY95)

Personnel	$122.9K
Travel	18.5K
Contracts	42.0K
Commodities	25.0K
Equipment	5.0K
Capital Outlay	0.0K
Sub-total	213.4K
General Administration	21.4K
TOTAL	$234.8K

B. Comprehensive Reporting - $119.2K (FY96)

Personnel	$ 96.7K
Travel	4.0K
Contracts	0.0K
Commodities	4.0K
Equipment	0.0K
Capital Outlay	0.0K
Sub-total	104.7K
General Administration	14.5K
TOTAL	$119.2K

Population Structure of Blue Mussels in Relation to Levels of Oiling and Densities of Vertebrate Predators

Project Number: 95075

Project Leader: Charles E. O'Clair

Lead Agency: National Marine Fisheries Service

Project Cost: FY 95 $233.6K FY96 $317.7K

Start Date: March, 1995

Finish Date: December, 1996

Project Duration: 2 years

Geographic Area : Prince William Sound

Contact Person:
Bruce Wright
National Marine Fisheries Service
Office of Oil Spill Damage Assessment and Restoration
P. O. Box 210029
Auke Bay, Alaska 99821
907-789-6600

B. INTRODUCTION

The blue mussel, *Mytilus trossulus*, is a dominant member of intertidal communities in Prince William Sound where mussel populations were injured by the *Exxon Valdez* oil spill (EVOS) to the extent that mussels continue to limit the recovery of a few key predator species. Sea otters (*Enhydra lutris),* harlequin ducks (*Histrionicus histrionicus*) and black oystercatchers (*Haematopus bachmani)* feed on mussels and other species in mussel beds. Although black oystercatchers are considered to be recovering from the EVOS, sea otters and harlequin ducks are not. There are two possible reasons for the continuing impacts: (1) heavy oil contamination of some mussel beds is exerting a direct toxicological effect on vertebrate predators; (2) oil pollution has had an impact on mussel abundance and population structure. Previous studies have confirmed the continuing oil-contamination of some mussel beds, but those studies have not examined mussel population structure, mussel growth or biomass distribution. Food limitation and changes in benthic community structure are important factors influencing the recovery of some injured resources (eg. sea otters). Because mussels represent a major part of the diet of young sea otters and females with large dependent pups, and because mussels are an important component of the diet of harlequin ducks in PWS, recovery of these species may be constrained by reduced prey abundance or biomass. Mussels provide spatial complexity, interact strongly with other occupiers of space and act as prey for a broad range of invertebrate and vertebrate predators. Changes in mussel abundance often result in major changes in intertidal community structure which could, in turn, affect recovery of vertebrate predators that forage in the intertidal region.

This project will coordinate with the vertebrate predator subgroup of the PWS nearshore ecosystem work group (by selecting study locations in accordance with known predator densities and predator use information). This project will measure the abundance, size distribution and growth of mussels in populations at oiled and unoiled locations and relate the measurements to known predator densities. The project will also coordinate with the mussel bed restoration study (by occupying the same sites and sharing chemistry data where appropriate).

C. NEED FOR THE PROJECT

This project is designed to bridge the gap between the contamination monitoring and cleaning of mussel beds in the mussel bed restoration project and the needs of the vertebrate predator group. The project will determine the relative influence of mussel contamination and food limitation on the recovery of injured vertebrate species. This information will benefit those researchers monitoring the recovery of sea otters, harlequin ducks and black oystercatchers.

D. PROJECT DESIGN

1. Objectives

a. Determine the distribution and abundance of *Mytilus* along segments of the coast in Prince William Sound with and without oiled mussel beds and under different densities of vertebrate predators.

b. Compare the size structure of populations of *Mytilus* in oiled vs unoiled habitats and under low vs high vertebrate predation pressure in Prince William Sound.

c. Measure growth of *Mytilus* in oiled and unoiled habitats and under low and high vertebrate predation pressure.

d. Compare concentrations of hydrocarbons in tissues of *Mytilus* in oiled and unoiled habitats. (This objective would supplement the chemical analyses of the mussel bed restoration project where needed).

2. Methods

The distribution and abundance of mussels will be determined over lengths of coastline to be determined by the vertebrate predator subgroup. Within a particular segment of coast mussel abundance will be estimated using stratified random sampling with proportional allocation. Mussel densities will be estimated using 1/16 m^2 quadrats. Each length of shore will be divided into segments of bedrock, unconsolidated coarse substrate and unconsolidated fine substrate. Sample size will depend on mussel density. Mussels in the quadrats will be counted and maximum shell length will be measured. Mussel tissues will be dried and weighed on a precision balance. Individual mussels from each substrate type in each segment of coast and in each oiled mussel bed will be tagged with calcein to measure growth. Mussels will be tagged and released at intervals of three months. Tagged individuals will be retrieved and growth measured at the end of each three month period.

Mussels will be collected for tissue hydrocarbon analysis immediately adjacent to a subset of the randomly placed quadrats used for density estimates. Three composite samples of mussels will be collected from oiled and unoiled mussel beds along each stretch of coastline. Samples will be placed in coolers with ice immediately after collection and will be frozen within an hour. Appropriate blanks will be collected at each site. Chain of custody procedures will be followed after collection of all hydrocarbon samples.

3. Schedule

Mussel sampling will be conducted in May, July and September 1995. Mussels will be tagged for growth in May, July, September and November 1995 and February and April 1996. Laboratory and chemical analyses will be completed by August 1996. Data compilation and computer analysis will be completed by October 1996. A final report will be completed by December 1996.

4. Technical Support

The project will require technical support in hydrocarbon chemistry (UV spectrophotometry and gas chromatography/mass spectrometry). The chemistry will be performed at the Auke Bay Laboratory. The cost of the hydrocarbon chemistry is included in the project budget. Vessel charters will be required to support the field sampling.

5. Location

The project will be undertaken at a minimum of four segments of coastline in Prince William Sound (2 in an area of low vertebrate predator density and 2 in an area of high vertebrate predator density). Each coastal segment will include at least one oiled mussel bed. Each substrate type will be sampled in each coastal segment. The exact coastal segments sampled will be selected in consultation with the vertebrate predator subgroup.

E. PROJECT IMPLEMENTATION

The project will be implemented by the Auke Bay Laboratory. The Auke Bay Laboratory is currently participating in the Mussel Bed Restoration and Monitoring Project and therefore information on site selection and existing data on recently studied mussel beds in Prince William Sound should be readily available to the present project. The Auke Bay Laboratory has unique expertise in and extensive experience with mussel beds in Prince William Sound.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

This project will be closely coordinated with the vertebrate predator subgroup, with any mussel recruitment projects that are proposed and with two ongoing restoration projects, the Mussel Bed Restoration and Monitoring Project and the Hydrocarbon Data Analysis and Interpretation Project. Sampling by the present project will be closely coordinated with the Mussel Bed Restoration and Monitoring Project occupying the same sites and sharing chemical analyses where appropriate.

G. PUBLIC PROCESS

The Public Advisory Group will be consulted to determine the nature of the information on this project that should be communicated to the public and to determine the mechanism by which the information should be communicated.

H. PERSONNEL QUALIFICATIONS

GS-12 Fishery Research Biologist - Charles E. O'Clair

University of Massachusetts, B.S., Zoology, 1963; University of Washington, Ph.D., Fisheries, 1977

Experience: 1977 - present: Fishery Biologist (Research), National Marine Fisheries Service, Auke Bay Laboratory, Juneau, Alaska. Research experience includes seven years of field and laboratory work on the effects of oil pollution and, later, the effects of logging on benthic invertebrates, eleven years of research on the ecology and behavior of Dungeness, king, and Tanner crabs in relation to the management of these species, four years of research on the impact of the *Exxon Valdez* oil spill on subtidal sediments in Prince William Sound and the Gulf of Alaska and one year on the recovery of subtidal sediments in PWS Sound.

I. BUDGET

A. Project - $197.5K (FY95)

Personnel	$ 94.0K
Travel	20.0K
Contracts	48.0K
Commodities	18.0K
Equipment	0.0K
Capital Outlay	0.0K
Sub-total	180.0K
General Administration	17.5K
TOTAL	$197.5K

B. Comprehensive Reporting - $116.6K (FY96)

Personnel	$ 94.0K
Travel	4.0K
Contracts	0.0K
Commodities	4.5K
Equipment	0.0K
Capital Outlay	0.0K
Sub-total	102.5K
General Administration	14.1K
TOTAL	$116.6K

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Effects of Oiled Incubation Substrate on Survival and Straying of Wild Pink Salmon

Project Number: 95076

Project Leaders: Alex C. Wertheimer, National Marine Fisheries Service
Stanley D. Rice, National Marine Fisheries Service
Ron A. Heintz, National Marine Fisheries Service
Adrian G. Celewycz, National Marine Fisheries Service

Lead Agency: National Marine Fisheries Service

Project Cost:
FY95: $179.9K
FY96: $310.9K
FY97: $361.3K
FY98: $286.7K
FY99: $241.6K

Start Date: January, 1995

Finish Date: September, 1999

Project Duration: 5 years

Geographic Area: Little Port Walter, Baranof Island, Alaska

Contact person:
Bruce Wright, NMFS
National Marine Fisheries Service
Office of Oil Spill Damage Assessment and Restoration
P. O. Box 210029
Auke Bay, AK 99821
907-789-6600

B. INTRODUCTION

The toxicological effects of the Exxon Valdez oil spill on pink salmon in Prince William Sound (PWS) remain a high priority research issue. Since 1991, the pink salmon returns to PWS have declined precipitously. Prior NRDA research projects have documented reduced survival of pink salmon embryos exposed to oil during incubation, and have suggested that the damage may be heritable, thus impacting subsequent generations of fish. High straying rates for pink salmon have also been observed in PWS since the oil spill: straying rates of wild pink salmon returning to PWS in 1991 ranged from 8 to 54% in three streams in oiled locations, and from 11 to 51% in three streams in non-oiled locations (NRDA F/S Study No. 3).

The effect of oil exposure on straying rates of pink salmon is unknown. Increased straying rates may result from disruption of the imprinting process caused by incubation in oiled substrate. Highly conserved characters such as emergence timing are disrupted by incubation in oiled substrate (Restoration Study No. 94191). A confounding factor in the previous NRDA research on straying was that even fish from non-oiled streams were probably exposed to oil during their saltwater migrations. In addition, too few replicates were used to evaluate differences in straying, given the observed variation. Pink salmon in this proposed study will be exposed to oil only during the incubation phase, and then released to migrate to the Gulf of Alaska through the non-oiled waters of southeast Alaska. The effects of exposure on straying rates will be determined from the returning adults. The study will also provide information that either validates the high straying rates documented for PWS pink salmon in NRDA F/S Study No. 3778778, or that identifies factors unrelated to oiling that could have caused the observed straying.

Whether incubation in oiled substrate can cause genetic damage is also being examined (Restoration Study No. 94191), and this proposed study will examine the potential for further genetic damage to populations resulting from introgression with straying salmon. This proposed study will complement Restoration Study No. 94191 by providing estimates of marine survival for wild pink salmon exposed to different levels of oil in the incubation substrate and by providing gametes for further analysis of the genetic damage hypothesis.

C. NEED FOR THE PROJECT

Reliable estimates of the straying rate and heritable damage of wild pink salmon are essential for the effective restoration of the damaged pink salmon population in PWS. Since the Exxon Valdez oil spill, returns of wild pink salmon to PWS have been poor, the full extent of injury is still unknown, and the exact mechanism of injury is unclear. Stock separation information to help management protection of damaged stocks has been identified as a high priority general restoration technique, but without knowledge of straying rate, stock separation information is of limited value. Little is known about the straying rate of wild pink salmon even without the confounding effect of oil in the environment. If straying rates as high as 50% occur without any influence from oil, then restoration of damaged pink salmon runs can be expected to occur naturally through recolonization from healthy stream systems. However, if the presence of oil increases straying, fisheries managers must be aware that genetic damage hypothesized to occur as a result of incubation in oiled substrate may be passed on to pink salmon in streams originally not oiled by the Exxon Valdez. Thus, damage to wild salmon populations may be more widespread and persistent than previously conceived. Documenting a greater degree of damage could allow additional damage claims under the civil settlement.

The degree of straying of wild pink salmon is also an important facet in the current controversy involving the effects of large-scale enhancement on wild pink salmon populations in PWS. If the high straying rates for wild fish observed in NRDA F/S Study No. 3 are representative of normal rates, then genetic structure of the populations in the region should be relatively homogeneous and large-scale mixing of wild stocks and the hatchery stocks derived from them should be of minor concern. If, however, oil exposure or hatchery practices have artificially increased the straying rates, and rates are normally low, then the genetic diversity among and within wild stocks may be in jeopardy from increased straying.

D. PROJECT DESIGN

This project has been designed with two components. Component A will examine the effect of oil exposure during embryonic development on marine survival, straying, and gamete viability. Comparisons of straying rates in Component A are valid for dosage response and can stand alone as an experiment, but estimation of actual straying rates is confounded by other factors. Component B evaluates the influence of factors such as the incubation environment, stock, and tagging, on straying. Component B greatly strengthens the evaluation of straying by controlling for these other factors, and is extremely cost-effective because of the resources necessary for Component A: Component B represents approximately 10-15% of the annual cost of the project.

1. Objectives

The objectives of Component A are to expose pink salmon to oil during egg incubation in a simulated intertidal environment, release the fry into salt water, and determine the effect on: 1) straying, 2) marine survival, and 3) gamete viability of returning adults. The objectives of Component B are to determine the influences on straying behavior of 1) incubation environment, 2) stock, and 3) coded-wire tagging.

2. Methods

a. Component A - Pink salmon eggs from two brood years will be incubated in a controlled simulation of oiled intertidal habitat which occurred in Prince William Sound after the Exxon Valdez oil spill. Pink salmon gametes will be collected in the fall of 1995 and 1996 from Lover's Cove Creek, Big Port Walter, Baranof Island, southeast Alaska and transported to the nearby NMFS research station at Little Port Walter (LPW). The fertilized eggs will be incubated at LPW under one of four treatments of oiled gravel: control, low oil, medium oil, and high oil. Eggs will be exposed to salt water for 4-hour intervals every 12 hours to simulate an intertidal environment. Dosing levels will be established by analyzing hydrocarbon concentrations in incubator effluent, substrate, and fish tissue with gas chromatograph and mass spectroscopy (GC/MS) at each major developmental stage: eyeing, hatching, and emergence. For each treatment group, survival to eyeing and emergence, and size at emergence and release will be determined. In the spring of 1996 and 1997, a total of 120,000 pink salmon fry (30,000 per treatment) will be coded-wire tagged (CWT, 3 code lots per treatment) each year before being released into salt water at LPW. An analysis of power indicates 80% certainty that differences in straying of 3-5% between treatments will be detected 95% of the time.

Marine survival and straying rates for the different treatment groups will be determined from the tagged adult pink salmon returning to spawn at LPW and the surrounding area in the fall of 1997 and 1998. Weirs will be set up across Sashin Creek (LPW) and Lover's Cove Creek to collect the adult fish. Additionally, tagged pink salmon will be collected from the Port Armstrong hatchery south of LPW and from streams on the eastern shore of Baranof Island within 20 km north and south of LPW.

Gamete viability and offspring survival to emergence will be determined for each treatment group in each brood year. Gametes from surviving adult pink salmon from each treatment group will be collected, crossed and incubated in a clean environment. Because incubation for the second generation will occur in a clean environment, differences in survival, size, or number of defective individuals can be attributed to oiling effects upon the first generation.

b. Component B - Pink salmon gametes will be collected from Sashin Creek concurrently with the egg-takes from Lovers' Cove Creek. The Sashin Creek pink salmon population is composed predominately of upstream spawners, while the Lovers' Cove Creek stock is composed predominately of intertidal spawners. Gametes from both stocks will be incubated in both the simulated intertidal environment used for Component A, and in freshwater only (to simulate an upstream environment). For each treatment group, 30,000 fry will be marked with CWTs (3 code lots per treatment. This requires an additional 90,000 fry to be tagged beyond Component A, since the control group in Component A doubles as a treatment in this experiment. In addition to these groups, wild fry emigrating from Sashin Creek and Lovers' Cove Creek in 1996 and 1997 will be captured, marked, and released. From each stream, 30,000 fry will be tagged with CWTs (3 code lots) and 30,000 fry will receive a ventral fin clip.

Tagged and fin-clipped adults from Component B releases will be recovered with no additional effort or resources than those necessary for Component A. Straying rates from the release groups in Component B will be compared to determine the effects on straying of: 1)incubation environment (freshwater vs. intertidal); 2)population origin (upstream population vs. intertidal population); 3) coded-wire tagging (ventral fin-clips vs. CWT wild fry); and 4) hatchery treatment (artificially spawned, and incubated fry vs. wild fry).

3. Schedule (see figure)

Date	Activity
1/95	Initiate procurements, hiring, contracts needed for project
6/95	Reconfigure LPW wetlab for experimental design
7/95	Set up incubators for 1995 brood
8/95	Oil gravel, spawn pink salmon (1995 brood)
9/95-3/96	Incubation, 44 GC/MS samples collected
3/96	Install weirs for collecting 1995 brood wild fry
4/96	Tagging and release of 1995 brood hatchery and wild fry
4/96	Annual Report
6/96	Contract deliverable, 44 GC/MS samples from 1995 brood
7/96	Set up incubators for 1996 brood

8/96	Oil gravel, spawn pink salmon (1996 brood)
9/96-3/97	Incubation, 44 GC/MS samples collected (1996 Brood)
4/97	Tagging and release of 1996 brood hatchery and wild fry
4/97	Annual Report
6/97	Contract deliverable, 44 GC/MS samples from 1995 brood
7/97	Install weirs for collecting returning 1995BY adults
8-9/97	Recovery and spawning of returning adults (95 brood) Contract deliverable, Port Armstrong Hatchery
9/97-3/98	Incubation of gametes from returning adults
4/98	Annual report
7/98	Install weirs for collecting returning 1996BY adults
8-9/98	Recovery and spawning of returning adults (96 brood) Contract deliverable, Port Armstrong Hatchery
9/98-3/99	Incubation of gametes from returning adults
4/99	Annual report
9/99	Final report

4. Technical Support

A biometrician will ensure that the study design provides a reasonable chance of reaching statistically valid conclusions. A chemist will establish a dosing protocol, determine hydrocarbon concentrations, and evaluate results of hydrocarbon analysis. The US Forest Service will provide use of a cabin at Lover's Cove Creek. Computer services, data archiving, tagging equipment, incubation facilities, vessel support, and a weir at Sashin Creek will be provided by the Auke Bay Laboratory.

5. Location

Gametes will be collected from Lover's Cove Creek and Sashin Creek, Baranof Island, southeast Alaska. Eggs will be incubated, and pink salmon fry will be tagged at the NMFS research station at Little Port Walter (LPW), located near the mouth of Sashin Creek, 10 km from Lover's Cove Creek. Returning adult pink salmon will be recovered from streams on the east coast of Baranof Island within 50 km of LPW.

E. PROJECT IMPLEMENTATION

The NMFS, Auke Bay Laboratory will implement this project. The NMFS will provide use of the research station at LPW as a base for the proposed fieldwork. This station will provide housing for project personnel, a wet lab for egg incubation, a weir across Sashin Creek for recovery of adult pink salmon, microscopes for the decoding of CWTs, and facilities for the spawning of adult pink salmon. The Auke Bay Laboratory will provide three tagging machines, vessel support, and computer services. The GC/MS samples will be analyzed under contract with the Auke Bay Laboratory. The Port Armstrong Hatchery will be contracted to provide any returning adult pink salmon that have strayed to this facility. Materials and personnel will be transported to and from LPW via the NOAA vessel R/V John N. Cobb and air taxi charters.

In addition to all the services mentioned above, the Auke Bay Laboratory has the technical expertise needed to implement this project. The principle investigator and each co-investigator have been involved with the NRDA process since the Exxon Valdez first ran aground on Bligh Reef in 1989.

F. COORDINATION OF INTEGRATED RESEARCH EFFORT

Research by NMFS on effects of oil exposure to pink salmon has been closely coordinated with concurrent research efforts by ADF&G and UAF. This project directly complements Restoration Study No. 94191 and will be fully coordinated with its continuation.

G. PUBLIC PROCESS

The necessity of examining the toxicological impacts of oil on the pink salmon resource of PWS, especially in relation to heritable genetic damage, has been identified in scientific workshops and public forums. It has been flagged as a high priority research issue in the Invitation for Projects. This project will continue to receive public review through the PAG and public review process established by the Trustee Council.

H. PERSONNEL QUALIFICATIONS

GS-14 Physiologist - Stanley D. Rice

Received BA (1966) and MA (1968) in Biology from Chico State University, and PhD (1971) in Comparative Physiology from Kent State University. Employed at Auke Bay Fisheries Laboratory since 1971 as a research physiologist, task leader and Habitat Program Manager since 1986. Rice has researched oil effects problems since 1971, and has published over 70 papers, including over 50 on oil effects. Studies have ranged from field to lab tests, behavioral to physiological to biochemical studies, from salmonids to invertebrates to larvae to meiofauna. Rice has conducted and managed soft funded projects since 1974 , including the Auke Bay Laboratory *Exxon Valdez* damage assessment studies since 1989. Activities since the oil spill have included leadership and management of up to 10 damage assessment projects, field work in PWS, direct research effort in some studies, establishment of state of the art chemistry labs and analyses in response to the spill, quality assurance procedures in biological-chemical-statistical analyses, establishment of hydrocarbon database management, servicing principal investigators and program managers in NOAA and other agencies with reviews and interpretations, provided direct input into agency decisions, interacted with other agencies in various ways (logistics coordination, critique experimental designs, interpret observations, etc.).

GS-13 Fishery Biologist - Alex C. Wertheimer

BS Fisheries Science, Oregon State University (1979); MS Fisheries Science, University of Alaska (1984). Currently employed by National Marine Fisheries Service, Auke Bay Laboratory as a Supervisory Fishery Biologist, Task Leader of Early Ocean Salmon Research. Author of over 20 peer-reviewed papers and 30 agency reports on various aspects of the biology and culture of Pacific salmon. Research on Pacific salmon has included determining early marine growth, distribution, and migration; in nearshore habitat utilization; predator/prey relationships; by-catch mortality; the effects of hydrocarbon contamination on juvenile salmon in the marine environment; the association of early marine conditions with year-class success of salmon; salmon aquaculture and genetics; and status of stocks. Principle Investigator *Exxon Valdez* NRDA Fish/Shellfish 4, NMFS Component, 1989 through project completion in 1993.

GS-11 Fisheries Biologist (Research) - Ron A. Heintz

BS Ecology, University of Illinois (1979); MS Fisheries Science, University of Alaska (1986). He has worked for the National Marine Fisheries Service, Auke Bay Laboratory since 1985 concentrating his efforts on salmon enhancement research and salmon genetics. He is the principle investigator and co-investigator on several salmon genetics projects.

GS-11 Fisheries Biologist (Research) - Adrian G. Celewycz

BS Biology, University of Illinois (1979); MS Fisheries Science, University of Alaska (1985). He has worked for the National Marine Fisheries Service, Auke Bay Laboratory since 1981, studying distribution, growth, habitat utilization, predator/prey relationships of juvenile salmon migrations. In addition to being recognized as "The Outstanding Student of Fisheries and Science" by the University of Alaska at Juneau in 1985, he was awarded Certificates of Recognition for superior performance by NOAA in 1989, 1990, and 1993. He served as co-investigator on *Exxon Valdez* NRDA Fish/Shellfish Study No. 4, and was awarded Certificates of Recognition by NOAA for outstanding contributions serving the public trust in response to the *Exxon Valdez* oil spill in 1989 and 1990.

I. BUDGET

A. Project - $179.9K (FY95)

Personnel	$ 76.1K
Travel	5.8K
Contracts	5.8K
Commodities	56.4K
Equipment	24.0K
Capital Outlay	0.0K
Sub-total	168.1K
General Administration	11.8K
TOTAL	$179.9K

B. Comprehensive Reporting - $108.0K (FY96)

Personnel	$ 85.6K
Travel	4.0K
Contracts	0.0K
Commodities	5.6K
Equipment	0.0K
Capital Outlay	0.0K
Sub-total	95.2K
General Administration	12.8K
TOTAL	$108.0K

Recreation Impacts In Prince William Sound: Human Impact As A Factor Constraining Long Term Ecosystem Recovery

Project Number: 95077

Lead Agency: The National Outdoor Leadership School (NOLS)

Project Leader: Chris Monz NOLS Research Manager

Contact Person: Don Ford NOLS Alaska Branch Director
Box 981 Palmer, Alaska 99645
(907) 745-4047

NOLS Research Advisory Board Members

Geographic Area: Prince William Sound

Project Startup Date: 1/95

Duration: Five years

Introduction: As a consequence of the Exxon Valdez oil spill, recreation in Prince William Sound (PWS) has been significantly affected. Recreationalists are now seeking areas that have not been disturbed by the spill and heretofore received little or no use. Moreover, areas that have been previously impacted by recreation are now seeing additional visitation. The National Outdoor Leadership School (NOLS), for example, has altered sea kayaking routes since the spill, resulting in a concentration of use. Since many other kayakers, fishermen, and hunters use these areas the potential for degradation of these sites is high. Little is currently known about the extent of use in these areas, or the resistance, resilience and tolerance of specific sites to recreation disturbance.

The proposed research addresses the issue of human impact in Prince William Sound. Is human impact a factor constraining long term ecosystem recovery?

Results of this work will be provided to the Trustees, land management professionals and users to assist in appropriate utilization and management of the spill affected area.

NOLS Background: The National Outdoor Leadership School is a non-profit educational institution. Research, publications, outreach and training, and other programs are central to the school's mission to be a leader in wilderness education and research.

NOLS has been instructing expedition-length sea kayaking courses in the PWS area since 1971. As a consequence, we have extensive expertise on recreation areas, visitation, and user impact. This knowledge, combined with our research capacity, will contribute to an effective research process that results in usable and practical outcomes.

Approach And Objectives

We propose a three phase study with the following overall objectives

- qualifying and quantifying use and impact from recreationalists
- determining the tolerance of specific ecosystem types to user impact
- examination of ecosystem processes altered as a consequence of user disturbance

Phase I: Site Surveys and Assessment

Using monitoring and assessment techniques specifically designed for recreation sites (Marion, 1991; Cole, 1983), we would conduct an overall evaluation of recreation sites in the area. In addition, visitor, outfitter and land management surveys would be conducted to assay the numbers and demographics of area users. This would be a two year study and would consist of initial site identification and subsequent impact assessment and monitoring. Data from the initial identification and assessment would assist the development of Phases II and III.

Phase II: Site Tolerance to User Impact: Trampling and Experimental Camping

Although the information regarding the tolerance of specific sites to recreational disturbance is not extensive, accurate experimental methods have been developed (Cole, 1993) and studies have been conducted in many backcountry areas (Cole and Bayfield 1993; Holmes and Dobson, 1976; Kuss and Hall, 1991; Marion and Merriam, 1985, and others). We propose to employ the techniques suggested by Cole (1993) and initiate a five year study on at least four distinct soil-plant associations impacted by recreational use. This study would involve both experimental campsites and applied trampling treatments and examine vegetation resistance, resilience and tolerance to user impacts. Changes in plant species composition, soil compaction and beach erosion would also be quantified. The first three years would involve applied trampling and camping treatments and assessment. Extensive follow-up measurements would be conducted the fourth year, and conclusionary data analysis and publication would be conducted in the fifth year.

Phase III: Recreation Impact: Process Level Research

To date, much of the research pertaining to user impacts on wilderness sites has focused on documenting intensity of use and its impact on vegetation ground covers. This research has greatly improved our knowledge of site durability and where, on a continuum of sensitive to durable, different vegetation types lie.

However, this type of research has been somewhat limited in scope, focusing primarily on site durability and response to impact. More comprehensive research would extend these studies to an examination of the time required for recovery on impacted sites and of the processes that are involved in controlling the rate and success of recovery. We therefore propose to examine a range of ecosystem processes that could be affected by disturbance in conjunction with phase II (above). This would be a two year study with measurements and analysis conducted in year two and four. A partial list of ecosystem processes to be examined is included (Table 1).

Table 1. Proposed soil and plant properties to be measured as an assessment of ecosystem health in sites disturbed by recreation. Not all properties would be appropriate measures at all sites.

Soil Properties	Plant Properties
Organic Matter Content	Biomass Production
Microbial Biomass	Nutrient Analysis
Physical Characteristics	Structural Compounds
C and N Mineralization Potential	Anatomical Damage/Response
	Mycorrhizal Response

NOLS currently has the internal capabilities to conduct all of Phases I and II of this proposal and are collaborating with the Natural Resource Ecology Lab at Colorado State University to conduct the analytical aspects of Phase III.

Budget

Phase I. Site Inventory
2 years x $28,080/yr. + overhead costs $70,200

Phase II. Trampling and Camping
4 years (field) x 28, 580/yr + overhead costs
1yr (analysis) x 12,500/yr + overhead costs $158,525

Phase III. Process Level Research
2 years (field and lab) x $59,260/yr + overhead costs $148,150

Total for all phases, 5 years $376,875

Literature Cited

Cole, D.N. 1983. Monitoring the condition of wilderness campsites. U.S.D.A. Forest Service, Intermountain Forest and Range Experiment Station. Research Paper INT-302. Ogden, UT. 10 pp.

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Kuss, F.R. and Hall, C.N. 1991. Ground flora trampling studies: five years after closure. *Environmental Management*. 10: 637-650.

Marion, J.L. and Merriam, L.C. 1985. Recreational impacts on well-established campsites in the Boundary Waters Canoe Area Wilderness. Stn. Bull. AD-SB-2502. St. Paul, MN: University of Minnesota, Agricultural Experiment Station. 16 pp.

Marion, J. L. 1991 Developing a natural resource inventory and monitoring program for visitor impacts on recreational sites: A procedural manual. Natural resources report NPS/NRVT/NRR-91/06. U.S. Department of Interior, National Park Service. 59 pp.

Culture, History, and Ecosystems: An Assessment of Cultural/Historical Strategies to Building Long-term Understanding of Ecosystem Dynamics in the Exxon Valdez Oil Spill Area

Project Number: 95078

Name of Project Leader: Ted Birkedal, National Park Service, Alaska Region

Lead Agency: National Park Service

Cost of Project: $166,650

Project Start-up/Completion Dates: 10/94 to 3/96

Project Duration: 1.5 years

Geographic Area: Largely library research with on-site consultation with Native Alaskan communities in the vicinity of the Exxon Valdez oil spill area.

Contact Person: Ted Birkedal, Chief, Division of Cultural Resources, National Park Service, Alaska Region, 2525 Gambell St., Anchorage, AK 99503; Phone: (907)257-2668.

B. Introduction

What is proposed here is an assessment of the potential value of archeological, ethnographic, and historical research as sources of long-term comparative data for understanding the ecosystem processes that may be affecting the recovery of injured biological resources. Lack of a long-term perspective on ecosystem dynamics has made it difficult to identify which conditions or changes are related to natural fluctuations or shifts in the ecosystems in contrast to those that may be directly or indirectly linked to the Exxon Valdez oil spill event. In this study, archeological sites, traditional Native Alaskan knowledge, and the historical record would all be evaluated for their specific ability to shed light on the causal factors that might explain current downturns in the health and populations of species that occur on the injured list. Three reports are envisioned, one for each discipline represented--archeology, ethnography, and history.

C. Need for the project--Why the project will Help Restoration

If we are to understand how the Exxon Valdez oil spill event has altered or otherwise affected present-day nearshore and upland ecosystems and their constituent subsystem components, it is imperative to have a basis for comparison, a point of reference from which to identify and measure changes that might be directly or indirectly attributed to the spill. Ecosystems are not static clockworks, but dynamic systems in a constant state of change and, as emphasized by the paleoecologist E. C. Pielou, they are always characterized by a greater or lesser degree of disequilibrium. Thus, the basis for informed comparison is a moving target, not time-bound portraits of the ecological systems of the Gulf of Alaska as these appeared in a brief snapshot of time on the eve of the oil spill.

How then can we obtain this historical perspective on the ecosystems of the region? One promising source of this long-term ecological data is the archeological record of the area. Archeological sites may be likened to a vast array of fortuitous environmental sampling stations extending back into time. For a period of at least 6000 years, humans along the coast launched out from their settlements and camps and sampled the world about them in their daily subsistence pursuits. The accumulated debris from this massive, but inadvertent environmental sampling effort has been conveniently concentrated in the archeological sites. This record, though often coarse-grained, may offer answers to some of the questions posed by contemporary ecosystem scientists who are trying to discriminate between changes that have links to the oil spill and those that represent fluctuations in natural systems over time.

Another source of long-term data may be found through ethnographic research. Native Alaskans over the past millennia have accumulated a rich storehouse of information about the local environment, and though much of this knowledge has been lost of late, much still survives. The survival of coastal Native peoples has always depended on accurate, empirical observations about the world and the challenges of the environment.

Historical archives may also offer valued information on the operation of the environment in the past. Old fisheries statistics and similar records have already been employed by biological scientists searching for answers in the past to inform the present. It is likely that there is much more to discover, particularly in the broader array of historical sources including personal diaries, official reports and correspondence by both industry and government, the observations of early scientists, etc. The newly-emerged fields of climate history and environmental history have already developed a solid track record in ecological research related to agricultural fluctuations and changes in plant cover over time in other areas (particularly northwest Europe). Based on this success, it is likely that the same approaches could be applied to the acquisition of a historical understanding of coastal ecosystems in the Gulf of Alaska.

The proposed project would explore and evaluate the potential of these archeological, ethnographic, and historical sources to provide answers to key questions about long-term ecosystem change and stability in the region, that would in turn provide the understanding necessary to determining what current changes in the environment are either directly or indirectly attributable to the oil spill. If the findings demonstrate that this potential can be realized in a timely manner through reasonable outlays of funds and effort, then follow-up research programs to compile and analyze the data could be developed and implemented in subsequent years.

D. Project Design--Objectives, Methods

1. Objectives: The purpose of the project is to provide professional evaluations of archeological, ethnographic, and historical data as sources for understanding long-term

ecosystem dynamics in the area of the Exxon Valdez oil spill. These assessments will help biological scientists and the Trustees decide whether or not the future acquisition and analysis of such data would have utility in discriminating between injured species recovery problems that are linked to the oil spill and those that are associated with natural fluctuations in natural systems. Separate evaluative reports, specifically designed for a biological scientist audience, would be produced for each of the three data sources.

2. Methods: In the case of the archeological and historical assessments the studies would be limited to library research. First, the principal investigators would review the existing literature relevant to the topic of inquiry. Second, on the basis of this review, they would evaluate the specific potential of their discipline to address questions of interest to biological scientists that are attempting to add time depth to their descriptions and explanations of ecosystem operation and understand factors that influence the relative success of select component species (i.e., harbor seals, herring) over time (100+ years). Third, if the evaluations clearly demonstrate that significant contributions can be made through programs of reasonable and practical future research, the investigators will outline, recommend, and prioritize the lines of inquiry that are considered to be the most productive from the stand point of cost/benefits.

For the most part, the ethnographic assessment will follow the same basic steps and emphasize literature review and evaluation. However, because ethnographic research demands the active participation and cooperation of the Native Alaskan communities that will assist any future research as collaborative researchers, close consultation with Native communities in the area of the Exxon Valdez oil spill will be required. Contact with members of these communities will also be required to ascertain the level and kind of traditional knowledge that exists today. A large number of the Native elders that were keepers of traditional knowledge about the local environment only a few years ago have since passed away or have acquired health problems that could preclude their participation in collaborative research.

The draft reports that are generated by these inquiries would not only be subject to standard peer review, they would also be distributed to key biological scientists engaged in ecosystem and injured species research for their review. Finally, the participating researchers in the three fields would review each others' products. The final reports would incorporate appropriate recommendations and corrections that emerged in the course of the review process.

3. Schedule:

a. Preparation of Research Plans/Scopes of Work: 8/94

b. Start of Work Under Plan: 10/94

c. Consultation With EVOS Scientists: Winter Workshop 95

d. Draft Reports Submitted: 8/95

e. Review of Draft Reports: 8/95 to 10/95

f. Final Reports Submitted: 1/96

g. Printing of Final Reports: 3/96

No fieldwork is required for the archeological and historical assessments. Consultation with Native groups and communities, however, will be an ongoing process that will be designed into the ethnographic evaluation.

4. Technical Support: Other than printing and minor archiving of data, no special technical support to the research will be needed.

5. Location: The work will largely take place in an office setting with occasional travel to archives, libraries, and workshops. The ethnographic research will differ somewhat in that several trips to Native Alaskan communities will be required to consult with elders holding traditional knowledge.

E. Project Implementation:

The National Park Service has assumed a lead role for this project to assure that there is an agency sponsor for the work. However, the National Park Service has no proprietary interest in the project. We invite the involvement of other Federal agencies and the state if they wish to participate and assume responsibility for one or more components of the work. In fact, the National Park Service would be more than willing to transfer its project lead role to another agency as long as there was strong assurance that the research would not significantly deviate from what is proposed here and that it be done well.

In this project, the work of the lead agency would be limited to project design, administration, and technical oversight. The actual research would be carried out by scholars with a demonstrated background in environmentally-oriented research within their respective disciplines. The services of these scholars would be obtained by means of competitive contracts and/or cooperative agreements with recognized educational institutions.

F. Coordination of Integrated Research Effort

The agency project manager will work closely with the Coordination Committee of the EVOS scientists and the EVOS Cultural Resource Working Group to insure that the work will properly address the need for archeological, ethnographic, and historical assessments of long-term ecosystem stability and change as outlined on page A-9 of the Draft Restoration Objectives and Strategies by Resource and Service. In addition, the principal investigators of the three studies will meet together at the winter EVOS science workshop, report on their progress to the assembled scientists and interested public, and seek corrective feedback on their work. The review of the EVOS scientists will also be sought for the draft reports. Finally, the principal investigator for the ethnographic study will develop appropriate and effective mechanisms for frequent consultation with the Native Alaskan communities in the oil spill area as well as collaborative researchers from these groups.

G. Public Process

The concept for this research strategy was introduced to the general public in the Draft Restoration Objectives and Strategies by Resource and Service Report(p.A-9). It was originally introduced and favorably discussed at the 1994 conference of EVOS scientists. As mentioned earlier, Native Alaskan participation will form an integral component of the ethnographic study. Progress on the research and preliminary findings for all three studies will be made known to the invited public at the annual EVOS winter science conference in 1995. Finally, each researcher will be asked to produce brief popular summaries of their findings and addition to the technical professional reports. These popular studies will be made available to the interested public through the EVOS Library in addition to the technical reports. Also, copies of the final technical report on the ethnographic assessment will be sent to all participating Native communities and groups together with multiple copies of the popular summary.

H. Personnel Qualifications

The National Park Service will serve in a project management role to oversee the production of the reports. Ted Birkedal(Ph.D.), Chief, Division of Cultural Resources, Alaska Region will serve as overall project manager. Birkedal has eighteen years of experience in the management of large-scale archeological, ethnographic, and historical projects. He will also draw upon the in-house staff expertise of the Regional Cultural Anthropologist(Tim Cochrane, Ph.D.), the Regional Archeologist(Gary Somers, Ph.D.) and the Regional Historian(Sandra Faulkner, M.A.) to assist in the technical oversight process.

The actual research will be performed by scholars enlisted through contracts and/or cooperative agreements with educational institutions. Every effort will be made to recruit leading researchers with strong backgrounds in environmental archeology, ethnography, and history.

I. Budget

1. Personnel: $12,000

2. Travel: $3,500

3. Contractual Services: $138,000

Archeology: $35,000(Includes travel, workshops, etc.)
History: $35,000(Includes travel, workshops, etc.)
Ethnography: $50,000(Includes travel to Native communities and fees for Native Alaskan collaborative researchers)
Printing: $18,000

4. Commodities: $1,000

5. Equipment: 0

6. Capital Outlay: 0

7. General Administration: $12,150

GRAND TOTAL: $166,650

Doc# 950616063

Project # 95079

RECEIVED
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EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

NERKA, Incorporated

A PROPOSAL TO THE *EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL

June 14, 1994

Pink Salmon Restoration through Small-Scale Hatchery Enhancement.

Principal Investigator: Jack M. Van Hyning, Ph.D.

Organizations: NERKA INC. and AQUABIONICS INC.

Suggested Funding:	FY 1995	$150,000
	96	75,000
	97	50,000
	98	50,000
	99	50,000
	2000	50,000

Start-up and Completion Dates: October 1, 1994 - December 31, 2000.

Duration: 6 years, 4 pink salmon cycles.

Area: South Bay, Perry Island, Prince William Sound.

Contact: Jack M. Van Hyning
PO Box 80165
Fairbanks, Alaska 99708
(907) 479-2476

95079

INTRODUCTION

Pink salmon in Prince William Sound are considered an injured resource which is not recovering. We propose to utilize our aquaculture operation and expertise at South Bay, Perry Island to enhance and increase the local pink salmon runs.

In addition to a large shellfish farm at this site (Aquabionics Inc.), we have a permit for a non-profit salmon hatchery (Nerka Inc., ADFG PNP Permit No. 1). A small hatchery operated during the late 1970's and early 1980's, but has been inactive for a number of years because of financial and personnel issues which have been resolved. In addition to the direct contribution of additional salmon to the fishery and escapement, we will monitor the environment and return of fish and contribute to an understanding of the factors that influence the productivity of the pink salmon stocks. There have been concerns expressed about the very large salmon hatcheries depressing the natural runs through competition, genetic mixing, overharvesting, etc. We propose to supplement the wild runs, without overwhelming them, and study the effects of incrementally increasing production.

NEED FOR THE PROJECT

The pink salmon resource was apparently injured by the oil spill and is showing little or no signs of recovery. There is thus the need for both direct additional recruitment of juveniles into a healthy ecosystem and an understanding of the dynamics of the system. We propose to contribute to both these needs.

PROJECT DESIGN

Objectives (Tasks):

1. To produce 10 million pink salmon fry by 1999 in a small, environmentally compatible hatchery.

2. To understand the ecosystem into which the pink salmon are introduced and the factors controlling population return of both wild and hatchery fish.

Methods:

Due to the short time frame available for preparation of this proposal, only a conceptual methodology is presented. Complete details can be presented later if the Council finds the concept of interest.

Each returning run will be carefully enumerated. The spawning areas are small and a complete count can be made by boat and on foot. Some fish will be collected for hatchery incubation. Lambert Lagoon and South Bay will be regarded as a study ecosystem and environmental data will be gathered on water temperature, salinity, turbidity, zooplankton abundance, predators, etc. The company trawler "New Wave" will trawl for predator fishes for several days each spring and skiffs and an anchored barge will be utilized for sampling and data collection. A proportion of the hatchery-raised fingerlings will be coded-wire tagged, or otherwise identified, for later identification.

Schedule:

The 1994 escapement of pink salmon will be enumerated during August-September, prior to contract funding. Project planning will begin during the fall and winter of 1994-95 as well as the procurement of equipment and permits. The ADFG salmon hatchery permit is still valid, but permits for salmon hatchery operation from the U.S. Forest Service and Alaska Department of Natural Resources have expired and will need to be reapplied for.

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Environmental monitoring will begin during March 1995 and continue through the contract period with emphasis on the spring and summer. Pinks are the only salmon spawning in the area and most are inter-tidal spawners. It is not possible to obtain any measure of downstream migration, but sampling of fry in the lagoon and bay for growth and survival will continue until they leave the area. Fry produced by the hatchery will be counted and sampled before release. Potential predators and competitors will also be sampled during the spring. Each summer's escapement will be counted during August and September and some eggs taken for
incubation. Data analysis will be conducted during the winter and a progress report submitted annually; a final report at the end of the contract.

Technical Support:

In addition to the Principal Investigator, the following will participate:
Dr. Steven Smith, biometrician with the University of Washington Center for Quantitative Studies in Fisheries, will be consulted for statistical analysis and computer programming.
Mr. Jeff Hetrick, manager of the Moose Pass Hatchery near Seward, will provide advice on hatchery design and operation.
Mr. Jon N. Van Hyning, a Prince William Sound commercial fishermen, will assist is sampling gear development, operation and maintenance.
Mr. Nate Hopkins, caretaker of the aquatic farm, with a few hired employees, will do the routine data collection and hatchery management.

Location:

All work except analysis and report preparation will be done at Perry Island, 25 miles southeast of Whittier. All fishermen and communities that are dependent on the pink salmon fishery, will benefit from the project. The outer areas of southern Perry Island had extensive oil deposition, but no oil penetrated into Lambert Lagoon, where the salmon spawning stream are located.

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PROJECT IMPLEMENTATION

The project should be done by Nerka Incorporated, a private non-profit salmon hatchery corporation, and Aquabionics Incorporated, an Alaskan consulting and sea food company specializing in shrimp fishing and oyster farming.

COORDINATION

This project will be fully coordinated with other related projects conducted by the University of Alaska, Alaska Department of Fish & Game, National Marine Fisheries Service, and the Forest Service.

PUBLIC PROCESS

No specific plans have been made, but the Principal Investigator will participate in any desired forum.

PERSONNEL QUALIFICATIONS

Jack M. Van Hyning will be Principal Investigator. He has B.S., M.S. and Ph.D. degrees in fisheries from the University of Washington, University of Miami, and Oregon State University, respectively, with 40 years experience in fisheries research and management with a specialty in salmonid population ecology. He was Marine Research Supervisor for the Oregon Fisheries Department, Associate Professor of Fisheries at the University of Alaska Fairbanks, and a private consultant and fish farmer. He is familiar with hatchery programs in Oregon and Prince William Sound and is finishing a study on the factors affecting the return of chum salmon to Norton Sound. He has been invited to present the findings at an Arctic Science Conference in Anchorage and Vladivostok, Russia.

Dr. Steven Smith has undergraduate degrees in statistics from Utah State University and a Ph.D. from the University of Washington in biomathematics. He worked with Dr. Van Hyning on Norton Sound chum salmon and is heavily involved with the Columbia River salmon problem.

Jon Van Hyning has as an Associate Degree in Fisheries Technology and has been a commercial fisherman in Prince William Sound for 10 years, including the development of a new deep-water shrimp fishery.

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BUDGET

Because of time constraints, the funding presented on the cover page is a very preliminary estimate. If the proposal is viewed with favor, we will submit a carefully drafted, realistic budget for further review. The 1995 budget covers the construction of a small, research hatchery. After that initial expense, annual expenses for time, travel, administration, etc. should be between $50,000 and $75,000. By the end of the contract period the project should be self-supporting in providing a continuing source of supplemental salmon to the fisheries of the Sound and an increased understanding of the possible benefits of small project salmon enhancement.

Project # 95080

DOC.#950616070 A

RECREATION RESTORATION PROJECT PROPOSAL

PROJECT NAME: Fleming Spit Recreation Area Enhancements

SPONSOR: The Cordova Sporting Club

PROJECT DESCRIPTION: Fleming Spit is located within the Cordova City limits and is within the Prince William Sound Recreation Project area. Fleming Spit is already the site of a strong terminal Coho sport fishery and in the last 4 years a fledgling King fishery has been started. The area is popular and accessible. The Cordova Sporting Club, a non-profit organization dedicated to the promotion and development of outdoor opportunities in the Cordova area, along with many other interested local agencies and groups, would propose a project funded by the Exxon Valdez Oil Spill (EVOS) civil settlement monies to improve the Fleming Spit site for added recreational use, safer access, and an improved and enlarged fishing area.

The ongoing recreational fisheries at Fleming Spit have been developed through the cooperation of the Sporting Club (CSC), the Alaska Department of Fish and Game (ADF&G), and Prince William Sound Aquaculture Corporation. The smolt release areas and the surrounding tidelands and beach areas where the fish return to, however, need to be enhanced and upgraded to handle the ever increasing pressure from local recreational fishermen as well as a growing number of tourists. Our proposal includes acquision of critical lands and tidelands in the immediate Fleming Spit area, a dredge and fill project to improve the existing smolt release ponds, a general clean-up of the area including the removal of a derelict barge, and the addition of a variety of recreational facilities.

Our proposal is broken down into two phases. Phase I focuses upon work that is directly related to enhancing the sport fishery in the area. Phase II includes projects and facilities that take advantage of other recreational opportunities that exist in the area such as camping. Our specific proposal including work tasks, facilities, and projected costs follows:

95080

Phase I:

Project/Task	Projected Cost
Acquire Parcel	$150,000
Dredge and Fill Operations/ (including engineering and permitting)	$150,000
Flood Plain Management (engineering)	$50,000
Surveying	$30,000
Barge Removal	$10,000
Composting Toilet Facilities	$30,000
Fishing Boardwalk (1,000 feet, 8 feet wide parallel to road with ramps and stairways.)	$300,000
Fish Cleaning Stations (two stations, 6 bays each)	$10,000
Off Street Parking (signs, curb stops, paving)	$20,000
Permanent Net Pens	$20,000
Total Cost/Phase I	$770,000

Phase II:

R.V. Campground (10-15 Units, electrical hookups, tables, fire pits)	$100,000
Sewerline Extension and R.V. Dumpstation	$450,000
Tent Platforms	$20,000
Covered Picnic Pavileon	$25,000
Total Cost/Phase II	$595,000
Total Cost/Project	**$1,365,000.00**

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We would anticipate that the total project would take 2 to 3 years to complete. A preliminary site plan depicting the approximate location of all proposed facilities is attached.

POTENTIAL CONFLICTS: We do not anticipate any significant or major conflicts. Fleming Spit and the recreational fishery there are enjoyed by local Cordovans and visitors alike from early spring through the Silver season in the fall. The Cordova Chamber of Commerce holds a Silver Salmon derby each fall and many people fish the area during that time. The Chamber has been a strong supporter of recreational development at the spit for years. Groups such as the Cordova Fly Fishers and the Cordova Trap and Gun Club support our recreational goals for the area as well.

This proposal also enjoys the support of other important local agencies and organizations. For example, the Alaska Department of Fish and Game has been a long time supporter. ADF&G has proposed a demonstration hatchery at the site in the past and it started the salmon release program there. The Sport Fish Division is a strong supporter and has indicated that it would provide matching funds for this project. Prince William Sound Aquaculture has expended its own monies over the past few years to keep the Silver and King fisheries going. It has also submitted a proposal to improve the rearing ponds to insure a better smolt survival rate.

The Division of Parks and Outdoor Recreation has considered Fleming Spit as a possible addition to the State Park System. Development at Fleming Spit is currently listed as a priority in the Department's Statewide Recreation Plan. The U.S. Forest Service has also demonstrated its support. Its staff have helped in the development of this proposal. Finally, this project has the strong support of the City of Cordova. It appears as a goal in the City's Overall Economic Development Plan. The City has developed plans and sought funding for this type of project since 1985. The land is already zoned for conservation and recreational uses by the Cordova Coastal Managment Plan. We have a willing seller for the land we want to acquire.

There are two potential conflicts which will need to be worked out however, we believe they are easily resolved. First, the Eyak Corporation has leased adjacent tidelands from the state for use as a log transfer facility. The leased area is a very large tract which extends into the fishing area. This area is not needed for the transport of logs and the actual facility is a good distance from where people fish. We believe we can work out an acceptable arrangement. Log trucks moving through the area pose a potential threat to pedestrians however, traffic control signs should be sufficient to mitigate that problem.

Second, there are often transient workers and other visitors who illegally camp on private lands and State owned tidelands in the area during the summer. We don't see this as a conflict because this project will enhance their camping experience by providing good clean places to camp complete with restroom facilities, dump stations, water, trash cans, and the like.

LINK TO EVOS INJURY: Since the oil spill in March, 1989, Prince William Sound commercial fisheries have declined drastically. A large majority of Cordova residents are involved in the fishing industry and because of the poor commercial seasons these residents have had increased free time and an increased need for sport caught fish. More and more of them have used the Fleming Spit area. The continued emotional impacts from the spill have also increased the need for recreational outlets and positive relationships with fishing for the people adversely affected. People have appeared to be hesitant and concerned about sport fishing in the oiled areas of the Sound and more and more of them have expressed an interest in and support for the enhanced fishery at Fleming Spit.

With the spill and the resultant media coverage, Prince William Sound has become an increasingly well known tourist destination. This is good for Cordova; with the decline in fishing since the spill, we need to concentrate on diversifying our economy. This area is an excellent location for facilities of this type because it is within walking distance of downtown and approximately 3,000 feet from the new Cordova Ferry Staging Area.

But there are also problems associated with the increase in visitors. These people need to have safe and accessible activities in the immediate area. Our desire would be to channel tourists to areas like Fleming Spit and relieve the recreational and fishing pressures on other fresh water spawning streams in the Copper River Delta area.

ECONOMIC FEASIBILITY: The enhancement of the Fleming Spit area and the recreational fishery would benefit an unlimited number of Cordova residents and visitors to Prince William Sound. The principal costs would be in land acquision and infrastructure inprovements. Maintenance of the facility/park could be financed through user fees on the campsites and the dump station, and user donations. As stated above, the City of Cordova, The Alaska Department of Fish and Game, the Division of Parks and Outdoor Recreation, the U.S. Forest Service, and Prince William Sound Aquaculture Corporation have all discussed and proposed enhancement projects for this area in the past. Following acquision of the land and construction of the facilities, the area could be turned over to one of these agencies. They would subsequesntly be responsible for the maintenance and upkeep of the improvements. PWSAC has been instrumental in obtaining the Coho and Chinook smolt and we see no reason why this won't continue.

CONSISTENCY WITH SURROUNDINGS: Fleming Spit is located on the edge of town directly on Orca Inlet. Because of the past efforts at

95080

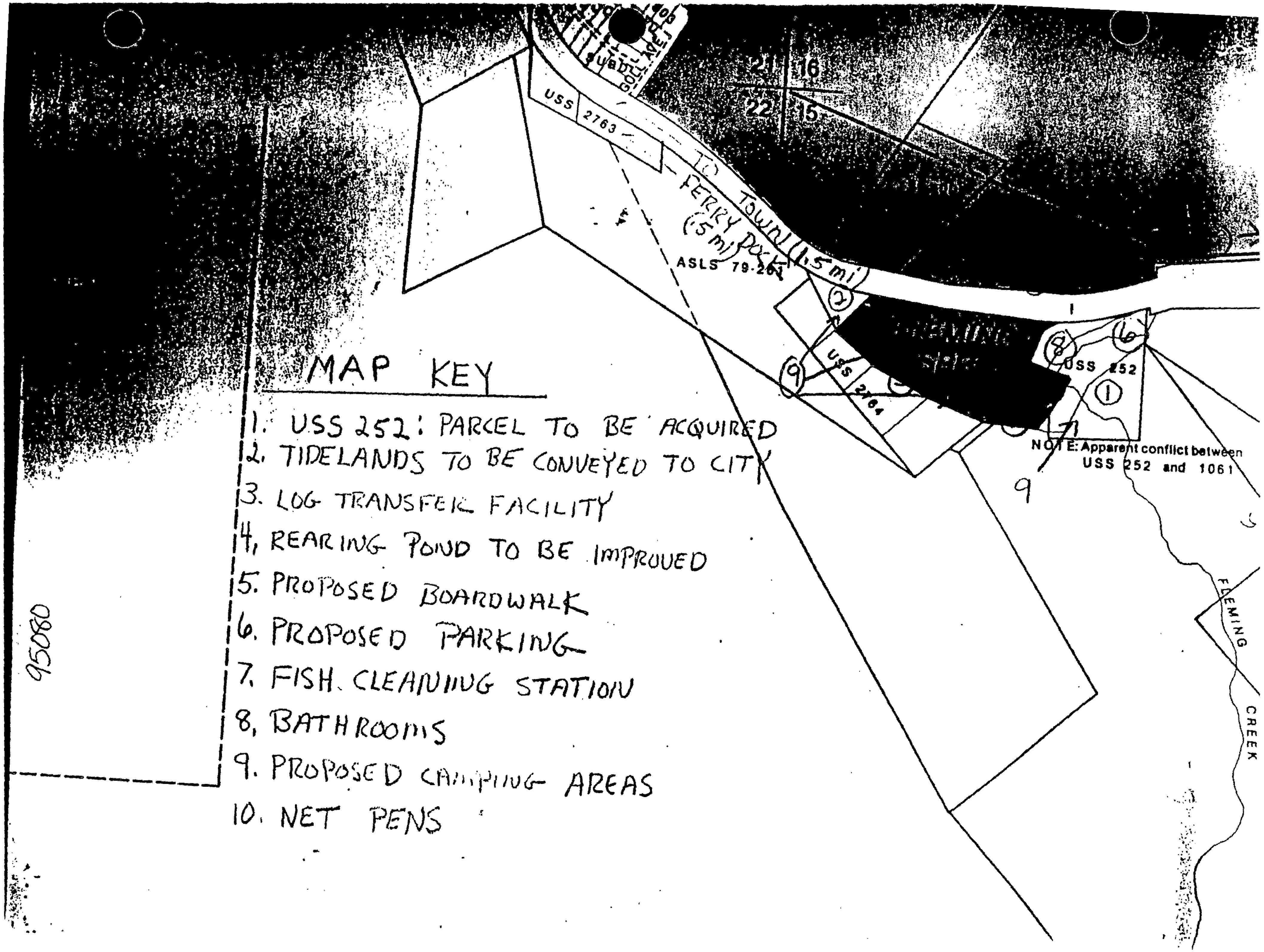
establishing the terminal Coho and Chinook runs, it has become a well known and heavily used "fishing hole". The area is accessible when weather prohibits boating and for those who don't have access to a boat suitable for the Inlet or one of the surrounding rivers or streams. Our project will increase the accessibility, the safety, and the appearance of the area. The existing smolt pond will be enlarged and improved to decrease the mortality rate among young salmon. The land is zoned for conservation and a recreation area is consistent with that designation.

NUMBER OF PEOPLE BENEFITTING: No established facilities are presently in place so accurate user counts are not available. However, it can be said that the improvement of the Fleming Spit area would benefit the entire population of Cordova. In addition, people using other parts of the Sound for recreation would be drawn to the enhanced fishery much as they are to the fisheries adjacent to the hatchery in Valdez. The Cordova Silver Salmon derby held in late August and easly September draws more and more entrants each year. The proposed improvements at Fleming Spit would allow more and more people access to the fish and would result in an expanded tourism industry for Cordova.

DISPLACEMENT OF CURRENT USERS: The only people being displaced would be transient campers who camp on private land and State owned tidelands during the summer months. These people would not really be displaced but rather, would be provided with a legitimate and significantly improved place to camp.

ADJACENT LAND MANAGEMENT: The tidelands immediately north of Fleming Spit are leased by the Eyak Corporation and used as a log transfer facility. We do not believe this presents a conflict with this project. Other surrounding tidelands are owned by the State of Alaska and the City of Cordova. Some of the uplands have private owners (including the parcel we hope to acquire). We would have to be sure that private landowners have legal access to their property. The rest of the uplands are owned by the State and the City. The area is zoned for Conservation; however, recreation projects are specifically permitted.

INFLUENCE ON OTHER PROJECTS: As stated above, the enhancement of the Fleming Spit area for recreation and sport fishing has been proposed and discussed by a number of agencies and other organizations over the years. Because legislation or budget allocations were not forthcoming, none of these proposals have come to fruition. No other use has been publically discussed for this area. All of the groups and agencies identified above would cooperate on the improvements proposed for Fleming Spit. It would be a community improvement and a project that everyone in Cordova could appreciate and use.



USS 2763
21 16
22 15
TO TOWN (1.5 mi)
FERRY DOCK (.5 mi)
ASLS 79-261
USS 2764
USS 252
NOTE: Apparent conflict between USS 252 and 1061
FLEMING CREEK
MAP KEY
1. USS 252: PARCEL TO BE ACQUIRED
2. TIDELANDS TO BE CONVEYED TO CITY
3. LOG TRANSFER FACILITY
4. REARING POND TO BE IMPROVED
5. PROPOSED BOARDWALK
6. PROPOSED PARKING
7. FISH CLEANING STATION
8. BATHROOMS
9. PROPOSED CAMPING AREAS
10. NET PENS

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Agenda of: 7/23/91

CITY OF CORDOVA, ALASKA

RESOLUTION 91-54

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF CORDOVA, ALASKA, IN SUPPORT OF ENHANCING SPORTFISHING ACCESS AND FACILITIES AT FLEMING SPIT

WHEREAS, the City of Cordova has been interested in enhancing and upgrading the Fleming Spit area for sportfishing activities for a number of years, and

WHEREAS, enhancement of sportfishing access and facilities will increase recreation opportunities for local residents and assist the City in its efforts to develop a tourism industry, and

WHEREAS, development of the Fleming Spit area for recreation purposes is a primary goal in the 1991 Cordova Overall Economic Development Plan, and

WHEREAS, the Alaska Department of Fish and Game has access to funds earmarked for the purpose of enhancing sportfishing opportunities and is very interested in working with the City on this type of development at Fleming Spit.

NOW THEREFORE BE IT RESOLVED, that the Cordova City Council fully supports the concept of enhancing sportfishing access and facilities at Fleming Spit and endorses the efforts of the Alaska Department of Fish and Game, and

BE IT FURTHER RESOLVED, that the Cordova City Council will assist and work with the Department wherever possible to achieve this goal.

PASSED AND APPROVED THIS 23rd DAY OF JULY, 1991.

Mayor Robert Van Brocklin

Lynda Plant, City Clerk

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DOC. #950616070 B

Project # 95082

RECREATION RESTORATION PROJECT PROPOSAL

PROJECT NAME: "Mor-Pac Hill" Campground Improvements

SPONSOR: The City of Cordova

PROJECT DESCRIPTION: Mor-Pac Hill is located directly across Railroad Avenue from the old Mor-Pac fish processing plant. It is less than a mile from downtown Cordova and a very short walk from the Cordova ferry dock. The Mor-Pac complex is under new ownership and is now known as Cannery Row Inc. Cannery Row Inc. owns the property that the campground is located on.

The existing campground contains 15 to 20 good campsites for tent campers. The site is located on a nine acre parcel and therefore, has the potential for a number of additional camp sites. The campground was constructed during the summer of 1989 as a direct result of the Exxon Valdez oil spill. During that period, the City was inundated with clean-up workers, people seeking work on the clean-up, and various other visitors. The City had no legitimate campground at that time and this one was quickly constructed under emergency conditions. The construction of this campground was a cooperative effort by the Chugach Alaska Corporation, owners of the Mor-Pac plant at that time, and the City of Cordova. Chugach provided the land and the City constructed a waterline and other basic improvements.

Since that time, the campground has fallen into disrepair. No one is currently responsible for managing and caretaking the area. The new owners do not have the resources nor the time to operate a campground and have posted no trespassing signs on the property. Campers have still been using it however, and this has resulted in periodic problems with litter, garbage, violence, trespass, and vandalism. The City is experiencing an increase in visitors every year and it still does not have a good tent campground. We desperately need to develop these types of facilities. This campground provides us with an opportunity to enhance an already existing facility.

This area has great potential because it already has 15 to 20 excellent camping sites, the potential for more sites, and an excellent location. It is less than a mile from both downtown Cordova and the Fleming Spit Recreation area. It is soon to be connected to downtown by a new bike trail. It is a very short walk from the Cordova ferry dock and it is close to trails that lead or will lead into the proposed Mt. Eyak State Park.

We propose to use EVOS recreation restoration funds to improve this campground so that it will be a safe and enjoyable experience for

95082

tent campers. We would begin by purchasing the parcel from the owners who have expressed a willingness to sell. The improvements we envision include chain link fencing to improve safety and protect other unrelated facilities, a bathroom and shower facility, a short sewer line, and various site improvements such as gravel and tent platforms. Following is a projected budget for this project:

<u>Projected Budget</u>:

Facility/Work Task	Estimated Cost
Land Acquision	$150,000
Surveying	$20,000
Bathroom Facility (with showers)	$100,000
Sewer Line (300 ft.)	$40,000
Chain link Fence (8 ft. high, 400 ft. Installed)	$20,000
Tent Platforms	$20,000
Gravel, Wood misc. materials	$10,000
Total Project Cost	**$360,000**

POTENTIAL CONFLICTS: The current owners of the property have closed the campground and posted no trespassing signs. People still camp there without permission. The owners have indicated a willingness to sell this property and have stated that they believe a campground is a good use for the site. We propose to eliminate existing conflicts by giving campers a safe and clean place to camp.

There are no other conflicts with existing uses or adjacent landowners that we are aware of. The area is surrounded by woods and we believe that a campground is an appropriate use of the parcel.

LINK TO EVOS INJURY: There are two specific links to injuries suffered as a result of the oil spill. First, this campground was originally built in response to the influx of clean-up workers and job seekers. The City was overwhelmed by this in-migration and was unable to provide the services necessary to accomodate these people. As a result, the City was forced to build this campground under emergency conditions.

Second, the oil spill has created a heightened awareness about Prince William Sound in general and Cordova in particular. People have become increasingly aware that 1) Cordova suffered and continues to suffer great econonic and emotional damage due to the spill and 2) that there are outstanding recreational opportunities in and around Cordova (especially since this area of the Sound was not oiled). The result is a marked increase in the number of visitors coming to this community. The City still does not have the capability to acomodate these visitors; especially those who want to travel by tent and backpack.

ECONOMIC FEASIBILITY: This project will not require any subsequent or incremental funding by the EVOS Trustees. After the campground is improved, it will be managed by the City of Cordova in a way that will make it self supporting. User fees will be implemented to pay for maintenance and upkeep.

CONSISTENCY WITH SURROUNDINGS: As noted above, we believe a campground is consistent with the character of the area. The campground is surrounded by forest for the most part. There are no residential areas close by. The nearest facilities are the Cannery Row complex and the Cordova Electric Copperative power plant. Both are far enough away from the campsites that we do not expect any adverse impacts or conflicts.

NUMBER OF PEOPLE BENEFITTING: There is only one legal place to pitch a tent within the City Limits at this time. We believe this campground would be used to capacity during the summer months. We estimate that this could translate into approximately 4,800 camper days. (20 sites, 2 people each, 120 day camping season).

It could also be argued that this facility would benefit the entire community. Since campground space is extremely limited in Cordova, campers are forced to camp wherever they can find a suitable piece of woods. This has resulted in a variety of problems for the community including trespassing, litter, sanitation problems, and violence. This effects everyone and the City would be better able to control these problems by directing campers into a safe and well equiped campground.

DISPLACEMENT OF CURRENT USERS: There would be no displacement of current users. The only people using the property now are campers who are camping there illegally. We propose to resolve this problem by providing these people with a legal and convenient place to camp.

ADJACENT LAND MANAGEMENT: Lands immediately to the North and South of this parcel are privately owned. They are undeveloped at present and are unlikely to be developed in any intensive way because of the extremely steep topography. The parcel is bounded by Railroad Ave. and the Cannery Row Complex to the east and by City and State land to the west.

INFLUENCE ON OTHER PROJECTS: This project will not have any influence upon any other projects that we are aware of. There are no other intended uses for this property.

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DOC. #950616070 C

Project #
95084

RECREATION RESTORATION PROJECT PROPOSAL

PROJECT NAME: Odiak Camper Park Expansion

SPONSOR: The City of Cordova

PROJECT DESCRIPTION: Odiak Camper Park is located on Whitshed Road immediately adjacent to Orca Inlet. It is approximately one mile from the Center of Cordova. The camper park currently has 18 RV sites. All of the sites have electricity and water is available at six locations through hose bib type hydrants. A sewerage dump station is provided for R.V.s equiped with holding tanks. A shower/restroom facility is located in the middle of the campground for use by both R.V. campers and the few tent campers who use the area. While the camper park provides camping space with the basic utilities for up to 18 vehicles, it is badly in need of expansion and upgrading in order to meet an increasing demand.

The current facilities are marginal at best. The single restroom/shower facility is being used to its full capacity. Lines of R.V's waiting to dump holding tanks frequently form at the septic dump station; the only legal dump site in Cordova. Campers have to haul water from hydrants to their sites, a situation which is not always sanitary and certainly not convenient. Finally, the campground, in its current condition, is not aesthetically appealing to many campers. Landscaping is desperately needed so that we can take advantage of an otherwise ideal location for a campground.

Odiak Camper Park is currently the only legitimate camper park in Cordova. We are experiencing increases in the number of visitors each year and the demand for camping space has increased porportionately. Therefore, the need for expansion and basic improvements at the park are warranted. We propose to expand the park by an additional 40 R.V. spaces and to add basic utilities to each site. We also invision adding playground areas, additional tent sites, and landscaping. A proposed budget follows:

Work Task/Improvement	Estimated Cost
Water and Sewer line extensions to 40 spaces including fire hydrants	$140,000
Landscaping including materials and Labor	$30,000
Electrical Hookups to 40 new sites, trenches to be shared with T.V. and Tel.	$76,000

95084

Tent Platforms	$10,000
Picnic Tables/Fire Grates	$10,000
TOTAL PROJECTED BUDGET:	$266,000.00

POTENTIAL CONFLICTS: The only potential conflict which exists is that the campground is located a short distance from the municipal landfill. We proposed to address the conflict be adding fencing and trees which will serve to mitigate the visual impacts. The landfill will be closed in 3-5 years and it has been suggested that that area could also be used for campground expansions.

LINK TO EVOS INJURY: The oil spill has created a heightened awareness about Prince William Sound in general and Cordova in particular. People have become increasingly aware that 1) Cordova suffered and continues to suffer great economic and emotional damage due to the spill and 2) that there are outstanding recreational opportunities in and around Cordova (especially since this area of the Sound was not oiled). The result is a marked increase in the number of visitors to this community. The City does not have the capability to adequately handle the increased demand for camping facilities. Improvements to this already existing campground would increase the City's ability to provide this service.

ECONOMIC FEASIBILITY: This project will not require any subsequest or incremental funding by the EVOS Trustees. After the campground is improved, it will be managed by the City in a way that will make it self supporting. The park is currently self supporting and is operated as an enterprise fund.

CONSISTENCY WITH SURROUNDINGS: The site is already used as a campground. It is surrounded on the North and East by water and on the south by woods. The landfill is located to the west. We believe campground expansion is consistent with the immediate surroundings.

NUMBER OF PEOPLE BENEFITTING: The City is desperately in need of campground facilities. This expansion and upgrade will provide suitable space for 58 R.V. campers and 10-15 tent campers.

It could also be argued that this facility would benefit the entire community. Since campground space is extremely limited in Cordova, campers are forced to park their R.V.s anywhere they can find space. This has resulted in a variety of problems for the community including trespassing, litter, sanitation problems, and blockage of public roads and alleys. The problem was so bad, particularly during the oil spill clean-up, that the City Council was forced to pass a trailer ordinance which strictly limited where motor homes could park. This forced many visitors outside of the City limits; a situation which is not good for either public relations or the local economy.

95084

DISPLACEMENT OF CURRENT USERS: There would be no displacement of current users. There are no users of this parcel other than campers. The City uses the expansion area for equipment storage.

ADJACENT LAND MANAGEMENT: All adjacent land and tidelands are owned by either the City of Cordova or the State of Alaska.

INFLUENCE ON OTHER PROJECTS: There are no other projects planned or in progress in the immediate area.

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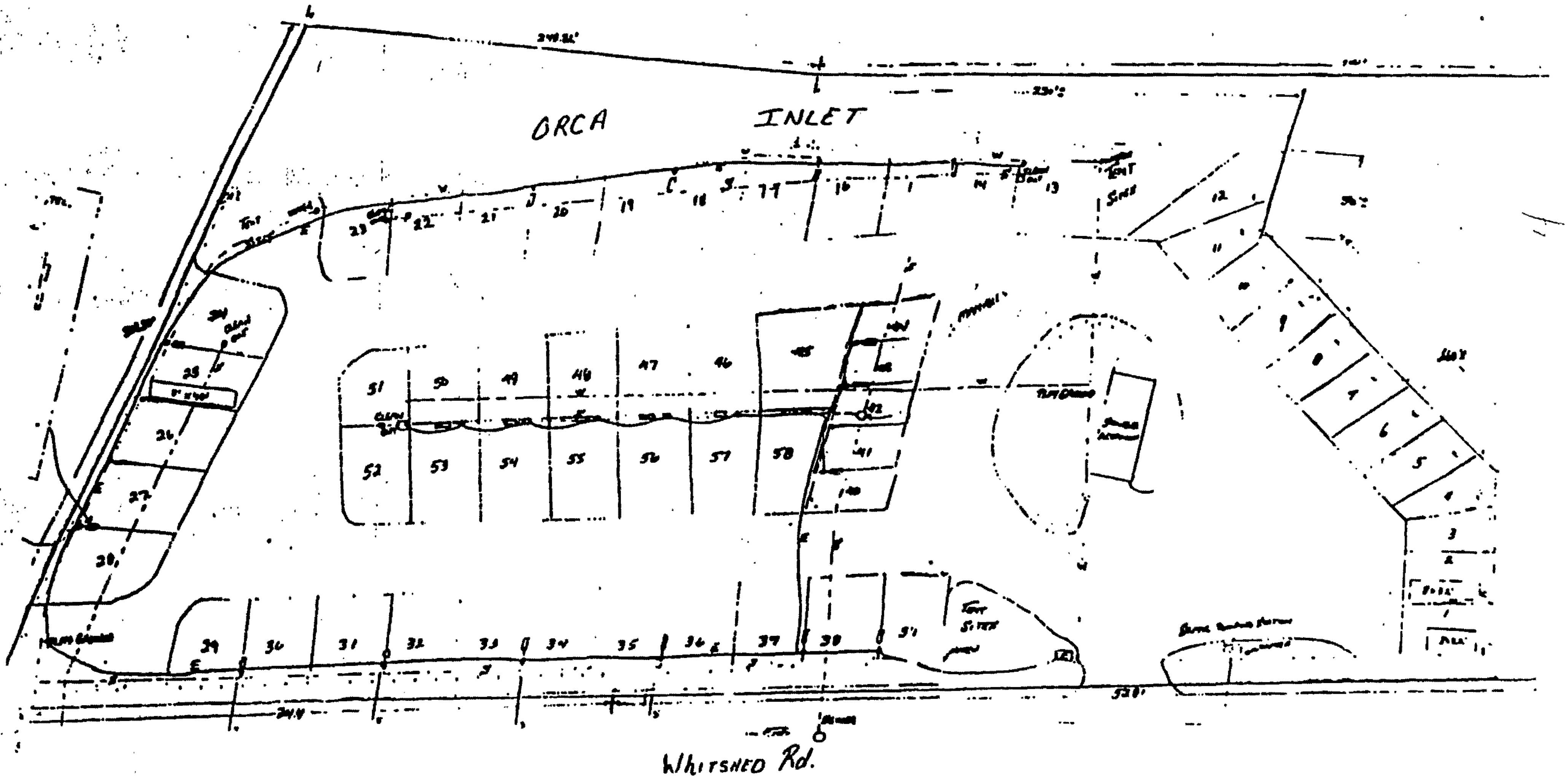
ORCA INLET
Whitshed Rd.
Tent Site
Tent Sites
Playground
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Project #95085

RECREATION RESTORATION PROJECT PROPOSAL

PROJECT NAME: Cordova Historical Marine Park

SPONSOR: The Cordova Planning and Harbor Commissions

PROJECT DESCRIPTION: The goal of this project is to acquire, restore and display vintage fishing vessels, which have been built and/or used by the Cordova fishing fleet during previous decades for commercial or subsistence harvest. Specific boats or boat types which have played an important part in Cordova's maritime and fishing history would be placed on display with interpretive signs describing what role the vessel played in Cordova's history, as well as design origins and how and where it was operated.

A potential site has been discussed by the City Planning, Harbor and Historical Commissions and found to be quite appropriate. In the plan for the new ferry terminal, there are several undesignated narrow strips of land surrounding the parking area. These open areas would be ideal for staging a variety of the historical vessels, offering maximum exposure and visibility to visitors, as well as local residents.

Six types of vessels have been identified as appropriate for the exhibit: (Specific boats that are available for those indicated *)

Charley Moore 24'*	Double Ender*
Tiedeman 22'	Plank Skiff
Cannery Boat (Seiner Style)*	Seine Skiff

It is anticipated that several of the vessels would be staged in a manner to allow boarding for closer observation, making this a "hands-on" exhibit.

It would be an outdoor museum, offering many benefits, such as:
- the preservation of vessels otherwise soon to be lost
- the actual lifesize examples displaying the development of the local fisheries
- an educational presentation for future generations of residents and visitors
- an attractive and interesting addition to Cordova's Ferry Terminal area, as well as great photo opportunities for tourists

PROJECT CURRENT STATUS

LAND to be donated by	City of Cordova	20,000.00
intage boat	City of Cordova	623.85
ransport of boats	Voluntary Equiment & labor	687.89
Restoration of Vessels	voluntary labor	3,600.00
Vintage Equiment donated		15,800.00
	Total Donations to date	40,711.74

95085

Projected Budget:

	Estimated Cost
Acquisition and Transport of Vessels	$35,000
Restoration to visual working condition (cosmetic repair, re-surfacing & painting)	
Charley Moore 24'	$ 5,000
Tiedeman 22'	$ 5,000
Cannery Boat (Seine Style)	$20,000
Double Ender	$ 9,000
Plank Skiff	$ 2,000
Seine Skiff	$ 3,500
Outfit with authentic or representational equipment	
Charley Moore 24'	$ 3,500
Tiedeman 22'	$ 3,500
Cannery Boat	$10,000
Double Ender	$ 5,000
Plank Skiff	$ 3,000
Seine Skiff	$ 3,000
Signs	
Overview of the historical diversity of the local fisheries (examples of shellfish, crab, salmon, herring, kelp)	$ 6,000
Vessel information delineating the era, usage, builders & operation	$18,000
Pavilions for Charley Moore, Tiedeman & Double Ender	$45,000
'Seascaping' and landscaping, finger docks, boarding gangways, lighting, various surrounding surface treatments.	$20,000
TOTAL PROJECT COST	$196,500

POTENTIAL CONFLICTS: There are no conflicts with land usage, the future staging area will largely be created by introducing fill into a current tidal zone. Other types of landscaping for visual aesthetics, or to create wind and weather breaks will be impossible with vegetation.

There is no better use for these vessels, which have become virtually obsolete. Subsequent maintenance and visitor safety issues will have to be addressed by a joint effort of the D.O.T., the City of Cordova and local non-profit organizations promoting tourism, however, no serious impediment is foreseen.

95085

LINK TO EVOS INJURY: There are many links to injury resulting from the oil spill. Demand for response vessels for the cleanup attracted boats from both local and distant fisheries, including from out of state. The high dollar contracts affected boat values in two specific ways. A large number of fishermen used their capital gains to invest in newer, more modern hulls, which devalued the previous average gillnetter or seiner. In addition, once the contracts were completed, many of the relocated vessels were 'dumped' onto the local market further reducing the value of older local vessels. Consequently, the less competitive vessels have little value, while the older models have become useless to the present fishery.

In a recent article about Cordova in the Anchorage Daily news, it noted **"More than any other town in South Central Alaska, Cordova's fortune has been tied to the sea. As long as the fishing was strong, Cordova did just fine."** After three disastrous fishing seasons, diversifying Cordova's economy has become a primary concern for the community. It has long been recognized that tourism offers a sustainable growth industry for the State of Alaska and has great potential in Cordova.

Public awareness of the Prince William Sound has increased dramatically since the oil spill, national news, printed coverage of many varieties, even movies, have drawn significant attention to Cordova. This awareness has stimulated curiosity and has attracted travellers visiting the State, as well as Alaska residents to Cordova, and will no doubt continue to do so. Much of the history of our City can be preserved by saving these vessels, to entertain and instruct those interested in the early days and to the recent changes in our fishing industry.

ECONOMIC FEASIBILITY: This project is a one-time request to help establish a permanent physical historical representation of Cordova's fishing fleet with examples from the claming and canning days, up to early gillnetting and seining. Once completed, maintenance and management should be nominal and could be overseen by local groups in conjunction with D.O.T.

CONSISTENCY WITH SURROUNDINGS: As seen on the plans, included, the vessels will blend in very appropriately with Cordova's new Marine Highway Terminal. Being adjacent to the City's haul-out yard, this area in general has been used to store many vessels of this nature for layup for years. With this proposal, there is an opportunity to make these vessels available and safe for public study.

95085

NUMBER OF PEOPLE BENEFITTING: The community as a whole will benefit. Newcomers will be able to understand the transitions experienced by the local industry and 'old-timers' will be able to reminisce and share their history with friends and visitors. Everyone waiting for the ferry will have an interesting variety of scenes to explore and appreciate.

DISPLACEMENT OF CURRENT USERS: There is no displacement, these strips are on the perimeter of the new parking area for the ferry terminal and are as yet undesignated.

ADJACENT LAND MANAGEMENT: As shown on the plan, the adjoining property is owned on one side by the City for a staging area and by the State Ferry System on the other.

INFLUENCE ON OTHER PROJECTS: This project will have only positive affects on all of the present and future recreational facilities in the area and can only enhance any other types of development in the area.

95085

MEMORANDUM

DATE: September 9, 1993

TO: Gary Lewis/Cordova City Council

FROM: Walt Wrede W.W.

SUBJECT: Planning Commission Support For Saving the APA 3 And For The Concept of Creating a Marine Historical Park.

As many of you know, Brooke Adkinson has been working hard to promote the idea of establishing a Marine Historical Park in Cordova. The general idea is to salvage and restore some of the old fishing boats which have historical significance; that is, specific boats or boat types that have played an important part in Cordova's maritime and fishing history. These boats would be placed on display with interpretative signs describing what part the boat or boat type played in Cordova's history. This project would preserve part of the town's heritage as well as serve as a visitor attraction.

Brooke has discussed this idea with the Commission on other occasions and it has conceptually endorsed the idea. At the September 9 meeting, Brooke asked the Commission to make some specific recommendations to the Council. The Commission voted to do that and its recommendations follow:

1. Take whatever steps are necessary to save the APA 3. This boat was apparently built here and it has a long and colorful history. It is currently owned by the City and is slated for either the auction block or the burn pile.

2. Give conceptual approval to the idea of a Marine Heritage Park.

3. Hold public hearings, refer the issue to the Historical, Parks, or Planning Commissions, or take some step to gather pubic input on whether we should do this and if so, where the park should be located.

4. The Commission would like the Administration to work with DOT/PF to see if the display could be located in the new ferry staging area. It was felt that that would be an excellent place for it.

Please do not hesitate to contact me if you have any questions. Thanks.

95085

MEMO

DATE: October 27, 1993

TO: City Council thru City Manager

FROM: Harbormaster Muma DPM

RE: "APA-3"

As you may or may not know, Brooke Adkinson has been working on the development of a Historical Marine Park in Cordova. He would like to salvage and restore some of the vintage fishing vessels used in the fishing industry and make them the attraction in this Marine Park. One of the vessels he has expressed interest in becoming a part of this park is the "APA-3" which was impounded by the Harbor department this last summer.

The issue of auctioning the vessel to recover the storage charges against the vessel or donating it to this Historical Marine Park was brought before the Harbor Commission at their regular meeting of 10/21/93. After a brief presentation by Mr. Adkinson and discussion by the Harbor Commission, the commission voted unanimously to donate the "APA-3" to the Historical Marine Park. The Planning Commission has also made a similiar recommendation to save the "APA-3" and to the establishment of a Historical Marine Park.

One final note! There is $623.85 worth of storage charges against the vessel. If the vessel is donated to the Historical Marine Park, will these storage charges be forgiven?

This recommendation is forwarded to you for your consideration.

95085

Cordova Historical Society

P.O. Box 391 Cordova, Alaska 99574
(907) 424-6665

November 2, 1993

To Whom It May Concern:

The Cordova Historical Society supports the concept of a Cordova Historical Marine Park.

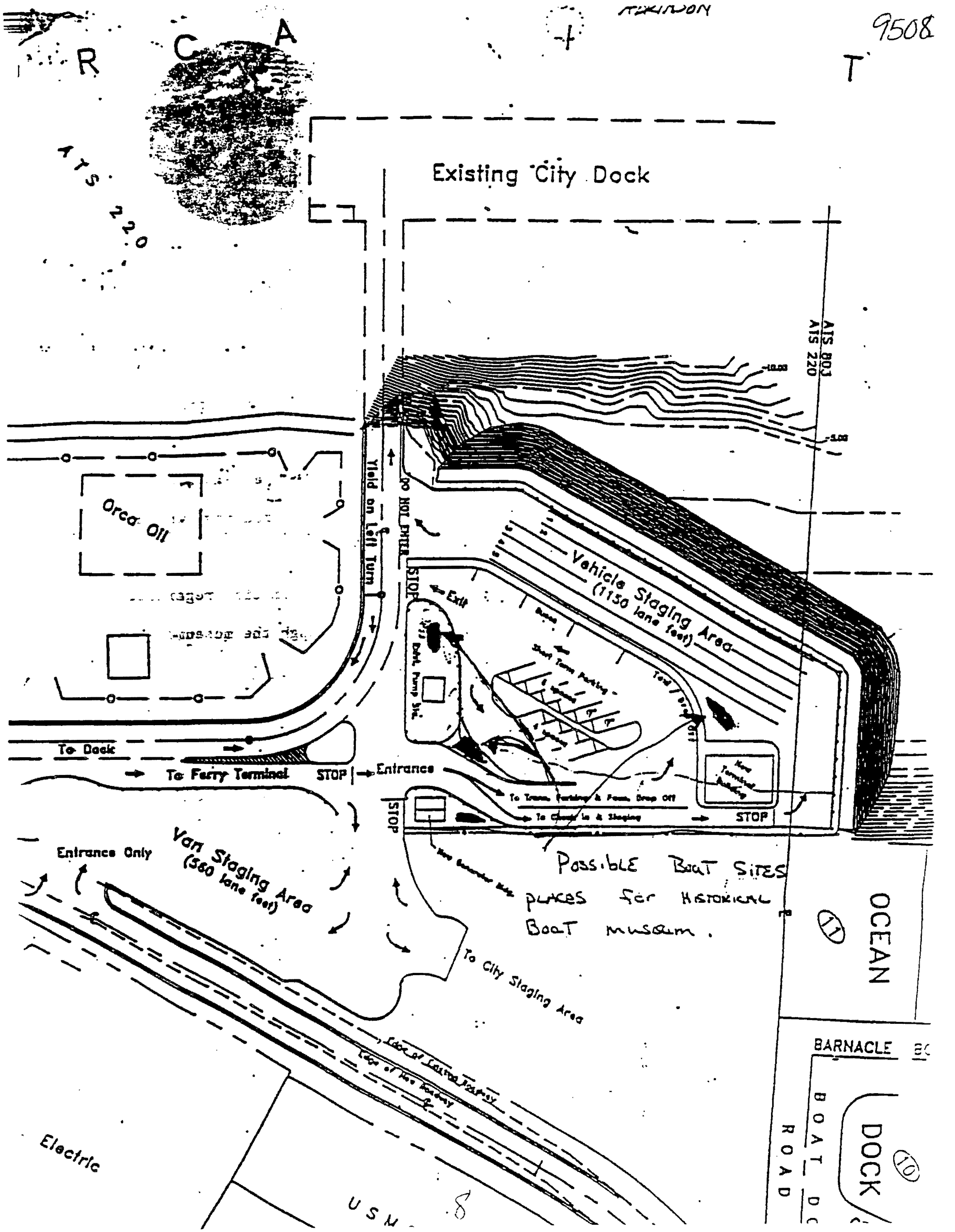
We believe a park designated for marine relics and vessels would promote an interest in the history of the fishing industry, which is an integral part of Cordova' heritage.

The Cordova Historical Society could provide information regarding the history of items displayed in the park through the museums archives.

Sincerely,

Sharon Ermold

Sharon Ermold
President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Existing City Dock
Orca Oil
Vehicle Staging Area
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Yield on Left Turn
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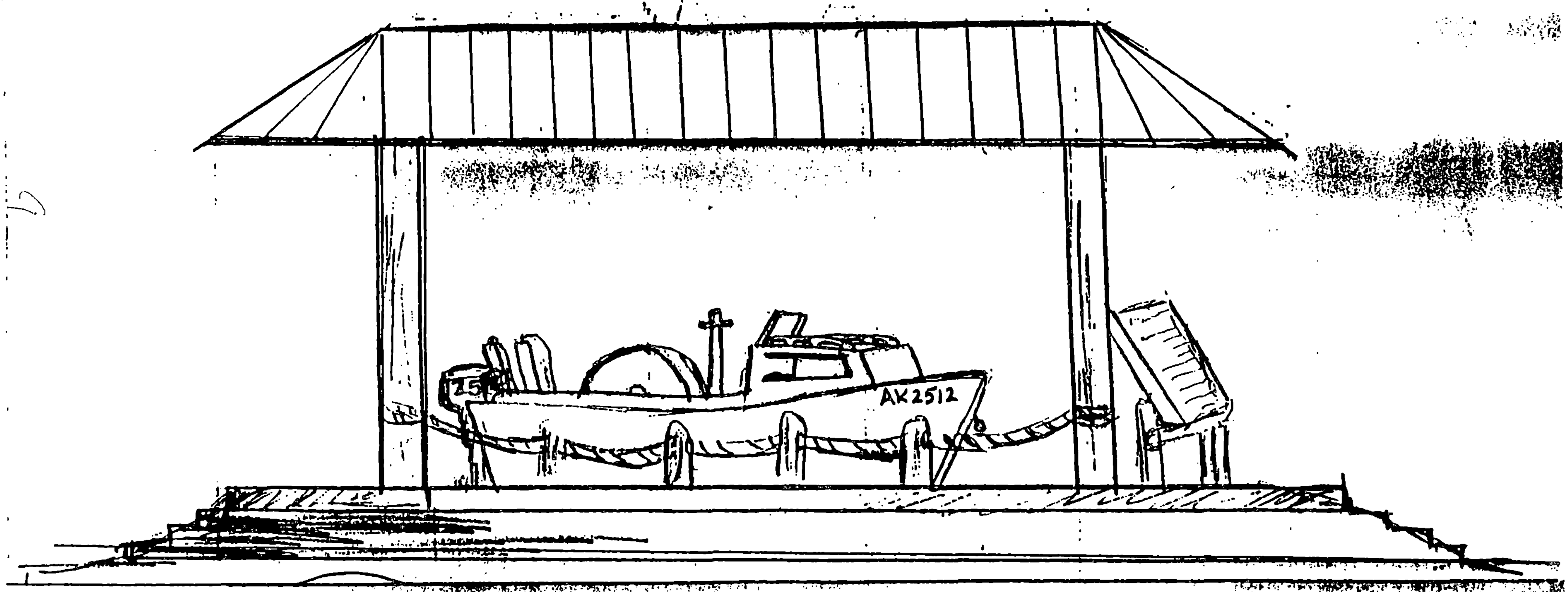
STOP
Exit
To Dock
To Ferry Terminal
Entrance
Entrance Only
Van Staging Area
(560 lane feet)
To City Staging Area
POSSIBLE BOAT SITES
PLACES FOR HISTORICAL BOAT MUSEUM.
OCEAN
BARNACLE
BOAT DOCK ROAD
DOCK
Electric
Edge of Existing Roadway
Edge of New Roadway
ATS 803
ATS 220



EXAMPLE of SITES.

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