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Killer Whale Monitoring and Habitat Studies

Cost 219.5 K

Marilyn E. Dahlheim
Thomas R. Loughlin

NOAA/NMML

Name of Project: Mile 18 Resident Sport Fish Pond

Injured Species to be Addressed: Cutthroat trout (Salmo, clarki)
Dolly Varden Char (Salvelinus, malma)

Principal Investigator, Lead Agency: D. Schmid, U.S. Forest Service (USFS)

Cooperators: Alaska Department of Fish and Game, Division of Sport Fish (ADF&G)

The Cordova Ranger District recently completed construction of several visiter facilities on the Copper River Delta. The gravel for the projects was excavated from a glacial outwash area with a high ground water table. Careful consideration was given to aesthetic and visual qualities of the borrow pit, so that an attractive pond was created. A wooded island was left in the pond and shorelines were contoured to give it a more natural appearance. Once the construction is complete the shorelines will be revegetated and the gravel parking and access areas will be sloped and graded.

The pond also has great potential for fish production (i.e. proper water quality and depth). It is a closed pond system, that is there are no inlets or outlets, and all water flow is subsurface, intragravel flow. A protective levee has been placed around the pond perimeter to prevent any surface flow into or out of the pond. The objective of this proposal is to provide a replacement angling opportunity for oil impacted stocks of dolly varden and cutthroat. As anglers are directed away from oiled areas in Prince William Sound in an effort to encourage natural recovery of impacted stocks, areas on the Copper River Delta may see more angling pressure. The proposed project will reduce fishing pressure on road accessible sport fishing streams on the Delta by providing an alternative angling opportunity. The project will also provide accessible fishing opportunities for the physically challenged anglers, and educational opportunities for local school children.

The principle investigator will begin working with cooperators in developing a stocking plan and acquiring fish for the pond during the winter of 1991-92. Fish stocking will begin in the spring of 1992 and continue annually until studies show alternative stocking plans are more feasible.

Beginning in 1992, an annual "Adopt a Pond" program will be developed in the Cordova schools to involve children in the project. The children will be engaged in revegetation efforts as well as stocking and monitoring of the fish. This provides an excellent opportunity to educate school kids on restoration of natural resources, pond ecology, and fishing ethics . This will be developed through the District Interpretive program and will require coordination efforts between District staff.

Monitoring of the pond will be done by District personnel as well as through educational programs. Monitoring efforts will include measuring water quality parameters both before and after stocking efforts. Success, growth and overall health of the fish populations within the pond will be monitored annually as well. All monitoring efforts will begin in 1992 and continue indefinately to incorprate education programs in the future as well.

Either an outside construction contract will be awarded, or the District personnel will construct two barrier free fishing piers in 1992. In addition, the District is considering developing a day use visitor facility at the pond site by adding picnic tables, garbage cans, interpretive signs and the like. This phase of the project will require expertise from the District's recreation and interpretation programs. Coordination efforts by District staff will begin in October 1991 and project plans will be developed by February of 1992. If adopted development of the day use site will begin in the spring of 1993 and be completed by 1994.

The estimated cost to the USFS for the project in 1992 is $25,000. This includes the cost for a construction contractor to complete fishing piers. Costs in 1993 and 1994 will be approximately $16,000 for development of the day use site and continued stocking and monitoring efforts. Continued monitoring and educational programs will cost approximately $8,000 annually once construction is complete.

In addition to USFS costs, ADF&G will have costs associated with the project. Some of those costs will include, but are not limited to, administrative costs, fish culturing and transport costs, and travel costs.

Once complete, this project will provide a replacement and an alternative angling opportunity on the Copper River Delta. It will be a project that will involve members of the community in a positive, constructive program of education, recreation, and natural resource improvement. As families and members of the community get involved in the development of a pond, there will be a sense of ownership, and pride. As the community assists in the evolution of a new recreation area, close to town, it will become the place people gather to enjoy the great outdoors. School children and adults alike can enjoy the new fishing opportunity as it grows.

Studies by ADF&G have indicated that sport fish species, namely cutthroat trout, were damaged by the Exxon Valdez oil spill. This project would directly benefit that species by providing a replacement area for fishing on the Delta. In addition it will reduce pressure on more locally sensitive species, as angling pressures is shifted from the Sound to the Delta.

It will be important to initiate this project in 1992 to maintain the visual and aesthetic qualities of the pond. Revegetation efforts need to begin early in the spring. Also, as fishing pressure on the Delta increases, it will be critical to offer a variety of angling opportunities so that will disperse anglers as well as be able to effectively manage angler use on the Forest.

Duplicate

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Dolly Varden Char (Salvelinus, malma)

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The pond also has great potential for fish production (i.e. proper water quality and depth). It is a closed pond system, that is there are no inlets or outlets, and all water flow is subsurface, intragravel flow. A protective levee has been placed around the pond perimeter to prevent any surface flow into or out of the pond. Therefore non-resident sport fish species such as arctic grayling or rainbow trout can be safely introduced into the pond without interacting with native species. The objective of this proposal is to provide a replacement angling opportunity for oil impacted stocks of dolly varden and cutthroat. As anglers are directed away from oiled areas in Prince William Sound in an effort to encourage natural recovery of impacted stocks, areas on the Copper River Delta may see more angling pressure. The proposed project will reduce fishing pressure on road accessible sport fishing streams on the Delta by providing an alternative angling opportunity. The project will also provide accessible fishing opportunities for the physically challenged anglers, and educational opportunities for local school children.

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A. Project Name

Cultural Resource Protection

B. Injured Species

Cultural resources impacted directly by the oil spill and clean-up activities

C. Principal Investigator and Lead Agency

Steve Hennig, Glacier Ranger District, Chugach National Forest
Chugach Alaska Corporation may provide limited assistance and support

D. Project Objectives

The primary objective of this project is to provide protection for cultural resource sites in Prince William Sound through active monitoring, patrol and law enforcement.

A secondary objective is to educate the public on the cultural resources of Prince William Sound and the laws protecting this resource.

E. Project Methods, including technical feasibiltiy

The project will be accomplished through increased patrols and Forest Service presence in Prince William Sound. Forest Service personel, with law enforcement training, will patrol the Sound aboard a boat, making regular rounds and frequent stops at known sites to monitor any impacts to sites and conduct investigations on any vandalism or theft from sites.

Additional Forest Service presence and regular monitoring of sites is one of the best deterents to vandalism. Additional public contacts with people using Prince William Sound can be used to educate users of the cultural resource and the laws protecting this resource.

This project is technically feasible and can be started immediately. A vessel will have to be acquired either through purchase or charter. Purchase of a vessel is preferred.

F. Duration of the Project

This project is proposed as a long-term, on going, project to continue as long as necessary to insure protection of the cultural resources of Prince William Sound.

G. Estimated Cost (1991 dollars)

Calendar Year 1992		$ 480,000	Staffing, housing & purchase of boat ($180,000 if charter boat)
	1993 and subsequent years	120,000	Staffing, housing & operational cost ($180,000 if charter boat used)

H. Restoration Activity or Endpoint to be Addressed

This proposal is intended to protect the cultural resource of Prince William Sound. Activity as a result of the oil spill located many new sites. Additionally, these sites are now known to many people and the potential for vandalism or theft is greatly increased.

I. Link to Other NRDA Damage Assessment or Restoration Studies

This proposal is linked to damage assessment studies inventorying the cultural resource sites in Prince William Sound as well as those located during the numerous beach surveys as a part of the clean-up.

J. Importance of Initiating Project in 1992

The cultural resources of Prince William Sound are already receiving some vandalism and theft. With the exposure the Sound received as a result of the spill and the discovery of many new and previously unknown sites, protection of this resouce is needed immediately. The Forest Service is obligate, by law, to actively protect this non-renewable resource.

3

(3)

United States Department of the Interior

NATIONAL PARK SERVICE

ALASKA REGIONAL OFFICE
2525 Gambell Street, Room 107
Anchorage, Alaska 99503-2892

IN REPLY REFER TO:

To: Sanford P. Rabinowitch, DOI Representative RPWG

From: Dan Hamson, Chief Office of Oil Spill Coordination

Subject: Restoration Projects for 1992

Enclosed are three projects for consideration by the Restoration Planning Work Group (RPWG) for the 1992 season.

* Public Education

* Monitoring Fate and Persistence of Oil in National Parks Affected by the Exxon-Valdez Oil Spill

* Trophic Investigation of Intertidal Use by Birds and Mammals in NPS Areas Affected by the Exxon-Valdez Oil Spill.

We have carefully studied the guidance provided by the RPWG and believe that these projects meet the various science needs and specific criteria put forward. The RPWG will also note that the NPS is a cooperating agency on several projects being submitted by the Fish & Wildlife Service. We believe strongly in cooperative projects and in fact are interested in making even more linkages with state and federal agencies.

The National Park Service expects to develop additional projects as completion of the NRDA damage assessment studies are brought to final conclusion and the results more completely understood. These three projects represent an initial list of restoration projects that the NPS is interested in proposing under the EVOS restoration program.

Should the RPWG have any detailed questions regarding these projects the NPS principal investigators are available to you upon request.

cc: Jack Morehead, Regional Director, NPS
Paul Haertel, Associate Regional Director, NPS
Anne Castellina, NPS - KEFJ
Alan Eliason, NPS - KATM
Curt McVee, DOI
Pam Bergman, DOI

Public Information and Education
-1992 Restoration Project Proposal-

Injured Species to be Addressed: This project proposes to advance recovery and restoration of natural resources, injured as a result of the Exxon Valdez oil spill, through the means of a public information and education program. The project seeks to recognize restoration within the context of the entire ecosystem, rather than through a species-specific approach.

Information regarding habitat needs, key life history facts, and the relationship of habitat to parks, refuges, forests and wilderness areas will be presented. Specifically identified will be those species and their habitats which appear to have suffered the most notable injuries. To be included are: Common and Thick-billed Murres, bald eagles, harlequin ducks, goldeneyes, scoters, black oystercatchers, pigeon guillemots, marbled and Kittlitz's murrelets, sea otters, harbor seals, killer whales, brown bear and river otter.

Principal Investigator: Valerie Payne, National Park Service

Lead Agencies: National Park Service and Fish and Wildlife Service

Cooperating Agencies: Forest Service and Environmental Protection Agency. Other agencies will be welcome to participate.

Project Objectives: This project will develop and distribute information designed to inform the public about ways they can help injured natural resources recover from the damages which resulted from the Exxon Valdez oil spill. Specifically, the information will explain changes to the ecosystem resulting from the oil spill and how people can lessen their potential for creating additional harmful human disturbance.

Project Methods: Project methods are simple and well understood. Educational information will be developed that explains how various users can inadvertently disturb injured resources (e.g. marine birds and mammals), and how they can avoid creating these disturbances. The information will be delivered through the medium of posters, brochures, slide programs, fact sheets, and possibly other media, which may include a video tape, production of a book and enhancement of school curricula. Delivery of the materials will be throughout the spill zone area, including park, refuge and forest visitor centers; participating private businesses (e.g. tour operators and kayak rental stores); local museums; and on the state ferries. It is anticipated that up to 100,000 people will be exposed to the information annually at government visitor centers and on the state ferries. Additional people will see posters and brochures where they are displayed by museums, businesses and individuals.

A "user survey," of individuals who receive the information and education, will also be considered. A well-designed survey of this type will aid the project in obtaining feedback on the type of information the general public most desires and will provide valuable insight into the public's perception of the restoration activities taking place.

The project will be accomplished by a single project leader working with a core staff composed of National Park Service (NPS) and Fish and Wildlife Service (FWS) staffs in Anchorage regional offices, along with staff from Kenai Fjords National Park in Seward and the Alaska Maritime National Wildlife Refuge in Homer. Cooperating agencies will also have regular participation.

The project is technically feasible. Much of the required information already exists, and any new information needed may be found in other ongoing restoration projects. The National Park Service and cooperating agencies are experienced at producing information for the public on a variety of subjects.

Project Duration: This project is proposed to commence in 1992 and continue through the year 2001. It is anticipated that the first two years of the project (1992 and 1993) will be the busiest, in that initial examination of existing information, and production and distribution of materials will take place during this time. Updates would be anticipated every two years (1995, 1997, 1999 and 2001), as new information becomes available. Every other year (1994, 1996, 1998 and 2000) will be used as a review year, in which the ongoing recovery efforts and results of those efforts will be reviewed and incorporated into updated informational material. This cycle will not only be cost efficient, but will also allow for the opportunity to update the material as new information becomes available.

Estimated Cost:

1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
100K*	150K	25K	50K	25K	50K	25K	50K	25K	50K

* An interagency agreement between the National Park Service and the Environmental Protection Agency (EPA) is already in place for this project. The EPA is supporting the project with partial funding in the amount of $20,000. Use of these funds must be made by September 30, 1992, under the terms of the agreement.

Restoration Activity or Endpoint to be Addressed: This project directly addresses endpoints for a number of species, most notably the endpoint of minimizing human disturbance. The proposed project benefits natural recovery by attempting to reduce further human disruption to marine birds and mammals, and any other injured natural resource affected by the oil spill and the resulting clean-up efforts.

Relationship to Science Information Needs Identified by RPWG: The "general needs" addressed by this project include:

- Improve understanding of the long-range underlying mechanisms causing injury or limiting populations;

- Extend focus of studies beyond Prince William Sound and throughout the affected area; and

- Shift emphasis to broader ecological, rather than species-specific approaches.

Importance of Initiating Project in 1992: The public desires information about the restoration of the environment, after the Exxon Valdez oil spill. Much of the information needed to initiate and complete this project is already in place and/or available for collection. The information can quickly be made available to the public, therefore generating an immediate restorative effect.

Link to Other NRDA or Restoration Studies: Numerous NRDA and potential restoration projects could benefit from this public information and education project. It will be a means of conveying information, gained elsewhere, directly to the public and in a "user friendly" format.

4

MONITORING THE FATE AND PERSISTENCE OF OIL IN NATIONAL PARKS AFFECTED BY THE EXXON VALDEZ OIL SPILL: A RESTORATION SCIENCE STUDY PROPOSAL

November 1991

Injured Species to be Addressed: This proposal addresses injury to the lost services of scientific, recreational, and park wilderness values in the national park areas affected by the Exxon Valdez oil spill.

Principal Investigator: Dr. Gail Irvine
Lead Agency: National Park Service (NPS)

Introduction

The Exxon Valdez oil spill (EVOS) directly affected the scientific and recreational values and wilderness characteristics of shorelines of three national park areas, namely Kenai Fjords National Park, Katmai National Park and Preserve, and Aniakchak National Preserve and Monument. Injury to Kenai Fjords and Katmai National Parks will be addressed by this proposal.

In addition to physical, chemical and biological effects, the spilled oil also affected and continues to affect the special land values and services provided by the national parks it contacted. These injured values and characteristics continue to be injured by the persistence of oil that degrades the "naturalness" of the coasts. These values and characteristics are clearly stated in both ANILCA (1980) and the Wilderness Act (1964). Surveys conducted in 1991 indicate that oil continued to persist in the affected national parks, and that fresh-looking mousse and sheening were observed in many locations, despite the predictions that this would not occur beyond the first year of the spill.

Project Objectives

1. To document, quantitatively and qualitatively, the location, persistence, and fate of oil from the Exxon Valdez spill along the Kenai Fjords and Katmai National Park coastlines.

2. To reconcile existing conceptual models of shoreline geomorphology and the persistence of oil with the actual persistence of EVOS oil through time.

Project Methods

Objective 1: Persistence of Oil

1992. Sites known to have oil in 1991 will be surveyed via boat or helicopter, depending on the location, weather, and logistical concerns. Other sites, such as sand beaches, that were heavily oiled in 1989 and that may not have been surveyed in depth may also be revisited. Qualitative description of the site and oil appearance will be made, and permanent quadrats and transects will be sampled in sites where it will be possible to relocate them. Samples will also be collected for chemical analysis. Some such sites were studied by the Park Service in 1989 along the Katmai and Kenai Fjords coastlines. Precise methodology will be decided upon after evaluating the methodology used in previous studies (Cusik, 1989; ADEC, 1989-91, NOAA, etc.). A stratified random design may be used in order to follow the persistence through time of oil of different concentrations or types.

1993 and beyond. These studies should be repeated at chosen sites at least every two years.

Objective 2: Geomorphology and the Persistence of Oil

The patterns in the persistence of oil along the coastlines will be compared to existing models relating such persistence to coastline geomorphology. At least two such models exist: one, developed by Research Planning Institute, Inc. (RPI) and based on their experiences with oil spills, especially the Amoco Cadiz; another, developed by Carl Schoch, National Park Service, which consists of more detailed vertical representation of the coastline geomorphology, both through the various intertidal and supratidal zones, and within a single zone (e.g., multiple layers). We would predict that Schoch's model, with its greater complexity, would better correlate with the actual persistence of oil. Field analysis of these models will allow for application of the more accurate method to other areas of concern.

Duration of the Project

Persistence of oil will be monitored along NPS coastlines until its presence is not detectable.

Estimated Cost

Objective 1. Quantitative Surveys of Oil Fate and Persistence, Katmai and Kenai Fjords National Parks, per year, every two years beginning in 1992.

1992	1994	1996	1998	2000	Total
$ 165K	$ 170K	$ 175K	$ 180K	$ 185K	$ 875K

Restoration Activity or Endpoint to be Addressed

Monitoring ecosystem recovery.

Relationship to Science Information Needs Identified by RPWG

This proposal fulfills several of the general needs outlined by RPWG in June 1992. These include:

1) Extending the focus of studies beyond Prince William Sound and throughout the affected area. This proposal focuses study in affected areas in the Gulf of Alaska and along the Alaska Peninsula.

2) Monitoring the fate (quantity, chemical status, persistence) of weathering oil, including in mussel beds.

a. The continued presence of oil may be causing continued harm to biological resources, and continues to cause damage to scientific and recreational values and wilderness characteristics of the park coastlines. Monitoring ecosystem recovery (which includes cleansing) will define the extent and persistence of injury.

Importance of Initiating Project in 1992

It is important to initiate this project as soon as possible in order to establish the best comparison between sites and to establish a base for future surveys. The last quantitative transects in Katmai National Park were conducted in 1989, so revisiting those sites in 1992 would provide a better time line than if the project were delayed. Also, initiating the project in 1992 means that there will be no lapse in data collected in each of the previous years under response actions.

Link to Other NRDA Damage Assessment or Restoration Studies

This proposal may provide pertinent information to the Coastal Habitat project (on persistent oiling of sites), the Oiled Mussel project, other projects that are examining single species but where work is concentrated at particular sites, and the proposed restoration project titled, "Trophic Investigation of Intertidal Use by Birds and Mammals in NPS areas."

(5)

TROPHIC INVESTIGATION OF INTERTIDAL USE BY BIRDS AND MAMMALS IN NPS AREAS AFFECTED BY THE EXXON VALDEZ OIL SPILL: A RESTORATION SCIENCE STUDY PROPOSAL

November 1991

Injured Species to be Addressed: This proposal addresses the trophic use of intertidal communities by bird and mammal species such as: bears, foxes, river otters, sea otters, harlequin ducks, black oystercatchers, bald eagles, pigeon guillemots and shorebirds. Some of these have been identified as being injured by the Exxon Valdez oil spill, but others have not, probably through lack of investigation, lack of good baseline information, or lack of a thorough knowledge of their interaction with the intertidal communities.

Principal Investigator: Dr. Gail Irvine
Lead Agency: National Park Service (NPS)
Suggested Cooperating Agencies: Alaska Department of Fish and Game (ADF&G), and the U.S. Fish and Wildlife Service (USFWS)

Introduction

The Exxon Valdez oil spill led to extensive examination of the coastal communities in the affected areas, and many individual species were targetted for investigation. The oil spill also pointed out many deficiencies in our knowledge, including the dynamics in the use of intertidal communities by various bird and mammal species. The purpose of this proposal is to address the comprehensive use of intertidal resources by birds and mammals in order to monitor additional and continuing injury and to increase our understanding of the ecosystem dynamics. Injury to many of the species mentioned above was documented in other areas of the spill, primarily Prince William Sound, but was not examined within the parks.

Project Objectives

1. To document, directly and indirectly, patterns of use of the intertidal by bird and mammal species. This study will concentrate its efforts on oiled national park coastlines, namely Katmai NP&P and Kenai Fjords NP.

   a. To identify and better understand pathways of potential contamination (past, present, and future) via food resources.

   b. To gain information that could be used to document injury compensable by the settlement's reopener clause (e.g., to identify and provide information on species that were potentially injured by the Exxon Valdez oil spill, including ones that were not scrutinized in the damage assessment process).

2. To continue to monitor productivity of coastal brown bears in

Katmai NP&P, since there was some indication of injury (death of a cub accompanied by high hydrocarbon values; elevated hydrocarbon values in fecal material) and effects of hydrocarbon contamination may be expressed as sublethal effects and decreased productivity through time. Continuing contamination of bivalve prey (mussels, clams) may mean that bears are still being exposed to hydrocarbons through their diet. Negative effects on bears could also be addressed through the reopener clause.

Project Methods

Objective 1. Areas of use by various animals will be identified through discussion with agency personnel and researchers, and survey of literature and observational records. Identified areas will be observed, and various established animal behavior methodologies (e.g., focal animal) may be used. Also, some areas will be chosen for more intensive observations. Direct observations of foods chosen will be made where possible, and scat and opportunistic gut analyses will also be used. Time-lapse photography also may be used to document use of areas. Chemical evaluation of bivalves or other prey will be obtained if not available from other studies (e.g., Oiled Mussels, Fish/Shellfish #13).

Objective 2. Survival and reproductive success of coastal brown bears will be determined through the use of existing and newly radio-collared female bears as surveyed aerially. Aerial surveys will be conducted from April through October. Some information on habitat use will also be gained from aerial survey data.

Duration of the Project

Observations on the use of the intertidal by bird and mammal species should be done over the course of at least five years (1992 through 1996), since sites and precise methodologies must be worked out, and a variety of species are going to be targetted.

Productivity of brown bears should be monitored for at least three more years (1992 through 1994) to allow for expression of reproductive effects and to make efficient use of the radio collars.

Estimated Cost

Objective 1. Investigation of trophic use of the intertidal by birds and mammals.

1992	1993	1994	1995	1996	Total
$ 785K	$ 775K	$ 800K	$ 820K	$ 825K	$4,005K

Objective 2. Brown bear productivity.

1992	1993	1994	Total
$ 110K	$ 60K	$ 110K	$ 280K

Total Cost of the Project (Objectives 1 and 2):

1992	1993	1994	1995	1996	Total
$ 895K	$ 835K	$ 910K	$ 820K	$ 825K	$4,285K

Restoration Activity or Endpoint to be Addressed

Monitoring ecosystem recovery by identifying the strengths of the various trophic interactions, the relative dependencies on the intertidal, potential for contamination, and potential for recovery.

Relationship to Science Information Needs Identified by RPWG

This proposal fulfills several of the general needs outlined by RPWG in June 1992. These include:

1. Shifting emphasis to broader ecological rather than species-specific approaches.

2. Improving understanding of the long-range underlying mechanisms causing injury or limiting populations.

3. Extending the focus of studies beyond Prince William Sound and throughout the affected area.

4. Analyzing further the linkages between predators and prey abundance, availability and quality.

Importance of Initiating Project in 1992

The initiation of this project in 1992 would allow for the earliest investigation of this broad use of the intertidal by birds and mammals, and may identify other species that might have been injured by the EVOS, but that haven't been studied (e.g., foxes). The results of the investigation might set the stage for further defining broad restoration initiatives. Due to the potential difficulty in establishing injury for the reopener clause, this project should be started as soon as is feasible.

In addition, the information on potential productivity effects on brown bears should be initiated in 1992 in order to maximize information carryover from the previous NRDA study (Terrestrial Mammal #4: Brown Bear). Collars already in place will probably stop transmitting within this next year, so the ability to follow the same individuals will be lost unless animals are recollared this year.

Link to Other NRDA Damage Assessment or Restoration Studies

This project has direct linkages to all studies that deal with species that feed in the intertidal, as well the Oiled Mussel Study, Fish/Shellfish #13, Coastal Habitat, the proposed restoration project "Monitoring the Fate and Persistence of Oil in National Parks Affected by the Exxon Valdez Oil Spill", and the RPWG synthesis of life history information.

November 15, 1991

EXECUTIVE SUMMARY
SUITE OF RESTORATION PROJECTS FOR SEA OTTERS
submitted by the U.S. Fish and Wildlife Service

EXECUTIVE SUMMARY: The U.S. Fish and Wildlife Service is recommending a comprehensive suite of projects to aid in the restoration of sea otter populations affected by the *Exxon Valdez* oil spill. These projects include monitoring populations, evaluating recovery in vulnerable life stages such as weaning, tracking the physiological health of sea otters as they recover, identifying key habitat areas for sea otters in the spill area and designing and implementing strategies to enhance the recovery of sea otters.

For 1992, the following projects are recommended:

(1) Population Monitoring - Continue 1991 restoration feasibility efforts field testing aerial survey techniques throughout the spill area and implementing of the population monitoring within Prince William Sound. In addition, reproduction and survival of sea otters will be monitored. The 1992 budget is $242,000.

(2) Habitat Utilization - Describe and monitor the distribution and seasonal patterns of sea otter habitat use to provide data pertinent to habitat enhancement, protection, or acquisition. The 1992 budget is $160,000.

(3) Recovery Model Validation - Modeling of the rate and method of recovery of the sea otters has been established in damage assessment studies. This model assumed certain rates of recruitment to the population. In order to evaluate the natural recovery and assess needs for potential enhancement activities, it is crucial to understand how the population is changing and to identify vulnerable life stages. The 1992 budget is $138,000.

(4) Bioindicators - Specific physiological changes to otters have been noted in impacted areas. Although the consequences of these abnormalities are not fully understood, potential exists for long-term damage affecting survival and recovery of the otter population. Although no data collection is recommended for 1992, (recommend that a biannual monitoring schedule be implemented) it is recommended that ongoing activities be supported through 1992. The 1992 budget is $44,000.

The total 1992 program budget is $584,000.

In these four studies, a conceptual program for sea otter restoration through the 10 year restoration program is presented for consideration only. This plan explains how the 1992 activities support proposed long-term sea otter restoration activities.

November 15, 1991

SUITE OF RESTORATION PROJECTS FOR SEA OTTERS
submitted by the U.S. Fish and Wildlife Service

SUMMARY: This summary explains the various activities being recommended for sea otter restoration and their interrelationships. These various activities work together to address the various components important to understanding and measuring sea otter recovery and to guide the development of strategies aiding in the recovery of this important species. This document presents a comprehensive program for monitoring and facilitating the recovery of the sea otter from 1992 through 2001. Each project is presented following the outline provided by the Restoration Planning Work Group in September 1991.

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Species and Injuries to be Addressed:

Injuries to sea otter populations as the result of the *Exxon Valdez* oil spill include but are not limited to: (1) recovery of more than 1,000 carcasses in areas affected by the spill; (2) reduced survival and reproduction of sea otters that were exposed to oil and subsequently captured, treated, held and released; (3) continued decline of sea otter densities in some portions of Prince William Sound with consistently lower densities in oiled versus unoiled shoreline habitats; (4) the presence of a high percentage of prime age sea otters dying in areas affected by the oil spill indicating continued effects; (5) significantly higher levels of some hydrocarbons in blood of sea otters exposed to oil versus those not exposed; (6) significant differences in some blood variables that suggest continued stress and/or continued exposure to toxic substances; and (7) higher mortality of weanlings in oiled versus unoiled habitats. Several lines of evidence suggest that sea otters continue to be exposed to hydrocarbon contamination. The effects of that exposure may range from subtle physiologic changes to reduced survivability.

Overall Objectives of Sea Otter Suite of Projects:

The *Exxon Valdez* oil spill resulted in the reduction of sea otter populations and the disruption of some normal physiological functions. There is evidence that suggests injury is still occurring. The primary objectives of these restoration projects are: (1) to monitor the rate and nature of the recovery (or continued decline) of the population, both in terms of size and physiological health; (2) to identify and evaluate habitat needs and use by sea otters within the spill area; (3) to monitor the health and status of various primary foods of sea otters; and (4) to identify habitat suitable and appropriate for long-term protection.

The population monitoring and demographic projects involving radio telemetry will provide information on habitat use. This information will be useful for further restoration projects such as habitat acquisition, establishment of management zones, including marine sanctuaries, and mitigation of the potential adverse affects of logging, mining, or other development.

The physiological monitoring projects relate directly to the continued contamination and exposure of the invertebrates that are the mainstay of the sea otters diet.

Potential cooperators are identified for each project where they may be possible. With the exception of the National Park Service we have not as yet solicited the cooperation of other agencies, but would intend to do so following preliminary approval of the project.

Project Methods:

The restoration package includes four key components.

1. Population assessment involves development and implementation of an effective sea otter survey technique throughout the spill area. The assessment work will provide data on abundance, distribution, reproduction and mortality. It will include the continuation of Prince William Sound boat surveys in cooperation with a companion bird study. Recovery of carcasses washed up on beaches will be continued in Prince William Sound and will be expanded outside of the Sound. The carcasses will be used to monitor the age and sex class distribution of dead animals and to describe spatial and temporal patterns of mortality. Carcasses in suitable condition will be necropsied and some samples will be subjected to contaminant and histopathological analysis to aid in determining cause of death. Carcasses of legally harvested sea otters will be obtained from within the spill area to provide comparisons to the beach-cast carcasses.

2. Sea otter habitat occurs continuously from Bligh Reef in Prince William Sound throughout the spill zone. One means of assisting the recovery of the affected population would be a protective designation of some portion of that nearshore marine environment affected by the spill. A protective designation would assure the maintenance of the quality of sea otter habitat. Additionally, a protected designation of nearshore habitat would afford protection to other mammals, seabirds and benthic communities affected by the *Exxon Valdez* oil spill. Such a restoration project would require defining patterns of habitat utilization and habitat quality, seasonal distribution of sea otters, and the development of management strategies to address key habitat issues. Movement data from previous and future telemetry studies will be used, where appropriate, to highlight important habitat use patterns.

3. Radio tracking of all sea otters instrumented as part of the damage assessment will be continued to monitor changes in survival and reproduction. Additional radio transmitters will be deployed, beginning in 1993. Data will be analyzed to determine if juvenile survivorship has increased relative to survival estimates in 1990-91 and to estimate rates of reproduction.

4. Blood will be analyzed for a variety of physiologic variables and for hydrocarbons. The monitoring, which has been restricted to Prince William Sound, will be expanded westward, to assess the geographic extent of spill caused abnormalities. Analysis of existing data, including data from those animals captured for treatment during the oil spill response, will provide an increased understanding of the physiological impact of exposure. This information will aid in providing a link between exposure and the consequences to survival and reproduction. Sea otter prey will be sampled from foraging areas for demographic and contaminant analysis. This project will investigate the linkage from the presence of environmental contamination, through physiological pathways, to the recovery of sea otter populations.

Many of the restoration projects for sea otters extend from 1992 through 2001. Timing of project implementation has been based on documented effects, the need for continuity of data collection, and anticipated schedules in ongoing studies. A staggering of implementation will allow adequate time for study design, efficiency in integrating methods and materials among projects, and analysis and preparation of results. Additionally, we will retain flexibility in modifying, adopting or deleting studies, as a result of findings.

Restoration Activity or Endpoint to be Addressed:

The restoration endpoint at which these studies are aimed is the complete recovery of the affected sea otter populations. Other restoration endpoints include long-term protection of habitat, planning for future environmental contamination events and reduction in population stresses caused by various habitat perturbations which may hinder recovery. Each of the projects will focus on one or more of the arenas in which losses or injuries occurred and the relationship between injuries and recovery of the population and restoration of the community.

The population assessment study will identify the rate and point at which affected populations have returned to their pre-spill abundance.

Habitat utilization studies will define spatial and temporal patterns of habitat use by sea otters throughout most of the spill area. The restoration endpoint will be the identification of one or more areas of sea otter habitat that would be suitable and appropriate for assignment of long-term protection or change in management.

Recovery model validation will allow us to track the demographic variables that contribute to the net rate of growth (or decline) in a population. Mortality in post-weaning juveniles has been identified as one cohort that has experienced significantly higher post-spill mortality. This work will begin in 1993 because of the delay in continued, chronic exposure and the limited battery life of radio-telemetry studies.

The pathology and toxicology study will identify the physiological and biochemical levels at which effects may be observed and describe the pathway for continued exposure to environmental hydrocarbons.

Relationship to Science Information Needs Identified by RPWG:

This suite of projects addresses many of the general needs identified by RPWG:

-Improve understanding of the long-range underlying mechanisms causing injury or limiting populations;
-Extend the focus of studies beyond Prince William Sound and throughout the affected area;
-Shift emphasis to broader ecological rather than species-specific approaches;
-Analyze further the linkages between predators and prey abundance, availability, and quality;
-Monitor ecosystem recovery, since the extent and persistence of damages will determine the level of recovery.

This suite of projects addresses all of the three specific sea otter recommendations made by RPWG:

-Integrate damages over time as well as geographically;
-Extend survey work outside of PWS; need to know trends and demography outside of PWS;

-Determine causes of continuing EVOS-related decline: What life stages are the problem(s).

Importance of Initiating Projects in 1992:

Several of these projects are continuations of ongoing projects. Continuity in collection of data will be critical to understanding long-term trends. Other projects may be implemented over the next two years.

Link to Other NRDA Damage Assessment or Restoration Studies:

Sea otters are an important indicator of the health of the oil spill environment. Recovery of sea otter populations will indicate that the prey species upon which sea otters depend are also recovering. Conversely, continued stress due to the spill will show up in (1) slower than expected population recovery (or continued decline) and (2) physiological abnormalities or stress. This suite of projects will provide continuity with several ongoing projects. It is anticipated that other restoration projects will be implemented which will include evaluation of the health of subtidal systems affected by the spill. The abundance and distribution of sea otters throughout the spill area and the mobility of individual otters will also provide a measure of the temporal recovery of the affected marine communities.

Estimated Cost:

[Costs for years subsequent to 1992 are estimates based on 1992 dollars and will require the use of equipment purchased under NRDA studies (boats, computers, optics etc.)]

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Population Assessment	242K	242K	242K	160K	160K	160K	160K	160K	160K	160K
Habitat Utilization	160K	121K	121K	121K	121K	121K	121K	121K	121K	121K
Recovery Model Validation	138K	347K	400K	290K	290K	290K	290K	0	0	0
Bioindicators	44K	330K	100K	220K	44K	220K	44K	220K	44K	165K
TOTAL	**584K**	**1040K**	**863K**	**791K**	**615K**	**791K**	**615K**	**501K**	**325K**	**446K**

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Project Title: Population Monitoring Component - Monitoring of Sea Otter Population Abundance, Distribution, Reproduction and Mortality in Areas Affected by the *Exxon Valdez* Oil Spill.

Species and Injury to be Addressed:

Immediate losses of sea otters associated with the *Exxon Valdez* oil spill probably ranged from 3,500 to 5,500 animals. Current sampling of sediments, sea otter prey items, and sea otter bio-chemistry and physiology indicate that sea otters may be continuing to be exposed to contaminants. Preliminary results suggest that this exposure, at a minimum, may be affecting sea otters at an organismic level, and at a maximum, may be affecting survival, and therefore recovery of the population. The age distribution of sea otter carcasses within some oiled areas of Prince William Sound continue to indicate an increase in mortality of prime-age sea otters. This evidence, together with results from blood analyses and contaminant analyses, suggests that the sea otters population within the spill zone may still be compromised by exposure to oil.

Lead Agency:

U.S. Fish and Wildlife Service R8 & R7

Co-operating Agencies:

National Park Service, U.S. Forest Service

Project Objectives:

The *Exxon Valdez* oil spill resulted in the death and removal of several thousand sea otters from affected habitats. Several lines of evidence suggest that spill-related mortality may still be occurring. The objectives of this restoration project are: (1) to monitor the abundance, distribution and mortality of sea otters in the spill area; (2) identify patterns of habitat use; and (3) to estimate annual reproduction in affected populations. In addition, beach surveys will record all mammal and bird species encountered.

Project Methods and Duration:

This restoration project has several components:

A. In order to monitor and evaluate the recovery of the sea otter population throughout the spill affected area, annual monitoring will be undertaken. Since the spill, detailed data has been developed primarily in the Prince William Sound portion of the spill area. Efficient techniques are being developed through RESTORATION

FEASIBILITY PROJECT #3 which can be implemented as a pilot project within Prince William Sound in 1992. Survey methodology will be field tested outside Prince William Sound in 1992 and 1993, and a complete monitoring program throughout the entire spill area will be in place from 1993 through 2001. In addition to aerial surveys, reproductive surveys and mortality surveys will be undertaken as part of this project.

Boat-based surveys of sea otters and marine birds in Prince William Sound will be conducted in cooperation with migratory bird personnel. (The budget for boat surveys is presented under the U.S. Fish and Wildlife Service Bird proposals.) It is important that the sea otter component of these surveys be continued in 1992 and possibly 1993 to provide the opportunity for calibrating the two techniques. In addition, the results of these surveys will be compared with pre-spill and damage assessment surveys.

Estimated Cost:

Year	1992	1993	1994	1995 to 2001
Cost	$242K	242K	242K	160K per year

Restoration Activity or Endpoint to be Addressed:

The primary objective of this project is to monitor the affected sea otter populations through recovery. The results of the population assessment project will be the endpoint against which the population recovery model, developed under the NRDA process, will be evaluated. It will also be the means by which recovery of the population is determined. The recovery model describes the mode and timing of recovery of the sea otter populations impacted by the spill. The variables which the model uses includes components such as the age and sex structure of the population, reproductive success, weanling survival, and adult mortality. By monitoring these various components it will be possible to estimate the period required for recovery of the population. The population recovery validation project will be directed at evaluating the variables of the model. The population assessment project will provide the direct measure of recovery. If recovery is not occurring as expected or desired, additional strategies to enhance recovery will be developed and considered.

Relationship to science information needs identified by RPWG:

This study addresses several of the general needs identified by RPWG:

- -Extend the focus of studies beyond Prince William Sound and throughout the affected area.
- -Monitor ecosystem recovery, since the extent and persistence of damages will determine the level of recovery.

This project addresses two out of the three specific sea otter recommendations made by RPWG:

-Integrate damages over time as well as geographically.
-Extend survey work outside of PWS; need to know trends and demography outside of PWS.

Importance of initiating project in 1992:

The aerial survey portions (RESTORATION FEASIBILITY STUDY #3), boat-based surveys, and beach surveys (NRDA MARINE MAMMAL STUDY #6) are continuations of projects which are currently ongoing. Continuity in collection of data will be critical to understanding long-term trends. The earlier the other project components can be implemented, the more meaningful the long-term data analysis will be to understanding the recovery of sea otters throughout the spill area.

Link to other NRDA damage assessment or restoration studies:

The current pathway of effects of contamination to sea otters is through their food supply. The results of this project bear directly on the presence and concentration of contaminants in sea otter prey items and the consequences of long-term exposure. Information on sea otter distribution and abundance may relate to other potential restoration projects including habitat acquisition, and mitigation of logging, mining, and development impacts. In addition, boat-based sea otter surveys and boat-based marine bird surveys were done concurrently using the same vessels and personnel; it is likely that this cooperation will continue in the future.

Project Title: Habitat utilization by sea otters and designation of protected areas

Species and Injury to be Addressed:

Damage assessment studies indicate that of all marine mammals species impacted by the *Exxon Valdez* oil spill, sea otters were the most adversely affected. Immediate losses of sea otters associated with the *Exxon Valdez* oil spill probably ranged from 3,500 to 5,500 animals. In addition, broad expanses of sea otter habitat were exposed to hydrocarbons. Ongoing sampling of sediments, sea otter prey items, and sea otter physiology indicate that sea otters are continuing to be exposed to contaminants. Preliminary results suggest that this exposure, at a minimum, may be affecting the physiology of sea otters, and at a maximum, may be affecting survival of some age cohorts of sea otters.

Lead Agency:

U.S. Fish and Wildlife Service

Co-operating Agencies:

NPS
Potentially: NOAA, ADFG, USFS

Project Objectives:

The primary objectives of this project are: (1) to describe and monitor the distribution and seasonal patterns of habitat use of sea otters for use in planning habitat protection; and (2) characterize and describe bottom habitats and sea otter prey assemblages within those sites to evaluate suitability of protective status for sea otters.

Project Methods:

The initial phase of this study will be to identify and digitize all sea otter habitat within the spill using available bathymetry data. The following phase will be to describe seasonal patterns in sea otter distribution and relative abundance. Those data will be used to initially evaluate sites within the oil spill zone for placement into potential protective status such as marine sanctuaries. Once sites for marine sanctuaries are proposed, those sites will be further evaluated as to the amount of available sea otter foraging habitat (depth), bottom type, and the kinds and availability of sea otter prey. In general, grids of nearshore areas will be randomly sampled in various water depth strata for substrate type and relative abundance of marine invertebrates.

Data from this restoration project could be used for planning a marine sanctuary or conservation area.

Project Duration:

The initial phases of this project including distribution surveys, seasonal use surveys and compilation of existing data will be completed in 1992 and 1993.

Once specific protection areas are identified, habitat surveys and evaluations will take approximately two years.

Estimated Cost:

Data compilation, GIS development, surveys of sea otter distribution and habitat:

Year	1992	1993-2001
Cost	160K	121K/yr

1995 through 2001 costs will be dependent on the areas to be evaluated.

Restoration activity or endpoint to be addressed:

Protection of habitats important to sea otters will be a means of ensuring sea otter recovery over the long-term. Identification of important habitat such as foraging and haulout areas will be crucial to identifying areas which are valuable to sea otters. In addition, this project will lead to the development of a data base of sea otter distribution and patterns of habitat use that would be integrated with available data on commercial, recreational, and subsistence uses. The proposed project would improve scientific knowledge, and promote public understanding of the area and its resources.

Relationship to science information needs identified by RPWG:

This project addresses at least three of the general needs identified by RPWG:

- -Analyze further the linkages between predator and prey abundance, distribution, availability, and quality.
- -Monitor ecosystem recovery.
- -Extend the focus of studies beyond Prince William Sound and throughout the affected area.

This project addresses two out of the three specific sea otter recommendations made by RPWG:

- -Integrates damages over time as well as geographically.
- -Extends survey work outside of Prince William Sound.

Importance of initiating project in 1992:

Prompt initiation of the project will result in more rapid implementation of restoration endpoints identified by RPWG.

Link to other NRDA damage assessment or restoration studies:

Various data on sea otters, collected as part of the damage assessment and restoration, would form thematic layers in the proposed data base used to evaluate protective status of certain marine or upland areas.

Project Title: Sea Otter Recovery Model Validation Component - Survival, Reproduction, and Movements of Sea Otters Associated With the *Exxon Valdez* Oil Spill

Species and injury to be addressed:

Survival and reproduction of sea otters that were captured, treated, held, and released following the *Exxon Valdez* oil spill were significantly lower than sea otters in a free-ranging control group that were instrumented after the treated otters were released. Results from a project involving pup survival indicate a higher mortality rate among weanlings living in the oil spill area. Results of a telemetry project involving instrumentation of free-ranging adult female sea otters show significant higher survival in western Prince William Sound and no differences in reproduction between oiled and unoiled areas.

Lead Agency:

U.S. Fish and Wildlife Service

Project Objectives:

Results to date suggest that exposure to oil and subsequent capture, treatment, and long-term holding compromised the ability of many sea otters to survive following release to the wild, particularly during their first winter. Data from the telemetry study of females and weanlings has been used in developing a model to predict the population recovery of sea otters in Prince William Sound. Movement data have identified patterns of habitat use for sea otters in Prince William Sound. A positive growth rate in the recovering sea otter population will depend on adequate survival and reproduction. The objective of this proposal is to conduct radio telemetry studies to provide estimates of survival, reproduction, and movements.

Project Methods:

All sea otters currently instrumented with radio transmitters will be monitored from fixed-wing aircraft and boats, on a periodic basis, for the duration of the life of their transmitters. Future telemetry work will use methods similar to those of previous studies, with the exception that a temperature switch will be integrated into the transmitter. This switch will detect a change in the pulse rate when the transmitter drops below a determined temperature. This modified package will allow dead sea otters to be identified and located much sooner than conventional methods. Up to 50 dependent pups will be implanted in 1993. Samples will be collected for blood chemistry and toxicology. The sample of otters surviving to 1994 will be supplemented with 50 additional transmitters in female sea otters to provide estimates of survivorship and reproduction. The recovery of fresh sea otter carcasses was identified as a high priority need during the damage assessment process and will continue to provide valuable information about cause of death in sea otters in the oil spill area. The implementation of this project will depend on acquiring the necessary permits.

Duration of Project: The expected life of the transmitters currently in Prince William Sound is through fall of 1992. Deployment of additional radio transmitters will begin in Fall of 1993. Those radios will be supplemented in 1994. The predicted life of three years of the radio transmitters would require monitoring through 1997. It is anticipated that field work would be concluded at that time, and data analysis and report preparation would be concluded in 1998.

Estimated Cost:	Year	1992	1993	1994	1995 to 1998
	Cost	138K	347K	400K	290K/yr

Restoration Activity or Endpoint to be Addressed:

The various components of this project in conjunction with results from the other sea otter projects described in this proposal will be used to validate the model of sea otter recovery developed as a result of NRDA studies. This model describes the mode and timing of recovery of the sea otter populations impacted by the spill. The model is based on certain assumptions which include components such as age structure of annual mortality, reproductive success, weanling survival, and quality of habitat availability. By monitoring these various components it will be possible to determine the overall recovery of the population. If recovery is not occurring as expected, additional strategies to enhance recovery will be developed and considered.

Relationship to science information needs identified by RPWG:

This project addresses at least one of the general needs identified by RPWG:

-Improve understanding of the long-range underlying mechanisms causing injury or limiting populations.

This project addresses two out of the three specific sea otter recommendations made by RPWG:

-Integrate damages over time as well as geographically.
-Determine causes of continuing EVOS related decline: what life stages are problem.

Importance of initiating project in 1992:

Continuation of monitoring existing transmitters will provide additional information on female sea otter reproduction and survival rates in 1992. The radios which are currently in place will begin to go off the air in the fall of 1992. Lack of funding for this study will result in termination of monitoring for those animals which are currently carrying transmitters. Initiation of additional radio telemetry studies would occur in 1993.

Link to other NRDA damage assessment or restoration studies:

Movement data from the telemetry study of free-ranging sea otters may provide data on important sea otter habitats in western Prince William Sound relative to other restoration activities including habitat acquisition, and mitigation of logging, mining, and development impacts. Results of the telemetry study on the "rehabilitated" sea otters will provide information on the efficacy of the "rehabilitation" process following oil spills, and hence may influence the direction of response effort to future oil spills.

Project Title: Pathology and Toxicological Monitoring Component - Monitoring Blood Parameters and Hydrocarbon Contamination of Sea Otters and their Prey Species Within the Oil Spill Zone.

Species and Injury to be Addressed:

Differences were observed in several blood variables of sea otters between spill affected areas and control areas. These variables include sodium/potassium ratios, total protein and total globulin, white blood cell counts, percentage of eosinophils, and packed cell volume. The observed differences in blood variables for western Prince William Sound sea otters may reflect organ (liver, kidney) tissue damage from initial acute and/or chronic exposure to hydrocarbons. Histopathological changes were found in liver samples from oiled sea otters that died at the rehabilitation centers shortly after the spill; similar damages may have occurred in sea otters that survived the initial exposure to oil. Because the full extent of such damage may not become apparent for several years following the initial exposure, continued monitoring of blood and organ tissue samples to detect pathological changes is warranted.

Toxicological analyses of tissue samples from sea otters indicate variations in concentrations of certain aliphatic and aromatic hydrocarbons. This reflects, in some cases, the exposure of the sea otters to oil. Hydrocarbon data analysis completed to date suggest continued exposure of sea otters to toxic compounds, and the persistence of some toxic compounds both in the environment and in sea otter tissues.

Results from the coastal habitat and fish/shellfish studies have identified elevated levels of hydrocarbon in several sea otter prey species including mussels and clams. Bi-valve mollusks are unable to metabolize hydrocarbons and as a result, concentrate these compounds over time. Bi-valve mollusks may continue to concentrate hydrocarbons in their tissues and sea otters may be exposed to those contaminants through feeding.

Although the consequences of altered blood parameters and tissue hydrocarbon contamination in sea otters are not fully understood, the potential exists for long-term damage affecting survival and recovery of the sea otter populations.

Lead Agency:

U.S. Fish and Wildlife Service

Project Objectives:

The project objectives are: (1) to provide information on the possibility of pathological and toxic damages from initial acute and ongoing chronic exposure to oil; and (2) effects on recovery of sea otter populations. Additional information on the possibility of ongoing chronic exposure and its effect on population recovery will be obtained.

Project Methods:

Methods for collection and analysis of blood (complete blood counts and hematology) and hydrocarbon levels of tissues, including blood, have been fully worked out for sea otters in previous studies, as have histopathological examinations. Sea otters collected under the model validation study will provide tissue samples for blood chemistry and toxicology analysis.

Additional monitoring of blood values of sea otters within the oil spill zone in Prince William Sound and along the Kenai Peninsula will occur in 1993 and every other year thereafter. If significant alterations in blood parameters or hydrocarbon levels are found along the Kenai Peninsula, blood samples will also be collected at Kodiak Island and the Alaska Peninsula in subsequent years. If no changes are noted, sampling in subsequent years will be restricted to Prince William Sound. A control group has been previously sampled outside the spill area in Southeast Alaska, and will suffice for continuing studies. Hydrocarbon analyses will be done on the same blood samples, as well as on tissue samples from carcasses recovered in adequate condition for necropsy. Tissues from these carcasses will also be collected for histopathological examination (see "Mortality Monitoring Component" of the Sea Otter Restoration Studies.)

Interpretation of the blood and toxicology data may be considerably enhanced if repeat samples are obtained on specific individuals. To facilitate this, one hundred sea otters in oiled areas of Prince William Sound will be captured and permanently marked with flipper tags in the first year of the study. In the first year, two subsets of the marked animals will be examined: (1) those four years of age or older, which would have been exposed to oil at the time of the spill and suffered acute and chronic exposure, and (2) those less than four years of age, which would suffered only chronic exposure to the oil. In subsequent years, up to 50 of the 100 marked sea otters will be targeted for recapture and resampling. On the Kenai Peninsula, 25 sea otters of age four years or older will be targeted the first year.

Sea otter prey will be collected (using methods similar to the MM6 damage assessment study) from foraging areas within areas of heavy shoreline oiling at the time of the EVOS. One monitoring site has been identified in Prince William Sound; two additional sites will be selected outside of PWS and contaminant levels will be measured using standard analytical techniques.

Duration of Project:

In Prince William Sound, monitoring will be done biannually through the life span of those sea otters which were exposed during the spill. In other oiled areas, the need for continued monitoring will be evaluated based on results of the 1993 collections.

Estimated Cost:

Year	1992	1993	1994	1995-97-99	1996-98-2000	2001
Cost	44K	330K	100K	220K/yr	44K/yr	165K

Restoration Activity or Endpoint to be Addressed:

The various components of this project in conjunction with results from the other sea otter projects described in this proposal will be used to validate the model of sea otter recovery developed as a result of NRDA studies. This model describes the mode and timing of recovery of the sea otter populations impacted by the spill. The assumptions on which the model is based include components such as age structure of annual mortality, reproductive success, weanling survival, population growth, and quality of habitat availability. By monitoring these various components, it will be possible to determine the overall recovery of the population. If recovery is not occurring as expected or desired, additional strategies to enhance recovery will be developed and considered.

Relationship to Science Information Needs Identified by RPWG:

This project addresses several of the general needs identified by RPWG:

-Improve understanding of the long-range underlying mechanisms causing injury or limiting populations.
-Extend the focus of studies beyond Prince William Sound and throughout the affected area.
-Monitor ecosystem recovery, since the extent and persistence of damages will determine the level of recovery.

This project addresses two out of the three recommendations made by RPWG:

-Integrate damages over time as well as geographically.
-Determine causes of continuing EVOS-related decline: what are physiological mechanisms?

Importance of Initiating Project in 1992:

It is recommended that this project be done biannually beginning in 1993 rather than 1992, to allow full analysis of existing data. Techniques for recapture of sea otters permanently marked with flipper tags are being developed.

Link to Other NRDA Damage Assessment or Restoration Studies:

Continued documentation of abnormal blood values and elevated levels of some hydrocarbons in sea otters suggest continued exposure of sea otters to contaminants within the oil spill zone. Additionally, histopathological changes in dead sea otters following exposure to oil suggest potential mechanisms for injury. Long-term survival of the animals in oiled areas may be compromised, thus extending the time required for overall population recovery. A likely source of hydrocarbon contaminants are the foods of sea otters, primarily clams, mussels, and perhaps sea urchins and crabs. Continued studies on availability of contaminants in the environment are important in analyzing the linkages between predators and prey abundance, availability, and quality.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
1011 E. Tudor Rd.
Anchorage, Alaska 99503

IN REPLY REFER TO:

15 1991

THROUGH: Department of the Interior Representative - Restoration Planning Work Group

TO: Restoration Planning Work Group

FROM: Deputy Assistant Regional Director - Oil Spill, U.S. Fish and Wildlife Service

Paul E Gertler

SUBJECT: 1992 Restoration Study and Project Proposals

As requested by the Restoration Planning Work Group (RPWG), attached are the 1992 proposals for restoration studies and projects recommended by the U. S. Fish and Wildlife Service (Service). These proposals were developed to meet both the general and specific guidance distributed by the RPWG. The Service considers the restoration program following the *Exxon Valdez* oil spill a high priority and will assist the RPWG in planning and implementing high quality restoration programs for those resources for which the Service has responsibility and expertise.

In addition to the proposals submitted for projects to begin or continue in 1992, we are also submitting preliminary proposals for projects and studies that we recommend begin after 1992. We intend these proposals to facilitate the RPWG in their planning efforts for 1993 and beyond.

We understand that the Alaska Department of Fish and Game will submit proposals for continuation of restoration studies on harlequin ducks and other sea ducks. Although we have not yet reviewed those proposals, we are supportive of the need to continue these efforts. We will review those proposals and offer comments to you as soon as possible.

We are also submitting several recommendations for studies and projects that need to be considered, but that should be implemented by another agency or group with more specific or broader expertise in these areas that the Service. The Service has an interest in these studies and requests it be consulted in study design and implementation to ensure that issues related to sea otters and migratory birds are specifically considered. One of these studies, a marbled murrelet study on foraging habitat proposed for implementation after 1992, could be expanded to cover all wildlife resources dependent on forage fish. Another study on management strategies for sea otters and seabirds could be expanded to cover all injured and recovering natural resources. We would also like to recommend an interagency program that promotes environmental education regarding injured and recovering resources.

You will note that a number of studies are joint efforts with other agencies (e.g. National Park Service). We think that studies such as these are important because they serve a wide variety of management needs and thus serve the public broadly. We look forward to providing additional input to be incorporated into a public education proposal for which the National Park Service will take the lead.

Thank you for considering these proposals. We will be available to answer any questions and provide any clarifications that might be needed. We look forward to working with RPWG in the future to plan for and implement projects and studies that will lead to restoration of resources injured by the *Exxon Valdez* oil spill.

Project Title: Management Strategies for Restoring and Protecting Migratory Bird and Sea Otter Populations and their Habitats in the *Exxon Valdez* Spill Zone.

Species and Injury to be Addressed:

The NRDA studies have indicated that of all organisms in the path of oil from the T/V Exxon Valdez sea otters and migratory birds were the most visibly impacted. Immediate losses ranged between 3,500 and 5,500 sea otters and 325,000 and 435,000 migratory birds. In addition to the immediate losses continuing impacts to otters and birds as a result of the oil spill, several resource development activities and potential threats may either slow recovery of these resources or contribute to their continuing decline.

Lead Agency:

U.S. Fish and Wildlife Service

Possible Co-operating Agencies:

NOAA, NPS, USFS, State of Alaska, Native Corporations, NMFS, Alaska Sea Otter Commission

Project Objectives:

A. Synthesize information on migratory bird and sea otter populations and habitat parameters for the spill zone.

B. Identify resource issues, conflicts, problems, and threats to populations of migratory birds and sea otters and their habitats in the spill zone.

C. Identify alternative management strategies and opportunities for restoring and protecting migratory bird and sea otter populations and their habitats in the spill zone.

Project Methods:

This study will synthesize existing biological information such as the distribution, abundance, and habitat parameters of migratory birds (e.g., raptors, seabirds, seaducks, waterfowl, shorebirds, and others) and sea otters for the spill zone area. Existing and potential human activities and other threats will also be analyzed and will include but not be limited to: petroleum exploration, development, and transportation, logging and log transfer facilities, subsistence and recreational harvests, commercial and subsistence fishing, mariculture development, tourism and other coastal developments. Data layers using GIS methods will be produced.

Following the data synthesis phase, alternative strategies for restoring and protecting sea otters and birds in the spill zone will be developed. Alternative management strategies will include but not be limited to: designation of protected areas, limiting/redirecting subsistence, recreational, and commercial harvests of sea otters, birds, and shellfish, limiting incidental mortalities of sea otters and birds, controlling predators, artificial enhancement of populations and habitats, and minimizing disturbances. Many other restoration options, already identified by the RPWG will also be addressed.

Project Duration:

Synthesis and analysis of data resources and the development of alternative restoration and protection strategies will take one year.

Estimated Cost:

Synthesis of resource data, GIS development and identification of management alternatives.

Marine Mammal Component	66K
Migratory Bird Component	39K
Total	105K

Restoration Activity or Endpoint to be Addressed:

Minimizing disturbance and protecting/acquiring marine and coastal habitats are restoration end points identified for migratory birds and sea otters. Currently within the area affected by the *Exxon Valdez* oil spill, migratory birds and sea otters are legally killed by Alaska Natives for subsistence, illegally killed as nuisance animals, taken incidentally in commercial fishing operations, and occasionally captured and removed for public display, all activities which may be contrary to restoration goals. The effects of logging and other forms of development in the coastal zone on birds and sea otters are largely unknown. The proposed project also would result in the acquisition and compilation of information that could be used in making decisions on ways to minimize disturbance, protect habitat, and resolve conflicting uses or management conflicts. It is unlikely that decisions of those kind could be made for birds and sea otters until existing data relating to their management and conservation were accessed and complied.

Relationship to Science Information Needs Identified by RPWG:

This project addresses at least three of the general needs identified by RPWG:

A. Shift emphasis to broader ecological approaches and resource syntheses and integrate those data into management alternatives.

B. Synthesize the effects of environmental disturbances.

C. Extend the focus of studies beyond Prince William Sound and throughout the affected area.

Importance of Initiating Project in 1992:

Prompt initiation of the project will result in more rapid implementation of restoration endpoints identified by RPWG. In addition, synthesis of information on populations, habitat and resource threats will reveal data gaps for future restoration studies and enhancement opportunities for developing alternative management strategies for restoring and protecting sea otters and migratory birds.

Link to Other NRDA Damage Assessment or Restoration Studies:

This project will synthesize some data collected during NRDA studies. It will also identify data gaps that can be filled by future restoration studies as well as identify management actions that could be implemented to achieve restoration.

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November 15, 1991

SUITE OF RESTORATION PROJECTS FOR BIRDS
submitted by the U.S. Fish and Wildlife Service

SUMMARY: Several projects are recommended for bird restoration and recovery monitoring. Pages 1 through 7 of this document provide a consolidated summary of the entire suite of projects. Each project is then presented following the outline provided by the Restoration Planning Work Group in September 1991.

Overall Summary....................................Page 1
Budget Summary by Year.............................Page 6

Recommended Waterbird Projects for 1992 (in order of FWS priority)

1. Murre Population and Productivity Surveys..........Page 8
2. Harlequin Duck Habitat & Productivity Surveys NOT RECEIVED
3. Aging of Alcid Carcasses...........................Page 11
4. Surveys to Monitor Seabird Populations.............Page 16
5. Pigeon Guillemot Recovery Enhancement and Monitoring..........................Page 20
6. Surveys to Identify Marbled Murrelet Upland Habitat Use......................Page 23
7. Identification of Marbled Murrelet Nesting Habitat and Reproductive Success........Page 26
8. Feeding Ecology and Reproductive Success of Black Oystercatchers.................Page 30
9. Murre Recovery Modeling............................Page 33
10. Control Human Disturbance at Impacted Murre Colonies..........................Page 34

Recommended Eagle Projects for 1992 (in order of FWS priority)

1. Identification of Important Bald Eagle Habitat.....Page 36
2. Develop Bald Eagle Population Model and age-specific survival and productivity......Page 39
3. Monitor Productivity of Bald Eagles................Page 42
4. Monitor Bald Eagle Hydrocarbon Contamination through Blood Analyses.................Page 44
5. Hydrocarbon Contamination of Bald Eagle Eggs.......Page 46

Projects Considered for Possible Implementation After 1992 (not in priority order)

1. Determine Annual Food Habits for Adult and Subadult Bald Eagles....................Page 50
2. Murrelet Foraging Habitat Requirements.............Page 52
3. Censuses of Seabird Nesting Colonies...............Page 54
4. Avian Predator Control at Seabird Colonies.........Page 56
5. Eradication of Introduced Foxes, Squirrels or Rats at Seabird Nesting Islands.............Page 58
6. Test Feasibility of using of Decoys or Vocalizations to Enhance Murre Recovery..............Page 60
7. Identify Post-Breeding and Wintering Concentrations of Murre Chicks and Adults.............Page 63

Species and Injuries to be Addressed:

Among the most conspicuous effects of the *Exxon Valdez* oil spill was the injury to many species of birds. Birds were present throughout the geographic area impacted by the oil. A wide range of habitat types, each supporting various life stages of any number of bird species, were totally engulfed in oil. Seabirds are particularly vulnerable to oil as they spend much of their time on the sea surface while foraging. Oiled plumage insulates poorly and loses buoyancy and birds died from hypothermia or drowning. Birds surviving initial acute exposure may later succumb from ingesting oil while preening. Approximately 36,000 dead birds were recovered after the spill; at least 31,000 of these deaths were attributed to the effects of oil. In addition to a large number of dead murres, sea ducks and bald eagles, carcasses of loons, cormorants, pigeon guillemots, grebes, murrelets and other species were also found. Only a small proportion of the total number of birds estimated to have been killed were found, as many undoubtedly floated out to sea, sank, were scavenged, decomposed, were hidden in masses of oil, were buried under sand and gravel, or simply beached in an area where they were not found. Analyses that account for some of these variables estimate that the total number of birds killed by the spill ranges from 300,000 to 645,000 with the best approximation between 375,000 to 435,000 birds. In addition to direct mortality, several bird species have experienced continuing effects due to reproductive failure, reduced productivity, contaminated prey species, and contaminated habitat.

Overall Objectives of Bird Suite of Projects:

Strategies and techniques to enhance reproduction, reduce ongoing impacts and population stresses, and facilitate recovery of impacted species will be identified and implemented where practical. Identification of habitat needs and life history requirements for the affected birds and their prey will be necessary in order to identify marine and upland habitat needs for affected species. Monitoring population and reproductive success of bird species injured by the spill is necessary to verify natural recovery or continued declines. The development of management strategies to further facilitate recovery of the injured species will rely on this information.

Project descriptions:

The restoration package includes 17 projects recommended for implementation beginning in 1992. In addition, a variety of other projects are included for consideration in future years. These additional projects address specific recommendations made by RPWG or recommendations developed by the FWS which may be important as part of a long-term restoration program.

Certain projects support the development of habitat models. These projects work to identify nesting, wintering or other critical life stage requirements to provide information necessary to evaluate habitat and make recommendations for the acquisition or change in management of upland or marine habitat areas important to these species.

Some of the projects entail population enhancement strategies to facilitate the recovery of an impacted species or group of species. These projects either implement or develop techniques to enhance productivity by increasing the opportunities for successful reproduction, identifying population stresses and developing recommendations for reducing those stresses.

Other projects monitor the natural recovery of individual or groups of species. Monitoring injured populations and their reproductive success is necessary to verify natural recovery or continued declines. For those species that are still undergoing decline or depressed populations, further understanding the injury caused by the spill will serve to guide the design of suitable restoration projects.

Project Durations:

Many of the restoration projects for various bird species extend from 1992 through 2001.

Restoration Activities or Endpoints to be Addressed:

The various projects included in this suite of projects will be essential for restoring injured species by increasing the opportunities for successful reproduction, providing information essential to protecting marine and upland habitat to enhance species recovery, and monitoring the recovery of injured species.

Relationship to Science Information Needs Identified by RPWG:

This suite of projects addresses many of the general needs identified by RPWG:

- -Improve understanding of the long-range underlying mechanisms causing injury or limiting populations;
- -Extend the focus of studies beyond Prince William Sound and throughout the affected area;
- -Shift emphasis to broader ecological rather than species specific approaches;
- -Analyze further the linkages between predators and prey abundance, availability, and quality;

-Monitor ecosystem recovery, since the extent and persistence of damages will determine the level of recovery;
-Synthesize the effects of environmental disturbances on EVOS-injured species.

This suite of projects addresses many of the recommendations specific to birds made by RPWG:
-Determine foraging habitat of incubating and brood rearing female harlequin ducks;
-Determine nest site preferences and characteristics of harlequin duck nesting habitats;
-Compare harlequin duck prey and other characteristics associated with successful streams in eastern PWS and western PWS;
-Extend results of NRDA studies beyond PWS for harlequin ducks;
-Determine whether harlequins will use artificial nest sites;
-Study reproductive success of black oystercatchers in cleaned versus non-cleaned and oiled versus non-oiled sites;
-Determine if predation of pigeon guillemots is a limiting factor;
-Explore use of predator-proof artificial nest structures to enhance productivity of pigeon guillemots;
-Study prey (forage fish) selection in relation to productivity at easily-accessible nest sites;
-Review existing data bases on distribution of marbled murrelets during breeding season prior to undertaking additional field surveys outside of PWS;
-Survey Afognak Island and other locations to determine presence/absence of murrelets during breeding season;
-Include areas with rocky habitats along with timbered habitats in marbled murrelet nesting habitat studies;
-Monitor small murre colonies to determine whether they are abandoned or whether they are inhabited by non-reproducing adults;
-Test feasibility of tape recordings, decoys, etc. to facilitate synchrony of murre nesting;
-Identify post-breeding concentrations of murre chicks with accompanying males and winter concentrations;
-Identify opportunities for acquiring areas which benefit public access and education purposes;
-Determine extent of bald eagle injury beyond PWS;
-Identify bald eagle winter roost sites;
-Develop bald eagle population model and understanding of age-specific survival rates and productivity;
-Determine winter food habitats for adult and subadult bald eagles; and
-Monitor contamination of bald eagles by residual petroleum hydrocarbons.

Importance of Initiating Projects in 1992:

Several of these projects are continuations of ongoing projects. Continuity in collection of data will be critical to understanding long-term trends. Other projects which directly benefit injured populations will hasten recovery the sooner they are implemented. The earlier the other project components can be implemented, the more meaningful the long-term data will be to understanding the rate and means of recovery and identifying the habitat needs required to support habitat protection and enhancement.

Link to Other NRDA Damage Assessment or Restoration Studies:

Birds and their prey species are an important and major component of the injured ecosystem. It is anticipated that other projects will specifically target those prey species. The broader perspective of the habitat provided by the affected area can best be understood, enhanced and protected by understanding the needs of the various individual species and their relationship with one another. Then, upland and marine habitat management can be related to specific and general habitat requirements of the various injured species.

Estimated Cost: Costs for years subsequent to 1992 are preliminary estimates based on 1992 dollars and require the use of equipment purchased under NRDA (boats, optics, etc.)

SEABIRD PROJECTS (in order of FWS priority)	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
MURRES - Population and Productivity Surveys	533K	490K	490K	490K	490K	490K	490K	490K	490K	490K
ALCIDS - Aging of Carcasses	220K	220K	220K							
SEABIRDS - Population Surveys	303K	578K	578K	578K	578K	578K	578K	578K	578K	578K
PIGEON GUILLEMOTS - Recovery Enhancement and Monitoring	243K	231K								
MARBLED MURRELETS - Surveys of upland habitat use	180K	176K	176K							
MARBLED MURRELETS - Nesting Habitat Criteria and Reproductive Success	240K	250K	250K	250K	250K	250K	250K	250K	250K	250K
BLACK OYSTERCATCHERS - Feeding Ecology and Reproductive Success	200K	200K								
MURRES - Recovery Modeling BUDGET TO BE DETERMINED										
MURRES - Control or Eliminate Human Disturbance Near Impacted Colonies	88K	88K	88K							
SUBTOTAL	**2007K**									

BALD EAGLE PROJECTS (in order of FWS priority)	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
BALD EAGLES - Identification and Protection of Important Habitats	267K	267K	267K	170K						
BALD EAGLES - Develop Population Model and Understanding of Survival and Productivity	154K	187K	187K	187K	187K	187K	187K	187K	187K	187K
BALD EAGLES - Monitor productivity within the EVOS area	60K	60K	60K	60K	60K	60K	60K	60K	60K	60K
BALD EAGLES - Monitor Hydrocarbon Contamination through Blood	128K	128K	47K	47K	47K					
BALD EAGLES - Monitor Contamination of Eggs by Hydrocarbons	128K									
SUBTOTAL	**737K**									
GRAND TOTAL FOR 1992 BIRD PROJECTS	**2744K**									

Project Title: Monitoring Rate of Recovery or Continuing Changes of Murre Numbers and Productivity in Seabird Colonies in or Downstream from the *Exxon Valdez* Oil Spill.

Species and Injury to be Addressed:

The *Exxon Valdez* oil spill caused significant injuries to many species of migratory birds, most of all to murres. As the oil spill exited Prince William Sound and moved though the Gulf of Alaska, it collided with large rafts of murres congregating around major colonies in anticipation of the upcoming breeding season. The resulting massive mortality included the death of an estimated 198,000 adult breeding birds, representing 60 to 70 percent of the total breeding population of certain major colonies such as those on the Barren Islands. Extrapolating to include mortality of non-breeding murres, the total initial mortality of murres is estimated to be as high as 300,000 birds. The loss of adult breeding murres resulted in a major disruption of breeding behavior and phenology which in turn resulted in complete reproductive failure for the past three years. Although there are some initial indications that some colonies or portions of colonies are returning to more normal phenology, continued monitoring is needed to determine if these changes will continue and result in improved reproductive success.

Lead Agency and Principal Investigator:

The U. S. Fish and Wildlife Service

Project Objectives:

The objective of this project is to monitor recovery of impacted colonies to determine how long it will take for them to recover considering the large mortality of adult breeding birds and at least three years of reproductive failure. This documentation will be needed to plan future specific restoration measures. The specific objectives of this project are:

1. Document rate of recovery of murres in terms of numbers of breeding adults and their reproductive success and chronology at colonies in and near the oil spill area.

2. Improve methods of documenting/censusing murre colonies where boat-based censusing is the only option.

3. Expand monitoring of murre colonies to other areas in the spill zone where murre declines may have occurred.

Project Methods and Feasibility:

Two methodologies will be utilized; replicate population counts and chronology/productivity plots.

1. Population counts will be a combination of total island or sub-colony counts as well as plot counts. These will be accomplished by a combination of land-based and boat-based counts, depending on the historical and feasible options available for each site. In all cases, the population counts will be replicated over 5 to 7 separate days when conditions are optimal during a certain window in the reproductive cycle when most birds are incubating eggs. Standard Service methodologies for counts will be followed. The use of new technology video cameras that might reduce the amount of time needed for the boat-based censuses will be considered.

2. The chronology and productivity plots will focus primarily on land-based plots since they require more intensive observation. Use of time lapse cameras will be considered.

Duration of Project:

Based upon the serious injuries to murre colonies, including continued lost production, it is important that monitoring be continued for at least ten years.

Estimated Cost:

It is recommended that this study be done at the following sites in 1992 and long term: Barren Islands, Puale Bay, Semidi Islands and Chiswell Islands. Costs for 1992 include equipment costs and replacement motors for aging equipment used under damage assessment.

Year	1992	1993 to 2001
Cost	533K	490K/year

In addition, in future years it may be appropriate to include other sites such as other Alaska Peninsula murre colonies (including Spitz, Karpa, Midun, Ugaiushak and Atkulik Islands), and Middleton Island.

Restoration Activity or Endpoint to be Addressed:

Monitor recovery of a resource significantly injured by the spill and monitor ecosystem recovery. It will assist in determining what sites and aspects of murre biology need more direct restoration measures.

Relationship to Science Information Needs Identified by RPWG:

This project addresses the following general and specific needs identified in the September 1991 RPWG memorandum:

-Improve understanding of the long-range underlying mechanisms causing injury or limiting populations;

-Extend the focus of studies beyond Prince William Sound and throughout the affected area;

-Monitor small murre colonies to determine whether they are abandoned or whether they are inhabited by non-reproducing adults;

Importance of Initiating Project in 1992:

Murre colonies impacted by the oil spill are just beginning to show slight indications of returning to a more normal breeding phenology. Monitoring the rate and degree of these changes during 1992 and beyond will be essential to determining whether these murre colonies will recover in 10 or in 70 years, or more. These data will also determine the type of restoration activity proposed in the future.

Link to Other NRDA Damage Assessment or Restoration Studies:

Other murre studies and NRDA Bird Studies 1 and 2.

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AGING OF ALCID CARCASSES FROM THE <u>EXXON VALDEZ</u> OIL SPILL: OBTAINING DEMOGRAPHIC INFORMATION FOR RESTORATION EFFORTS

<u>Species and Injuries to be Addressed</u>: Members of the seabird family Alcidae, with particular emphasis on those species which been most affected, ie., Common Murres, Pigeon Guillemots and Marbled Murrelets. This project would provide information for a variety of restoration projects.

<u>Lead Agency</u>: U.S. Fish and Wildlife Service

<u>Cooperating Agency</u>: Possibly EPA (final carcass disposal)
Possibly ADF&G (identification of prey)

<u>Project Objectives:</u>

Seabirds suffered the greatest mortality from the EVOS, particularly the diving birds of the family Alcidae, such as murres, puffins, murrelets, auklets and guillemots. Knowledge of the age demographics for the species affected would support restoration efforts by 1) providing information to model estimated recovery time for each species, 2) identifying what age group was impacted for each species, 3) determining what age groups are at risk in late winter/early spring. Where possible, additional information will be obtained, including sex and breeding status, and prey use from stomach samples.

There is a critical lack of data on the demographics of these birds. The most basic information, such as age at first breeding or total life span, is unknown for these birds in Alaska. For key species, the age of birds is needed to interpret boat survey results. For instance, it is unknown if murrelets counted in March surveys (about 25% of murrelet counts in summer) are comprised of primarily juveniles or adults. If juveniles comprise most of the March population, it would drastically alter the estimated recovery rate, since juveniles are more "expendable" than adults, and March birds were directly impacted by the oil spill. The ratio of juveniles to adults may also vary among geographic areas if there are age-specific wintering habits. Additionally, if juveniles are being censused in March, it may be an estimate of annual breeding success for marbled murrelets, otherwise unobtainable for the entire spill zone. Similar unknowns exist for murres, guillemots and other alcids.

The carcasses which have been stored since EVOS contain other information valuable to a better understanding of the mechanisms affecting long-range population changes. For example, blood samples can yield data on genetic separation of breeding colonies and stomach samples can provide an outline of prey use throughout the spill zone. All of these variables are required to adequately model recovery of murres, and ultimately all alcid species. Estimates of recovery and restoration end-points will not be supportable without well substantiated input for any current or future modeling effort.

Specific Objectives:

A. Select a subsample, by geographic area of recovery and species, of birds to analyze.

B. Determine sex, breeding status and prey consumed by individual birds selected for analysis.

C. Obtain and store blood samples for future DNA analysis.

D. Determine age of the birds by examination of femur bone cross-sections.

E. Provide a computerized data base and a comprehensive report of the data for use by appropriate restoration projects.

Project Methods:

Objective A: A subset of carcasses will be selected to represent each alcid species, although it may be advisable to increase sample size for those most affected by the EVOS, such as murres, guillemots and murrelets. Samples will also represent major geographic areas of the spill zone, ie., Prince William Sound, Kenai Peninsula, Kodiak Archipelago, Alaska Peninsula. At a minimum, this objective must be accomplished in 1992, and samples stored for future work.

Objective B: During dissection of individuals, whenever possible, measurements will be taken and the sex, plumage and breeding status recorded. Stomachs will be removed, preserved and individually labeled for analysis of contents. Although soft fish parts may not be identifiable from these specimens, hard parts such as fish otoliths and vertebrae can be used for this purpose.

Objective C: During dissection, blood samples will be taken, labeled and stored for future DNA analysis. This has been identified as a key component of the murre restoration project. Analysis will focus on distinguishing among breeding populations of murres, to determine the importance of emigration and gene flow. It may also indicate the wintering range of birds from different geographic areas.

Objective D: For each carcass, a femur bone will be removed and eventually cross-sectioned for aging. Cross-section preparation and analysis may be done under a separate contract. Each carcass will be assigned a unique identification number to enable cross-referencing with the information obtained in objective B. Thus, an outline of age structure of each alcid species will be provided along with corresponding sex, breeding condition, diet and geographic area of recovery.

Objective E: Results of all measurements and analysis will be made available in the form of a computerized data base and a comprehensive report.

Duration of Project: Estimate three years to completion. The first phase, involving selection of carcasses and removal of appropriate samples, should be done in 1992, since all carcasses will be destroyed and the data loss irretrievable. Subsequent analysis of the samples can be delayed as funding dictates.

Estimated Cost:	Year	1992 through 1994
	Cost	220K per year

Restoration Activity or Endpoint to be Addressed: Estimates of recovery times and identification of the restoration endpoints for these species will require the demographic information provided by this project. Results will benefit and guide restoration efforts for common murres, pigeon guillemots and marbled murrelets. Results will also aid interpretation of future monitoring efforts, which will greatly enhance their applicability to management agencies. Important prey species will be identified throughout the spill zone. This will contribute to the data base guiding protection of marine resources important to alcids in all regions of the spill zone.

Relationship to Science Needs Identified by RPWG:
This study addresses many needs identified by the Restoration Planning Work Group:

(1) It improves understanding of long-range mechanisms limiting populations of alcids, which will support effective restoration efforts. In the case of marbled murrelets and pigeon guillemots, which showed declines previous to EVOS, it will assist understanding of root causes.

(2) It extends the focus of several studies beyond Prince William Sound, since carcasses were retrieved throughout the spill zone. It will provide data on

age-specific use of different geographic areas, prey use throughout the spill zone and genetic mixing of the alcids in the spill zone.

(3) It emphasizes a broad ecological approach by addressing data needs of many species over a wide geographic area and covering aspects of their biology ranging from age composition, breeding status and their aggregate and specific prey base.

(4) It will analyze the linkages between predators and prey for the entire spill zone.

(5) It provides data necessary to fully monitor ecosystem recovery. Any modeling effort will require the information provided by this project. Individual restoration efforts will benefit from knowledge of species' longevity, breeding age and age-specific distribution and prey use.

(6) For marbled murrelets, it will extend the data base outside of PWS. Gathering similar data on new collections of murrelets may meet resistance, due to its sensitive status.

(7) For common murres, it may identify concentrations of non-breeding birds.

Importance of Initiating the Project in 1992: Current plans consider the disposal of the EVOS carcasses in 1992, which would be an irretrievable loss of data. Although actual dissection and aging will probably not be accomplished in 1992, it is advisable that a commitment and solicitation of proposals by universities and consulting firms begin in 1992, to insure that the carcasses are retained for scientific purposes.

Link to Other Studies: This study would be linked to the following restoration efforts:

(1) For common murres, age demographics will be provided to model recovery and estimate a restoration endpoint. Blood samples for DNA analysis will be available for analysis, which will fulfill one of the objectives of monitoring rate of recovery and productivity.

(2) For marbled murrelets, restoration efforts will be enhanced by knowledge of age-specific geographic distribution, breeding status relative to location and life span of breeding adults. Equally important, an

outline of prey use throughout the spill zone will indicate prey species of importance by geographic area.

(3) For pigeon guillemots, restoration efforts will be enhanced for reasons cited above. Guillemots and murrelets both were declining prior to the spill, which makes demographics and prey use information particularly critical to restoration efforts.

(4) The Boat Surveys will benefit from this information by enhancing the ability to interpret survey data for all alcid species and greatly expanding its applicability to management agencies.

(5) Fish studies, in particular possible forage fish studies, will benefit from this study by obtaining information on predator use of the resource and geographic information on prey distribution and relative abundance.

6) Colony censusing will benefit by obtaining demographics of all alcid species throughout the spill zone, their prey use and the genetic distinctness of breeding colonies.

7) There will be coordination with bald eagle and sea otter projects to retrieve samples needed for these projects concurrent with the waterbird sample retrieval.

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Project Title: Surveys to monitor marine bird and Sea Otter populations in the area of the *EXXON VALDEZ* Oil Spill

Species and Injury to be addressed: This study addresses all marine bird species and sea otters. More than 30,000 carcasses representing over 90 species of birds were collected the spill zone in 1989. In addition, both direct and lingering population effects of the spill have been demonstrated in NRDA studies on cormorants, harlequin ducks, black oystercatchers, black-legged kittiwakes, arctic terns, marbled murrelets, common murres and pigeon guillemots. Intensive studies on sea otters have revealed evidence of damage to populations of this mammal.

Lead Agency: U.S. Fish and Wildlife Service

Cooperating Agency: U.S. National Park Service

Project Objectives: This project would continue population surveys established in Prince William Sound (NRDA Bird Study 2/Marine Mammal Study 6), and extend surveys to the remainder of the spill zone. Restoration of injured marine bird species will require population estimates to determine whether declines continue, and to document recovery. These surveys provide a cost-effective, statistically rigorous method for monitoring populations. Even when baseline data do not exist, repeated surveys can show whether populations are stable. Surveys also provide valuable information on the distribution and habitat use of these species. NRDA surveys have already been used for these purposes by investigators of harlequin ducks, marbled murrelets, black oystercatchers and sea otters. Survey methods are flexible enough to provide for collection of more detailed information (such as age class data) when such information is requested by investigators of particular species.

Objective A: To support restoration studies on marine bird and sea otter ecology by monitoring population recovery or continuing declines in Prince William Sound, using surveys established by NRDA Bird Study 2.

Objective B: To support restoration studies on marine bird ecology in the remainder of the oil spill zone by establishing and maintaining near-shore population surveys on the lower Kenai Peninsula, lower Cook Inlet, Kodiak and Afognak Islands and the Alaska Peninsula.

Objective C: To support restoration studies (particularly murre winter distribution study) as for Objective B by establishing and maintaining pelagic population surveys in the northern Gulf of

Alaska. This objective would be designed to facilitate the murre winter distribution study.

PROJECT METHODS:

Objective A: Prince William Sound Surveys.

1992. Boat surveys will be conducted in March and July using methods developed by NRDA Bird Study 2, so that results will be comparable to those collected during the three years since the spill. The current design is powerful enough to detect small population changes (e.g. 15%) for some species. However, previously collected data can now be used to further improve the design for other species, possibly lowering costs at the same time. For example, the design of the offshore strata will be altered because analyses of previously collected data indicate that variances can be decreased by doing so. Such alteration will not affect the ability to compare population estimates among years.

Other analyses aimed at reducing survey variances, detecting population changes, and identifying habitat use and distribution will continue. Such analyses include exploration of post-stratification by habitat (using shoreline type or bathymetry to define habitats), examination of observer differences, and calculation of optimal sampling unit size and number of samples. Completed population estimates and statistical tests (Laming 1991) may be re-calculated when final oiling definitions are developed. This study supports studies on individual species. As such, we welcome requests to collect specific information during surveys. For example, we have agreed to collect pup ratio data for the sea otter study.

1993 until determination of recovery of damaged species (i.e. populations are stabilized). Surveys will be conducted on an annual or biannual basis.

Objective B: Surveys outside Prince William Sound.

1992. Statistically rigorous survey methods will be designed for the following areas in the oil spill zone: lower Kenai Peninsula, lower Cook Inlet, Kodiak and Afognak Islands, and the Alaska Peninsula. To design these surveys, it will be necessary to gather data from previous studies done in these areas, and to coordinate with FWS and NPS scientists and managers concerning logistical constraints. Survey design for these areas may not be identical, depending on these constraints, but will produce comparable population estimates.

1993 until determination of recovery of damaged species (i.e. populations are stabilized). Surveys will be conducted. Annual scheduling of surveys will be determined in 1992.

Objective C: Pelagic/murre distribution surveys.

1992. Data from all previous pelagic surveys will be reviewed, and a statistically rigorous study design for surveys will be developed. Design will be developed in conjunction with the murre winter distribution study.

1993 until determination of recovery of important species (i.e. populations are stabilized). Surveys will be conducted. Annual scheduling of surveys will be determined in 1992.

Duration of the project: Population monitoring of the oil spill zone would conclude when population recovery was complete for damaged species. For areas where no baseline data exist, this point would be reached when populations were stable. Studies on individual species would also be used to determine recovery.

Estimated Cost:

1992:	Conduct PWS Surveys (Obj. A)	$253,000
	Design Surveys for Obj. B & C	$ 22,000
	TOTAL 1992 COST:	$275,000

1993-2001:
Several options exist for the cost of this study after 1992, depending upon which objectives are funded. Each objective will cost $275,000 each year it is implemented. The best information (i.e. population estimates for the entire spill zone) would be gained by funding all objectives in a given year, but this option would be the most expensive. Two possible options are listed below.

Option A: Fund Objectives A & B in alternating years, & Objective C annually: Annual rotation of PWS and near-shore surveys, and annual pelagic surveys outside Prince William Sound

Per year implemented $550,000

Option B: Fund Objectives A, B & C annually (or every two years): Annual PWS and near-shore surveys, and annual pelagic surveys outside Prince William Sound

Per year implemented $825,000

Restoration endpoint or activity to be addressed: This project is an important tool to monitor recovery of populations of bird and mammal species damaged by the oil spill. It also provides habitat use and distribution information used by other studies to document needs to acquire or protect habitat and to restore food and nesting resources.

Relationship to science information needs identified by RPWG: This project fulfills many general needs outlined by RPWG in the 20 September 1991 Memorandum. These needs (from p. 1) include:

(1) "Extend focus of studies beyond Prince William Sound and throughout affected area". This project provides information for the entire spill zone.

(2) "Shift emphasis to broader ecological rather than species-specific approaches". This project provides habitat data for many species by coupling shoreline type and bathymetry data with distribution and abundance data gathered on surveys.

(3) "Monitor ecosystem recovery, since the extent and persistence of damages will determine the level of restoration necessary. Certain species, such as the Harlequin Duck, Pigeon Guillemot, and Black Oystercatcher, may be good indicators of ecosystem recovery". Data already gathered indicate that this project is an effective way to monitor these species: populations of all these species declined significantly in oiled (compared to unoiled) areas, according to statistical tests from these surveys (Laming 1991).

Importance of initiating project in 1992: This project should be initiated in 1992 for two reasons. First, it is important to continue monitoring the Prince William Sound populations so that post-spill trends can be established for the years closest to the spill. Second, it is important to carefully design surveys for the remainder of the spill zone, so that monitoring can begin there as soon as possible.

Link to other NRDA or Restoration Studies: 1) This project is based on NRDA Bird Study 2/Marine Mammal Study 6, and the survey design benefits from analysis of data collected during that study. 2) The survey supports all marine bird and otter studies. These surveys are required to support Sea Otter studies until an aerial survey has been designed. The survey has also responded to requests for information from NRDA and restoration scientists studying harlequin ducks, black-legged kittiwakes, pigeon guillemots, marbled murrelets and black oystercatchers. GIS-generated distribution maps for all species observed (over 150) are available for both pre-spill and post-spill surveys. The expanded surveys are a cost-effective way to support restoration studies.

Project Title: Pigeon Guillemot Recovery Enhancement And Monitoring

Species and Injury to be Addressed:

Pigeon guillemots in PWS are at a 20 year low and have declined significantly along oiled shorelines compared to unoiled shorelines in both the Sound as a whole and more specifically in the Naked Island area. This study will investigate parameters affecting reproductive success of guillemots in Prince William Sound (PWS) and monitor their recovery at specific colonies.

Lead Agency:

U.S. Fish and Wildlife Service

Co-operating Agency:

Possibly U.S. Forest Service (shoreline/ forest habitat)
Possibly ADF&G (mammalian predators and nearshore fish)

Project Objectives:

The pigeon guillemot is highly vulnerable to oil spills and was subject to direct mortality from oiling throughout the EVOS zone. Reproductive studies at Naked Island indicate that pigeon guillemots may experience long-term impact from the oil spill which could impair their natural recovery in the affected area. At Naked Island, predation was a proximate source of nest failure, but there was also evidence of changes in prey species and availability. In addition, there is evidence of continued contamination of eggs from oiling, which can reduce hatching success. Determining the causes and remediating these impacts could assist recovery of the species. To be meaningful, these studies should be expanded beyond Naked Island. Information about breeding concentrations in the spill zone could be added to knowledge of other species using forest edges in order to guide land acquisition and marine habitat protection efforts. Currently, there is insufficient information about the location and size of major guillemot breeding colonies in the spill zone.

a. To locate pigeon guillemot colonies and accessible nests throughout PWS in order to monitor reproductive success, diet and population recovery.

b. To determine reproductive success of pigeon guillemots and identify parameters affecting their success at selected sites.

c. To implement a pilot project on the feasibility of reducing nest predation by nest site alteration.

d. To implement a pilot project on prey selection through otolith identification from chick feces.

e. To provide for complete analysis of pigeon guillemot data including integration with data collected in previous years.

Project Methods:

Objective A: Locate guillemot colonies and select study sites

Observers will census guillemots at periods of peak colony attendance and document nests as accessible or inaccessible throughout the Sound. Two to four observers may travel with a support vessel, or with the U.S. Forest Service as part of a cooperative effort with the plant association surveys in May. The observers will return to colonies later in the summer to locate nests for future studies of reproductive success.

Objective B: Reproductive success

Naked Island studies will be continued following methodology developed and refined in past years. The study will concentrate on identifying predators and types of susceptible nests. Unhatched eggs will be tested for oil contaminants.

Objective C: Nest predation

Tests will be conducted to determine if predators key in on nest markers, or if vulnerable nest sites can be altered to reduce predation. Since guillemots exhibit very high nest site fidelity, decreasing predation at specific nests could prove beneficial. All nest sites will be monitored for reproductive success.

Objective D: Prey selection

In order to develop an efficient means of documenting prey use by guillemots raising chicks, the efficacy of collecting otoliths and bone parts from chick feces will be tested. Selected nests will be observed following past protocol and feces will be collected and analyzed in the lab to determine whether otolith samples are representative of observed prey deliveries.

Objective E: Data analysis

All current data as well as data from past years will be integrated and analyzed. Chick feces and prey samples will be examined in the lab for otolith and bone part identification.

Duration of Project:

This project would continue from three to six years depending upon the population recovery time for pigeon guillemots and the success of nest site enhancement.

Estimated Cost:	Year	1992	1993 through 1997
	Cost	303k	578k per year

Restoration Activity or Endpoint to be Addressed:

This project will investigate parameters affecting pigeon guillemot reproduction and suggest means of enhancing recovery in the spill zone. By locating major breeding colonies, lands and marine areas suitable for protection can be identified. Selected colonies will be monitored for recovery.

Relationship to Science Information Needs Identified by RPWG:

This project will expand study sites for guillemot studies in PWS, and the results and refined methodology can be applied to other areas in the spill zone. It will investigate the limiting factors of predation and prey selection on reproductive success, and provide a base for monitoring recovery throughout PWS.

Importance of Initiating Project in 1992:

Because the decline in pigeon guillemots was exacerbated in the spill zone, immediate action should be taken to identify the impact of and recovery from the spill. Identification and monitoring of colonies throughout PWS is a necessary part of this process. A complete study of pigeon guillemot reproduction cannot begin until at least one season is devoted to locating colonies and nest sites. Thus, further delay of this step would reduce the study's effectiveness.

Link to Other NRDA Damage Assessment or Restoration Studies:

This study uses and is a continuation of NRDA Bird Study 9 and NRDA Bird Study 2. Facilities at Naked Island can be shared with the marbled murrelet restoration project. The colony census may be conducted in conjunction with the U. S. Forest Service plant association surveys in PWS, which can also provide detailed upland habitat information in conjunction with pigeon guillemot colony sites. Results of this study may have management implications for other colonial alcids, specifically, parakeet auklets, tufted and horned puffins. This study will be linked to coastal habitat studies targeting forage fish species as well as mammalian and avian studies targeting species that prey upon guillemots and their chicks.

Project Title: SURVEYS TO IDENTIFY UPLAND USE BY MURRELETS IN THE EVOS ZONE

Species and Injuries to be Addressed:

Marbled murrelet numbers have declined since 1973 in PWS, and have been affected by the Exxon Valdez oil spill. Because it is difficult to distinguish between marbled and Kittlitz's murrelets, which coexist and both of which suffered direct mortality from the oil spill, this study addresses the recovery of both species.

Lead Agency: U.S. Fish and Wildlife Service (USFWS)

Cooperating Agency and Contact: U.S. Forest Service (USFS)

Project Objectives:

Prince William Sound (PWS) has one of the largest concentrations of marbled and Kittlitz's murrelets, both of which breed throughout the spill zone. The most practical method of enhancing natural recovery and protecting murrelets from future disturbance is to protect their nesting habitat. Thus, identifying and evaluating nesting and high use areas is crucial if habitat protection is to succeed. The 1991 Marbled Murrelet Restoration Study documented tree nesting by marbled murrelets in PWS, but the study site included only a small fraction of the Sound and did not possess all the habitats found within the spill zone. To be applicable throughout the spill zone, a large-scale habitat study should be implemented, integrating upland marbled murrelet surveys with USFS habitat mapping.

A. To develop a training program and tools for the USFS and other management agencies that will use a protocol refined for Alaskan conditions.

B. Survey upland areas throughout the spill zone to investigate upland murrelet use in the full spectrum of available habitat, in cooperation with the USFS.

C. To specifically identify which lands or marine areas will provide the greatest benefit to murrelets through habitat acquisition, protection or proper management practices.

Project Methods:

Objective A: Training Program

Two conclusions of the 1991 Marbled Murrelet Restoration Study were: (1) that experienced, trained personnel are important to a successful study of upland use by marbled murrelets, and (2) that an Alaskan protocol needs to be fully developed. As upland murrelet surveys expand geographically and among agencies, there is a need to provide standardization and training appropriate to the Alaskan environment. In alpine areas, we must also distinguish between marbled and Kittlitz's murrelets. In 1992, dawn watches will be conducted in alpine areas of known Kittlitz's concentrations (i.e., Kachemak Bay or Unakwik Inlet) to record and document the species' vocal and behavioral differences in this type of habitat. The final product will be training aids such as audio and video tapes, a protocol manual and a pool of trained personnel. With this background, future murrelet surveys will be more accurate and useful in guiding land acquisitions.

Objective B: Prince William Sound Surveys

FWS personnel will use the same vessel, in cooperation with the USFS plant association mapping survey of PWS, to map murrelet high use areas by conducting nearshore dawn watch surveys. Murrelet activity will be analyzed relative to upland habitat while simultaneously identifying areas of high use.

Objective C: Land Identification

Once habitat use patterns are described and high use areas identified, this project will provide a base to survey for specific sites for protection. After 1992, upland surveys will be conducted to identify those lands which would provide the highest benefits to murrelets (e.g. Afognak, Kachemak Bay, Resurrection Bay, Montague Island, Cordova area).

Duration of Project:

An Alaska protocol and training program will be ready for the 1993 field season and will be updated as additional experience and data are acquired. This survey, in cooperation with the USFS, is expected to last at least from 1992-1994. Surveys of specific sites can be done as required by the Restoration Management Team after 1992.

Estimated Cost:

Year	1992	1993	1994
Cost	180k	176k	176k

This budget is based on a study design dependent on funding and implementation of the USFS project to survey ecological mapping units. If the USFS project is not funded, logistics and costs for the murrelet surveys of PWS will have to be adjusted accordingly.

Restoration Endpoint or Activity to be Addressed:

Critical upland habitat in the spill zone must be identified in order to protect the murrelet population in PWS through habitat acquisition or protection.

Relationship to Science Information Needs Identified by RPWG:

This study will expand surveys for use of upland areas by murrelets to all habitats and geographic areas of the spill zone. The information can be integrated with USFS mapping to augment habitat use data for affected species. Methodologies and training aids developed will provide a basis for future upland surveys to monitor murrelet recovery.

Importance of Initiating Project in 1992:

To be successful in following years, training and standardization for upland murrelet surveys should begin in 1992. To fully benefit from the cooperative effort with the USFS, this project should coincide with the beginning of the USFS mapping cruise in 1992.

Link to Other Studies:

This study is an expansion of the 1991 Marbled Murrelet Restoration Study, and will complement results of the detailed marbled murrelet nesting study to be conducted on Naked Island. Both marbled murrelet restoration studies will benefit from the other's products and both will work closely with the USFS to fully integrate with their habitat mapping system. This study will also benefit from complete analysis of data collected during NRDA Bird Study 6 and Bird Study 2.

Project Title: Identification of Nesting Habitat Criteria and Reproductive Success for the Marbled Murrelet

Species and Injury to be Addressed:

The marbled murrelet population, which suffered direct mortality in the EVOS zone.

Lead Agency:

U.S. Fish and Wildlife Service

Co-operating Agency: U.S. Forest Service

Project Objectives:

One of the major population centers of the marbled murrelet lies within the EVOS zone. This population suffered direct mortality from EVOS and may face additional impacts from contamination of prey, logging and gill-netting. Protection of nesting habitat and marine habitat is an identified approach for enhancing murrelet recovery in the EVOS zone. To date, little is known of the species' nesting habitat requirements. Further, recovery rates may be slow, based on the scarce data available on reproductive success. To address these issues, a pilot study was undertaken on the Naked Island Archipelago in 1990 and a Restoration Project on use of upland habitat by marbled murrelets was implemented in 1991. This project proposes continuation and expansion of that effort.

a. Determine marbled murrelet nest habitat requirements within forested portions of the EVOS zone.

b. Identify and define murrelet behaviors that indicate use of habitat for nesting to aid in identification of suitable areas for habitat protection.

c. Determine murrelet reproductive success, assess possible differential success among forest types and clarify parameters affecting success.

d. Define use of the nearshore environment around nesting areas in order to identify potential marine habitat for protection.

e. Provide a complete analysis and synthesis of all murrelet data available for the EVOS zone.

Project Methods:

Objective A: Marbled murrelet nest habitat requirements.

Primary emphasis will focus on locating murrelet tree nests using previously developed ground search techniques. Results from the 1991 Restoration study of murrelet habitat use on Naked, Peak and Storey islands will be used to increase the sample size of murrelet nests. This will provide a more accurate delineation of crucial features of murrelet nesting habitat. The continued cooperation with the U.S. Forest Service (USFS) will facilitate quantitative assessment of tree, stand and basin characteristics at nest sites.

Objective B: Identification of murrelet nesting behavior.

Although methods have been devised to document areas of murrelet activity, it is still unclear which behaviors indicate habitat use for nesting, display areas, or flight corridors or how activity reflects actual numbers of murrelets. Systematic dawn censuses and monitoring behavior at nests (via observers and time-lapse video recordings) will define those murrelet activities which indicate nearby nesting. This information can be used to interpret activity at documented use areas in the EVOS zone and refine identification of murrelet nesting areas. Accordingly, documented use areas can be prioritized for habitat acquisition.

Objective C: Murrelet reproductive success.

An understanding of murrelet reproductive success and parameters affecting their success will allow for a more accurate estimate of potential population recovery rates in the EVOS zone. We will attempt to locate all nests within a few stands on Naked Island to determine nesting density and monitor success. We will ascertain causes of egg and chick mortality, predation pressures and determine which forage fish are important for chick-raising.

Based on the results from the 1992 season the study will be expanded in subsequent years to examine murrelet nesting in other habitats within the EVOS zone. Differential nesting density and reproductive success among habitats will be examined.

Objective D: Define use of the nearshore environment.

To enhance murrelet reproductive success and recovery, preservation of nesting habitat must be coupled with identification of important nearshore habitat. Murrelet distribution within 2 km of Naked, Peak and Storey islands will be monitored early, mid and late in the season, following the methods implemented in the 1991 at-sea pilot study. Based on previous studies, one or two high use areas will be more closely monitored throughout the breeding season.

Objective E: Analysis of existing murrelet data.

To date, there are unanalyzed data available that will benefit the restoration efforts of murrelets in the EVOS zone. These include files from damage assessment studies in 1989 and 1990, FWS and OCSEAP studies. Funds will be appropriated to ensure complete analysis, synthesis and reporting of this data base.

Duration of Project:

This project will conclude when lands and marine areas benefitting marbled murrelets have been identified for acquisition or protection and recovery has been adequately assessed.

Estimated Cost:	Year	1992	1993-2001
	Cost	240k	250k

Some cost savings may be realized through cooperation with other projects funded in the study area.

Restoration Endpoint or Activity to be Addressed:

The ultimate goal of this project is to aid in habitat acquisition and marine habitat protection by identifying lands with habitat beneficial to the recovery of marbled murrelets.

Relationship to Science Information Needs Identified by RPWG:

The results of this study can be applied throughout the EVOS zone to guide habitat acquisition and marine habitat protection. Identification of suitable murrelet habitat can be integrated with upland use and forage requirements of other species to provide an ecosystem approach to the goals of acquisition and protection. Data on reproductive success will help determine the time frame expected for recovery. Continued monitoring of the Naked Island Archipelago will provide an index of restoration success.

Importance of Initiating Project in 1992:

This project can best provide information to guide habitat acquisition and protection efforts in a reasonable time frame by full implementation in 1992. Uninterupted continuation of the 1990 pilot study and 1991 Restoration Project will provide continuity of data and trained personnel. Early investigation of documented nests, suspected nest sites and high use areas will enhance the success of locating nests and generating a substantial data base on murrelet nesting.

<u>Link to Other NRDA Damage Assessment or Restoration Studies</u>:

This project can use data obtained from NRDA Bird Study 6 and Bird Study 2 to monitor at-sea distribution and abundance of murrelets in the study area. Additionally, it will be a continuation of the 1991 Marbled Murrelet Restoration study, a cooperative effort with the USFS. Resulting habitat data will be provided in a format that allows integration with USFS ecological mapping units to develop future acquisition, protection and management guidelines for public lands and marine resources. Results will also be used to interpret the data collected during the proposed project on murrelet use of the EVOS zone.

Project Title: Feeding Ecology and Reproductive Success of Black Oystercatchers in Prince William Sound

Species and Injury to be Addressed: The black oystercatcher is an obligate member of the rocky intertidal community. Thus, deleterious effects of the *Exxon Valdez* Oil Spill resulted in reduced productivity of the Prince William Sound (PWS) population. Additionally, intertidal prey organisms of the oystercatcher experienced diminished productivity and direct mortality.

Lead Agency: U.S. Fish and Wildlife Service

Project Objectives: Work assessing the reproductive success of PWS black oystercatchers was initiated on Green Island and Montague Island in 1989 and continued at these sites, as well as at Knight Island, in 1991. Information collected in 1991 was used to determine habitat requirements of breeding oystercatchers. Breeding pair density greatly differed between Knight Island and Green/Montague Island. Elevation and shoreline type were largely responsible for these differences. Reproductive variables of oystercatchers were also contrasted between oil-impacted and oil-unimpacted sites (1989 and 1991). Oiling of beaches affected oystercatchers in various ways. Data from 1989 indicated that the relative egg volume of clutches in impacted sites was lower than clutches in unimpacted sites. Although clutch size, hatching success or fledging success did not differ between these same shorelines, growth rates of chicks in 1991 were significantly lower on impacted shorelines than on unimpacted shorelines. Higher mortality of mussels on impacted shorelines than on unimpacted shorelines did not translate to a difference in the quantity of food delivered to chicks. Some segments of the PWS oystercatcher population appear to be recovering. The number of breeding pairs on impacted Green Island increased by 50% between 1989 and 1991 while no change occurred on unimpacted Montague Island. Further information is needed to monitor the oystercatcher recovery, particularly on Knight Island, and to examine the predation pressure oystercatchers exert on invertebrate prey populations.

Specifics objectives of this project are:

1. Further develop habitat models and test those produced in 1991;

2. Continue to monitor the population recovery, reproductive success and chick growth rates of PWS oystercatchers at impacted and unimpacted sites and determine the role predators may play in oystercatcher recovery;

3. Determine if the continued persistence of hydrocarbons in mussel beds is being transferred to chicks and may be responsible for depressed growth rates;

4. Compare the foraging ecology of black oystercatchers on impacted and unimpacted shorelines and elucidate the role that oystercatchers play in structuring the intertidal invertebrate community and the effect they may have on population recovery of their prey species.

Project Methods: Study methodology will primarily follow previous plans. From mid May to late August, two field camps will be used to monitor the reproductive success of oystercatchers. Habitat variables of nest sites and foraging territories will be measured. Foraging of adults will be quantified during incubation. Deliveries of prey items to chicks will be recorded at sites not sampled in 1991. Chicks will be banded when $\geq$7 days old and will be reweighed twice before fledging. At $\geq$25 days, blood samples will be collected from chicks. Standard Operating Procedures of the Coastal Habitat Project will be implemented to assess prey density in oystercatcher foraging territories at the beginning of the season and at the end of the field season. Density of invertebrate prey items will also be quantified at impacted and unimpacted sites. Samples of mussels will also be collected for hydrocarbon analysis. Shell collections from territories not sampled in 1991 will be used to determine the size structure of invertebrate species taken by oystercatchers. Predation on oystercatcher nests will be monitored during incubation and chick-rearing phases.

Duration of Project: This project can be accomplished in 2 years.

Estimated Cost:

Year	1992	1993
Cost	200k	200k

Restoration Activity or Endpoint to be Addressed: This project will provide information needed to protect suitable marine habitat for oystercatchers, monitor the natural recovery of the PWS population and explore the role oystercatchers play in the recovery of invertebrate species.

Relationship to Science Information Needs Identified by RPWG: This project addresses general and avian-specific needs identified by RPWG in several ways. Firstly, elucidation of the predation role that black oystercatchers have on structuring intertidal invertebrate assemblages directly responds to a shift of emphasis from a species-directed approach to a community-directed approach and forges a link between predator-prey consequences of the spill. Coupling the role of predator and prey with the influence of environmental factors will provide some mechanistic answers to the question of exactly how oystercatchers were affected by the spill. If hydrocarbons persist in the oystercatchers' environment, future reproductive percussions may occur. Secondly, monitoring the reproductive success and the pair occupancy of oiled sites will document the natural recovery of an obligate, intertidal predator.

Importance of Initiating Project in 1992: Implementing this project in 1992 will guarantee continuation of work that began in 1989. Information gained in 1992 will be important in determining trends in the recovery of black oystercatchers in PWS. Delaying implementation may make oil-induced effects between predators and prey increasingly difficult to detect.

Link to Other NRDA Damage Assessment or Restoration Studies: Predator-prey and mussel hydrocarbon aspects of this study will be conducted in cooperation with Coastal Habitat Project personnel in Herring Bay. Collaboration on individual studies in 1991 will continue in 1992. Habitat requirements of oystercatchers will contribute to overall habitat assessment of PWS.

Project Title: Murre Recovery Modelling

A murre recovery model was identified as a high priority need and was scheduled to be developed with the assistance of Dr. Dennis Heinemann, a peer reviewer. Subsequent to settlement, it has not been possible to determine the status of initiating the effort with Dr. Heinemann. The need for modelling is equally important for natural recovery monitoring as well as to facilitate planning of more aggressive restoration measures should the model indicate the need. A more complete proposal will be submitted after we have an opportunity to check with Dr. Spies regarding Dr. Heinemann's effort.

Project Title: Control or Eliminate Human Disturbance near Murre Colonies Showing Decreased Numbers, Delayed Chronology, and Decreased Production from past Estimates.

Species and Injury to be Addressed:

The *Exxon Valdez* oil spill caused significant injuries to many species of migratory birds, most of all to murres. As the oil spill exited Prince William Sound and moved though the Gulf of Alaska, it collided with large rafts of murres congregating around major colonies in anticipation of the upcoming breeding season. The resulting massive mortality included the death of an estimated 198,000 adult breeding birds, representing 60 to 70 percent of the total breeding population of certain major colonies such as those on the Barren Islands. Extrapolating to include mortality of non-breeding murres, the total initial mortality of murres is estimated to be as high as 300,000 birds. The loss of adult breeding murres resulted in a major disruption of breeding behavior and phenology which in turn resulted in complete reproductive failure for the past three years. Minimizing human disturbance around impacted colonies will prevent other factors from further delaying the rate of natural recovery.

Lead Agency and Principal Investigator:

U. S. Fish and Wildlife Service.

Project Objectives:

Objectives:

(1) Educate tour operations, charter boats, and commercial fishing industry in seabird conservation, protection, and viewing etiquette;

(2) Fund more regular visits and presence of Service personnel to affected colony sites to encourage compliance with proper behavior near murre colonies;

(3) Gather information to identify buffer zones for recommendation to commercial fisherman or increase enforcement around sensitive colonies along the Alaska Peninsula.

Project Methods and Feasibility:

Human disturbance were observed at two injured colonies during the last three years; Barren Islands and Puale Bay/Jute Peak/Cape Unalishagvak vicinity. Charter boat disturbance (shooting of halibut in close proximity to colony sites) impacted reproductive success in the Barren Islands while commercial fishing (seining and associated activities) impacted murre colonies along the Alaska Peninsula area (Cape Unalishagvak, Jute Peak, and Puale Bay). A public education program, combined with a possible law enforcement presence and increased presence of Service personnel will increase public awareness of steps they can take to reduce disturbances to murre colonies.

Duration of Project:

The education program should be tried over a three year period while biologists are in the field studying these sites. Then decisions can be made to modify the program.

Estimated Cost:

Year	1992 through 1994
Cost	$88,000/year

Restoration Activity or Endpoint to be Addressed:

This project is a direct restoration measure and is expected to reduce existing disturbance factors that drive murres from the cliffs, exposing eggs and chicks to predation.

Relationship to Science Information Needs Identified by RPWG:

This project is consistent with specific concerns related to enhancing murre productivity.

Importance of Initiating Project in 1992:

Every year in a row that murre chicks are not produced has the potential to greatly increase the time needed for the murre colony to completely recover. This project will benefit murre productivity immediately and cost-effectively.

Link to Other NRDA Damage Assessment or Restoration Studies:

This will complement other restoration and monitoring projects on murres that are likely to be occurring at the same time.

Project Title: Identification and Protection of Important Bald Eagle Habitats.

Species and Injury to be Addressed:

Bald Eagles are a conspicuous component of coastal ecosystems in Alaska. The EXXON Valdez Oil Spill (EVOS) caused direct mortality to hundreds of Bald Eagles and significant losses in productivity. Evidence exists of lingering effects of the oil spill on the remaining eagles.

Lead Agency:

U.S. Fish and Wildlife Service

Potential Cooperators:

U.S. Forest Service will likely be interested in this project. The National Park Service is also a likely cooperator.

Project Objectives:

Bald Eagles are closely associated with intertidal habitats throughout the spill area. They use these areas for feeding and nest almost exclusively within 200 meters of the beach. Eagle habitat is susceptible to the effects of oil spills and other water-born contaminants. Some eagle habitats within the spill area have been identified in development plans for timber, minerals, oil and gas and other types of uses that may not be compatible with eagle nesting and feeding requirements. If bald eagle habitats are adversely altered, the loss may be permanent. For example, estimated age of nest trees in southeastern Alaska exceeds 400 years while timber rotations are less than 150 years. With proper coordination, many of these activities can take place with little disturbance to eagles. A better understanding of year around habitat requirements for Bald Eagles must precede meaningful coordination of development activities. The following specific objectives will address these concerns:

1. Inventory and mark Bald Eagle nests within the spill area, emphasizing areas likely to be developed.

2. Monitor a sample of radio-tagged Bald Eagles to gain a better understanding of shoreline use for feeding and nesting and improve management guidelines.

3. Provide land managers with maps depicting locations of Bald Eagle nest sites on their lands.

4. Identify important concentration areas for Bald Eagles.

5. Develop a list of lands that require additional measures to ensure protection, such as conservation easements or outright acquisition.

Project Methods:

Habitat reconnaissance would be conducted by helicopter to locate Bald Eagle nest sites. Areas with nests would subsequently be visited by boat to mark the tree and record the characteristics of the site. The location would be verified using Global Positioning System (GPS) receiver. These data would be entered into the GIS database. Land owners would be provided with a map of nests on their lands and a copy of the regional guidelines for Bald Eagle management.

The second element of this project will involve monitoring a sample of radio-tagged adult and immature eagles to document habitat use throughout the year. Specific locations will be collected and mapped for each age group. These locations will be examined to determine the extent and types of habitats that eagles use as requirements for food and shelter shift throughout the year. Information will be gathered on concentration areas as they are observed, recording the location and cause of the concentration.

Duration of Project:

The inventory work is suggested for a period of five years. The spill area would be broken into at least four areas with one area inventoried each year. A final year is needed to complete data entry, map preparation and distribution. The work could be completed in a shorter period of time if funds are available.

The telemetry portion of the study is recommended for four years. Eagles nest in two significantly different regions, the forested lands of Prince William Sound, the Kenai Peninsula and Afognak Island, and the essentially unforested lands on Kodiak Island and the Alaska Peninsula. It is reasonable to expect that eagles in these two regions will relate to their habitats differently. The study would be conducted in a forested area for two years and then in a non-forested area for an additional two years. As above, if adequate funds are available the work could be conducted in both areas simultaneously.

Estimated Costs:	Year	1992-1994	1995
	Cost	267k	170k

Restoration or Endpoint Activity to be Addressed:

Minimizing disturbance throughout the spill area and the protection of threatened habitats will maintain healthy Bald Eagle reproduction over the long term, providing for the security of the population at current levels. Information collected would also provide benefits to other populations of Bald Eagles outside of the spill area.

Relationship to Science Information Needs Identified by RPWG:

A study of bald eagle winter roosts was recommended by RPWG. Winter roost sites would be identified through the telemetry work. It would also assist in the understanding of food habits. Considering only the winter habitat will not provide a complete picture of the habitat required by Bald Eagles. Important portions of the habitat required by Bald Eagles may be lost unless a comprehensive look is taken of their needs throughout the year.

Importance of Initiating Project in 1992:

Some threats to habitat are imminent, such as logging of what may be essential habitat in Prince William Sound, the Kenai Peninsula and Afognak Island. The sooner important habitats are identified and land managers informed of the nest locations, the better. The EVOS has demonstrated the importance of baseline data and inventory of existing wildlife resources that may be at risk by a major catastrophe. This project will provide essential information to prevent or minimize significant disturbance to Bald Eagles.

Link to Other NRDA Damage Assessment or Restoration Studies:

This project will identify the land owners and catalog potential threats within the EVOS area. These data would be of use in most of the studies considering damages. Data collected here will provide input for an overall habitat protection strategy for the EVOS area. It would be realistic to collect additional data during aerial and boat surveys that may be of consequence to other projects.

Project Title: Develop Bald Eagle Population Model and Understanding of Age-specific Survival Rates.

Species and Injury to be Addressed:

Bald Eagles are a conspicuous component of coastal ecosystems in Alaska. The EXXON Valdez Oil Spill (EVOS) caused direct mortality to hundreds of Bald Eagles and significant losses to productivity. Evidence exists on lingering effects of the oil spill to the remaining eagles.

Lead Agency:

U.S. Fish and Wildlife Service

Project Objectives:

The primary objectives for this project would be as follows:

1. Determine age-specific survival rates for Bald Eagles from hatching until maturity.

2. Determine average age at first breeding for Bald Eagles.

3. Determine the numbers of eagles throughout the EVOS area.

4. Determine the proportion of the population that breeds successfully.

5. Use these data to develop a population model for Bald Eagles.

Project Methods:

Approximately 30 fledgling, 20 subadult and 10 adult Bald Eagles will be radio-tagged each year using transmitters designed to last at least 4 years. Transmitters will be equipped with mortality sensors. Tagged birds will be relocated at least monthly from fixed wing aircraft. Eagles at least 5 years old will be monitored during the breeding season to document breeding efforts and success. Survival rates will be calculated using the Kaplan-Meier procedure.

The basic number that the model would be constructed from is the number of adult eagles within the spill area. Eagles with in PWS have been surveyed each year since 1989. Eagle numbers in the western EVOS have not been estimated since the earlier 1980's. We would propose to conduct a population survey each year in one of three areas, Kodiak/Afognak, Alaska Peninsula and PWS. These three areas would be inventoried once every three years during the study period beginning in 1993. This would result in three estimates for each area over a period of nine years and provide a good basis for the model.

Data collected during the telemetry work would be used to develop a population model for Bald Eagles. Data do not exist for age at first breeding, age-specific survival rates for all age classes from hatching to maturity and for the portion of the population that breeds - all critical parameters in the development of a realistic model.

Duration of Project:

The study needs to be continued through at least one Bald Eagle generation. Bald Eagles have been assumed to take at least 5 years to mature sexually, but the actual age is unknown. Birds also take several years after their first breeding attempt to achieve the nest success rates of established breeders. It is likely that an extended study is necessary to encompass at least one generation and obtain an adequate sample to estimate survival and age at first breeding. Because of the length of time it takes for eagles to acquire adult plumage characteristics and the delay expected for physiologically mature eagles to become behaviorally mature, we recommend that the study be continued for ten years.

Estimated Costs:

Year	1992	1993-2001
Cost	154k	187k

Restoration or Endpoint Activity to be Addressed:

Develop a population model that will further our understanding of Bald Eagle population dynamics and help to predict the effect of oil spills or other perturbations on Bald Eagle reproduction, survival, and population stability.

Relationship to Science Information Needs Identified by RPWG:

This study directly addresses a specific recommendation made by the RPWG for the development of a population model and the collection of the necessary data for the development of such a model.

Importance of Initiating Project in 1992:

The development of a population model will require knowledge of age-specific survival rates and certain reproductive parameters. To obtain adequate samples within specific age groups and determine inter-year variability, several years of data must be pooled. The most practical way to obtain survival data for certain age classes (e.g. 2- to 4-year-olds) is to tag eagles when they are fledglings when their age is known with certainty and monitor them as they mature and become part of these age groups. This process will require several years; therefore it would be prudent to start as soon as possible. There has also been a considerable investment (> $200,000) in equipping eagles with transmitters that are still functioning in the field. A delay in initiating this project will result in the loss of these transmitters as their battery life is consumed. Some of these individuals have been followed as nestlings since 1989. The data on this cohort will be sacrificed if the study is not initiated this year.

Project Title: Monitor Productivity of Bald Eagles within the EVOS Area.

Species and Injury to be Addressed:

Bald Eagles are a conspicuous component of coastal ecosystems in Alaska. The EXXON Valdez Oil Spill (EVOS) caused direct mortality to hundreds of Bald Eagles and significant losses to productivity. Evidence exists on lingering effects of the oil spill to the remaining eagles.

Lead Agency:

U.S. Fish and Wildlife Service

Potential Cooperators:

National Park Service for work outside of PWS. This work is not in the current budget. USDI-Forest Service may be interested in cooperating on surveys of their lands.

Project Objectives:

Information was collected on reproductive success in 1989 and 1990 in the EVOS area. Reproduction was strongly influenced by the oil spill in 1989, but it is not clear if there were continuing impacts in 1990. Results of hydrocarbon analyses of Bald Eagle eggshells and prey remains in 1990 suggest there was continuing contamination that might have affected reproduction. Casual observations and hearsay reports suggest productivity was down in 1991, but no surveys were conducted in 1991 that could verify these reports or demonstrate any relationship to continuing effects of the spill. Population level impacts may not be readily apparent due to the slow population turnover rates in Bald Eagles. To further evaluate the impact of EVOS and document recovery of Bald Eagle populations, it is necessary to monitor reproduction for several years. Because the impacts to Bald Eagle reproduction were most apparent in Prince William Sound (PWS), this study will be conducted within PWS.

The specific objectives of the project are to:

1. Document recovery.

2. Provide information necessary to model population dynamics.

3. Evaluate the suitability of using 1990 reproductive rates as "normal" for modeling purposes.

Project Methods:

Complete data for both 1989 and 1990 exist for approximately 300 nests within the Sound. A helicopter survey of these nests will be conducted in mid May of each year to assess nest occupancy. A second survey will be flown in late July and early August to determine nest success and count chicks. These two surveys will provide an estimate of the standard nest success parameters for this population.

Duration of Project:

Reproductive surveys will be continued for five years or until recovery is documented.

Estimated Costs:	Year	1992-2001
	Cost	60k per year

Restoration or Endpoint Activity to be Addressed:

Monitor reproductive parameters of Bald Eagles to document recovery and provide information for a population model which will help understand the effects of the EVOS and predict the effect of other perturbations on Bald Eagle populations in PWS and elsewhere.

Relationship to Science Information Needs Identified by RPWG:

This study addresses a specific recommendation by the RPWG to assess productivity as one step in developing a detailed population model.

Importance of Initiating Project in 1992:

Reproduction surveys were not conducted in 1991. A lapse of another year will further obscure effects of EVOS and make interpretation of the data that much more difficult or perhaps impossible. Surveys need to be conducted in 1992 to prevent the loss of any more time sensitive after impact data.

Link to Other NRDA Damage Assessment or Restoration Studies:

Methods in this study could be coordinated with other proposed studies, particularly the eagle survival studies and habitat inventory study. Conducting these studies simultaneously would reduce logistic and personnel costs.

Project Title: Monitor Contamination of Bald Eagles by Residual Hydrocarbons Through Blood Analyses.

Species and Injury to be Addressed:

Bald Eagles are a conspicuous component of coastal ecosystems in Alaska. The EXXON Valdez Oil Spill (EVOS) caused direct mortality to hundreds of Bald Eagles and significant losses to productivity. Evidence exists on lingering effects of the oil spill to the remaining eagles.

Lead Agency:

U.S. Fish and Wildlife Service

Potential Cooperators:

National Park Service

Project Objectives:

Blood chemistry analyses have proven to be useful in identifying exposure of Bald Eagles to hydrocarbons from the EVOS. However, data from controlled experiments that identify normal blood chemistry values, how they vary normally and how these parameters change on exposure to oil are lacking. The following objectives are proposed to resolve these deficiencies:

1. Monitor continuing effects of the EVOS on resident Bald Eagles in PWS through blood chemistry analyses.

2. Determine natural range of blood chemistry parameters and the seasonal variation in these parameters.

Project Methods:

The following methods will be used to accomplish the objectives:

1. Collect 15 blood samples annually from areas that had significant oiling from the EVOS to monitor recovery. This objective will depend on results of samples collected in 1991 and each year thereafter to determine if continuing effects are observable.

2. Collect 10 blood samples each month for two years from an eagle population distant from the oil spill to determine the normal range of blood chemistry values and seasonal changes in these values in response to breeding condition, food stress or other temporal factors.

3. Compare the fates of eagles with abnormal blood chemistry values with those considered to be normal through logistic regression. This element can be accomplished at no additional cost.

The geographic scope of the project could be increased by sampling eagles in the western EVOS, but these costs are not reflected in this proposal.

Duration of Project:

Element #1 would be a continuing study until no observable differences were detected, element #2 would be a two year project, and element #3 would be a one year project.

Estimated Costs:

Year	1992	1993	1994-1996
Cost	128k	128k	47k

Restoration or Endpoint Activity to be Addressed:

Element #1 will complete work initiated during the oil spill assessment and indicate the length of time that effects of the spill could be detected in the population that was exposed to oil to monitor recovery. Elements #2 and #3 will provide background data to understand blood chemistry values we have observed in the field and assist in identifying limiting factors. These data will provide a framework to use in interpreting blood data collected during future spills and for other situations where eagles have been exposed to contaminants and normal values are needed for comparison.

Relationship to Science Information Needs Identified by RPWG:

This proposal addresses the need for monitoring contamination of Bald Eagles by residual hydrocarbons identified by the RPWG.

Importance of Initiating Project in 1992:

Element #1 will need to be conducted in 1992 to maintain continuity of the data collected in previous years to monitor trends in blood chemistry values of Bald Eagles impacted during the EVOS. Elements #2 and #3 could be initiated in subsequent years.

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Project Title: Monitor Contamination of Bald Eagle Eggs by Residual Hydrocarbons.

Species and Injury to be Addressed:

Bald Eagles are a conspicuous component of coastal ecosystems in Alaska. The EXXON Valdez Oil Spill (EVOS) caused direct mortality to hundreds of Bald Eagles and significant losses to productivity. Evidence exists on lingering effects of the oil spill to the remaining eagles.

Lead Agency:

U.S. Fish and Wildlife Service

Potential Cooperator:

National Park Service

Project Objectives:

Avian eggs are acutely sensitive to the effects of oiling (Albers 1977, 1978, Hartung 1965, King and Lefever 1979, Couillard and Leighton 1989, 1990).

Addled eggs were collected in 1989 and 1990 from Bald Eagle nests in Prince William Sound (PWS), and eggshells and contents were analyzed for the presence of petrogenic hydrocarbons. About 75% of the eggs collected in 1989 from western PWS were exposed. In 1990, none of the five eggs collected in west PWS were exposed, but at least 9 of the 11 collected from eastern PWS were considered to be exposed. Although we originally thought that the eastern Sound would serve as a control area for sample collections, hydrocarbon data from our samples indicate otherwise. It is possible that 1) the effects of EVOS were more widespread than originally believed, or 2) petrogenic hydrocarbons from other sources such as fishing vessels, bilge or ballast water are present in sufficient quantity to indicate exposure. To examine possible persistence of hydrocarbons in the environment, the appropriateness of Eastern PWS as a control area and to document background levels of hydrocarbons in the environment, this study will:

1. Document continuing exposure of Bald Eagle eggs to hydrocarbons.
2. Determine background concentrations of hydrocarbons in marine environments where Bald Eagles nest.

Project Methods:

A sample of eggs will be collected from nests with addled eggs in PWS and in a location remote from EVOS, such as an area in southeastern Alaska. Additional collections on Kodiak Island and the Alaska Peninsula would be conducted if adequate funding is available. Random collection of eggs will not be comparable with previous collections. Previous collections were made only of addled eggs that may have been addled due their exposure to oil.

An analysis of the variability of hydrocarbon concentrations will be used to determine the necessary sample size. The selected study areas will be surveyed by helicopter to identify nests with addled eggs. These sites will be re-visited by boat to collect a single egg from each nest. The number of eggs in each nest will be recorded. Most nests are expected to have two or more eggs. The eggs will be handled to prevent unintentional hydrocarbon contamination, processed and analyzed following methods previously employed. Appropriate statistical tests will be conducted to determine differences and similarities between previous collections and those eggs collected during this study.

Duration of Project:

This will be a one year project.

Estimated Costs:	Year	1992
	Cost	128k

Restoration or Endpoint Activity to be Addressed:

This project will document persistence of hydrocarbons in the environment, and how they may be manifested in certain aspects of Bald Eagle biology. This will help with the interpretation of effects identified in earlier phases of the Bald Eagle study, and improve our understanding of mechanisms that may be limiting eagle populations.

Relationship to Science Information Needs Identified by RPWG:

This study directly addresses the need to monitor contamination by residual hydrocarbons, as identified by the RPWG.

Importance of Initiating Project in 1992:

Hydrocarbons may diffuse in the environment with time. Therefore, it is important to collect samples as soon as possible.

Link to Other NRDA Damage Assessment or Restoration Studies:

Because Bald Eagles are high on the food chain, they are good indicator species. If contamination by hydrocarbons exists in Bald Eagles, it likely exists in elements lower in the food web and other birds which forage in the intertidal zone. Information on hydrocarbon contamination in Bald Eagles will help to identify pathways by which hydrocarbons are distributed and move through the ecosystem.

THE FOLLOWING PROJECTS ARE NOT RECOMMENDED FOR IMPLEMENTATION IN 1992. HOWEVER, THEY WERE CONSIDERED FOR 1992 AND WILL LIKELY BE CONSIDERED FOR SUBSEQUENT YEARS. THEY ARE PROVIDED FOR PLANNING PURPOSES ONLY.

1. Determine Annual Food Habits for Adult and Subadult Bald Eagles....................Page 50
2. Murrelet Foraging Habitat Requirements.............Page 52
3. Censuses of Seabird Nesting Colonies...............Page 54
4. Avian Predator Control at Seabird Colonies.........Page 56
5. Eradication of Introduced Foxes, Squirrels or Rats at Seabird Nesting Islands..............Page 58
6. Test Feasibility of using of Decoys or Vocalizations to Enhance Murre Recovery...............Page 60
7. Identify Post-Breeding and Wintering Concentrations of Murre Chicks and Adults..............Page 63

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Project Title: Determine Food Habits for Adult and Subadult Bald Eagles

Species and Injury to be Addressed:

Bald Eagles are a conspicuous component of coastal ecosystems in Alaska. The EXXON Valdez Oil Spill (EVOS) caused direct mortality to hundreds of Bald Eagles and significant losses to productivity. Evidence exists on lingering effects of the oil spill to the remaining eagles.

Lead Agency:

U.S. Fish and Wildlife Service

Project Objectives:

For Bald Eagles, exposure to oil comes primarily through their search for food on the beaches and intertidal areas of coastal habitats. Little has been done to understand the food habits of Bald Eagles in Alaska since the work of Imler and Kalmbach (1955) in the late 1940's. This proposal would be to assess the food habits of Bald Eagles throughout the year along the coasts of Alaska.

Specifically, we would try to:

1. Determine the food habits of territorial breeding Bald Eagles throughout the year.

2. Determine the food habits of non-territorial Bald Eagles throughout the year.

3. Assess the significance of oil contamination to prey species used by eagles.

Project Methods:

Intensive observations would be conducted at nest sites throughout the breeding season to identify prey items brought to the nest. Prey remains would be collected below and at the nest. Individual eagles would need to be radio-tagged so they could be followed throughout the day and the prey they obtain observed. Similarly a group of immatures would also need to be radio-tagged so they could be followed and their prey identified. In most cases it will be relatively simple to identify the prey source, depending on the season and location of the observed eagle. Field personnel will need to be able to follow eagles when they move to foraging areas and monitor their feeding. This will require aerial surveillance on some occasions. An evaluation of prey availability will also be conducted using appropriate sampling strategies for the species being inventoried.

Duration of Project:

This will be a three year project. Observations will be difficult to collect and it will be desirable to have repeated observations during the various seasons to detect temporal patterns in foraging.

Estimated Costs:	Year	1992	1993-1994
	Cost	146k	113k

Restoration or Endpoint Activity to be Addressed:

This study would provide an understanding of exposure pathways for Bald Eagles to oil contamination and of the resources important to their success in coastal Alaskan ecosystems. The data collected here would identify potential limiting factors and restoration measures.

Relationship to Science Information Needs Identified by RPWG:

This was a project identified by the RPWG.

Importance of Initiating Project in 1992:

This project is not time sensitive and could be initiated later than 1992.

Link to Other NRDA Damage Assessment or Restoration Studies:

This study would be integrally linked to other Bald Eagle studies using radio telemetry. This would be a strong reason why to initiate the study simultaneously with other eagle work. This study would also need to be closely coordinated with studies of potential prey species such as salmon or other nearshore marine organisms or otter prey collections. This work would also provide input to the Bald Eagle habitat determination project and overall habitat protection strategy for the EVOS area.

Project Title: Assessment of Marbled Murrelet Foraging Habitat Requirements During the Breeding Season

Species and Injury to be Addressed:

The marbled murrelet population which suffered direct mortality in the EVOS zone.

Lead Agency and Principal Investigator:

U.S. Fish and Wildlife Service

Project Objectives:

A major population center of the marbled murrelet exists within the EVOS zone. This population suffered direct mortality from EVOS. To adequately insure recovery of this population, protection of appropriate foraging areas must be integrated with acquisition of nesting habitat.

a. Design a comprehensive study to assess critical foraging areas for marbled murrelets breeding in the EVOS zone.

b. Implement a pilot study investigating murrelet foraging area requirements during the breeding season in conjunction with a proposed nesting study on Naked Island.

Project Methods:

Objective A: Design of foraging study.

A comprehensive study design will be developed for future implementation in the EVOS zone. This design will address suitable techniques for identifying crucial foraging areas for breeding murrelets. Authorities on murrelet distribution, forage fish, censusing techniques and use of hydroacoustics will be asked to collaborate in this effort.

Objective B: Foraging requirements of breeding murrelets.

A pilot effort examining the relationship between murrelet distribution during the breeding season and available prey will be conducted in the Naked Island Archipelago. Systematic surveys of murrelets in the nearshore environment will be coupled with hydroacoustic techniques for estimating relative prey abundance.

This endeavor will be in conjunction with the proposed study of nesting murrelets at Naked Island.

Duration of Project:

This will be a one year study.

Estimated Cost: To be determined.

Restoration Endpoint or Activity to be Addressed:

This project will provide a comprehensive study design for assessing important foraging areas for murrelets breeding in the EVOS zone.

Project Title: Censuses of Seabird Nesting Colonies (Except Murre and PWS Guillemot Colonies) in the Exxon Valdez Oil Spill Zone

Lead Agency

U.S. Fish & Wildlife Service

Cooperating Agency

Potential Cooperating Agencies: NPS, USFS, State of Alaska

Project Objectives

Census breeding colonial seabirds (except murre and PWS pigeon guillemot colonies) in the oil spill zone (Prince William Sound, outside coast of the Kenai Peninsula, Kodiak Island, and upper southside of the Alaska Peninsula) to determine their population status.

Introduction

There are about 320 colonial seabird nesting colonies in the spill zone that contain about 1.121 million breeding seabirds.

The Exxon Valdez oil spill killed many seabirds in Prince William Sound (PWS) and northern Gulf of Alaska. This prompted the recensus of selected seabirds at selected seabird colonies in the PWS, Chiswell, Barren, Kodiak, Semedi, and Ugiaushak islands, and the upper southside Alaska Peninsula. Some of the colonies recensused had been censused between two and six times since 1983, and provided a baseline to assess population trends. However, most colonies in the spill zone were not surveyed after the spill, have not been censused for several years, and have a weak baseline of historical data. In addition, past surveys used census methods that are considered inadequate today; e.g., replicate counts were not used.

Project Methods

The first year all colonies in the PWS except pigeon guillemot colonies area will be censused. The murre colonies in the spill zone and the pigeon guillemot colonies in PWS will be surveyed as a ongoing objectives of the complimentary murre and guillemot studies.

All colonies will be censused using standard Fish and Wildlife Service (FWS) methods for land-based and boat-based censuses of breeding colonial seabirds. Colony catalog forms used by the FWS will also be completed and data entered into the Alaska Seabird Colony Catalog Database. Total populations of all seabirds (except nocturnals) at each colony will be estimated. In addition, established census plots will also be censused where they exist. Photograph and video documentation will be completed to evaluate future changes in colonies and to assist in establishing population estimates.

This study is a component in the continuing FWS statewide seabird colony catalog project. The FWS has just completed a new Alaska Seabird Colony Catalog Database Management System including GIS capabilities. This new system is now available to catalog and analyze new data.

Estimated Cost To be determined.

Restoration End Point

The end points of seabird colony censusing are acquiring and protecting habitats, establishing reliable population estimates, and monitoring population recoveries.

Relationship to Science Information Identified by the RPWG

The RPWG is concerned about monitoring ecosystem recovery. Colonial nesting seabirds that are vulnerable to oil spills or other perturbations to the marine ecosystem are good indicators of the health of the marine ecosystem. In addition, RPWG has indicated a need to emphasize a broader ecological approach to studies.

Importance of Initiating the Project in 1992

This project can be initiated in 1993 without losing data.

Link to Other NRDA Studies

The information can be valuable for developing and evaluating alternative restoration strategies such as habitat protection and acquisition, and for interpreting population survey data.

Project Title: Control, translocation, or removal of specific avian predators (eagles, glaucous-winged gulls, ravens) of murre breeding adults, eggs, and chicks so as to improve murre reproductive success.

Species and Injury to be Addressed:

Murres have generally failed to produce young the last three years at sites in the oil spill zone while they have produced young at control sites outside the spill. This failure appears to correlate with a delayed laying phenology, a decrease in number of breeding adults, and a lack or greatly delayed synchrony of egg laying. One of the observable results of this breakdown of colony structure and synchronization is a large amount of predation by avian predators such as eagles, large gulls, and ravens. If this predation could be moved or controlled, then the murres might be able to reorganize and reestablish their successful breeding strategies faster.

Lead Agency and Principal Investigator:

U. S. Fish and Wildlife Service.

Project Objectives:

Seabirds and predators have coexisted over the years and this project would only be an effort to expedite the recovery of murre productivity on a faster schedule than that being observed. If this project is implemented, it would be a short-term enhancement effort until murre egg laying returns to normal.

Objectives:

(1) Evaluate the degree of predation and disturbance of murre reproduction caused by eagles and consider translocating immature bald eagles from certain key colonies like the Barren Islands if eagles are found to hinder the return of normal breeding chronology and synchrony;

(2) Control and lessen the numbers and reproductive success of glaucous-winged gulls in the vicinity of certain breeding colonies like the Barren Islands;

(3) Evaluate whether corvids need to be controlled to facilitate murre reproductive success.

The feasibility of these efforts is varied and needs to be more fully assessed. Therefore, implementation of this project is not proposed for 1992.

Duration of Project:

To be determined.

Estimated Cost:

To be determined.

Restoration Activity or Endpoint to be Addressed:

This project would address shortening the time period needed for murres to recover earlier phenology and higher reproductive success.

Relationship to Science Information Needs Identified by RPWG:

This project deals specifically with efforts that might enhance the recovery of murre productivity and phenology.

Importance of Initiating Project in 1992:

Since the murre colonies at the impacted colony sites were beginning to show some slight signs of recovery in 1991, it is recommended that further consideration of this proposal be delayed until more data on colony recovery trends are available.

Link to Other NRDA Damage Assessment or Restoration Studies:

Other murre studies.

Project Title: Removal of Introduced Foxes on Selected Colonial Seabird Nesting Islands

Species and Injury to be Addressed:

The *Exxon Valdez* oil spill caused direct mortality to thousands of marine birds and reduced productivity of others in the spill area. Ground and burrow nesting species such as auklets, storm-petrels and puffins were among birds collected dead as a result of the spill.

Lead Agency:

U.S. Fish and Wildlife Service

Project Objectives:

In the past, foxes were introduced to many islands in Alaska to create fur farms. They were left to prey on the various resources of the islands, primarily seabirds and their eggs. The harvest of the foxes has largely been discontinued, and the animals continue to prey heavily on seabirds and destroy nesting habitat on the islands they still inhabit. Some species such as storm-petrels, tufted puffins, some auklets, terns and gulls were extirpated while others were reduced to remnant populations. Fox-eradication efforts will primarily benefit these ground and burrow nesting species. The proposed project has the potential of increasing remnant or re-establishing seabird populations in these areas. Although these islands are primarily outside the area affected by the spill, some of the same species will benefit from the removal of the foxes.

The specific objectives of this project are:

A. To eliminate foxes on selected colonial seabird nesting islands to reestablish populations of burrow- and ground-nesting seabirds or enhance remnant populations.

B. To monitor the recovery of selected burrow- and ground-nesting seabird species.

Project Methods:

Eradication may follow distinct methodologies: (1) eradication using poison (1080) and M44's; (2) eradication using trapping and shooting; (3) eradication using sterilization; or (4) a combination of these techniques. Eradication using poison would require the registration of the poison 1080. The poisoning would then be carried out on 10 islands for 4 years. Trapping and shooting of foxes could be carried out on 14 islands over 8 years. Although the introduction of sterile foxes has been used in a very small study, use of this technique on a wide-scale will have to be further studied and evaluated.

Duration of Project:

This project would take from four to six years depending upon the techniques to be used and the number of islands involved.

Estimated Cost:

To be Determined

Restoration Activity or Endpoint to be Addressed:

This project will provide for long-term increased populations of ground and burrow nesting birds.

Relationship to science information needs identified by RPWG:

This project does not address needs identified by RPWG. No seabirds other than murres and marbled murrelets were specifically addressed by RPWG.

Importance of Initiating Project in 1992:

This project will provide direct benefit to target species. The more quickly it is implemented, the more quickly the population increases will occur.

Link to Other NRDA Damage Assessment or Restoration Studies:

This project will provide habitat enhancement for a multiple of bird species on the islands targeted for fox removal.

Project Title: Test Feasibility of Tape Recordings, Decoys, Habitat Modification, and Other Methods to Facilitate Breeding Synchrony and Higher Reproductive Success for Murres at a Selected Site in Alaska.

Species and Injury to be Addressed:

Murres have generally failed to produce young the last three years at sites in the oil spill zone, while they have produced young at control sites outside the spill. This failure appears to correlate with a delayed laying phenology, a decrease in number of breeding adults, and a lack or greatly delayed synchrony of egg laying.

Lead Agency and Principal Investigator:

U. S. Fish and Wildlife Service.

Project Objectives:

Work has been done in recent years (Science News, September 1990) where decoys and recordings of colony sounds and vocalizations have been used to encourage the return of terns, puffins, petrels, and razorbills to breeding islands that no longer contained those species because of past perturbations. No work is published or known that has been done with murres and hence the goal is to see if the restoration of earlier, synchronized egg-laying and murre numbers at colony sites can be enhanced by techniques such as decoys, vocalizations, and habitat modifications.

Objectives:
1) Try different applications of decoys, vocalizations, and habitat modifications to determine if these techniques can be used successfully to hasten restoration of murre breeding colonies or portions thereof that have lost either numbers of birds or a normal egg laying phenology.
2) To refine our understanding of how a murre colony reestablishes itself.

Project Methods and Feasibility:

This type of study will probably require a site which has the following characteristics: (1) murre colony or breeding ledges that can be reached; (2) site has a known history of murre use and change in usage; (3) accessibility; and (4) no biological complexities that limit its capability to increase murre numbers.

There are only a few murre colonies in Alaska where the ledges can be reached very easily. Some colonies in the Pribilof Islands meet all of the above requirements and they have relatively few avian predators. There are perhaps two sites in the Barren Islands - one on East Amatuli Light and one on Nord Island where similar work might be done although the logistics would be much more difficult.

Pribilof Island site: Productivity Plot 62 and other nearby sites at St. Paul Island, Pribilof Islands are sites that the biologists at the Alaska Maritime National Wildlife Refuge would recommend. Plot 62 used to be utilized by approximately 80 common murres and some thick-billed murres. Since a fox discovered how to get onto this ledge, the murres have not been able to breed and have abandoned the spot other than for occasional roosting. It would not be hard to modify this cliff so that the fox could not get on it again. The use of decoys and vocalizations could then be used to see if recolonization could be restored. There are other sites where a wall could be built or cliffs modified and the same procedures could be used to see if murres can be encouraged to use suitable habitat that did not previously exist.

Barren Islands site: When the seas are calm enough, East Amatuli Light can be approached and climbed. Decoys, vocalization devices, and three-sided boxes simulating caves could be positioned here along with time lapse cameras. The major problem is this is the one of the few sections of the murre cliffs at the Barren Islands that is already beginning to recover normal phenology and better reproductive success. It might therefore be hard to conclude what really caused an effect. The one site on Nord Island (Plot D) has not as yet demonstrated much recovery; also, it is quite difficult to climb and you need the very best weather for such an effort.

Duration of Project:

Since most murres are long-lived and do not reproduce until 3-5 years of age, this study needs to be monitored for at least 5 years to determine success.

Estimated Cost:

To be determined.

Restoration Activity or Endpoint to be Addressed:

The development of methods to enhance the recovery of murre numbers and productivity.

Relationship to Science Information Needs Identified by RPWG:

This project addresses specific needs of a specific species.

Importance of Initiating Project in 1992:

Not recommended for implementation in 1992.

Link to Other NRDA Damage Assessment or Restoration Studies:

Murre studies.

Project Title: Identify post-breeding concentrations of murre chicks with accompanying males and winter concentrations and evaluate other questions about winter distribution and whether regional murre populations intermix.

Species and Injury to be Addressed:

Murre colonies in the oil spill area have experienced decreased numbers of breeding birds and low reproductive success the last three years. Little is known about either the distribution of adult male/chick pairs immediately after fledging and throughout the fall or the environmental factors or resources that enhance the survival of those chicks. In addition, little is known about the winter distribution of murres and the interchange of regional populations. Knowledge of either of these categories would have an impact on the restoration strategies adopted.

Lead Agency and Principal Investigator:

U.S. Fish and Wildlife Service.

Project Objectives:

This study seeks to answer several different questions about murre distribution in Alaska away from the colony sites.

Objectives: 1) Conduct pelagic studies immediately after fledging in some radial design around selected colony sites emphasizing the movement and distribution of male murre-chick pairs.

2) Conduct pelagic censuses and studies in fall, winter and spring over a wider area to map murre concentrations;

3) Investigate if blood samples or DNA or satellite radio tracking systems can answer if regional murre populations intermix.

Project Methods and Feasibility:

There are accepted methods of pelagic census, but there are data gaps in the atlases and information known. The major limitation is financial funding because it is expensive to run the large boats necessary in the fall and winter to gather this type of data. One methodology focuses a specific breeding site right after chicks jump from the cliffs while the other two work on mapping a wider distribution in time and space. The technology is not yet available for satellite radio tracking for such a small animal, but may be possible in the future.

Duration of Project:

To account for annual variation in the distribution patterns, this type of survey should extend for at least three sampling years (falls and winters).

Estimated Cost:

To be determined.

Restoration Activity or Endpoint to be Addressed:

This study would provide data to determine whether or not there is interchange between different murre colonies in Alaska and therefore what restoration activities are most appropriate.

Relationship to Science Information Needs Identified by RPWG:

This project addresses a specific request made for a specific species, murres.

Importance of Initiating Project in 1992:

This project is not proposed for implementation in 1992.

Link to Other NRDA Damage Assessment or Restoration Studies:

Other murre studies.

SFOS-IMS 92-44

RESEARCH PRE-PROPOSAL

TO:	Dr. Stan Senner Oil Spill Restoration Planning Office 645 G St. Anchorage, AK 99501
FROM:	Institute of Marine Science School of Fisheries & Ocean Sciences University of Alaska Fairbanks Fairbanks, Alaska 99775-1080
TITLE:	Injury and Recovery of Deep Benthic Macrofaunal Communities

PRINCIPAL INVESTIGATOR:	Howard M. Feder Affiliate Professor SS# 548-38-8943
NEW/CONTINUING:	New
PROPOSED STARTING DATE:	1 March 1992
PROPOSED DURATION:	5 years
AMOUNT REQUESTED:	$1,350,000

for 11-18-91
Howard M. Feder — Date
Principal Investigator
(907) 474-7956

11/18/91
Vera Alexander — Date
Dean, School of Fisheries & Ocean Sciences
(907) 474-7531

11/18/91
John J. Goering — Date
Associate Director, Institute of Marine Science
(907) 474-7895

11/19/91
Luis M. Proenza — Date
Vice Chancellor for Research
(907) 474-7314

11-18-91
Joan Osterkamp — Date
Executive Officer
School of Fisheries & Ocean Sciences
(907) 474-7824

November 1991

A. Injury and Recovery of Deep Benthic Macrofaunal Communities

B. Infaunal (invertebrate) taxa collected on 0.5 and 1.0 mm nested screens

C. Howard M. Feder. Alaska Department of Fish and Game and University of Alaska Fairbanks.

D. Objectives

1. To document continuing changes to the deep benthos subsequent to the *Exxon Valdez* oil spill by comparing taxon richness and diversity, abundance and biomass of dominant taxa, and trophic types of biota living on similar substrata in oiled sites adjacent to sea grass beds.
2. To assess the effects of faunal changes on the benthic ecosystem of the above sites.
3. To determine the time required for the benthic components of the above sites to recover to an undisturbed or relatively stable condition.

E. Project Methods, including technical feasibility of the study

The project is a continuation of "Injury to Deep Benthic Communities" initiated in summer of 1990 under AIR/WATER STUDY 2 (Injury to Deep Water Benthic Infaunal Resources from Petroleum Hydrocarbons). The sampling plan called for collection of five replicate samples at each of three stations (40, 100, and >100 m) within seven sites identified as oil-exposed sites and seven sites determined to be uncontaminated sites. A commonality of all sites was their location adjacent to shores with seagrass (*Zostera* sp.) beds. Sites were occupied in summer of 1990 and 1991. Analyses of all data from 1990 and some data from 1991 are available. Effects of the oil spill on benthic communities within oiled bays, based on these data, will be included in the Annual Report. Since the deep-benthic study was initiated almost 14 months after the spill, toxic effects were no longer apparent at six of the seven oiled sites. Instead, fauna at six sites showed classic responses expected after organic enrichment of the bottom following an oil spill (as documented in the literature for benthic fauna after other oil spills such as the Amoco Cadiz spill off the French coast). The Prince William Sound study areas, as well as the Amoco Cadiz sites, showed significantly higher abundance values of opportunistic taxa compared to unoiled sites at the same depth. Many of these opportunists were surface deposit feeders and scavengers responding to a new carbon source – oil, associated hydrocarbon degrading bacteria, and detritus derived from oil-related mortality of plants and animals within the adjacent intertidal and shallow subtidal region.

Stations at 40 and 100 m will be sampled in July (the >100 m stations did not seem to show major impact in the 1990 data) with a 0.1-m^2 van Veen grab. Five replicate samples will be taken at each station. Material will be washed on nested 1.0- and 0.5-mm stainless steel screens. Organisms will be identified in the laboratory to the family level or higher to facilitate the identification process (this is the same procedure used successfully for the 1990-91 data). Various measures of diversity will be calculated and compared between stations at similar depths within unoiled and oiled sites. Indices to be calculated are: Shannon Diversity (measures total diversity), Simpson (useful for identifying dominance by one or a few taxa at a station), Evenness, and Species Richness (details included in the Detailed Study Plan cited above). Other univariate measures will be applied to abundance and biomass data as appropriate. Taxonomic groups will be assigned a trophic category. Analysis of Variance (ANOVA) will test differences in abundance, biomass, and trophic type between dominant taxa at similar depths within unoiled and oiled sites for each year of the study and for the combined data collected on subsequent cruises in future years will be identified using multivariate techniques. Use of these techniques make it possible to examine similarities or dissimilarities between groups of stations and should be useful for temporally comparing oiled vs. unoiled bays.

F. Duration of the Project

No consensus has been reached by benthic scientists on a global basis concerning the time required to assess the return of a benthic system from a disturbed condition to a relatively stable state. However, many investigators suggest that five years might be an appropriate time limit provided there is not continuous contamination of the deep benthos by oil trapped and continually released by intertidal and shallow subtidal sediments. I suggest that an additional five years of sampling might be appropriate. It should be noted, however, that the 1991 deep benthic data (approximately 2.5 years after the spill) tentatively suggest that the benthic environment of some oiled sites (in particular, Herring Bay) is showing a continuing as well as an increasing enrichment effect.

G. Estimated Cost per Year: $273,000 (5 years: 3/1/92-2/28/97)

H. Restoration Activity of Endpoint to be Addressed

The method applied in this investigation was successfully used for assessment of the deep benthos after the Amoco Cadiz oil spill. The approach taken will be to recognize taxonomic groups, composed of taxa of equal sensitivity to decreasing levels of oil pollution. The successive appearance of these various groups, their relative importance, and their disappearance, will be the key features of this dynamic approach. The range of taxa will be expected to vary from opportunists several months after the spill through tolerant species and finally sensitive species that are largely dominant in normal conditions.

I. Relationship to Science Information Needs Identified by RPWG

Many of the needs listed by RPWG are addressed by this benthic study:

1. Improve understanding of long-range mechanisms causing injury or limiting populations. Such information is needed to understand when a system is restored to a state where it will support various components of that system in a manner similar to that existing prior to EVOS.
2. Shifts emphasis to broader ecological rather than species-specific approaches. The study emphasizes the need to understand initial responses of a benthic system to organic enrichment and determine the possibilities that such enriched areas may become eutrophic and ultimately anoxic.
3. Monitor ecosystem recovery. This is the primary basis of this study.

J. Important of Initiating Project in 1992

As of 28 February 1992, about two-thirds of the samples collected in 1991 will be analyzed. Thus, initiation of the project 1 March 1992 will enable the project to maintain its momentum with existing trained personnel and finish analysis of the second year of data. Project initiation in 1992 will also enable a third year of sampling in July 1992 to occur.

K. Link to Other NRDA Damage Assessment or Restoration Studies

The deep benthic study will be linked to microbiological investigations of Dr. Joan Braddock, who demonstrated an increase in hydrocarbon degrading bacteria at oiled sites where we documented benthic disturbance effects. Study results will be compared with shallow subtidal studies of Stephen Jewett. Assessment of food benthos by our study will aid investigations assessing commercially-important crustaceans (e.g., spot shrimp that feed on benthos). No ship platform cost is included in this proposal. It is assumed the benthic project will continue to utilize the shipboard platform funded by the NOAA sediment-hydrocarbon investigations.

OIL SPILL (DEEP BENTHIC)

3/1/92-7/1/92

			Line items (Including) Indirect Costs)
SALARIES & BENEFITS			
H. M. Feder	$ 16,505		
Lab Assistant II	15,357		
A. Blanchard	7,696		
K. Coyle	864		
N. Foster	821		
Student Assistant II	8,706		
Leave accrual	4,590		
Staff benefits	7,407		
TOTAL SALARIES & BENEFITS		$ 61,946	$ 74,335
TRAVEL			
Per diem (5 days each, Anchorage, Seattle)	$ 560		
Hotel - Anchorage	600		
Hotel - Seattle	300		
2 R/T Fairbanks/Anchorage	640		
R/T Fairbanks/Seattle	1,365		
Ground transport (taxi, bus, etc.)	150		
TOTAL TRAVEL		3,615	4,338
SERVICES			
Statistician @ $50/hr	$ 4,000		
Data management	6,000		
Publications	5,500		
Phone, FAX, copying, etc.	350		
Equipment rental	1,383		
TOTAL SERVICES		17,233	20,680
SUPPLIES			
Miscellaneous field, lab and office supplies		1,000	1,200
EQUIPMENT			
		0	
TOTAL DIRECT COSTS		$ 83,794	
INDIRECT COSTS (20% Total Direct Costs)		16,759	
TOTAL REQUESTED		$ 100,553	$ 100,553

OIL SPILL (DEEP BENTHIC)

7/1/92-2/28/93

			Line items (Including) Indirect Costs)
SALARIES & BENEFITS			
H. M. Feder (2 mos)	$ 14,973		
J. Johnson (8 mos)	15,042		
Lab Assistant II (8 mos)	16,249		
A. Blanchard (4 mos + ship time, weekends)	12,287		
Lab Asst. II (ship time & weekends)	3,559		
C. Geist (30 hrs)	1,295		
Student Asst. II (7 x 8 mos)	30,473		
Graduate Student (1 mo - sediment analysis)	987		
Student Asst. II (2 mos - sediment analysis)	1,088		
Student Asst. IV (6 mos ½-time, 2 mos full time)	7,131		
Leave accrual	9,251		
Staff benefits	18,219		
TOTAL SALARIES & BENEFITS		$ 130,554	$ 156,665
TRAVEL			
R/T Fairbanks/Seward (rental vehicle)	$ 500		
Fuel (rental vehicle)	100		
Per diem (5 days)	455		
Hotel - Seward	125		
Hotel - Anchorage	500		
2 R/T Fairbanks/Anchorage	600		
Ground transport (taxi, bus, etc.)	150		
TOTAL TRAVEL		2,430	2,916
SERVICES			
Data management	$ 1,500		
Publications	2,000		
Phone, FAX, copying, etc.	300		
Equipment service	350		
Equipment rental	2,765		
TOTAL SERVICES		6,915	8,298
SUPPLIES			
Miscellaneous field, lab and office supplies		4,500	5,400
EQUIPMENT		0	
TOTAL DIRECT COSTS		$ 144,399	
INDIRECT COSTS (20% Total Direct Costs)		28,880	
TOTAL REQUESTED		$ 173,279	$ 173,279

OIL SPILL (DEEP BENTHIC)

3/1/93-7/1/93

			Line items (Including) Indirect Costs)
SALARIES & BENEFITS			
H. M. Feder (1.25 mos)	$ 9,358		
J. Johnson (4 mos)	7,750		
Lab Assistant II (4 mos)	8,125		
A. Blanchard (3 mos)	7,596		
C. Geist (60 hrs)	2,590		
Student Asst. IV (4 mos)	2,853		
Student Asst. II (7 x 4 mos)	15,237		
Leave accrual	4,900		
Staff benefits	9,648		
TOTAL SALARIES & BENEFITS		$ 68,057	$ 81,668
TRAVEL			
Per diem (5 days ea/Anchorage,Seattle)	$ 560		
Hotel - Anchorage	600		
Hotel - Seattle	300		
2 R/T Fairbanks/Anchorage	640		
R/T Fairbanks/Seattle	1,365		
Ground transport (taxi, bus, etc.)	150		
TOTAL TRAVEL		3,615	4,338
SERVICES			
Data management	$ 6,000		
Publications	5,000		
Phone, FAX, copying, etc.	350		
Equipment rental	1,383		
TOTAL SERVICES		12,733	15,280
SUPPLIES			
Miscellaneous field, lab and office supplies		1,500	1,800
EQUIPMENT		0	
TOTAL DIRECT COSTS		$ 85,905	
INDIRECT COSTS (20% Total Direct Costs)		17,181	
TOTAL REQUESTED		$ 103,086	$ 103,086

OIL SPILL (DEEP BENTHIC)

SERVICES			
Ship Charter ($10,000/day x 16 days)	dis[illegible] p[illegible]	$	~~160,000~~
Indirect Costs (20% TDC)			32,000
TOTAL		$	192,000

PHONE MEMO

TO Stan	DATE 11/22	TIME	AM PM
FROM Howard Feder	AREA CODE		
OF	NO.		
	EXT.		

MESSAGE

Budget proposal needs to be removed.

I called him back & he just want to make sure we had a correct copy of his proposal minus a budget sheet he didn't want added. (delete ship charter cost) bi

SIGNED

PHONED ✓ | CALL BACK ☐ | RETURNED CALL ☐ | WANTS TO SEE YOU ☐ | WILL CALL AGAIN ☐ | WAS IN ☐ | **URGENT** ☐

A. STUDY NAME:

Injured Species Habitat Identification

B. SPECIES TO BE ADDRESSED:

Harlequin duck, marbled murrelet, cutthroat trout, Dolly Varden, pink salmon, black oystercatcher, bald eagle.

C. PRINCIPAL INVESTIGATORS AND LEAD AGENCIES :

Susan Borchers, USDA Forest Service
Mark Kuwada, Alaska Department of Fish and Game

D. PROJECT OBJECTIVES:

The project goals are to:

- Develop an ecological data base to assist in restoration, protection, acquisition or enhancement of habitat for injured species.

- Provide a tool to assist in restoration and long-term maintenance and monitoring of ecosystem integrity.

Specific project objectives are:

- Characterize and delineate injured species habitat.

- Identify habitats for restoration, protection, acquisition and enhancement within the oil spill area.

- Produce products consistent with the needs of resource managers (public and private).

E. PROJECT METHODS:

The final product will be an Ecological Data Base made up of landforms, soils, and plant association layers that will be a component of Geographic Information System, derived from Thematic Mapper remote sensing and extensive field sampling.

Landsat Thematic Mapper (TM) image data, along with ancillary Geographic Information System (GIS) based information, will be used as the spatial basis. Spatial information will consist of landforms, edaphic factors, terrain features, elevation, aspect, slope, physical characteristics of streams, and vegetation composition and structure. The combination of spatial information and extensive field sampling and verification will provide the habitat information needed to guide many of the Prince William Sound oil spill recovery efforts.

Landsat based ecological mapping techniques have evolved from numerous and extensive studies throughout Alaska (Borchers 1992; Tande and Jennings 1986; Walder and Acevedo 1986, Talbot et al. 1985). Development of an ecological classification system for Prince William Sound has been ongoing since 1988 (Borchers 1989 and 1992). An ecological unit is a unique combination of plant associations, soils and landforms (FSM 2060.6). Using established techniques a preliminary map delineating ecologically similar units will be developed prior to the 1992 field season. This initial map, along with information on habitat requirements of injured species, will be used to direct field sampling efforts that will begin in 1992. Ecological classification types will be selected across as many environmental gradients as possible, prior to on-the ground survey. A GIS stream map, attributed with channel type information (Paustian 1991) and Alaska Department of Fish and Game anadromous habitat delineations, will be generated to assist in directing sampling efforts for injured aquatic species and species, such as the Harlequin duck, that are associated with stream habitats.

The ecological data base field procedures will follow Alaska Region 10 direction established in the Ecosystem Classification Handbook (FSH 2090.11 and Jon R. Martin 1987 with revision by Susan L. Borchers 1990) and consistent with the direction of Chugach National Forest Ecology Program. Soils will be described and classified using standard soil description techniques and the Soil Taxonomy. The soils will be correlated by the Soil Scientist under the direction set forth in the National Cooperative Soil Survey program. Landforms will comply to Alaska Region 10 direction (FSM 2061.13 and 2061.16).

Field survey sites will be selected to provide an unbiased statistically valid sample. Additional sites will be selected in areas known to be used by the injured species. Presence of injured species will be validated and habitats used will be mapped using a Geographic Positioning System (GPS). Following the 1992 field season, draft habitat capability models will be developed that will operate in conjunction with the ecological database and GIS stream channel type maps. Because it will be impossible to physically visit all sites in the spill area, these models will be used to predict additional habitats likely to be important to injured species.

Subsequent years efforts will essentially be a reiterative process of additional field sampling, refinement of the TM image interpretations, and validation and fine tuning of the habitat capability models. The final products year will be a GIS based map depicting the locations of important habitats for injured species and a data base describing the ecological characteristics of these habitats, both with a known degree of reliability.

F. DURATION OF PROJECT:

The project will last three to five years. The initial focus of work will be on Prince William Sound with interim products for

Prince William Sound available in one year and final products in three years. The rest of the oil spill area will be worked on concurrently with PWS with interim products in two to three years and final products in five years.

G. ESTIMATED COST:

GIS and thematic mapping	1992	1993	1994
Salary	$215,000	$195,000	$195,000
Contract	$280,000	$200,000	$200,000
Equipment	$31,000	$2,000	$2,000
10% Contingency	$53,000	$40,000	$40,000
SUB-TOTAL	$579,000	$437,000	$437,000
Field Budget			
Salary	$70,000	$70.000	$70,000
Transportation	$342,000	$342,000	$342,000
Equipment	$16,000	$3,000	$3,000
10% contingency	$42,800	$41,500	$41,000
SUB-TOTAL	$470,800	$456,500	$456,500
TOTAL	$1,049,800	$893,500	$893,500

H. RESTORATION ACTIVITY OR ENDPOINT:

Restoration endpoints that this project would work toward are:

- Minimize human disturbance to injured species habitat
- Protect/acquire coastal and upland habitats
- Enhance stream/lake habitats
- maintain water quality
- monitor recovery

I. RELATIONSHIP TO SCIENCE INFORMATION NEEDS:

This project provides an ecological basis for understanding species distribution and habitat requirements. It will provide information throughout the spill area that can be used by any agency or group having arc-info GIS capabilities. It contributes to the science information needs of harlequin ducks by identifying habitat characteristics and displaying habitats similar to known nesting sites. It would also provide similar information for marbled murrelets. This project would facilitate the identification of non-oiled streams with cutthroats and Dolly Varden, both in and outside PWS.

J. IMPORTANCE OF INITIATING PROJECT IN 1992

Several restoration endpoints, the most obvious being the protection or acquisition of upland habitats, require the identification of injured species habitat characteristics and knowledge about the distribution of those habitats. The starting point for any field verification of species habitat needs is an accurate map. Providing accurate maps that are useful to scientists studying the species, resource managers, or restoration project managers will take several years. Delaying this project could reduce the scientific credibility of restoration projects aimed at protecting or acquiring upland habitats.

Any acquisition program would require a quantification of the habitat being protected. This project would provide those acreage figures as well as display the relationship of the habitat being protected to adjacent land.

K. LINK TO OTHER NRDA DAMAGE ASSESSMENT OR RESTORATION STUDIES

This project is directly linked to the ongoing marbled murrelet study conducted on Naked Island in 1991. It will easily link to the ongoing harlequin duck study being conducted in PWS.

L. LITERATURE:

Borchers, Susan L. 1992. Ecological Classification and Mapping of Naked Island, Prince William Sound, Alaska (unpublished).

Borchers, Susan L., Jay Wattenberger, and Rob Ament. 1989. Forest Plant Associations of Montague Island, Chugach National Forest. In Proc Watershed 1989, Juneau, Alaska. Alaska Region R10-MB-77.

Hemstrom, Miles A. and Sheila E. Logan. 1986. Plant Association and Management Guide Siusilaw National Forest. R6-Ecol 220-1986a.

Henderson, Jan A., David H. Peter, Robin D. Lesher, and David C. Shaw. 1989. Forested Plant Associations of the Olympic National Forest. R6-Ecol-TP 001-88.

Paustian, S., 1991. Draft Channel Type User Guide. USDA Forest Service publication. 146 pp.

Talbot, S.S., M.B. Shasby and T.N. Baily. 1985. LANDSAT - Facilitated Vegetation Classification of the Kenai National Wildlife Refuge and Adjacent Areas, Alaska. In. Pecora10, Remote Sensing in Forest and Range Resource Mgmt, Fort Collins, CO.

Tande, Gerald F. and Thomas W. Jennings. 1986. Classification and Mapping of Tundra Near Hazen Bay, Yukon Delta National Wildlife Refuge, Alaska. U.S.F.W. FWS/AI-87/1. 187pp.

Walker, D.A. and W. Acevedo. 1986. A LANDSAT-derived vegetation map of the Beechey Point Quadrangle, Arctic Coastal Plain, Alaska. U.S. Army Cold Regions Res. and Eng. Lab., Hanover, NH., CRREL Rept. 363. 77pp.

STUDY TITLE:

FOOD HABITS OF STAGING WATERFOWL ON THE INTERTIDAL HABITATS OF THE WESTERN COPPER RIVER DELTA

Injured species: Waterfowl Staging in Intertidal and Shallow Subtidal Habitats

The extensive intertidal and shallow subtidal habitats of the Copper River Delta are used as a staging grounds for large concentrations of migratory waterfowl during spring and fall migration. Because of upland snow cover throughout April, the intertidal and shallow subtidal zone are often the only available foraging and roosting habitats for migrant waterfowl. Lipid and protein reserves necessary for breeding and migration are accumulated by many species during this time. At the same time, cold temperatures and snow conditions often delay waterfowl migration from the Copper River Delta to breeding areas in interior and northern Alaska. In the fall, migrant waterfowl show a strong preference for the intertidal areas over inland ponds and marshes. Fall storms on the Delta restrict migration, causing large numbers of waterfowl to remain on the Delta until more favorable conditions. The most abundant migrant waterfowl on the Copper River Delta include 4 species of dabbling ducks and 9 species of diving and sea ducks with northern pintails the most abundant species in spring.

Currently there is no baseline information on food resources available or food habits of dabbling and sea ducks staging in the intertidal and shallow subtidal habitats on the Copper River Delta. At the same time, the Exxon Valdez oil spill in Prince William Sound has underscored the vulnerability of the Delta to catastrophic oil spills. Waterfowl staging areas on the western end of the Delta overlap with areas that could be impacted by a future oil spill in Prince William Sound.

Crude oil causes severe damage to marine invertebrates and over time accumulates in the food chain. If dabbling duck food habits in the intertidal zone are similar to sea duck food habits in Prince William Sound (mussels and other invertebrates), then in the event of a spill, both sea ducks and the large concentrations dabbling ducks staging on the Delta are likely to be exposed to petroleum hydrocarbons through their food.

The data this study proposes to gather together with the proposed complementary study on migrant waterfowl abundance and distribution will enable efficient and effective deployment of response and containment resources to best protect strategic waterfowl staging habitat in the event of a spill. At the same time, this study will also establish a solid baseline from which damages can be assessed for any future oil spill.

Objectives

1. Develop a data base describing spring and fall food habits of dabbling and sea ducks staging in the intertidal and shallow subtidal habitats on the western Copper River Delta.

2. Determine intertidal and shallow subtidal food resources available to waterfowl by area and habitat.

3. Monitor seasonal availability of food resources.

Methods

Food habits of dabbling and sea ducks will be determined from collections in the intertidal and shallow subtidal zone of the western Copper River Delta throughout spring and fall migration. Gizzards and stomach contents will be analyzed for frequency of occurrence and percent volume of prey items. Based on waterfowl distribution, a stratified random sampling design will be used to sample prey availability and waterfowl habitat use. Key foraging concentration areas will be identified for future management and protection.

Relationships with Other Studies

The Coastal Habitat Study will provide data on the potential persistence of oil in the intertidal and shallow subtidal areas, and the potential contamination of prey species for sea and dabbling ducks. The current study on harlequin ducks in Prince William Sound will provide comparative information on food habits in the intertidal zone. That study will also provide data on potential physiological and life-history effects from hydrocarbon uptake. Results from the harlequin duck study will also be used to estimate potential mortality from oil spills.

Restoration Endpoint Addressed

Sea ducks, in particular the 3 species of scoters, were retrieved from oiled areas after the spill. All three species (white-winged, surf and black) occur on the western Copper River Delta. Four species of dabbling ducks also occur as migrants in the same intertidal mudflat and shallow subtidal habitats of the western Copper River Delta. There is a need to monitor waterfowl food habits in the intertidal mudflats and shallow subtidal habitats to assist in the recovery efforts.

Principal Investigator: Mary Anne Bishop, Copper River Delta Institute
Lead Agency: US Forest Service, Copper River Delta Institute and Chugach National Forest Cordova Ranger District
Cooperating Agencies: Federal: USFWS
State: ADF & G

Budget: US Forest Service

	FY 92	FY 93	FY94
Salaries	$20,000	$20,000	$15,000
Flights	5,000	5,000	
Supplies	5,000	5,000	
Equipment	15,000	5,000	
	$45,000	$35,000	$15,000

Schedule:

1 April-15 May 1992 & 1993
15 August-15 October 1992-1993
Final report February 1994

Justification for 1992

Currently there is no baseline information on food resources available or food habits of dabbling ducks and sea ducks staging in the intertidal and shallow subtidal habitats on the Copper River Delta. Waterfowl staging areas on the western end of the Delta overlap with areas that could be impacted by a future oil spill in Prince William Sound. By monitoring food habits, the study will document the potential exposure to petroleum hydrocarbons through the intertidal and shallow subtidal food resources in the event of another spill.

STUDY TITLE:

MIGRATORY SHOREBIRDS STAGING IN ROCKY INTERTIDAL HABITATS OF PRINCE WILLIAM SOUND

Injured Species: Shorebirds Staging on Rocky Intertidal Habitats

Up to one half-million shorebirds, representing 5 species, stage each spring in rocky intertidal habitats of Prince William Sound. These species include black turnstone (Arenaria melanocephala), ruddy turnstone (Arenaria interpres), surfbirds (Aphriza virgata), rock sandpiper (Calidiris ptilocnemis) and Wandering Tattler (Heteroscelus incanum). Prince William Sound's rocky intertidal zone is particularly important to black turnstones and surfbirds. As much as 20-45% of their respective breeding populations have been observed staging in the Sound during spring. At the same time, no comparable aggregations have been sighted in any other parts of their range.

All 5 species regularly feed on small crustaceans and mollusks. Large concentrations of surfbirds and black turnstones (18,700 and 9,800 birds respectively) have also been recorded feeding on herring spawn deposition on northern Montague Island. Although the Prince William Sound rocky intertidal habitat supports large concentrations of shorebirds each spring, baseline information is lacking on the relative abundance of shorebirds, their spatial and temporal distribution patterns, their length of stay, and their key concentration areas.

The coastal intertidal zone was the most severely contaminated habitat after the Exxon Valdez oil spill in Prince William Sound. Portions of northern Montague Island, including Rocky Bay where large aggregations of black turnstones and surfbirds have been observed, were in the oil trajectory from the spill. Shorebird species staging in the rocky intertidal habitats are likely to be exposed to petroleum hydrocarbons through their food. To date, however, there have been insufficient baseline studies to establish if the staging shorebird species were injured by the spill. The data this study proposes to gather will enable efficient and effective deployment of response and containment resources to best protect rocky intertidal shorebird habitats in the event of a spill. At the same time, this study will also establish a solid baseline from which damages can be assessed for any future oil spill.

Objectives

1. Determine the phenology, relative abundance, and species composition of shorebirds using the rocky intertidal zone in Prince William Sound during spring migration.

2. Monitor shorebird spatial and temporal distribution in relation to habitat type and the abundance of Pacific herring eggs.

3. Identify key shorebird concentration areas in Prince William Sound.

4. Assess the relative importance of prey items for shorebirds staging in rocky intertidal habitats.

5. Determine length of stay during spring migration in Prince William Sound.

Methods

The numbers, distribution and species composition of staging shorebirds in rocky intertidal habitats will be determined using a combination of aerial and boat surveys. Boat shoreline surveys will be conducted daily at northern Montague Island, and bi-weekly at Green Island. All birds seen in the intertidal zone and on the water to approximately 100m will be recorded. Aerial surveys of the entire Montague and Green Island shorelines will be conducted 2-3x weekly. During peak migration, the remaining rocky shorelines in Prince William Sound will be sampled using a stratified random design to estimate shorebird abundance and to identify key concentration areas. Paired shoreline surveys from aircraft and boats or the beach will be conducted along selected sections of shoreline to develop visibility correction factors. Habitat use patterns in relation to habitat type (drift-line, upper intertidal, middle intertidal, lower intertidal) and environmental attributes will also be determined from boat surveys.

A sample of surfbirds and black turnstones will be collected to determine which prey items are of importance to these birds while in Prince William Sound. Gut contents will be analyzed for frequency of occurrence and percent volume of food items. At northern Montague Island, black turnstones and surfbirds will be captured and marked with dye and colored leg-bands to determine length of stay (turnover rate) and total bird-day-use.

Relationships with Other Studies

The Coastal Habitat Study will provide data on the potential persistence of oil in the rocky intertidal areas, and the potential contamination of prey species for shorebirds. The Pacific herring spawn study will provide data on the effects of oil on egg abundance and potential contamination.

Restoration Endpoint Addressed

Portions of the rocky intertidal zone on northern Montague Island where large concentrations of shorebirds stage in spring were oiled during the spill. There is a need to monitor shorebird use of the rocky intertidal zone to determine the long-term effects on survival and productivity on these species of shorebirds and assist in the recovery efforts.

Principal Investigator: Mary Anne Bishop, Copper River Delta Institute
Lead Agency: U.S. Forest Service, Copper River Delta Institute and Chugach National Forest Cordova Ranger District.
Cooperating Agencies: Federal: USFWS
State: ADF & G

Budget: US Forest Service

	FY 92	FY 93	FY 94
Salaries	$ 20,000	$ 20,000	$ 25,000
Flights	25,000	25,000	25,000
Supplies	10,000	10,000	10,000
Equipment	25,000	10,000	10,000
	$ 80,000	$ 65,000	$ 70,000

Schedule:
20 April-31 May 1992, 1993, 1994
Final report November 1991

Justification for 1992

Portions of northern Montague Island, including Rocky Bay where large aggregations of black turnstones and surfbirds have been observed, were in the oil trajectory from the Exxon Valdez spill. No hydrocarbon analyses are available yet to evaluate whether shorebirds could have been ingesting petroleum hydrocarbons through their food. If petroleum is found to persist in barnacles and mussels, then shorebirds staging in the rocky intertidal zone will be vulnerable to contamination in future years.

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STUDY TITLE:

SURVEYS TO DETERMINE DISTRIBUTION AND ABUNDANCE OF MIGRATORY WATERFOWL STAGING IN INTERTIDAL HABITATS OF THE WESTERN COPPER RIVER DELTA DURING SPRING AND FALL

Injured species: Waterfowl Staging in Intertidal and Shallow Subtidal Habitats

The extensive intertidal and shallow subtidal habitats of the Copper River Delta are used as a staging grounds for large concentrations of migratory waterfowl during spring and fall migration. Because of upland snow cover throughout April, the intertidal and subtidal zones are often the only available foraging and roosting habitats for migrant waterfowl in spring. Lipid and protein reserves necessary for breeding and migration are accumulated by many species during this time. At the same time, cold temperatures and snow conditions often delay waterfowl migration from the Copper River Delta to breeding areas in interior and northern Alaska. In the fall, migrant waterfowl show a strong preference for the intertidal areas over inland ponds and marshes. Fall storms on the Delta restrict migration, causing large numbers of waterfowl to remain on the Delta until more favorable conditions. Abundant migrant waterfowl on the Copper River Delta include 4 species of dabbling ducks and 9 species of diving and sea ducks with northern pintails the most abundant species in spring.

The Exxon Valdez oil spill in Prince William Sound has underscored the vulnerability of the western Copper River Delta to catastrophic oil spills. Waterfowl staging areas on the western end of the Delta overlap with areas that could be impacted by a future oil spill in Prince William Sound. Potential injuries to migrant waterfowl from exposure to any future oil spill include, but are not limited to, death, changes in behavior, and decreased productivity.

The data this study proposes to gather will enable efficient and effective deployment of response and containment resources to best protect strategic waterfowl habitat in the event of a spill. At the same time, this study will also establish a solid baseline from which damages can be assessed for any future oil spill.

Objectives

1. Document timing and distribution of staging waterfowl in intertidal and shallow subtidal habitats on the western Copper River Delta.

2. Determine the relative abundance and species composition of staging waterfowl in intertidal habitats.

3. Identify key waterfowl concentration areas.

4. Estimate the length of stay waterfowl use the intertidal and shallow subtidal habitats on the delta.

Methods

The numbers, distribution and species composition of staging waterfowl in intertidal habitats will be determined using a combination of aerial, ground, and boat surveys along the western delta shoreline and barrier islands. Aerial shoreline surveys at high tide and aerial fixed-strip transects for shallow subtidal habitats will be used to estimate waterfowl abundance. Extensive exposed intertidal areas will be surveyed in their entirety. Paired shoreline surveys from aircraft and boats or the beach will be conducted along selected sections of shoreline to estimate the proportion of birds not seen from the air. Population estimates will be calculated for each species using established double-sampling procedures. Differences within and between years will be evaluated using ANOVA or other appropriate statistical procedures.

Relationships with Other Studies

The Coastal Habitat Study will provide data on the potential persistence of oil in the intertidal areas, and the potential contamination of prey species for sea and dabbling ducks. The current study on harlequin ducks in Prince William Sound will provide comparative information on abundance and distribution of that species. The harlequin duck study will also provide data on potential physiological and life-history effects from hydrocarbon intake. Results from the harlequin study will also be used to estimate potential mortality from oil spills.

Restoration Endpoint Addressed

Sea ducks, in particular the 3 species of scoters, were retrieved from oiled areas after the spill. All three species (white-winged, surf and black) occur as migrants on the western Copper River Delta. There is a need to monitor waterfowl use of the intertidal and shallow subtidal habitats to assist in the recovery efforts.

Principal Investigator: Mary Anne Bishop, Copper River Delta Institute
Lead Agency: US Forest Service, Copper River Delta Institute & Chugach National Forest Cordova Ranger District

Cooperating Agencies: Federal: USFWS
State: ADF & G

Budget: US Forest Service

	FY 92	FY 93	FY 94
Salaries	$20,000	$20,000	$15,000
Flights	30,000	30,000	
Supplies	20,000	20,000	
Equipment	21,000	8,000	
	$91,000	$78,000	$15,000

Schedule:

1 April-15 May 1992 & 1993
15 August-15 October 1992-1993
Final Report February 1994

Justification for 1992

Waterfowl staging areas on the western end of the Delta overlap with areas that could be impacted by a future oil spill in Prince William Sound. If petroleum is found to persist in sea and dabbling duck food resources in the intertidal and shallow subtidal habitats, then waterfowl will be vulnerable to contamination from oil spills. There is a need to establish a solid baseline of information in order to identify and protect strategic waterfowl habitats, and so that damages can be assessed for any future oil spill.

A. Project name
Paulson Creek Fish Ladder Modification

B. Injured Species to be addressed
Dolly Varden char, Chum salmon, Pink Salmon would be benefited by the project. Paulson Creek is in Culross Passage on the western side of Culross Island which was oiled by the Exxon Valdez Oilspill. Culross Passage with the Forest Service cabins and recreational fishing resources is one of the most popular recreational destinations in Prince William Sound.

C. Principal Investigator and Lead Agency
Kate Wedemeyer, Fisheries Biologist, Glacier RD, Chugach Nat Forest

D. Project Objectives
Provide access to unutilized habitat for anadromous Dolly Varden char by modifying the fish pass at the barrier falls on Paulson Creek. The steeppass orignally installed in 1981 proved to be ineffective in passing Dolly Varden during low to moderate flows and was subsequently modified in 1989. Monitoring in 1991 indicated that additional modifications are required to successfully pass Dolly Varden at low to moderate flows. Efforts by the ADF&G Sport Fish personnel indicated very low populations of Dolly Varden above the fishpass. Additional values for recreation and for pink and chum salmon would accrue from improving fish passage on Paulson Creek.

1. Observe fish passage
Observations would continue in 1992, concentrating on how further modifications can improve fish passage. Habitat for Dolly Varden would be surveyed and additional sampling of present populations would be done.

2. Perform engineering survey of fishpass and barrier falls
An engineering survey would be performed in 1992 to help verify theories on why the present fishpass has limited success. The survey would also fulfill data needs for actual engineering designs.

3. Design fish passage structures
Appropriate structures for fish passage will be determined by the project leader and a design engineer with 10 years experience including 6 years in Prince William Sound. Design would be completed in 1992 or early 1993.

4. Feasibility assessment,benefit/cost analysis, environmental documentation
Public scoping and an environmental assessment of building additional fish passage structures would be written in 1993. This would include consideration of several alternatives and a benefit/cost analysis.

5. Determine whether to construct
A final decision by the Forest Service on the preferred alternative (including no action) based on the environmental assessment would be made in 1993.

6. Construction
Construction of the fish pass is slated for 1994 if it is determined to be most feasible alternative. There is some possibility that the fishpass could be built as early as 1993.

7. Monitoring of fish passage and fish populations
Monitoring would continue for 4 seasons after the fish pass is built.

E. Project methods, including technical feasibility
The feasibility of building fish passage structures has been well demonstrated by the Forest Service in Alaska. Presently, the Glacier Ranger District of the Chugach National Forest administers 8 fish passage projects in western Prince William Sound.

F.Duration of the project (number of seasons to fulfill project objectives)
Project duration of six years includes:

One year to observe fish passage and perform engineering survey
One year to determine project feasibility, develop engineering design and write environmental documents.
One year to construct (if project is determined to be feasible).
Three years of project monitoring.

G. Estimated cost (per year, if more than one year)

1992-	$ 12,500	fisheries and engineering surveys
1993-	$ 20,000	engineering design, environmental documents
1994-	?	estimated construction cost dependent on design
1995-	$ 5,000	monitoring of fish populations and fish passage
1996	6,000	monitoring of fish populations and fish passage
1997	$ 7,000_	monitoring of fish populations and fish passage

NOTE: These costs based on detailing personnel from other forests and pay ing transportation, per diem and lodging.

H. Restoration activity or endpoint to be addressed
Restoration of dolly varden char populations near Culross Island which was oiled. Secondary benefits to pink, sockeye and coho salmon. Restoration of potential recreation opportunities.

I. Link to other NRDA damage assessment or restoration studies
This project is linked primarily to damage assessment of Dolly Varden char. Together with biologists from the Alaska Department of Fish and Game Sport fish Division who have been active in Oil spill assessment work on Dolly Varden char, we determined that improving access to resident or uninhabited lakes is among the methods that have the highest potential for restoring and dolly varden populations dammaged by the 1989 Exxon Valdez oilspill.

J. Importance of initiating project in 1992
The estimated lifespan of fishpasses is 25 years. The early this fishpass is modified to improve fish passage for Dolly Varden, the longer they will benefit from it.

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STUDY TITLE:

MIGRATORY SHOREBIRDS: TEMPORAL AND SPATIAL USE PATTERNS ON THE WESTERN COPPER RIVER DELTA

Injured Species: Shorebirds Staging on Intertidal Mudflats

The extensive 500+km^2 tidalflats on the Copper River Delta are the largest staging area for shorebirds migrating on the Pacific Coast of North America. Historic estimates included up to 20 million shorebirds from over 30 species using the Copper River Delta during the spring. This includes nearly 100% of the western sandpiper (Calidris mauri) and dunlin (Calidris alpina pacifica) populations on the Pacific coast, the two largest Pacific coast shorebird populations. Although the Copper River Delta supports the largest concentration of shorebirds in the Western Hemisphere each spring, baseline information is lacking on the relative abundance of shorebirds, their spatial and temporal distribution patterns, their length of stay, and their key concentration areas.

The recent Exxon Valdez oil spill in Prince William Sound has underscored the vulnerability of the western delta to catastrophic oil spills. Shorebird stopover areas on the the western end of the delta, including Orca Inlet and mudflats adjacent to Hawkins Island Cutoff, overlap with areas that could be impacted by a future oil spill in Prince William Sound. The data this study proposes to gather will enable efficient and effective deployment of response and containment resources to best protect shorebird habitats in the event of a spill. At the same time, this study will also establish a solid baseline from which damages can be assessed for any future oil spill.

Objectives

1. Determine the phenology, relative abundance, and species composition of shorebirds staging on the western Copper River Delta during spring and fall.

2. Monitor spatial and temporal distribution in relation to habitat type and major uses.

3. Identify key shorebird concentration areas on the western Copper River Delta.

4. Determine length of stay during spring migration on the Copper River Delta.

Methods

The numbers, distribution and species composition of staging shorebirds in intertidal habitats will be determined using a combination of aerial, ground, and boat surveys along the western delta shoreline and barrier islands. Aerial shoreline surveys at high tide will be used to estimate shorebird abundance and to identify key concentration areas. Extensive exposed intertidal areas will be surveyed in their entirety. Paired shoreline surveys from aircraft and boats or the beach will be conducted along selected sections of shoreline to estimate the proportion of birds not seen from the air. Ground and boat surveys at Hartney Bay at Orca Inlet, Pt. Whitshed, and at Egg Island will be conducted to determine species composition. Habitat use patterns in relation to habitat type and environmental attributes will also be determined. Length of stay (turnover rate) and total bird-day-use will be determined monitoring Western sandpipers previously radio-tagged in San Francisco Bay and on the Fraser River Delta, British Columbia.

Relationships with Other Studies

The Coastal Habitat Study will provide data on the potential persistence of oil in the intertidal areas, and the potential contamination of prey species for shorebirds.

Restoration Endpoint Addressed

Twelve species of shorebirds were retrieved from oiled areas after the spill. All twelve species occur in substantial numbers on the intertidal mudflats of the western Copper River Delta during spring migration, and to a lesser extent during fall migration. There is a need to monitor shorebird abundance and distribution on the western Copper River Delta to assist in the recovery efforts.

Principal Investigator: Mary Anne Bishop, Copper River Delta Institute
Lead Agency: U.S. Forest Service, Copper River Delta Institute
Cooperating Agencies: Federal: USFWS
State: ADF & G
International: Canadian Wildlife Service
Private: Pt. Reyes Bird Observatory

Budget: US Forest Service

	FY 92	FY 93	FY 94
Salaries	$35,000	$35,000	15,000
Flights	30,000	30,000	
Supplies	15,000	15,000	2,000
Equipment	15,000	8,000	
	95,000	88,000	17,000

Schedule:
20 April-31 May 1992 & 1993
15 August-15 October 1992-1993
Final report April 1994

Justification for 1992

The recent Exxon Valdez oil spill in Prince William Sound has underscored the vulnerability of the western delta to catastrophic oil spills. Shorebird stopover areas on the the western end of the delta overlap with areas that could be impacted by a future oil spill in Prince William Sound. If petroleum is found to persist in shorebird food resources in the intertidal mudflats, then shorebirds will be vulnerable to contamination from oil spills. There is a need to establish a solid baseline of information in order to identify and protect strategic shorebird habitats, and so that damages can be assessed for any future oil spill.

Project Proposal

Fish Limiting Habitat Factors Analysis

Species Addressed: Cutthroat, Dolly Varden, Pink Salmon, and Chum Salmon.

Principle Investigator: Robert Olson, USFS - Chugach National Forest.

Introduction and Project Objectives: Sea run cutthroat salmon, dolly varden charr, and pink salmon were impacted as a result of the 1989 Exxon Valdez oil spill. In response to these impacts, the oil spill restoration planning team has been charged with the task to identify appropriate mitigation, protection, and where appropriate, restoration measures for injured species and their habitat. Identifying mitigation, protection and restoration measures will require adequate knowledge of the habitat limiting features for injured species. For example, if a restoration project proposes to enhance spawning habitat for sea run cutthroat salmon, when in fact freshwater rearing habitat for young of the year fish (Trotter 1989) is limiting their production then, obviously, the restoration efforts will not accomplish the end goal.

Currently, the Chugach National Forest has mapped channel types (Paustian 1991) for most of Prince William Sound. These channel types, which identify broad physical characteristics (e.g., gradient, width, surrounding landforms, and hydrologic process) for a given segment of stream, were mapped using aerial photographs and topograph maps. With ground verification and further delineations of specific habitats present within channel types, this habitat inventory technique could be used to conduct limiting factors analysis to guide restoration, mitigation, and protection measures. We propose to field verify channel type designations and to define specific fish habitat characteristics within channel types used by injured fish species. This information will be used to conduct limiting habitat factors analysis for species such as sea run cutthroat salmon and to predict where non documented populations of injured fish species may exist should mitigation measures be proposed.

Methods: The study area will focus on the Nellie Juan, College Fiord, Big Islands, and Gravina management areas of the Chugach National Forest (figure 1) but may be expanded to other areas. Initially, using ADF&G anadromous water maps, along with other sources, streams known to provide habitat for injured fish species will be identified. The fish distribution information will be overlayed on USFS channel type maps to identify areas to focus field verification and habitat surveys (see link to other activities).

Habitat surveys will be tiered to channel type designations. A statistically valid sample of each channel type within the drainages known to contain injured fish species will be sampled for presence of habitat and cover. Habitat sampling will be conducted using visual estimates (Hankin and Reeves 1988) that are verified by actual measures. Habitat delineations will be consistent with those that are defined by Bisson et al. (1982) and are an adopted standard of the American Fisheries Society. A habitat unit (e.g., plunge pool, lateral scour pool, low gradient riffle, rapids, etc...) containing specific characteristics is first identified and measured for area and depth. Once the habitat unit has been identified the percent cover (e.g., root wad, large woody debris, overhanging bank, etc...) and spawning habitat provided within the habitat unit is estimated. Using these techniques, approximately two to four kilometers of stream can be surveyed per day. Tiering these specific habitat measures to channel types will allow predictions of the amount and quality of habitat present within other streams which have the same channel type designation but have not been field verified.

The final step will involve predicting habitat limiting factors for the injured species. Using Known habitat requirements (e.g., Trotter 1989) along with the habitat surveys that have been tiered to channel types, limiting habitat factors analyses will be developed for the injured fish species. In addition, the information will be used to refine broad fish habitat capability models that are proposed as a portion of the plant association study, thereby further enhancing abilities to predict where prevously unidentified populations of fish species may exist (see link to other studies).

Project Duration: 2.5 years.

Estimated Cost: Years one and two $125,000/year, Year three $30,000.

End Point: Limiting factors analysis that can guide restoration needs. Also, increased capability to predict locations of unknown populations of injured fish species -- used to identify mitigation sites.

Link To Other Activities: Will be coordinated with the proposed ADF&G injured species surveys. Injured species surveys could be conducted to verify the predictive capabilities of this work. Field surveys would likely occur in conjunction with the injured species surveys. The detailed information collected in this study, in addition to allowing limiting factors analysis, will be used to refine the predictive capabilty of fish habitat capabiltiy models proposed for development in the ecological mapping and species survey project submitted as a separate proposal.

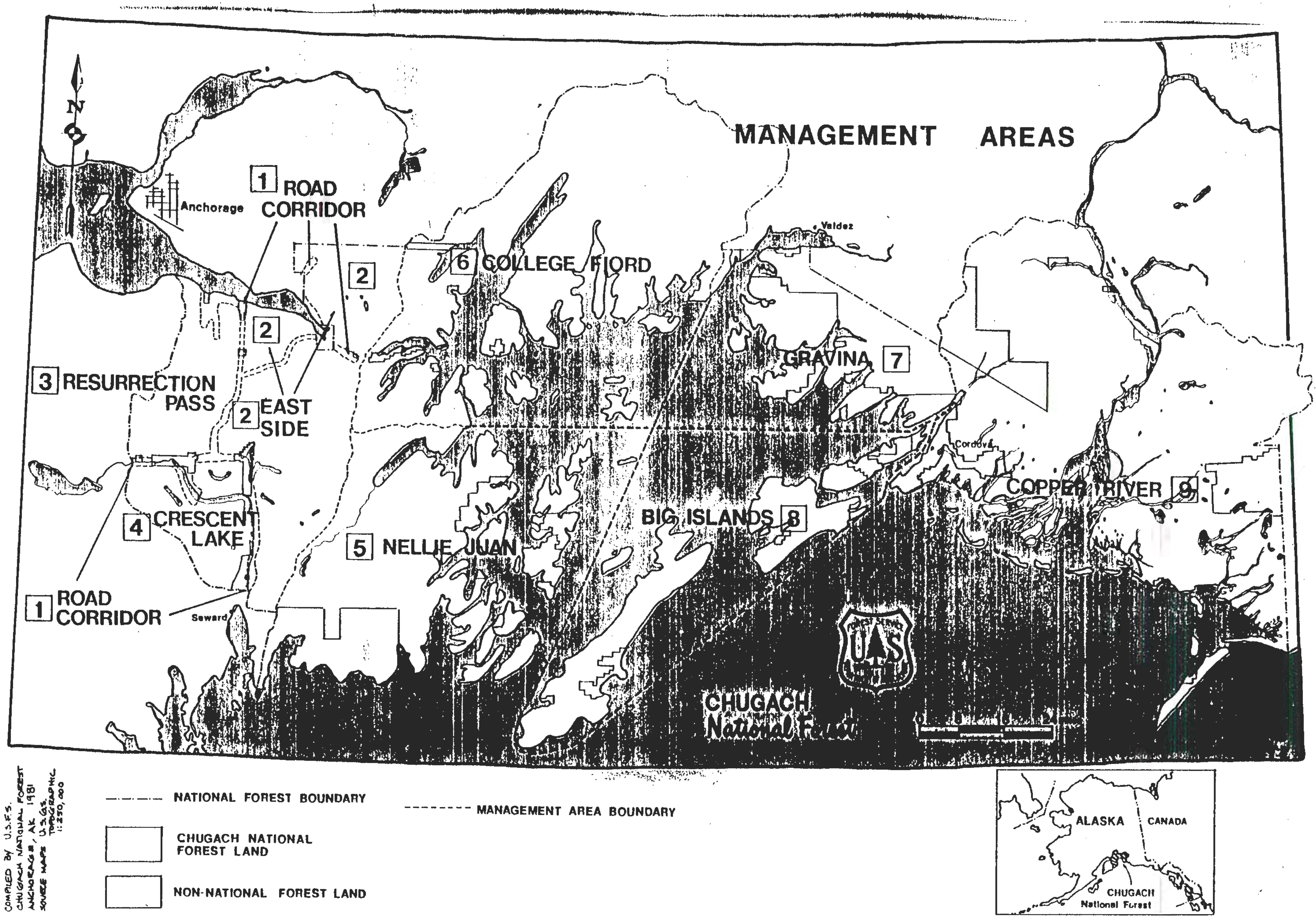
Importance of Initiating in 1992: A significant amount of money will be spent annually on projects to maintain, enhance, or mitigate damages to fish populations. This effort is meant to guide restoration, mitigation, and protection projects as well as to provide guidance for long term management of injured fish species, thus, to be most useful the project should be initiated in 1992.

Literature Cited

Hankin, D. G., and G. H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Can. J. Fish. Aquat. Sci. 45:834-844.

Paustian, S. 1991. Draft Channel Type User Guide. Dept. of Agriculture U. S. Forest Service Publ. 146 pg.

Trotter, P. C. 1989. Coastal cutthroat trout: a life history compendium. Trans. Am. Fish. Soc. 118(5):463-473.


MANAGEMENT AREAS
N
Anchorage
1 ROAD CORRIDOR
2
2
2 EAST SIDE
3 RESURRECTION PASS
4 CRESCENT LAKE
1 ROAD CORRIDOR
Seward
5 NELLIE JUAN
6 COLLEGE FIORD
Valdez
GRAVINA 7
Cordova
COPPER RIVER 9
BIG ISLANDS 8
CHUGACH National Forest
NATIONAL FOREST BOUNDARY
MANAGEMENT AREA BOUNDARY
CHUGACH NATIONAL FOREST LAND
NON-NATIONAL FOREST LAND
ALASKA
CANADA
CHUGACH National Forest
COMPILED BY U.S.F.S.
CHUGACH NATIONAL FOREST
ANCHORAGE, AK 1981
SOURCE MAPS U.S.G.S. TOPOGRAPHIC
1:250,000

40

Project Proposal

Prince William Sound Wild Fish Stock Information Assessment.

Species Addressed: Cutthroat, Dolly Varden, Chum Salmon, Pink Salmon and all other freshwater and anadromous fish species in PWS.

Principle Investigator: Robert Olson, USFS - Chugach National Forest.

Introduction & Project Objectives: Recognizing the cultural, social, economic, and health benefits of maintaining genetic diversity, in 1973 Congress passed the Endangered Species Act (ESA), setting forth a policy that we would not be indifferent to the loss of plant and animal species (Rohlf 1989). Noting that populations or stocks are the fundamental units in preserving genetic diversity, the ESA further provides for the "protection of distinct populations of fish and wildlife" (Goodman 1990). In addition to the ESA, the National Forest Management Act (1968) requires the maintenance of viable populations of all native and desirable non-native vertebrates by maintaining plant, animal, and habitat diversity. The Prince William Sound has long been a significant producer of wild salmon in Alaska. These salmon stocks, along with other fish species, support a diverse, economically important, and culturally significant fisheries. As witnessed by the collapse of the salmon fishieries in the Columbia River, as well as numerous other drainages in Washington, Oregon, Idaho, and California (Nehlsen 1991), fish stocks in the Prince William Sound are not immune to depletion. The recent Exxon Valdez oil spill has further heightened awareness for the vulnerability of wildlife species to habitat destruction. To maintain the genetic diversity, and hence, the commercial, subsistence and sport fisheries in the Sound, thereby; avoiding legal and social complications associated with threatened or endangered species, it is imperitive that systematic land planning measures be taken now.

The U. S. Forest Service is the major land management agency in Prince William Sound. Although the Forest Service is not responsible for managing fish populations, we do manage habitat that is critical in producing those fish populations.

To manage habitat for the fish populations that were affected by the Exxon Valdez oil spill, the Forest Service requires adequate knowledge of where the populations exist, their significance (eg., biological, commercial, and cultural), habitat limiting factors, susceptibility to disturbance, and potential impacts to the populations. Currently, a substantial amount of information on fish in Prince William Sound is available. For example, Alaska Department of Fish and Game (Commercial Fish Division) annually collects information on catch, escapement and run timing for index streams. Similarly, the Sport Fish Division (ADF&G) collects data pertinent to sport fishing in the Sound. Numerous other agencies and Universities (eg., Univ. of Alaska, National Marine Fisheries Service, and Fish and Wildlife Service) have conducted extensive research efforts in the Sound. Finally, the Forest Service conducts stream habitat surveys in the Sound. The amount and variety of information available is somewhat overwhelming. Not only is the information unconsolidated but furthermore it is not available in a format that allows the Forest Service, as a land manager, to readily make use of it with regards to maintaining population diversity.

We propose to systematically compile and review existing information on all wild freshwater and anadromous fish stocks in the Sound, making this information available in a readily useable format, which is catalogued by stream and species. The ultimate goal is to use the information to evaluate and prioritize fish stocks based on their biological, economic, and cultural significance. Compiling and reviewing the existing information will be the first step towards systematically identifying the various fish stocks (including those that were injured as a result of the Exxon Valdez oil spill), defining potential impacts on them, and developing appropriate programs for maintaining or enhancing them. This information will be linked to a

Forest Service GIS stream data base for fish habitat in the Sound. This system could be made readily available to all planning agencies for PWS fisheries (eg., ADF&G and PWSAC).

Methods:

The study area will include the Nellie Juan, College Fiord, Big Islands, and Gravina management areas (figure 1) of the Chugach National Forest. Initially, using USFS channel type maps, ADF&G anadromous water maps, and USGS 1:63,360 topographic maps, all streams and lakes will be identified, listed in a tabular format and numbered. Streams and lakes will be named using names provided on the USGS maps. When unnamed streams are encountered they will receive a generic name such as "Unnamed Chenega Island Stream A." Streams will be numbered using the convention set forth in the ADF&G anadromous water catalog.

Once streams have been tabulated, all fish species either known to be present or likely to be present in each stream and lake will be identified. Sources for identifying species presence will include, but will not be limited to, the ADF&G Alaska Fisheries Atlas, ADF&G anadromous water catalog, etc.... The Species list will not be limited to commercial and game fish.

The final step in the information compilation portion of the study will be to identify known information sources for each species of fish in each stream. All information sources will be catalogued using a set format (see sample format for data compilation), where information sources are listed under general topics (e.g., Research Efforts, Genetic, Population Size, Habitat Availability, etc...). Sources of information may include past studies, agency data bases, inhouse reports, publications, personal communication, etcetera. The compilation of data sources will be computerized, therefore, when existing computerized data sources are referenced (e.g., ADF&G Escapement Counts) a copy of the data base will be obtained and it will be linked to compiled information sources. Numerous literature and information searches have already been conducted as a part of the oil spill restoration planning, thereby aiding this effort to compile the information.

After all the information for streams in the study area has been compiled, the data will be evaluated using a set of ranking criteria similar to those developed by the Natural Heritage Program of The Nature Conservancy. Populations will be ranked based on their global, state, and local significance regarding contribution to the gene pool. In addition, the populations will be ranked with regards to their ecological, cultural, commercial, and recreational value. Where additional information is needed it will be so noted. Finally, potential impacts and habitat limitations to the populations will be identified. The end product for the proposed information compilation and assessment will be a data base that will direct and prioritize on the ground projects for maintenance and where appropriate enhancement of wild fish populations.

Project Duration: Two years.

Estimated Cost: $50,000/year.

End Point: Data base that will guide and prioritize on the ground enhancement activities.

Link to Other Activities: Can be used as a source for prioritizing other activities.

Importance for Initiating in 1992: A significant amount of money will be spent annually on projects designed to maintain or enhance fish populations. Of paramount interest is the desire to maintain strong species diversity. Currently, the approach has been to identify given species or populations of fish and prescribe measures to maintain or enhance them. While this approach will likely help to maintain specific populations of fish, it may or may not accomplish the end goal of maintaining overall population diversity and strength. The proposed approach will allow us to first identify all the populations, then prioritize them based on their biological, economic, and cultural significance, and finally develop projects to maintain overall species diversity and strength.

Sample Format For Data Compilation

Stream: Unnamed Chenega Island Stream, 226-20-16182

Species: Pink Salmon (list of sources).

Habitat Availability: (list of sources)
Channel Types
Barriers
Spawning
Rearing
Water Quality
Flow Data

Population Size:
10 year average escapement + catch = ?????????
ADF&G Comm. Fish Division
R-Base Data Base Record # ????
Cordova, AK

3 year average carcass count (1986-1989) = ?????
Doe, J. 1990. Stock Assessment of Pink Salmon. ADF&G Federal Aid in Fish Restoration, Annual Performance Report, 1986-1989, Project F-9-17, 46 pp.

Run Timing/Behavior: (list of sources)

Physical Characteristcs:
Largest Pinks in the State
(list of sources)

Genetic: No Known Sources

Ecological:
Supports population of 20 brown bears.
(list of sources)

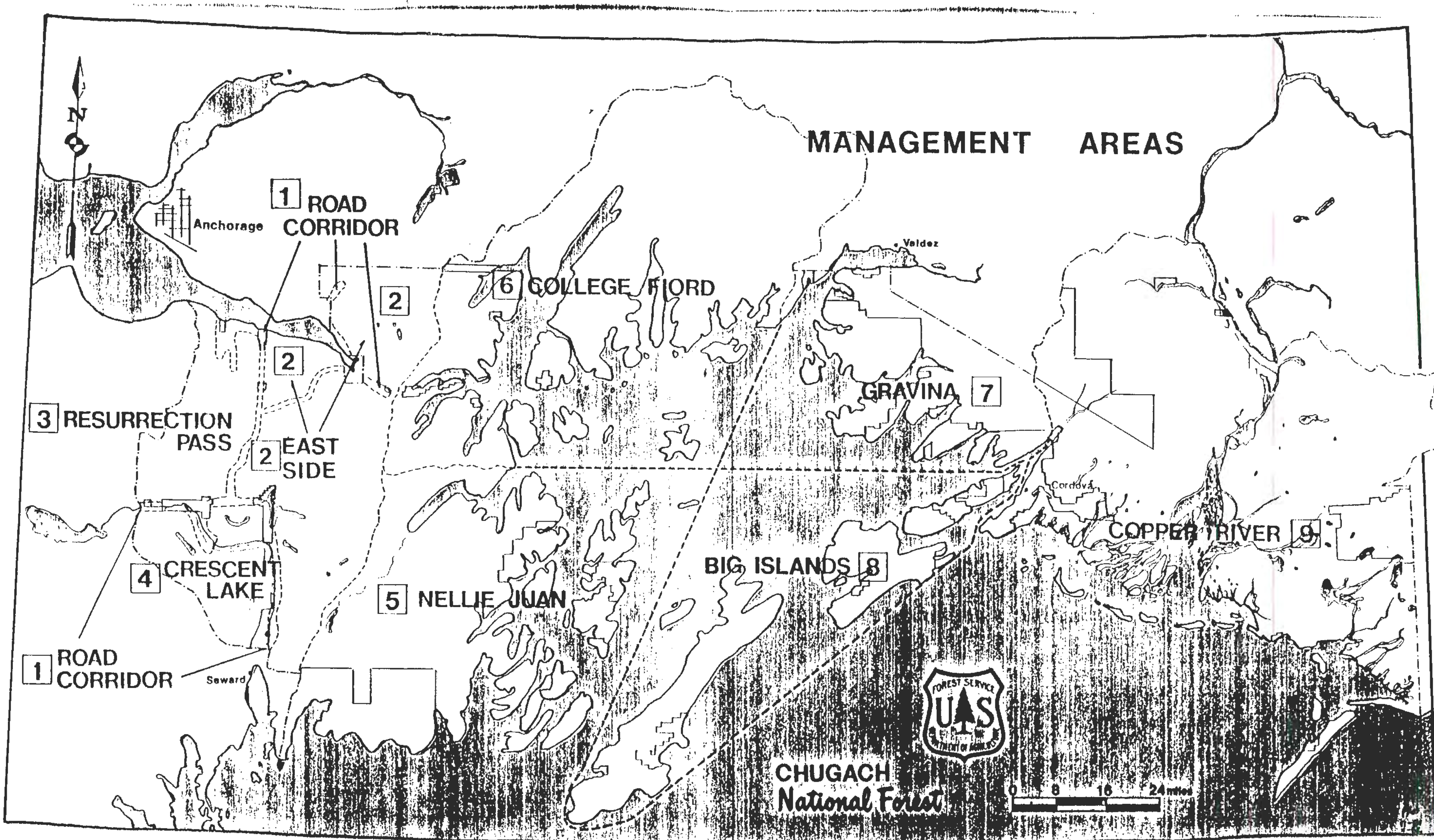
Research Efforts: (list of sources)

Cultural Values:
Subsistence use by population of 500 people
(list of sources)

Commercial/Sportfishery:
10,000 average harvest
(list of sources)

Land Ownership: (list of sources)

Development Impacts: (list of sources)



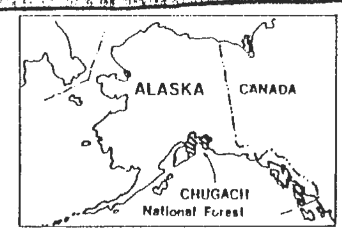
COMPILED BY U.S.F.S
CHUGACH NATIONAL FOREST
ANCHORAGE, AK 1981
SOURCE MAPS U.S.G.S.
TOPOGRAPHIC
1:250,000

NATIONAL FOREST BOUNDARY

MANAGEMENT AREA BOUNDARY

CHUGACH NATIONAL FOREST LAND

NON-NATIONAL FOREST LAND



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Rohlf, D. J. 1989. The Endangered Species Act: a guide to its protections and implementation. Stanford Environmental Law Society. ISBN 0-942007-33-6 347.3064695. 207 pp.

A. **Project name**
Otter Creek Fish Pass

B. **Injured Species to be addressed**
Cutthroat, dolly varden. Pink salmon, sockeye salmon coho salmon would also be benefited by the project. Otter Creek and Lake provide potential recreation use.

C. **Principal Investigator and Lead Agency**
Kate Wedemeyer, Glacier Ranger District, US Forest Service

D. **Project Objectives**
Provide access to unutilized habitat for anadromous cutthroat by designing and constructing a fish pass at the barrier falls on Otter Creek. Presently there is an Alaska steep pass, built in 1982, on a barrier falls near the mouth that allows Cutthroat access past the falls. A July 1991 monitoring trip by the US Forest Service indicated, however, that Cutthroat trout would be unable to move past a 5-foot vertical falls above the steep pass. Additionally, there are two five foot cascades that could be modified for easier passage to allow access to a 55 acre lake and a 3 acre pond.

Additional values for sockeye, coho and pink salmon and for recreation would accrue from improving fish passage to Otter Lake. The original steep pass was built for sockeye, coho, cutthroat and dolly varden char but no stocking for any of these species took place. Our 1991 surveys documented a run of wild, pink salmon which were spawning in the mouth of the stream. This wild run would also utilize the habitat made accessible by additional fish passage structures at the falls and cascade. Only the Bay of Isles and Herring Bay on Knight Island have documented populations of Sockeye and only Otter Creek has been documented for coho in the ADF&G anadromous stream catalog map of Knight Island. The Bay of Isles is well protected and receives some hunting and fishing use. Recreational fishing opportunities could be greatly enhanced by fishable populations of these species.

1. Observe fish passage
Observation for fish passage was made in July and August of 1991 and identified a barrier to cutthroat trout, dolly varden char and pink salmon once they clear the presently operating steep passes.

Observations would continue in 1992, concentrating on fish now present in the lake and pond and further observations of fish passage. Juveniles of sockeye and coho would also be targeted when practical.

Previous habitat surveys will be reviewed on the ground to verify that habitat has not changed significantly.

2. Perform engineering survey of barrier falls
Field work on engineering survey is in process and survey will be completed in winter of 1991-92.

3. Design fish passage structures
Appropriate structures for fish passage will be determined by the project leader and a design engineer with 10 years experience including 6 years in Prince William Sound. Design would be completed in 1992.

4. Feasibility assessment,benefit/cost analysis, **environmental documentation**
Public scoping and an environmental assessment of building additional fish passage structures would be written in 1992. This would include consideration of several alternatives and a benefit/cost analysis.

5. Determine whether to construct
A final decision by the Forest Service on the preferred alternative (including no action) based on the environmental assessment would be made in 1992.

6. Construction
Construction of the fish pass is slated for 1993 if it is determined to be feasible

7. Monitoring of fish passage and fish populations
Monitoring would continue for 3 seasons after the fish pass is built.

E. Project methods, including technical feasibility
The feasibility of building fish passage structures has been well demonstrated by the Forest Service in Alaska. Presently, the Glacier Ranger District of the Chugach National Forest administers 8 fish passage projects in western Prince William Sound.

F.Duration of the project (number of seasons to fulfill project objectives)
One year to determine project feasibility.
One year to construct (if project is determined to be feasible).
Three years of project monitoring.

G. Estimated cost (per year, if more than one year)

1991-	$ 6,000	fisheries surveys
1992-	$ 72,900	engineering surveys, design, fisheries surveys, EA
1993-	?	estimated construction cost dependent on design
1994-	$ 9,000	monitoring of fish populations and fish passage
1995	10,000	monitoring of fish populations and fish passage
1996	$ 11,000_	monitoring of fish populations and fish passage

NOTE: These costs based on detailing personnel from other forests and pay ing transportation, per diem and lodging.

H. Restoration activity or endpoint to be addressed
Restoration of cutthroat and dolly varden char populations on Knight Island which was most heavily oiled. Secondary benefits to pink, sockeye and coho salmon. Restoration of potential recreation opportunities.

I. Link to other NRDA damage assessment or restoration studies
This project is linked primarily to damage assessment of cutthroat trout and Dolly Varden char. Together with biologists from the Alaska Department of Fish and Game Sport Fish Division who have been active in Oil spill assessment work on Cutthroat and Dolly Varden char, we determined that improving access to resident cutthroat or uninhabited lakes is among the methods that have the highest potential for restoring cutthroat and dolly varden populations dammaged by the 1989 Exxon Valdez oil spill.

Otter Creek is in the Bay of Isles of Knight Island which recieved the most oiling from the spill. It supports a resident population of cutthroat trout and a few dolly varden char. Prince William Sound is the northern extent of cutthroat trout range, and within Prince William Sound, only the southern portion contains documented cutthroat populations. Because a population of 50 is a significant population in this region, we have identified Otter Creek as a high priority for restoration of Cutthroat and Dolly Varden Char.

J. Importance of initiating project in 1992

The lifespan of any new fish passage structures is limited by the lifespan of the fish passage structures now in operation on lower portions of the stream. Fish passage structures built in 1982 on lower portion of Otter Creek are essential to the package to provide fish passage to the lake. Those passes were designed for a 25 year life-span. Delays in building the upper structures shorten the expected life span of the total project thereby decreasing the benefits.

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A. Project name
Western Prince William Sound Restoration Survey and Project Planning

B. Injured Species to be addressed
Cutthroat trout, Dolly Varden Char, Pink Salmon, Sockeye Salmon

C. Principal Investigator and Lead Agency
Kate Wedemeyer, Fisheries Biologist, Glacier Ranger District, US Forest Service

D. Project Objective
In the present study, surveys of oil-impacted fish habitats will be conducted specifically to identify particular sites and techniques for fish restoration. The purpose of the study is to determine the optimal methods of restoration and identify opportunities to replace damaged fish populations in the Exxon Valdez oil spill (EVOS) impact area. The NRDA studies have not collected the data needed to fully evaluate all resorations and resource replacement options.

1. Evaluate fish habitat, abundance and limnological data from priority sites
Sites on our list of priorities were selected in 1991 on the basis of 1990 assessment reports, stream and lake survey information and oilspill records. Work will emphasize actual field investigations.

2. Determine optimal fish restoration methods for selected sites.
Emphasis will be placed on restoring salmonid populations and lost recreational opportunities.

3. Develop proposals for restoration projects for selected sites.
Options considered would emphasize fish habitat improvements such as fish passes, spawning channels, stream-side incubation boxes, barrier removal and instream improvements which would be appropriate to implement on the Chugach National Forest.

E. Project methods, including technical feasibility
This project is considered technically feasible based on past research and experience with salmonid habitat enhancement throughout U S Forests, particularly in Prince William Sound, the Kenai Penninsula and Southeast Alaska. Additionally, the restoration planning is a coordinated effort with the restoration planning surveys of the Alaska Department of Fish and Game FRED Division and Sport Fish Division.

In 1991 the U S Forest Service worked with The FRED Division to develop a cooperative plan to survey and develop proposals for restoration projects. A bibliography was prepared by the USFS of information and past reports . A compendium of information on potential enhancement site surveys done in the past by Forest Service personnel was developed and shared with the FRED Division. The Forest Service also developed a map of areas likely to have groundwater conditions favorable to developement of spawning channels which is being used to prioritize further investigations such as installing stand pipes to monitor ground water levels at specific sites. Damage Assessment reports of 1990 were reviewed and a list of high priority oil sites was developed by the Forest Service. A site in the Bay of Isles was evaluated for fish passage and determined to be a high priority. An individual project is being submitted for this project at Otter Creek. The Forest Service also coordinated with the

National Marine Fisheries Service and the Commerical Fish Division of ADF&G to collect tissue samples of Prince William Sound salmon for a prelimary genetic survey. Samples were collected in 1991 and will be analyzed as laboratory resources allow.

In 1992, the Forest Service and Fish and Game FRED Division will review recent file information along with the preliminary field data agathered by ADF&G this past fall. Each of the high priority sites will be reviewed to determine possible restoration strategies for that particular stream. In order of priority will be projects that directly restore damaged habitat, improve habitat in the stream itself, improve habitat nearby which is likely to enhance the same or very similar genetic stock, replace the habitat in other areas. The emphasis will be on wild stocks and will use the latest genetic information available on Prince William Sound genetics, including any available results of 1991 collection. Benefit/cost expectations and recreational opportunities will also be used in prioritizing restoration planning efforts.

Along with the fisheries staff of the Glacier Ranger District the services of a fisheries engineer with 6 years of experience in Prince William Sound and a stream hydrologist will be employed to develop restoration strategies and evaluate proposals.

F.Duration of the project (number of seasons to fulfill project objectives)

one full year (1 field season, 1 planning season)

G. Estimated cost (per year, if more than one year)

Estimated cost for year one is $92,2000

Costs include:

fish biologist 3 months	$9,200
engineer 10 days	$,500
hydrologist 10 days	$2,500
engineering survey 2 weeks GS-9,5,4,4, +$500/day	$7,000
fish habitat surveys 2 techs to assist biologist	$8,000
flights, 13 @$1500	$8,000
boat charter @ $1000/day 10 days fish bio, 10 days eng surveys, 10 days fish habitat surveys	$30,000
travel per diem, housing, overtime $1.5k, 11.9k, 5k, .9	$27.400
	=========
	$92,200

NOTE: These costs based on detailing personnel from other forests and pay ing transportation, per diem and lodging to perform regular duties of biologist, engineer and hydrologist while they work on restoration.

H. Restoration activity or endpoint to be addressed

Development of priority projects which we feel will best use restoration funds to address actual effects on Prince William Sound.

I. Link to other NRDA damageassessment or restoration studies

This survey is coordinated with restoration surveys and planning in the Alaska Department of Fish and Game.

J. Importance of initiating project in 1992

Sufficient time and funding to address restoration projects in an objective and systematic method will greatly increase the value of efforts and resources put into restoration efforts.

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A. Project name
Coghill Lake Sockeye Salmon Habitat Rehabilitation

B. Injured Species to be addressed
Sockeye salmon, Dolly Varden

C. Principal Investigator and Lead Agency

Kate Wedemeyer, Fisheries Biologist, Glacier Ranger District, US Forest Service
The Alaska Department of Fish and Game FRED Division is working as a partner in this project. (See their related proposal)

D. Project Objectives

Return Coghill Lake to historical levels of fisheries productivity.
Insure maintenance of wild sockeye population, Dolly Varden population.
Restore recreational fishing opportunities.

This project will contribute to restoring a very popular sport fishery at the Coghill Lake site which also includes a Forest Service cabin. (In 1990 a new trail was built from saltwater to the cabin and lake, a distance of approximately 3.5 miles.) Rebuilding the nutrient base of the lake will benefit not only the Sockeye recreactional fishery but also the Dolly Varden recreational fishery. Additionally, the restoration will make a significant contribution to the commercial fishery.

1. Conduct project planning and environmental analysis.
Public scoping and an environmental assessment of fertilizing Coghill Lake and restoring the sockeye population will be written in 1992. This will include consideration of several alternatives and a benefit/cost analysis. These alternatives will be developed by analyzing the smolt enumeration and sampling, hydroacoustic survey and townetting, and adult escapement enumeration, limnological and zooplankton sampling conducted last season and in past years. A memorandum of understanding or a cost-share agreement will be developed with the Alaska Department of Fish and Game and the Prince William Sound Aquaculture association who are active partners in this project.

2. Initiate Lake Fertilization
Lake fertilization is recommended for one life cycle, and as 70% of the adults returning to Coghill Lake are five-year-old fish, treatments would be conducted for five continuous years. Fertilization consists of applying approximately 100 tons of fertilizer per year. Fertilizer is applied on a weekly basis starting in May and ening in July. The fertilization plan will be modified based on results of monitoring of zooplankton and sockeye populations.

3. Rebuild wild salmon stock at Coghill Lake.
In addition to the lake fertilization, adjustment of the biological escapement goals and possible bioenhancement of the stock wil be considered in order to reach the goal of stabilizing sockeye production at a level consistent with the increased rearing capacity of Coghill Lake. A cooperative effort between the US Forest Service, the Alaska Department of Fish and Game and the Prince William Sound Aquaculture Association to identify optimum stocking strategies in Prince William Sound will be continued.

E. Project Methods, including technical feasibility
This project is considered technically feasible and is based on past research and experience with sockeye lake populations in Prince William Sound, the Kenai Penninsula and South east Alaska. Research conducted by the US Forest Service and the Alaska Department of Fish and Game at nearby Esther Island in Prince William Sound tested portions of the theory that over-population of sockeye juveniles in a lake can lead to over exploitation of the food resource which can in turn can severely reduce fisheries populations. Once the salmon populations are reduced the major source of nuturients to the system is lost further exacerbating the problem. This and other research has also indicated that the nutrient cycling can be restarted by artificial fertilization methods and tested application periods and rates.

Coghill Lake would be fertilized for five years to restore the zooplankton portion of the food chain. Once the zooplankton population is restored, the wild sockeye salmon population would be restored to historic levels. Hatchery enhancement projects will take into account genetic concerns for the Coghill Lake wild stocks.

F.Duration of the project (number of seasons to fulfill project objectives)

1992-6 fertilize lake; continue limnological sampling, smolt and adult counts,

1997 Begin stocking sockeye fry or presmolt in Coghill Lake. This may be moved forward in time if zooplankton populations have recovered sufficiently.

G. Estimated cost (per year, if more than one year)
$118,000 first year, $100,000 on succeeding years.
Costs include:

fertilizer applications (1 per week, May-July)	$90,000
10 days Contract Vessel @ $1000/day	$10,000
2 charter flights @ $1500	3,000
Biologist **	9,600
Overtime/travel/housing/supplies	7,000

NOTE: These costs based on detailing personnel from other forests and pay ing transportation, per diem and lodging.

H. Restoration activity or endpoint to be addressed

Restoration of Coghill Lake sockeye salmon stock will provide for restoration of recreational opportunities in Prince William Sound and provide for other sustained human uses including subsistence and commercial fishing.

I. Link to other NRDA damageassessment or restoration studies

Although few studies have assessed damage to sockeye populations, there is concern that they were, in fact, impacted by the oilspill as were other salmon species. The Coghill Lake sockeye population was already exhibiting an alarming decline at the time of the 1989 Oilspill. The probable addition of even a small amount of additional stress due to oil could be of critical concern for this population.

The Coghill Lake sockeye salmon population has historically provided a significant contribution to the commercial, subsistance, and sport fisheries for sockeye salmon in Prince William Sound. The US Forest Service cabin on Coghill Lake is one of the most popular of our remote cabin sites. We have recently improved the 3 mile trail from saltwater to the lake cabin because of the popularity of the cabin. In the past, 20-30 private planes have been seen there on weekends taking advantage of the popular sockeye salmon sport fishery.

In the 1980's, as with other systems, there was a three to five-fold increase in production to over a million fish returning to the 3,000 acre Coghill lake system. Historically, it had a return of 200,000 to 300,000.

1988-1990 escapements have varied from 7,000 to 187,000 averaging 68,000. Limnological and fisheries surveys conducted during the last several years in Coghill Lake have indicated very low productivity, specifically in terms of the zooplankton food base and juvenile fish density.

In 1990 the numbers of smolt exiting the lake to the ocean for their adult growth phase have plummeted to the point where state Fish and Game personnel shut down the counting weir to avoid the loss of even a few smolt.

J. Importance of initiating project in 1992

Rebuilding this wild stock may take 10 to 15 years. Rebuilding the nutrient cycling and the zooplankton food source must take place before the wild stock can be rebuilt. This is expected to take five years. It will take a minimum of an additiona four years to rebuild the wild stock. Due to genetics concerns, we plan to use only eggs taken from wild stock rather than hatchery stock which originiated some time ago from Coghill lake. Because of this it may take longer than 5 years since Coghill Lake already has such a low number now returning. Even with hatchery methods, the source of eggs from this wild stock may be so limited that two full life cycles will be required instead of one life cycle.

Project Name: Anadromous Sport Fish Status and Evaluation

Injured Species to be Addressed: Cutthroat Trout (Salmo, clarki)
Dolly Varden Char (Salvelinus, malma)

Principle Investigators, Lead Agency:
K. Hepler, Alaska Department of Fish and Game, Division of Sport Fish (ADF&G)

Cooperators:
D. Schmid, U.S. Forest Service, Chugach National Forest, Cordova Ranger Distsrict (USFS)

Populations of many stocks of anadromous sport fish species were negatively impacted by the Exxon Valdez oil spill. In order to allow for natural healing and recovery of those stocks, while still meeting the demands of the public for angling opportunities, there is a need to locate other fishable stocks of cutthroat and dolly varden in non-oiled areas on the Copper River Delta and Eastern Prince William Sound. Working cooperatively with ADF&G, a three tiered approach will be used in which road accessible, trail and hiking accessible and remote stocks will be identified. In conjunction with their population assessment, the USFS will perform habitat evaluations of each of the systems and make recommendations on habitat improvement or restoration measures.

The Forest Service will conduct studies on the overall habitat capability of systems being considered for supporting re-directed angling efforts. This will require three years of field evaluation and data analysis using methods developed by Olson and Wenger (1991). The studies will be donde in conjuction with population studies being conducted by ADF&G and will require field crews to work together in selected areas.

Development of detailed study plans and data analysis methods will be completed in October through December 1991. This will require coordination meetings between principal investigators of both agencies. Field evaluations will begin in the spring of 1992 and continue until 1994. Data analysis will be completed annually with final recommendations completed by January 1995.

The cost to the USFS for this project will be approximately $12,000 annually for three years. In addition, the lead agency will have their own associated costs for the project.

Once complete, this study will provide the necessary habitat information to properly regulate the fishery. This will provide for best angling opportunities for Forest users while allowing for the natural recovery of oiled stocks of anadromous sport fishes. It will also point the way for future habitat restoration and improvement measures in both oiled and non-oiled areas of the Prince William Sound area.

While the USFS was not funded for this project, it was initiated in 1991. In order to maintain continuity and consistency in data collection it will be important to continue this project, un-interupted in 1992. As this study continues, data will become available for making informed decisions on necessary regulatory measures so as not to depleat any locally sensitive stocks. As angling efforts are shifted away from oiled areas of the Sound, it will become increasing important to develop an effective plan for riparian management, and habitat improvement to enhance native wild stocks.

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RESTORATION SCIENCE PROPOSAL

1992 FIELD SEASON

Study Name:

Identification of suitable early-run pink salmon stocks for development as broodstock at Prince William Sound hatcheries

Injured species to be addressed:

Pink salmon (*Oncorhynchus gorbuscha*) are a critical part of the ecosystem in Prince William Sound (PWS). The Exxon Valdez oil spill (EVOS) deposited various amounts of oil in intertidal habitats utilized by spawning pink salmon. Up to 75% of the pink salmon spawning occurs in intertidal areas. The proportion of spawning that is intertidal is highest in streams that flow into southwestern Prince William Sound. Salmon eggs from 1988 and all subsequent brood years that were deposited in oiled intertidal spawning areas in western PWS have been contaminated and adversely affected by oil from the EVOS. Emergent salmon fry and smolt from throughout PWS were also damaged when they migrated through and reared in areas where oil contamination was greatest. Injuries from spawning ground contamination include increased mortality of eggs and higher incidence of somatic, cellular, and genetic abnormalities in alevins and fry. Diminished growth and survival have been demonstrated for salmon fry and juveniles which reared in oiled areas of PWS. The observed injuries have lead to declines in numbers, health, and overall fitness of salmon populations in PWS and those effects may persist for many years.

Principal Investigator(s):

Mark Willette, Area Biologist, FRED Division, ADFG, Cordova
Greg Carpenter, Fishery Biologist, FRED Division, ADFG, Cordova

Project objectives:

Hatchery pink salmon production is comprised largely of late-run stocks that return at the same time as most damaged wild stocks in PWS. Harvest of hatchery stocks in mixed hatchery-wild stock fisheries causes increased fishing pressure on damaged wild stocks. Shifting hatchery production to early-run stocks will reduce fishing pressure on damaged wild stocks and accelerate recovery.

Previous studies indicate that early-run pink salmon spawn in some upstream habitats in PWS. These fish are larger than other pink salmon in PWS, and they may utilize colder feeding habitats in the northern Gulf of Alaska (Noerenberg 1963). Large early-run pink salmon also spawn in some upstream habitats in southeastern Alaska. These fish produce relatively large fry that outmigrate early in the spring (Skud 1955). This study will focus on locating early-run upstream spawning pink salmon stocks and on describing their biological characteristics. This information will be used to select a suitable stock for development as a broodstock at PWS hatcheries. This project will focus on the following objectives.

1. Select streams for field study after a thorough review of previous reports and ADFG databases.

2. Locate early-run upstream spawning populations of pink salmon in PWS.

3. Describe the biological characteristics of stocks that appear to be suitable for broodstock development.

References:

Noerenberg, W.H. 1963 Salmon forecast studies on 1963 runs in Prince William Sound. Informational Leaflet No. 21. ADFG, Juneau, 29p.

Skud, B.E. 1955 Length-weight relationship in migrating fry of pink salmon (*Oncorhynchus gorbuscha*) in Sashin Creek, Little Port Walter, Alaska. Copeia 3: 204-207.

Project methods:

Previous reports and existing ADFG databases will be reviewed to identify streams that may support populations of early-run upstream spawning pink salmon. Aerial and foot surveys will be conducted to document spawning times and areas for each population. Adult length, fecundity, and egg size will be measured in representative samples collected during stream surveys. Tissue samples will be collected for electrophoretic analysis. Intragravel probes and electronic temperature loggers will be installed to monitor water temperatures during egg incubation. Samples of alevins will be collected during early winter to monitor developmental rates and obtain otoliths. Inclined plane traps will be operated in the lower reaches of each stream to capture outmigrant fry. Fry traps will be checked periodically to determine fry outmigration timing and collect samples. Otolith banding patterns and microchemistry will be used to identify outmigrant fry from upstream habitats. The following year returning adults will be recovered in the commercial fishery and at stream mouths and adjacent bays. Otolith banding patterns and microchemistry will be used to identify fish recovered in the commercial fishery and elsewhere. Gonadosomatic index, egg size, condition factor, and muscle lipid content will be used to evaluate rate of maturation and growth rate.

Duration of the project:

Two years of study will be required to describe the biological and life history characteristics of each broodline. This project will continue for four years, because broodstocks must be identified for both the even- and odd-broodlines.

Estimated costs: $80,000

Restoration activity or endpoint to be addressed:

The results from this project will facilitate recovery of damaged late-run pink salmon stocks, because the information obtained will accelerate a shift of hatchery production to early-run stocks. Fishing pressure on damaged wild stocks in mixed-stock fisheries will subsequently be reduced.

Relation to science information needs identified by RPWG:

This project will provide additional information about genetic distinctness and adaptations of pink salmon stocks in individual streams. The maturation rates of stocks selected for study will also be evaluated.

Importance of initiating project in 1992:

Development of an early-run broodstock at PWS hatcheries will be accelerated if this project is funded in 1992. Several years of study will be required to locate and adequately describe broodstocks for odd- and even-years. Several additional years will be required to develop an early-run broodstock after it is selected.

Link to other NRDA damage assessment or restoration studies:

The information obtained from NRDA F/S Study #1 and proposed escapement enumeration studies will assist us in identifying streams that may support stocks of early-run pink salmon. This project will also benefit from the services provided through the proposed genetic stock identification and otolith stock separation projects.

Restoration Proposal

Name of Study: **Stream Habitat Assessment.**

Injured Species to be Addressed: **Pacific Salmon; Dolly Varden Char/Cutthroat Trout; Harlequin Ducks; Bald Eagles.**

Lead Agency and Principal Investigator: **ADF&G; Mark Kuwada.**

Project Objectives:

1. Document anadromous fish distribution and stream habitat characteristics within the oil spill impact area to assist in restoration, protection, acquisition or enhancement decisions.

Objectives for Oil Spill Needs:

1. Characterize and delineate habitats and areas which are important to the recovery of injured resources and the services those resources provide.

2. Prioritize surveys to focus on privately owned land on which ongoing or possible land use changes may conflict with the recovery of an injured species in Prince William Sound, or the Gulf of Alaska.

Project Methods and Products:

1. Methods: Surveys will utilize two, 2-person field crews with vessel and helicopter support to access study sites. Field crews will locate stream channels and tributaries using a Global Positioning System (GPS). Streams will be electroshocked to determine fish presence and upstream distribution. At a minimum, habitat characteristics such as water clarity, substrate, gradient, stream width, bank incision, streambank vegetation, and in-stream obstructions will be recorded. Additional information needed to specifically delineate injured species habitats will also be recorded. The survey program utilizes established techniques and has been designed to be consistent with provisions of the Forest Practices Act that define anadromous fish stream classification procedures for private and public lands.

2. Products: Annual report and GIS maps detailing fish distribution and habitat characteristics for survey streams in each study area. Automated database of survey results.

Duration of the Project: Three years.

Estimated Cost: See attachment.

Restoration Activity or Endpoint:

1. Provide information that could be used to implement protective measures under provisions of the Forest Practices Act and other legal or administrative mechanisms.

2. Develop a comprehensive survey of resources related to anadromous fish streams throughout the oil spill area so that restoration managers can identify and compare habitats that either singularly, or in combination with other resources, need to be considered for restoration, protection, enhancement or acquisition.

3. Supplement the state's Anadromous Waters Catalog to facilitate and enhance Title 16 permitting activities to enable the recovery of injured resources.

4. Protect anadromous fish streams and associated riparian zones in order to maintain existing fish and wildlife habitat values.

Relationship to Science Information Needs:

1. Addresses the general needs of shifting emphasis to broader ecological rather than species-specific approaches. Extends the focus of studies beyond Prince William Sound and throughout the spill-affected area. Allows linkages to be developed between habitat quality and species availability. Promotes the monitoring of ecosystem recovery by identifying key habitat areas.

Importance of Initiating Project in 1992:

1. Certain development activities, particularly clearcut logging of old growth forests, provide an imminent threat to fish and wildlife resources. Unless site-specific surveys are conducted in 1992, opportunities may be lost to identify and protect key habitats that sustain existing fish and wildlife populations.

Link to other NRDA Damage Assessment or Restoration Studies:

1. Study objectives will complement ongoing research in Fish/Shellfish No. 5 (Injury to Dolly Varden Char and

Cutthroat Trout in PWS) and Restoration Project No. 7 (Technical Support Study for the Restoration of Dolly Varden and Cutthroat Trout Populations in PWS), and Bird Study No. 11 (Injury Assessment of Hydrocarbon Uptake by Sea Ducks in PWS). In the case of Dolly Varden/cutthroat trout, surveys may enhance the possibility of recovering tagged study fish and provide new information on Dolly Varden/cutthroat trout distribution and habitat. In the case of harlequin ducks, key habitat requirements remain undefined for birds in the oil spill area; therefore, survey results can assist in documenting features that promote habitat use. It is also possible that surveys may record observations of previously unidentified bald eagle nesting habitat.

Stream Habitat Assessment
Budget

Personnel (Line 100):

HB III: Project Coordinator: 12 months at Range 18F (5918/mo.) = $71,015.

HB II: Field and Data Coordinator: 12 months at Range 16C (4590/mo.) = $55,080.

HB I: Crew Leader: 5 months at Range 14C (4042/mo.) = $20,210.

Tech III: Field Survey Technician: 5 months at Range 11B (3306/mo.) = $16,530.

Tech III: Field Survey Technician: 5 months at Range 11B (3306/mo.) = $16,530.

CT III: Clerk Typist: 6 months at Range 8C (2901/mo.) = $17,406.

TOTAL: $179,365.

Travel (Line 200):

Staff travel and per diem: = $5,500.

Contractual (Line 300):

Vessel Charter: 60 days at 2300/day = $138,000.

Helicopter Charter: 30 days at 750/hr./4 hr. min. = $90,000.
+ 30 hr. contingency = $22,500.

Phone, Fax, Photo-video processing, Maps, Xerox, Repairs = $2,000.

Supplies (Line 400):

Office and Field Supplies (GPS units) = $30,000.

Equipment (Line 500):

GIS Software and Computer Equipment = $18,000.

TOTAL: $485,365. Three Year Total = $1,456,095.

MEMORANDUM

STATE OF ALASKA
DEPARTMENT OF FISH AND GAME

TO: Stan Senner
Restoration Program Manager
Division of OSIAR
Anchorage

DATE: November 4, 1991

FILE NO:

TELEPHONE NO: 465-4160

FROM: James O. Cochran
Mariculture Coordinator
FRED Division-Juneau

SUBJECT: Aquatic Farming and Oil Spill Restoration/ Enhancement

I attended the fisheries restoration planning meeting on October 17 at the invitation of Linda Brannian and Joe Sullivan. The intent was to begin the process of determining if there is a role for for the FRED Division mariculture program and possibly, the aquatic farm industry in Alaska, to play in restoration efforts.

I view our participation in restoration efforts as primarily providing services. Services might be in the form of expertise or products, such as shellfish seed to re-establish a specific population or aquatic plants to provide herring spawn substrate. It is important to begin the process of assessing those areas that might benefit from mariculture technology and determining the state of available technologies that might be adapted to restoration or enhancement efforts.

The projects that I perceive as having merit in the near future are:

1) <u>Pandalid shrimp restoration and enhancement techniques</u>

    a) literature survey to locate applicable existing technology
    b) restoration needs assessment
    c) technology assessment and adaption

    Charlie Trowbridge is the PI of the spot shrimp project in Prince William Sound. He is taking the lead in developing a project plan.

2) <u>Bivalve shellfish restoration and enhancement</u> (though the Commercial Fisheries Division project did not demonstrate specific effects, I suspect that other projects demonstrated localized damage to populations and general damage to earlier lifestages)

    a) current technology assessment and evaluation
    b) restoration needs assessment
    c) restoration trial project

3) <u>Intertidal and subtidal restoration needs assessment</u>

survey (aquatic plants and animals)

a) survey of relevant NRDA projects
b) restoration/enhancement feasibility analysis

I believe that mariculture is a tool that should not be overlooked by restoration planners. Many of the species we deal with are at or have lifestages that are at the very base of the food chain. I offer the services of the division's mariculture program to the Restoration Planning Workgroup to assess using this technology in restoration efforts. To initiate this, two restoration science study proposals are included for your consideration.

If the group wishes to discuss this further, please contact me at your convenience.

cc Jeff Koenings
Joe Sullivan

PROPOSAL FOR A RESTORATION SCIENCE STUDY
1992 FIELD SEASON

ALASKA DEPARTMENT OF FISH AND GAME
F.R.E.D. DIVISION

Name of Study: Bivalve Shellfish Restoration and Enhancement

Injured Species to be Addressed:

1) Little-neck clam (Protothaca staminea)
2) Butter clam (Saxidomus giganteus)
3) Blue mussel (Mytilus edulis)
4) Weathervane scallop (Patinopecten caurinus)
5) Other bivalves identified by the needs assessment

Principal Investigator and Lead Agency

James O. Cochran, Mariculture Coordinator
F.R.E.D. Division

Project Objectives

Assess restoration needs relative to these species. Determine if mariculture techniques are a valid tool to use in restoration or enhancement of the identified species. Initiate one demonstration project.

Project Methods

1) Review relevant NRDA project findings. Establish liaisons with project PI's.
2) Conduct literature searches to determine available culture technologies
3) Establish technical feasibility.
4) Identify one project/site for a demonstration project using shellfish hatchery or other technology.
5) Initiate demonstration project.

Duration of the Project

Year one=> Conduct NRDA needs assessment and project status. Perform literature search and establish expert contacts. Identify and catalog demonstration project site.

Year two=> Initiate demonstration project using identified restoration techniques (hatchery seed, wild seed, etc.)

Year three=> Assess demonstration project. Proceed with project development as appropriate.

Estimated Cost

Year one=> $20,000 (3 months FBII + travel, materials)

Year two=> $35,000 (6 months FBII + travel, materials)

Year three=> $35,000 (6 months FBII + travel, materials)

Restoration Activity or endpoint

Accelerated restoration of damaged intertidal and subtidal populations of bivalve shellfish in areas impacted by the Exxon Valdez oil spill using mariculture technologies.

Relationship to science information needs identified by RPWG

This project is designed to furnish information on available restoration technologies.

Importance of initiating this project in 1992

There is a considerable lead time in developing the type of mariculture technologies envisioned as useful for restoration. By initiating this project in 1992 much of the background work would be accomplished at the time that the F.R.E.D. Division's proposed Mariculture Technology Center will be coming on line.

Link to Other NRDA Damage Assessment or Restoration Studies

This project links to the Coastal Damage Assessment Project and the Butter Clam Damage Assessment Project. It will provide information to those projects as well as a potential tool for restoration and enhancement.

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RESTORATION SCIENCE STUDY PROPOSAL

DRAFT November 12, 1991

A. Study Name:

Butter Clam and Pacific Littleneck Clam Restoration and Enhancement

B. Injured animals to be addressed:

Butter clam (Saxidomus gigianteus) and Pacific littleneck clam (Protothaca staminea). Injuries from the Exxon Valdez oil spill (EVOS) has included decreases in relative abundance, growth, and loss of habitat due to hydrocarbon contamination. Incidences of degenerated kidney or digestive gland epithelium and gonadal suppression in littleneck clams indicative of exposure to toxins has also been documented.

C. Principle Investigator(s)

Charles Trowbridge, Shellfish Biologist, Comm. Fisheries Division
J. Johnson, Shellfish Biologist, Commercial Fisheries Division
Agency: Alaska Department of Fish and Game

D. Project Objectives:

The goal of the project is to restore butter and littleneck clam populations injured by EVOS through the application of artificial enhancement techniques. Before restoration efforts commence, populations dynamics must be determined by:

1. describing baseline population dynamics (growth, size at age, distribution, and abundance) of butter and littleneck clams within EVOS affected areas.

2. reviewing and analyzing relevant NRDA studies to assess damage to populations.

artificial enhancement must be evaluated by:

1. assessing the need for population restoration.

2. searching the available literature and consulting with investigators in the field of clam propagation to determine appropriate techniques.

3. identifying stocks to be used in enhancement efforts.

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To Joe Sullivan	From J Johnson
Co. OSIAR	Co. Cordova
Dept.	Phone # Shellfish
Fax #	Fax #

E. Project methods, including technical feasibility of study:

Butter and littleneck clams will be collected for age and growth analysis. Bivalve samples collected after EVOS (Fish/Shellfish Study 13) will be used to establish population dynamics.

Evaluation of artificial propagation techniques will include a literature search, cost benefit analysis, outline of permitting process and a technology assessment.

F. Duration of the project: (number of seasons needed to fulfill project objectives):

It is estimated that three years will be needed to determine population dynamics, complete literature review, recommend appropriate artificial enhancement techniques and prepare final report.

G. Estimated cost (per year if more than one year):

$85,000 per year

H. Restoration activity or endpoint to be addressed:

A report on the feasibility of rehabilitating injured stocks using appropriate stocks and artificial enhancement techniques.

If feasible, a project proposal to initiate enhancement experiments and rebuilding injured stocks will be prepared.

I. Relationship of science information needs identified in RPWG:

This study relates directly to the first general science information need identified by RPWG. It will identify and evaluate artificial enhancement as a restoration option. As requested for salmon and herring, it will provide basic population information on stock structure.

J. Importance of initiating project in 1992:

This project needs to begin before reductions in population abundance and distribution make identification of established populations and donor stocks even more difficult.

K. Link to other NRDA damage assessment or restoration studies:

PROPOSAL FOR A RESTORATION SCIENCE STUDY
1992 FIELD SEASON

ALASKA DEPARTMENT OF FISH AND GAME
F.R.E.D. DIVISION

Name of Study: Intertidal and Subtidal Restoration Needs Assessment Survey

Injured Species to be Addressed:

1) Intertidal animals and aquatic plants

Principal Investigator and Lead Agency

James O. Cochran, Mariculture Coordinator
F.R.E.D. Division

Project Objectives

Assess restoration needs relative to intertidal and subtidal organisms impacted by the Exxon Valdez oil spill. Determine if mariculture techniques are a valid tool to use in restoration or enhancement of the identified species.

Project Methods

1) Review relevant NRDA project findings. Establish liaisons with project PI's.
2) Conduct literature searches to determine available culture technologies
3) Establish technical feasibility.

Duration of the Project

Year one=> Conduct NRDA needs assessment and project status.
Perform literature search and establish expert contacts.
Identify and catalog potential restoration sites.
Based upon information gathered, develop project proposals.

Estimated Cost

Year one=> $20,000 (3 months FBII + travel, materials)

Restoration Activity or endpoint

Provide information to agencies regarding the potential, feasibility and applicability of mariculture technologies for restoration and enhancement of damaged resources.

Relationship to science information needs identified by RPWG

This project is designed to furnish information on available restoration technologies.

Importance of initiating this project in 1992

There is a considerable lead time in developing the type of mariculture technologies envisioned as useful for restoration. By initiating this project in 1992 much of the background work would be accomplished at the time that the F.R.E.D. Division's proposed Mariculture Technology Center will be coming on line.

Link to Other NRDA Damage Assessment or Restoration Studies

This project is intended to provide a broad-based knowledge source for rational decision making regarding implementation of restoration and enhancement projects.

RESTORATION SCIENCE STUDY PROPOSAL
1992 FIELD SEASON

A. **Study Name:**

Tanner Crab Population Monitoring and Restoration.

B. **Injured species to be addressed:**

Tanner crab (*Chionoecetes bairdi*). Injuries from the Exxon Valdez oil spill (EVOS) to Tanner crab are inferred from observed injuries to spot shrimp (*Pandalus platyceros*), a representative shellfish indicator species which share aspects of their life history, habitat, and food habits. Injuries to spot shrimp include decreased fecundity and recruitment, and a high occurrence of gill lesions in adults indicative of exposure to toxins. These injuries pose an additional threat to the Tanner crab population that was severely depressed prior to the Exxon Valdez oil spill.

C. **Principal Investigator/Biometrician:**

Charles Trowbridge; Shellfish Biologist, Commercial Fisheries, Cordova.
Ivan Vining; Biometrician, Commercial Fisheries, Anchorage.
Agency: Alaska Department of Fish and Game

D. **Project Objectives:**

This project strives to restore Tanner crab populations injured by EVOS through the regulation of human use. Before restoration efforts begin, population status must be determined by:

1. describing distribution of Tanner crab in the oiled and unoiled areas of Prince William Sound (PWS) and Lower Cook Inlet (LCI);

2. estimating population size in oil and unoiled areas and monitoring a series of recruitment events beginning with the 1989 year class;

3. reconstructing historic population estimates for PWS and LCI based on the relationship between estimates from the proposed trawl survey and the current CPUE index of abundance from a pot survey;

4. estimate historic fishery exploitation rates and model sustainable exploitation rates in the oiled and unoiled areas assuming differing levels of injury and productivity.

Using this information restoration will be effected through:

1. differential fishing mortalities on the oiled and unoiled populations based on the above results (population status);

2. protection of weak or damaged stock components allowing the population to recover and prevent overexploitation;

3. development of a stock recovery management plan to facilitate the long term recovery and health of the Tanner crab populations in PWS and LCI.

E. **Project Methods, including technical feasibility of the study:**

Since 1978 Tanner crab stocks have been monitored by a pot survey resulting in an annual CPUE index of abundance. A multispecies trawl survey was conducted in 1989 (NRDA Fish/Shellfish No. 18). The trawl survey continued on a very small scale in 1990 and 1991 improving gear performance and fishing technique to target Tanner crab. This study will expand the trawl survey to estimate the population size in oiled and unoiled areas using area-swept methodology. Recruitment events will be monitored and compared between areas using mixture modal analysis. A model relating area-swept estimates of abundance and pot survey CPUE will be developed to estimate the population back to 1978. Good relationships exist between pot survey indices and trawl survey estimates for adult Norton Sound red king crab and Kodiak Tanner crab. Models based on age/size-structure analysis will be used to estimate fishing and natural mortalities and estimates of sustainable fishing pressure will be evaluated for varying injury and productivity regimes.

F. **Duration of the project (number of seasons needed to fulfill project objectives):**

It is anticipated that five years will be required to complete project objectives. Four years will be devoted to assessment work and monitoring stock recruitment events into the study population. The final year will be used to complete population reconstruction, develop management recommendations and final project reporting.

G. **Estimated cost (per year if more than one year):**

$80,000 per year.

H. **Restoration activity or endpoint to be addressed:**

A fishery management plan will be developed to insure protection and rehabilitation of damaged stock components and provide for a long term sustained yield or fixed exploitation harvest level.

A completion report documenting population estimates from trawl surveys and reconstructed population estimates from pot surveys, with analysis and supporting data to the fisheries management plan.

I. **Relationship to science information needs identified by RPWG:**

This study seeks to improve understanding of long-range underlying mechanisms that cause injury to the resource (such as EVOS) or that limit populations (such as overexploitation by human use). Because Tanner crab populations were depressed prior to the EVOS, lethal and sub-lethal effects of the spill may have been of even greater consequence. Human use through commercial exploitation has been a contributing factor to population declines. Because human use can be modified, deliberate and directed regulation can be a primary mechanism to bring about rehabilitation of the damaged populations.

Tanner crab play an important part in the marine ecosystem not only as a predator of a variety of marine organisms, but also as one of the most commonly taken benthic prey organisms in the northern Pacific Ocean. Tanner crab are an important food source for a number of other EVOS effected species including rockfish, pollock, Pacific cod, sea otters and seals. A parallel recovery of the various interrelated species damaged by the EVOS is essential to restore ecosystem homeostasis.

J. **Importance of initiating project in 1992:**

The 1989 year class of Tanner crab will have reached sufficient size to be catchable in the trawl gear starting in 1992. Initiation of the collection of these data, will provide the beginning of the time series necessary to develop meaningful stock trends and relationships, that are needed to develop and implement an effective recovery management plan.

K. **Link to other NRDA damage assessment or restoration studies:**

NRDA Fish/Shellfish No. 18, conducted during the 1989 and 1990 seasons, will be utilized to provide a baseline for this study as to survey boundaries, stratification, and sample size for the desired level of precision and accuracy.

School of Fisheries and Ocean Sciences

UNIVERSITY OF ALASKA FAIRBANKS
Fairbanks, Alaska 99775-1080

FAX FORM

TO: Stan Senner
Mark Fraker

FAX #: 276-7178
522-3148

FROM: Stephen Jewett

NUMBER OF PAGES INCLUDING COVER: 4

DATE: 11/13/91 TIME:

IMS FAX # 907-474-7204

IMS VOICE # 907-474-7824

TELEX # 7402055 SFOS UC

COMMENTS: Restoration Proposal - hard copy to follow

David Wilcove
Charles Smith

A. Name of the Study: Natural Restoration of the Shallow Subtidal Communities in Prince William Sound

B. Injured Species to be Addressed: Eelgrass, infaunal and epifaunal (invertebrate) taxa, and Pacific cod.

C. Co-Principal Investigators and Lead Agency: Stephen C. Jewett (UAF) and Thomas A. Dean (CRA), Alaska Department of Fish & Game

D. Project Objectives: Monitor the recovery of the shallow (<20 m) subtidal communities in Prince William Sound that were impacted by the Exxon Valdez Oil Spill (EVOS) by:
a) comparing taxon richness, diversity, abundance, biomass and feeding strategies of dominant taxa from paired (oiled:control) habitat sites; and
b) temporally comparing these population parameters.

E. Project Methods: This is an extension of a project that orginated under COASTAL HABITAT (Subtidal) in 1989-90 and continued under AIR/WATER (STUDY 2: Injury to Benthic Communities - Shallow Benthos) in 1991.

Recent analyses of the 1990 field data indicates that the impacts to shallow subtidal communities were most pronounced in areas of soft substrate in protected embayments. The dominant plant within these habitats is eelgrass (*Zostera marina*) which generally occurs within a depth range of 3 to 5 meters. Attached to the eelgrass are a variety of small sessile invertebrates including the small mussel, *Musculus* spp. Fish (mostly juvenile Pacific cod *Gadus macrocephalus*) and larger epibenthic invertebrates (e.g., the leather star *Dermasterias imbricata* and sunflower sea star *Pycnopodia helianthoides*, and the helmet crab *Telmessus cheiragonus*) live in association with the eelgrass and feed on the infauna and epifauna within the eelgrass habitat. The largely unvegetated sand or mud bottom extending beyond the eelgrass is rich in infauna (e.g., polychaetes, bivalves, gastropods, and amphipods) that are food to a variety of fish species.

Almost all components of this system were affected by the EVOS. At oiled sites, there was a significant decrease in the diversity, abundance and biomass of infaunal invertebrates in the mud/sand bottom adjacent to the eelgrass beds. Within the eelgrass beds at the oiled sites, there was a reduction in the density of eelgrass, helmet crabs, and leather stars. Also, within the bed, we detected a significant increase in juvenile cod density and invertebrate density and biomass, including one of the cod's primary food, mussels.

Preliminary analyses from more recent surveys, conducted during the summer of 1991, suggest that some populations (e.g., the helmet crab) may have recovered. Other components, especially the benthic infauna, appeared not to have recovered fully, and based on evidence from previous oil spills, may not do so for years.

Effects on subtidal communities were also observed within other habitats, including relatively protected rocky reefs dominated by the smaller kelps (*Laminaria sacharrina* and *Agarum cribosum*) and more exposed reefs dominated by the bull kelp, *Nereocystis*. Significant changes were observed in the populations of some algae, invertebrates, and fishes.

The proposed study for 1992 will primarily focus on the eelgrass habitat and secondarily on *Laminaria/Agarum* island bay habitats. Within the eelgrass habitat, we will determine abundance of eelgrass, infauna, small epifauna attached to eelgrass, large epifauna (i.e., crabs and sea stars), and juvenile Pacific cod. Surveys will be conducted at the same five pairs of oiled and control eelgrass sites and three pairs of *Laminaria/Agarum* bay sites sampled in 1991. Methods will be the same as was used in 1990 and 1991.

We will mainly focus our monitoring efforts on the eelgrass habitat for several reasons. First, the impacts to populations in habitats other than eelgrass were often short lived. For example, algal populations were apparently reduced by the spill, but began to recover almost immediately following the spill, and were almost fully recovered by 1990. Second, many of the impacts observed in the other habitats were similar to, but often less severe, than observed in the eelgrass habitat. For example, we noted an increase in *Musculus*, and a decrease in leather star and helmet crab abundances at oiled sites in both eelgrass and in *Laminaria/Agarum* island bay habitats. Because of the similarity of many of the observed effects, a signal of natural restoration in the eelgrass should also signal natural restoration in other habitats.

We anticipate that the shallow subtidal sampling for 1992 will occur in concert with another restoration investigation in order to minimize field costs. In 1991 our shallow subtidal investigations and rockfish studies conducted by the Alaska Department of Fish and Game (AIR/WATER 2 : Subtidal Study 6) were carried out from the same platform at a major cost saving. Both studies utilized the same divers on the same platform to sample the shallow waters in western Prince William Sound. The rockfish component carried the cost for the platform and the benthic component carried the cost for the divers. Therefore, as in 1991, our 1992 budget does not accomodate cost for securing a sampling platform.

F. Duration of the Project: Since no baseline information was available for the shallow subtidal regions prior to the spill, it is essential to obtain long-term temporal data to determine the rate and extent of natural restoration to pre-spill conditions or to a stable community. Most post-spill subtidal environmental studies elsewhere have been three to five years in duration. To date, we have only two years of data (1990 and 1991) for the habitats noted above. Therefore, it is essential to continue to monitor the recovery process of the eelgrass habitat for an additional two or three years. The *Laminaria/Agarum* bay habitat may only need another year of monitoring.

G. Estimated Cost: $391,973 (3/1/92 - 2/28/93)
$330,000 (3/1/93 - 2/28/94)
$330,000 (3/1/94 - 2/28/95)

H. Restoration Activity or Endpoint: No man-made restoration will occur. Complete restoration or recovery implies not only a return to prior abundance levels, but moreover, a return to ecological pathways within the community which may have taken years to develop. These ecological pathways involve a range and magnitude of biological, chemical, and physical mechanisms with synergistic effects which are little understood, but are believed to be essential to the stability of the community. Drastic changes induced by EVOS undoubtedly altered these pathways and the resulting community may never return to its pre-spill structure and internal integrity, although abundance may return to pre-spill levels.

Our approach is to follow the various successional stages of a community toward stabilization. By the summer of 1992 most components of the benthic environment should have passed through the toxic phase of EVOS and it is reasonable to assume that recovery is well underway. Our goal is to document the responses of key taxa that are sensitive and tolerant to disturbance (presumably oil, but lack of adequate hydrocarbon data within sediments may negate this supposition) and to follow the community changes until stability is reached, at least for the few habitats studied.

I. Relationship to Science Information Needs Identified by RPWG: This study addresses the science information needs identified by RPWG through:

a. documenting the tolerant and sensitive taxa within the domain studied;
b. emphasizing broader ecological rather than species-specific approaches;
c. examining the predator/prey linkages between dominant taxa;
d. conducting a long-term monitoring of the recovery process;
e. monitoring the fate of oil in sediments in the habitats studied.

J. Importance of Initiating Project in 1992: As stated above, most post-spill environmental studies elsewhere have been three to five years in duration. To date, we have only two years of data. Therefore, it is essential to continue to monitor the natural restoration process for an additional two or three years, without any interruption in sampling. Interruption of sampling may lead to the inability to trace key successional stages inherant in the natural restoration process.

K. Link to Other NRDA Damage Assessment or Restoration Studies: Our finding will directly integrate with the investigations currently underway on sediment hydrocarbons, benthic microbiology, deep benthos and sea and river otters. We propose to further examine many of the linkages that exist among components within the eelgrass system, and between these and components from other systems. We will focus on determining both the predators and prey of three important species within the system, leather stars, helmet crabs, and juvenile Pacific cod. Preliminary observations suggest that these species prey heavily on invertebrates within the system, and in turn serve as important prey items for a variety of fish and bird species. Therefore, these species may be important links between lower trophic components and larger carnivores, both in the sea and on land. Understanding these linkages may provide a clearer understanding of the effects of the EVOS. This may also suggest key indicator species that can be used in monitoring future impacts.

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LITIGATION SENSITIVE / ATTORNEY WORK PRODUCT

RESTORATION SCIENCE STUDY PROPOSAL

A. Study name:

Development of a Restoration Plan for Groundfish Stocks Affected by the Exxon Valdez Oil Spill.

B. Injured species to be addressed:

Rockfishes (Sebastes and Sebastolobus spp.) and lingcod (Ophiodon elongatus). Adult demersal rockfishes suffered direct lethal and sublethal injuries from the Exxon Valdez oil spill (EVOS). Larval and pre-recruit rockfishes, as well as lingcod, probably sustained injury, although no studies were initiated to document this. In addition, the directed harvest and bycatch of rockfishes increased dramatically in 1990 and 1991 as fishing effort was redirected from salmon and herring to groundfish.

C. Principal investigators and biometricians:

William Bechtol, Biologist, Alaska Dept. of Fish and Game
Andrew Hoffmann, Biologist, Alaska Dept. of Fish and Game
Lisa Seeb, Statewide Geneticist, Alaska Dept. of Fish and Game
Patricia Hansen, Biometrician, Alaska Dept. of Fish and Game
Ivan Vining, Biometrician, Alaska Dept. of Fish and Game

D. Project objectives:

The goal of this project is to develop a restoration plan that modifies human use for the enhancement of groundfish resources in the area impacted by the EVOS. Initial objectives of this study are to:

1. Identify the species of concern. Over 20 species of rockfish are present in the study area; the species of concern will be identified by collecting species composition data from the sport and commercial fisheries.

2. Describe the biological characteristics of the species or stocks of concern. The commercial and sport fisheries will be sampled to describe age and size composition, natural mortality rates, growth rates, general seasonal movements, relative stock abundance, and relative recruitment.

3. Identify and define stocks to be enhanced through modification of human use. Genetic studies will document population structure and gene flow within and outside of the study area. These data can be used to predict how rapidly damaged or overfished populations can be restored from adult migration or larval drift from outside the

affected area. Tagging studies will be initiated, based on results of genetic and port sampling, to describe stock movements and potential recruitment sources in order to refine stock definition.

4. Describe the current and past patterns of human use of the groundfish resource. This will be done by summarizing current and historical harvest data by date, area, and fishery.

E. Project methods, including technical feasibility of the study:

Species, sex, size, and age data will be collected from commercial landings at ports processing rockfishes and lingcod from the EVOS affected area. Sampling and logistics will be coordinated with the ongoing sport harvest sampling (Assessment of Southcentral Alaska Sport Groundfish Harvest).

Observers will be placed on board a sample of commercial fishing vessels to quantify the magnitude and species composition of the discard.

Natural mortality rates will be estimated using: 1) age composition of unexploited or lightly exploited rockfish and lingcod stocks obtained by sampling from a chartered vessel, and 2) empirical relationships based on related biological characteristics.

Genetic structure and gene flow will be estimated using allozyme electrophoresis and restriction fragment length polymorphism (RFLP) of mitochondrial DNA (mtDNA). Rockfish and lingcod specimens will be collected from five sites within the EVOS affected area through coordination with commercial and sport fishery sampling described above. Rockfishes will be sampled from the three primary management groupings used by state and federal regulatory agencies: demersal shelf, pelagic shelf, and slope.

Biological data from current and historical landings (fish ticket system) will be analyzed over time and area to describe temporal and spatial patterns in human use of the groundfish resource.

The direction, magnitude, and timing of seasonal movements will be described through tagging. Results of port sampling and genetic analysis will be used to define the scope and objectives of tagging. Shallow dwelling rockfishes and lingcod will be tagged with external anchor tags, while demersal rockfishes will be marked with detachable hook tags. Tags will be recovered through port sampling programs and through voluntary returns. A reward and lottery program will be used to encourage voluntary returns.

All of the methods described are common, reliable tools that have been or are currently applied successfully to rockfishes and lingcod. The integrated approach to sampling and data-sharing reduces cost and fosters development of a balanced, practical restoration plan.

F. Duration of the project (number of seasons needed to fulfill project objectives):

A minimum of five years are required to collect data and formulate a workable restoration plan. Port sampling, estimation of natural mortality, and genetic analyses will begin immediately. Within two years, results from these studies will guide formulation of tagging objectives and refinement of furthur sampling. Tagging studies will require two to three years. Analysis and formulation of a management plan will require one year.

G. Estimated cost (per year if more than one year):

Year 1: $255,000; Year 2: $180,000; Year 3: $235,000; Year 4: $195,000; Year 5: $195,000.

H. Restoration activity or endpoint to be addressed:

A restoration plan will be developed to enhance and protect injured stocks and provide for sustained human uses including recreational, commercial, and subsistence fishing.

I. Relation to science information needs identified by RPWG:

This proposal addresses several general science information needs identified by the RPWG. First, it will "improve our understanding of the long-range mechanisms limiting populations..." With population concerns present before the spill, and additional concerns imposed by the lethal and sub-lethal effects of the spill, there is a greater need to understand the population dynamics of these species and identify restoration options. Second, data will be collected from "beyond Prince William Sound and throughout (the) affected area." Third, rockfishes and lingcod can be considered appropriate indicators to "monitor ecosystem recovery" and "determine the level of restoration necessary."

J. Importance of initiating project in 1992:

A restoration plan with clearly defined objectives is needed to enhance groundfishes impacted by the EVOS. Rockfish populations supporting present and future fisheries suffered direct and indirect impacts. Documented <u>direct</u> impacts included mortality of adult demersal rockfishes, and sublethal effects on spawning age adults. In addition, potential damage to larval and pre-recruit rockfishes and lingcod was acknowledged although no larval or pre-recruit studies were conducted. <u>Indirect</u> impacts included a substantial increase in fishing mortality during the 1990 and 1991 seasons. Fishermen who normally utilized short-lived pelagic species, such as salmon and herring, shifted to long-lived demersal rockfishes as a primary or secondary income source. This shift in fishing effort increased both targeted harvest and bycatch of rockfishes.

Rockfishes and lingcod are important links in the marine ecosystem, serving as important prey for other fishes and marine mammals. Rockfishes live long, grow slowly, have low larval-to-recruit survival rates, are often territorial, and require from 7 to 17 years to reach sexual maturity. Because many rockfishes in the EVOS affected area are at northern or western range limits, these populations represent an important genetic resource. Lingcod are also territorial and have highly variable recruitment. For both rockfishes and lingcod, recovery from overfishing or other perturbations can take decades, particularly if recruit and pre-recruit age classes are affected.

The documented direct and indirect effects of oil, combined with EVOS related increases in fishing mortality, threaten rockfish and lingcod populations. The slow recovery rates characteristic of these fishes necessitate the prompt formulation of a restoration plan to assure their future.

K. Link to other NRDA damage assessment or restoration studies:

The NRDA Fish/Shellfish Study #17 (now Sub-tidal Study #6), Injury to Rockfish and Shallow Reef Habitat in Prince William Sound, documented lethal and sub-lethal effects on rockfishes in oiled areas of the sound.

Annual budget breakdown for the groundfish restoration proposal:

Year	Project	Cost (K)
1	Commercial port sampling	120
	Genetics	60
	Estimation of natural mortality	75
	Total	255
2	Commercial port sampling	120
	Genetics	60
	Total	180
3	Commercial port sampling	120
	Genetics analysis & reporting	40
	Migration (tagging study)	75
		235
4	Commercial port sampling	120
	Migration (tagging study)	75
		195
5	Commercial port sampling	120
	Migration (tagging study)	75
		195

RESTORATION SCIENCE STUDY PROPOSAL
1992 FIELD SEASON

A. *Study Name:*

Kenai River Sockeye Salmon Restoration

B. *Injured Species Addressed:*

Sockeye salmon (*Oncorhynchus nerka*) spawning in the Kenai River system injured by the Exxon Valdez oil spill (EVOS) will be addressed by this proposal. Greatly reduced fishing time in the Upper Cook Inlet (UCI) area due to EVOS caused sockeye spawning escapement levels in the Kenai River system to exceed the desired amount by three times. The biological, as well as the economic, impact of EVOS on Kenai River sockeye salmon stocks may be one of the most serious documented. Data collected by NRDA Fish/Shellfish Study 27, *Sockeye Salmon Overescapement*, resulted in greatly reduced survival of juvenile sockeye salmon during the winter-spring rearing period. The extremely high escapement may have initially produced enough fry to not only deplete invertebrate prey populations and cause high fry mortality, but also to alter the species composition and productivity of prey populations for several years. Limiting sockeye salmon fry production by closely regulating the number of spawning adults may be the only way to restore the productivity of these rearing areas. However, the number of adult sockeye salmon returning from the 1989 escapement may be so reduced that a severe reduction, or complete elimination, of human use of this species may be necessary starting in 1993 to ensure even minimally adequate escapements.

C. *Principal Investigators:*

Kenneth Tarbox, Biologist, Alaska Dept. Fish and Game
Linda Brannian, Biometrician, Alaska Dept. Fish and Game

D. *Project Objectives:*

The goal of this project is to restore Kenai River sockeye salmon stocks injured by EVOS. This will be accomplished through improved stock assessment capabilities, more accurate regulation of spawning levels, and modification of human use. Information collected during this study will also allow the success of restoration efforts to be monitored. Specific objectives of this proposal are to:

1. improve stock identification capabilities by using parasites as biological markers;

2. increase the accuracy and precision of escapement monitoring by replacing obsolete hydroacoustic equipment;

3. provide more accurate estimates of abundance of Kenai River sockeye salmon within UCI by increasing the sampling power of the offshore test fishing program.

E. Project Methods and Technical Feasibility:

Stock identification studies used to regulate human use of UCI sockeye salmon have relied on scale growth patterns. The accuracy and precision of this technique has not been great. However, since Kenai River sockeye salmon have been the most abundant stock, results were sufficient to regulate human use of this resource. However, Kenai River sockeye salmon may represent only a small proportion of the total sockeye salmon run to UCI in 1993. To be able to identify the contribution of Kenai River sockeye salmon to the total run accurately will require improvements in stock identification procedures. Recent work by the Principal Investigators, in cooperation with National Marine Fisheries Service staff, has shown that parasite occurrence can be used to improve estimates of stock contribution during the fishing season. Therefore, sampling of sockeye salmon in commercial catches and spawning escapements will include observations on parasites, and this data will be included in stock identification models.

Presently, Bendix Corporation side scan hydroacoustics equipment is used to count adult sockeye salmon entering the Kenai River to spawn. This equipment has been used since 1976 and, while repairs and modifications have been done by a retired Bendix employee under contract to the State, is no longer manufactured by Bendix. Not only is it difficult to obtain parts for these units, but advances in hydroacoustic technology have made this equipment obsolete. Court actions associated with the Glacier Bay oil spill in UCI placed the hydroacoustic escapement monitoring program under intense scrutiny. Lack of design, repair, and calibration records compromised the defense of escapement estimates made using this equipment. However, recovery of Kenai River sockeye salmon from EVOS requires precise and accurate escapement estimates. Purchase of new hydroacoustics equipment will be required to accomplish this objective.

The stock assessment program is an expansion of an existing test fishing project in UCI. Sockeye salmon returning to UCI are captured with a drift gill net at a series of stations between Anchor Point and the Red River delta. Salmon are identified by species and sex and length measurements are made. Estimates of total sockeye salmon return are made several times during the fishing season by estimating expected total test fishery catch per unit of effort (CPUE) for the season and catchability of sockeye salmon in the test fishery. Analysis of historical data has indicated that existing sampling effort and catch has not been proportional to abundance. To assess stock size more precisely, additional test fishing vessels will be added to the existing program. Also, hydroacoustic equipment, operated by a contractor experienced in marine salmon investigations, will be used to monitor and verify drift gill net results. This information, when combined with improved information on stock identification and escapement monitoring, should allow better regulation of human use to ensure spawning goals are met.

F. Duration of Project:

A minimum of five years will be required to meet project objectives. Adult returns from the injured 1989 brood year will occur during 1993-1995, but information on the 1990, 1991, and 1992 brood years will also be needed to monitor recovery of the system. Adult returns from the 1992 brood year will not be observed until 1996.

G. Estimated Cost (per year):

Stock identification -	$ 40,000
Escapement enumeration -	$ 40,000
Stock assessment -	$300,000
Total per year -	$380,000

Initial cost (not included above) of purchasing new hydroacoustic equipment for escapement enumeration is estimated to be $150,000.

H. Restoration Activity or Endpoint Addressed:

Restoration of Kenai River sockeye salmon stocks will be achieved when average fry, smolt, and adult production are maintained. Prey resources of rearing lakes must also be restored to normal levels. (Rearing lakes will be monitored under another restoration study, which will be based on information obtained from NRDA Fish/Shellfish Study 27).

I. *Relation to RPWG Science Information Needs:*

This proposal relates directly to the first general science information need identified by the Restoration Program Working Group (RPWG). Information gained from this project will improve our understanding of the long-range mechanisms limiting populations and be used to modify human use of injured resources. Since methods of enhancement and rehabilitation other than management of human use to regulate spawning escapements are unsuitable for Kenai River sockeye salmon, it is imperative that the population biology of this species be understood.

J. *Importance of Initiating Project in 1992:*

Success of restoration efforts depends upon initiation of this project in 1992 since adults from the injured stock will begin to return to the Kenai River to spawn in 1993. Only a one season window is available to refine methods and techniques needed to improve stock assessment and regulate escapements prior to 1993.

K. *Link to Other NRDA or Restoration Studies:*

NRDA Fish/Shellfish Study 27, *Sockeye Salmon Overescapement*, documented injuries from EVOS on this resource.

This restoration project proposal is linked to other restoration proposals for UCI and Kodiak sockeye salmon which will monitor fry and smolt survival as well as rearing conditions in nursery lakes. This study will provide information on fishing mortality and stock structure needed to restore these injured resources. Without this information, protection and restoration of injured sockeye salmon stocks will be more difficult and less certain of success.

RESTORATION SCIENCE STUDY PROPOSAL
1992 FIELD SEASON

A. Study Name:

Juvenile Spot Shrimp Habitat

B. Injured species to be addressed:

Spot shrimp (*Pandalus platyceros*). Injuries from the Exxon Valdez oil spill (EVOS) have included decreases in recruitment, relative abundance, and fecundity and a greater number of females without eggs and with dead eggs. A high occurrence of gill lesions in adults indicative of exposure to toxins has also been documented.

C. Principle Investigator(s)/Biometrician(s):

Charles Trowbridge, Shellfish Biologist, Commercial Fisheries Division
Ivan Vining, Biometrician, Commercial Fisheries Division
Agency: Alaska Department of Fish and Game
A.J. Paul, Associate Professor of Marine Science, Institute of Marine Science, University of Alaska

D. Project objectives:

An understanding of larval distribution, habitat requirements of juveniles, and the relationship between juvenile and adult abundance is needed to direct restoration of spot shrimp populations injured by EVOS. This project will aid efforts to restore through the regulation of human use and application of artificial enhancement techniques discussed in the *Spot Shrimp Restoration and Enhancement* proposal.

Initial objectives will be to collect the data necessary to answer the following questions:

What is the relative abundance and distribution of larval spot shrimp throughout Prince William Sound (PWS)? Where are late stage larval spot shrimp found? This will be accomplished by processing biological samples collected during 1989.

What are the habitat requirements for juvenile spot shrimp? This will be addressed by a literature search, analysis of existing coastal habitat data, and data on juvenile shrimp and their habitat to be collected in PWS.

What is the relationship between abundance of adult and juvenile spot shrimp? This will be accomplished by comparing adult abundance data from NRDA Subtidal 5, *Injury to Spot Shrimp*, and juvenile abundance data collected in PWS.

E. Project methods, including technical feasibility of the study:

Measure abundance and identify by species and developmental stage, decapoda larvae in biological samples collected during the eight months following the EVOS when six research cruises were executed, sampling 62 representative oiled and non-oiled sites in PWS (NRDA Fish/Shellfish Study 19).

Using available physical oceanographic and larval distribution data, model likely movement of spot shrimp larvae, propose areas of settlement, and estimate relative abundance.

Coordinate with other coastal habitat NRDA and restoration projects to identify the presence of juvenile spot shrimp. Provide gear, taxonomic expertise, and personnel to describe habitat use of juvenile shrimp.

Survey potential habitat identified by the presence of late stage spot shrimp larvae, our literature search, or results of other NRDA work. Sample using artificial collectors, pots, small trawls, or a gear suitable for nearshore assessment. Juvenile shrimp have been successfully collected by ADF&G staff in Kodiak using artificial collectors developed to capture settling red king crab juveniles.

F. Duration of the project (number of seasons needed to fulfill project objectives):

It is anticipated that five years will be needed to estimate larval abundance and distribution, coalesce existing information on juvenile distribution and habitat preference and analyze and report field collections of juvenile spot shrimp.

Schedule:
Year 1: Describe larval distribution, model juvenile distribution, and add juvenile shrimp collection to existing near-shore subtidal studies.
Year 2-5: Continue working with other subtidal studies and add a survey to investigate specific juvenile spot shrimp habitat.
Year 5: Submit final report.

G. Estimated cost (per year if more than one year):

$65,000 per year

H. Restoration activity or endpoint to be addressed:

Describe spot shrimp larval distribution, relative abundance, and settlement areas.

Describe habitat requirements for juvenile spot shrimp and recommend critical habitat areas for protection.

Recommend potential release sites for artificially reared juvenile spot shrimp.

I. Relationship to science information needs identified by RPWG:

This study relates to the general science information need identified by the Restoration Planning Work Group (RPWG). We are attempting to define critical habitat and make that available for synthesis on the effects of other environmental disturbances (e.g. logging, log storage). We are also providing the type of information requested for other species as an understanding of critical components of habitats (as asked for harlequin ducks). Planning of future restoration of spot shrimp through enhancement or manipulation of human use will require results of this project. Lastly, by becoming informed we will guard against further degradation of spot shrimp habitat which could occur out of ignorance by competing development or enhancement projects.

J. **Importance of initiating project in 1992:**

The first step necessary to define likely habitat for juvenile spot shrimp is the processing of the biological samples collected by NRDA Fish/Shellfish Study 19. They have been carefully preserved, catalogued, and are currently stored at the University of Alaska, Fairbanks. We can not guarantee continued storage and would like to begin analysis immediately. Stocks have also continued to decline in the oiled area since 1989. This project needs to begin before a further reduction in population size and distribution makes identification of critical habitat and donor stocks for enhancement difficult. Starting now we can gather the information to appropriately manipulate human use in time to restore the spot shrimp resource.

K. **Link to other NRDA damage assessment or restoration studies:**

The NRDA Subtidal Study 5, *Injury to Spot Shrimp*, will provide the relative adult abundance data to relate with juvenile abundance data collected by this project. Suitable habitat will be identified by this project from which to choose a seeding location for either juvenile or larval spot shrimp for the proposed *Spot Shrimp Restoration* project. Lastly, this project will provide valuable information on larval abundance and distribution of decapods identified in the 1989 biological samples. This will provide the linkage necessary to interpret survival of the 1989 year class for other shellfish species whose larvae were also vulnerable to EVOS in March through May 1989.

RESTORATION SCIENCE STUDY PROPOSAL
1992 FIELD SEASON

A. **Study Name:**

Spot Shrimp Restoration

B. **Injured species to be addressed:**

Spot shrimp (*Pandalus platyceros*). Injuries from the Exxon Valdez oil spill (EVOS) have included decreases in recruitment, relative abundance, and fecundity and a greater number of females without eggs and with dead eggs. A high occurrence of gill lesions in adults indicative of exposure to toxins has also been documented.

C. **Principle Investigator(s)/Biometrician(s):**

Charles Trowbridge, Shellfish Biologist, Commercial Fisheries Division
Lisa Seeb, Statewide Geneticist, Commercial Fisheries Division
James Cochran, Mariculture Coordinator, FRED Division
Ivan Vining, Biometrician, Commercial Fisheries Division
Agency: Alaska Department of Fish and Game

D. **Project objectives:**

This project strives to restore spot shrimp populations injured by EVOS through the regulation of human use and application of artificial enhancement techniques. Before restoration efforts begin, stock structure must be determined by:

1. describing baseline population genetic structure (population attributes) of spot shrimp aggregations within EVOS affected areas as well as major aggregations within the Gulf of Alaska;

2. using the genetic data define stock boundaries within EVOS affected areas;

artificial enhancement techniques must be evaluated by:

1. searching the available literature and consulting with investigators working in the field of shrimp propagation to determine appropriate techniques;

2. identifying stocks to be used in enhancement efforts.

Using this information, restoration will be effected through:

1. developing a management plan regulating human use of spot shrimp to allow rebuilding of damaged stocks and insure long term health of the resource;

2. conducting a pilot study to confirm the feasibility of using artificial enhancement techniques;

3. developing plans for a full scale artificial enhancement effort by identifying an appropriate stock within the guidelines of the ADF&G genetic policy and rebuilding EVOS affected spot shrimp stocks.

E. **Project methods, including technical feasibility of the study:**

In the first year stocks within the EVOS affected areas (Kodiak, Outer Kenai Peninsula, and PWS) and Southeast Alaska will be screened for genetic variability both within and between stocks. Analysis should be completed during the second year so that stock boundaries can be defined. The genetic technique of allozyme electrophoresis will be used. The genetic variability of another pandalid, pink shrimp (*P. borealis*), has been investigated for the Gulf of Alaska. ADF&G personnel have extensive experience with crustacean genetic studies having worked with the genera *Paralithodes*, *Chionoecetes*, and *Panulirus*.

An initial literature review has revealed examples of successful transport of live shrimp from the wild to the laboratory for artificial insemination, hatching of eggs from females with broods in advanced stages of development, and rearing of larvae in the laboratory through to adults. Evaluation of artificial propagation techniques will involve a literature search, cost-benefit analysis, outline of the permitting process, and a technology assessment.

F. **Duration of the project (number of seasons needed to fulfill project objectives):**

It is anticipated that three years will initially be needed to determine the extent of genetic variability among stocks, define stock boundaries, prepare a management plan, recommend appropriate artificial enhancement techniques, and prepare the final report.

G. **Estimated cost (per year if more than one year):**

$65,000 per year

H. **Restoration activity or endpoint to be addressed:**

A fishery management plan will be developed to protect and rebuild injured spot shrimp stocks and provide for sustained utilization.

An analysis comparing the advantages of alternative fishery management versus hatchery production.

A report on the feasibility of rehabilitating injured stocks using appropriate stocks and artificial enhancement techniques.

If feasible, a project proposal to initiate enhancement experiments and rebuild injured stocks will be prepared.

I. **Relationship to science information needs identified by RPWG:**

This study relates directly to the first general science information need identified by the Restoration Planning Work Group (RPWG). It will identify and evaluate artificial enhancement as a restoration option. As requested for herring and salmon, it will provide basic population biology information on stock structure. Since spot shrimp abundance was depressed before the EVOS, lethal and sub-lethal effects of the spill may have been of even greater consequence. This makes understanding the population biology of this species even more critical in restoring this resource.

J. **Importance of initiating project in 1992:**

A management plan with clearly defined objectives is necessary to assure the recovery of spot shrimp stocks impacted by the EVOS. Stocks have continued to decline even though commercial fishing has been severely reduced since 1989. The project needs to begin before further reductions in abundance and distribution makes identification of stock boundaries and donor stocks even more difficult. At this time we believe it is still possible to gather the information to appropriately manipulate human use in time to restore the spot shrimp resource.

K. **Link to other NRDA damage assessment or restoration studies:**

NRDA Subtidal Study 5, *Injury to Spot Shrimp*, will provide samples of adults for genetic work as well as relative abundance and distribution information necessary to develop the management plan. The restoration proposal titled *Juvenile Spot Shrimp Habitat* will identify suitable habitat in which artificially propagated juvenile or larval spot shrimp may be released to enhance restoration efforts.

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RESTORATION SCIENCE STUDY PROPOSAL
1992 FIELD SEASON

A. Study Name:

Herring Spawn Substrate and Egg Transplanting Studies

B. Injured Species:

This study is directed at Pacific herring, *Clupea harengus pallasi*. Injuries from the *M/V Exxon Valdez* oil spill have included a wide range of both lethal and sublethal effects: egg and larval mortality, larval tumors, elevated anaphase aberration rates, increased cytogenetic and cytologic anomalies, and morphological abnormalities. In 1989, stress-related hemorrhaging around the vent and enlarged bright gall bladders were observed in adults, and hydrocarbon metabolites were found in samples of bile and whole fish.

C. Principal Investigator(s)/Biometricians and Lead Agency:

Evelyn Biggs, Fisheries Biologist, Division of Commercial Fisheries
Tim Baker, Biometrician, Division of Commercial Fisheries
Agency: Alaska Department of Fish and Game

D. Project Objectives:

A direct restoration tool that deserves evaluation is transplanting spawning substrate (either natural or artificial substrates) and transplanting loose egg windrows (which normally die unless resubmerged in seawater) carried to shore following storms. There is evidence that herring egg survival and hatching success varies with the type of kelp substrate used for spawning and with the number of egg layers deposited. Generally, kelp species with large interstitial spaces (hair and fern kelps) promote better oxygen exchange and spacing among eggs, which enhances egg survival and hatching success. In addition, as the number of egg layers deposited increases, fertilization rate, egg survival and hatching success decrease. Therefore increasing spawning substrate in an area being utilized by spawners should decrease overall egg density per area unit and enhance survival.

In years when storms coincide with egg incubation, wave action may dislodge tons of herring eggs from spawning substrate and carry them to the upper limit of the high tide line. Normally, these eggs remain exposed to air and die. Canadian biologists have transplanted stranded eggs to underutilized areas where they observed successful hatching.

The following objectives have been identified to determine the effectiveness of this stock restoration technique in EVOS affected areas:

1) Examine the feasibility of transplanting natural spawn substrate (kelp) and introducing artificial spawn substrates in an oiled area typically utilized by spawners. Success of efforts will be measured by comparing egg survival, hatching success, and larval densities between the experimental transplant area and a control area with similar total egg density.

2) Determine egg survival and hatching success of eggs dislodged from spawning substrates by storms and transplanted to specially designed containment trays submerged in nearshore areas.

E. Project Methods:

The study area will include the northern and western portions of Montague Island. The following methods will be used to meet the objectives of this study:

1) Three control and three experimental sites will be selected in Rocky Bay and western beaches of northern Montague Island. Hair kelps, other species of red kelps, and artificial substrates will be cut from areas on southern Montague Island and anchored in nearshore experimental sites. After spawning, control and experimental sites will be surveyed and egg densities measured. These sites will be monitored every 4-5 days until most eggs have hatched to measure egg survival and percent hatch. After hatching, larval trawls, designed after the ones successfully used by Finnish researchers, will be used to measure larval density.

2) After storm events in areas near study sites, eggs deposited on the beach will be carefully shovelled onto holding trays and transported by skiff to experimental sites. Transported eggs will be kept moist by periodically spraying with seawater. At the experimental site, eggs will be placed in two meter square small mesh trays suspended one to two meters below the water surface. Suspended trays will be periodically sampled to measure egg survival and percent hatch. After hatching has been completed, the total number of eggs remaining will be measured to determine overall survival.

F. Duration of the Project:

The time frame for the field portion of this project is April to mid-May, 1992. Data analysis will be completed during the winter of 1992-1993. At the completion of this study, recommendation will be made concerning large scale application of this technique to restore injured herring populations.

G. Estimated Cost (per year):

Both objectives for this one year study can be met at a cost of approximately $70,000.

H. Restoration Activity or Endpoint:

To evaluate spawn substrate enhancement and loose egg mass transplants as potential restoration tools for injured herring resources.

I. Relationship to Science Information Needs Identified by RPWG:

This proposal meets the first RPWG scientific information need for "identification and evaluation of restoration options".

J. Importance of Initiating the Project in 1991:

Damages have been documented for the herring resource and effects upon the reproductive stock will be evident beginning in 1993. Evaluation of this restoration technique in 1992 will provide information needed to determine whether implementation on a large scale would speed up the recovery process.

K. Link to Other NRDA Restoration Studies:

This proposal is in response to damages to herring shown by NRDA Study #11, *Injury to Prince William Sound Herring*. This study could be combined with a similar Kodiak proposal. The scope can also be expanded to include a survey of Prince William Sound kelp resources since a large database has been compiled over the course of six years of underwater surveys. Knowledge of kelp types, percent cover, importance as herring spawning substrates, and survival rates of herring eggs deposited on different kelp species would enhance our understanding of herring spawning success and egg survival. Such information would be useful in restoration planning and study implementation.

RESTORATION SCIENCE STUDY PROPOSAL
1992 FIELD SEASON

A. Study Name:

Herring Restoration and Monitoring

B. Injured Species:

This study is directed at Pacific herring, *Clupea harengus pallasi*. Injuries from the *M/V Exxon Valdez* oil spill have included a wide range of both lethal and sublethal effects: egg and larval mortality, larval tumors, elevated anaphase aberration rates, increased cytogenetic and cytologic anomalies, and morphological abnormalities. In 1989, stress-related hemorrhaging around the vent and enlarged bright gall bladders were observed in adults, and hydrocarbon metabolites were found in samples of bile and whole fish.

C. Principal Investigator(s)/Biometricians and Lead Agency:

Evelyn Biggs, Fisheries Biologist, Division of Commercial Fisheries
Lisa Seeb, Statewide Geneticist, Division of Commercial Fisheries
Tim Baker, Biometrician, Division of Commercial Fisheries
Agency: Alaska Department of Fish and Game

D. Project Objectives:

In order to directly restore or evaluate and direct restoration efforts on herring, more accurate stock assessment is necessary. This can be achieved through an increased understanding of stock identification, recruiting processes, and through an improved population dynamics model. The most effective restoration tool, in terms of cost and completion time, is accurate fisheries management. However, accurate fisheries management hinges on accurate stock assessment. Fine tuned adjustments in fishing quotas can result in measurable rehabilitation for herring stock(s) and provide benefits to mammals, birds, other fish, and invertebrates that utilize herring as a food source. The following goals and objectives have been identified that will provide information to improve stock assessment and therefore restoration of herring:

A. Population Dynamics and Modeling
   1) Maintain high accuracy in the spawn deposition survey estimate which is used to estimate the total spawning biomass of herring in Prince William Sound (PWS);
   2) Continue an egg loss study, as an estimate of egg loss is important in the model to estimate the spawning biomass, and
   3) Improve stock assessment by incorporating a PWS population dynamics model (age-structure analysis).

B. Stock Identification
   1) Employ genetic stock identification techniques to estimate the discreteness and distribution of herring stocks both inside and outside PWS,
   2) Implement a herring tagging study to identify the level of immigration and emigration in herring populations inside and outside PWS and identify the extent of habitat utilized by the individual stock(s), and
   3) Analyze herring otoliths for elemental composition to identify the origins of spawning and rearing areas.

C. Larval Trawl Survey and Monitoring
   1) Implement a larval and juvenile herring trawl survey to identify

sensitive larval retention areas and to provide information that will aid in understanding recruitment processes, and

2) Use daily otolith increments to estimate and compare growth rates of larval herring in PWS.

D. Project Methods:

The study area for all components except genetic stock identification will be coastal areas within PWS, and outer cape areas westward from Seward to Gore Point and eastward to Cape Suckling. Sampling for genetic stock identification will include the entire EVOS area as well as Southeast Alaska.

The following methods will be employed to complete the objectives listed above:

A.1. The spawn deposition survey (underwater enumeration of actual herring egg deposition) provides an estimate of herring biomass which is improved by increased sampling (adding more survey transacts), by employing third year calibrated divers, and by conducting sufficient age, weight, length (AWL), and fecundity sampling in all the major spawning areas.

A.2. Egg loss data has been collected and analyzed in 1990 and 1991 in Prince William Sound and a literature review has been completed. Methods similar to those employed in 1991, using changes in egg density in fixed locations, will be improved and implemented for one additional season and analyzed to improve the accuracy of the biomass estimation model.

A.3. Staff biometricians and university experts would incorporate several historic biomass indices into an age-structured analysis, to improve current stock assessment models. Much more is known about the PWS herring stock(s) due to intensified studies over the past 3 years that can be incorporated in the model. In addition, an early life history model incorporating egg and larval survival rates and recruitment information, will be synthesized with the adult population model. The improved stock assessment model will increase the accuracy of predicted future herring stock sizes, age compositions, and recruitment reducing, the risk of overfishing.

B.1. Herring would be collected as part of an existing herring AWL program for examination of genetic differences. Allozyme protein electrophoresis and the analysis of mitochondrial and nuclear DNA will be used to identify genetic stock(s) of herring in PWS. In addition, herring from Cook Inlet, Kodiak, and Southeast Alaska would be analyzed.

B.2. A marking program would be done using tags shown in previous studies to have good retention and to be economical to use in large numbers. Tagging would be done in the spring, during AWL sample collection, fishery monitoring and research activities, as well as in the summer and fall. Recovery of tagged herring would begin in the fall of 1992 and continue for 3-5 years. Other studies of herring in PWS and British Columbia have resulted in recoveries as high as 6% of the total tagged population.

B.3. Elemental analysis of otoliths will be employed, on an experimental basis, to detect differences in chemical composition. It may be possible to identify the area of origin for an individual herring based on differences in microchemistry of the nearshore marine environment. Larval and adult herring will be sampled from spring spawning areas, summer rearing areas, and from known wintering areas. Although this analysis is expensive, small sample needs should keep costs down.

C.1. A larval and juvenile herring trawl survey will be designed following analysis of the 1989 larval fish survey done by Brenda Norcross. Sites will be randomly selected within defined areas that have been stratified according to herring abundance and distribution found in the Norcross study. Three trawl sizes will be used to sample macroplankton, larval herring, and juvenile fish. Other species collected will be identified, counted, and classified as possible prey for or predators on herring. Three sampling trips of 10 days each will be conducted during the summer.

C.2. Larval and adult otoliths will be collected and analyzed for incremental growth analysis. Environmental conditions that appear to affect differential growth will be identified.

F. Duration of the Project:

The duration of the various project components will be from one to seven years:

A.1 - 7 years
A.2 - 1 year
A.3 - 7 years
B.1 - 4 years
B.2 - 2 years of tagging; 3-5 years of recovery
B.3 - 1 year for development; 2 years for monitoring
C.1 - 3 years for baseline development; 4 years for monitoring
C.2 - 3-5 years

G. Estimated Cost (per year):

A.1 -	$ 210,000
A.2 -	$ 85,000
A.3 -	$ 45,000
B.1 -	$ 160,000
B.2 -	$ 225,000
B.3 -	$ 125,000
C.1 -	$ 125,000
C.2 -	$ 150,000
Total	$1,125,000

Computed cost by duration times cost per year for each segment
J

H. Restoration Activity or Endpoint to be Addressed:

This project, by providing improved stock assessment information (including a better understanding of the recruitment process), will improve the State's abilities to modify human use of herring in EVOS affected areas. This is the most effective restoration tool available to ensure restoration of damaged herring resources. Monitoring of the various life history phases of herring will also enable biologists and resource planners to monitor and evaluate restoration of damaged stocks and ecosystems in which herring play a major role.

An increase in knowledge of herring egg and larval growth and survival, stock identification, and identification of retention areas will contribute significantly to our understanding of the role of herring to the ecosystem both inside and outside of PWS. Better understanding of early life history stages, as well as adult stages, will all allow resource agencies to better protect sensitive stocks and areas from future toxic events.

I. Relationship to Science Information Needs Identified by RPWG:

This proposal relates to several of the scientific information needs identified by RPWG. It will improve the understanding of mechanisms causing injury or limiting populations through the understanding of population dynamics and stock assessment. Much of this project is aimed at long range monitoring which will enable researchers to evaluate herring restoration. This study will rely on information collected from NRDA study 11 that identified injuries to herring from oil.

Herring are an important indicator that can be used to monitor the health of the ecosystem. Ecosystem damages will be easier to assess and restore with an increased knowledge of herring life history. Information from this study may be important to bird and mammal restoration efforts since herring is an important prey species.

The focus of this restoration study extends beyond PWS into two other EVOS affected areas: Kodiak and Cook Inlet. Proposals relating to herring in Kodiak can be combined with these studies.

J. Importance of Initiating Project in 1992:

Injuries caused to 1989 herring year class eggs and larvae by EVOS have been documented. However, damages to the recruiting class will only begin to be observed in 1992. Therefore, it is essential that improved monitoring and assessment tools are in place to effectively execute and evaluate restoration activities. The 1992 field season will begin April 1992, which is part of FY92. Since funding for herring studies in FY92 will not be addressed until FY93, some components necessary for immediate implementation of herring restoration activities will need funding in FY92.

K. Link to Other NRDA or Restoration Studies:

This proposal stems directly from NRDA Fish/Shellfish Study #11, *Injury to Prince William Sound Herring*. Many of the components proposed are areas where a need for increased understanding of the processes was identified in the NRDA study. In addition, this study may relate to bird and sea mammal studies where population abundances may be linked to abundance of food resources such as herring. Processes that affect larval herring may also affect other larval fishes and invertebrates as well as juvenile salmon, all of which may be important prey items. The scope of some of study components within this proposal, particularly the larval trawl survey, can be expanded to include some of these other species in the analyses. This may greatly aid our understanding of the marine ecosystem.

Restoration Science Study Proposal

Genetics Studies of Salmonids

A. Study Name:

Assessment of Genetic Stock Structure of Salmonids for Restoration Planning and Monitoring

B. Injured Species to be addressed:

Salmonids, including pink and chum salmon, Dolly Varden, and cutthroat trout, suffered both direct lethal and sublethal injuries as a result of the Exxon Valdez oil spill (EVOS). Pink salmon embryos and alevins suffered increased mortality, diminished growth, and a high incidence of somatic cellular and genetic abnormalities as a result of spawning ground contamination and rearing in oil areas. Additionally, in 1989 the commercial harvest of pink salmon had to be shifted away from the hatchery and wild stocks in the oiled areas to target only the wild stocks in eastern Prince William Sound. This resulted in over-harvest and depletion of these stocks evidenced by general run failures of eastern-Sound stocks in 1991. Dolly Varden and cutthroat trout also showed substantial increased mortality in the oil-affected areas.

Additionally, cutthroat trout from oiled sites grew up to 68% slower than fish from control sites. Sublethal petrochemical-related DNA damage can cause both reduced performance and sterility. Residual sterility could have devastating effects on these depleted populations. These are especially important populations because they inhabit the northern-most part of the species' range, and as such they likely possess unique adaptations important to the diversity of the species. These attributes make populations of cutthroat trout from the EVOS-affected areas excellent candidates for listing under the Endangered Species Act.

C. Principal investigators

James Seeb, Ph.D., Principal Geneticist, FRED Division, ADF&G
Lisa Seeb, Ph.D., Statewide Geneticist, Division of Commercial Fisheries, ADF&G

D. Project Objectives:

This project will provide population genetic information for four species of salmonids, pink salmon (*Oncorhynchus gorbuscha*), chum salmon (*Oncorhynchus keta*), Dolly Varden (*Salvelinus malma*), and cutthroat trout (*Oncorhynchus clarki*) inhabiting EVOS-affected areas. The specific objectives are to:

1. To define the genetic structure of pink and chum salmon, Dolly Varden, and cutthroat trout in the EVOS-affected area.

2. To identify those population which are important components to the evolutionary legacy of the species and whose extinction would represent an irreversible genetic loss.

3. To provide genetic risk assessment and monitoring of supplementation programs.

E. Project methods

Tissues will be collected from up to 100 individuals from each of several spawning aggregations each year. The genetic sampling of pink and chum salmon will entail removing the heart, a sample of liver and muscle, and eyes from spawned out carcasses. Dolly Varden and cutthroat trout will be sampled live; the fish will be anesthetized, a small fin clip taken, a few drops of blood collected from the caudal artery, and returned live to the stream. Tissue samples will be immediately frozen on liquid nitrogen and returned to Cordova for storage at -80° C. Pink salmon specimens will be collected from two hatcheries and up to 25 wild-stock spawning aggregations from the affected areas ranging from Prince William Sound, to eastern Kenai Peninsula, and through Kodiak Island. Pink salmon sampling will be designed to include both early and late stocks and inter-tidal and upstream-spawning stocks. Chum salmon will be collected from the one hatchery broodstock and approximately ten wild stocks. Ten Dolly Varden populations and approximately five cutthroat populations will be sampled at weirs constructed within Prince William Sound. Sampling will be done in coordination with other restoration programs to greatly reduce costs and facilitate cross-referencing of biological data.

Genetic data will be collected using the techniques of allozyme protein electrophoresis and restriction fragment length polymorphism (RFLP) analysis of mitochondrial DNA (mtDNA). These procedures are well-established and currently being conducted in the genetics laboratory of ADF&G. As appropriate data will be merged into the state and federal inter-agency coast-wide databases for each of the respective species.

F. Duration of the project

Pink and chum salmon baseline	4 years
Dolly Varden and cutthroat trout baseline	3 years
Genetic monitoring of supplementation (if done)	as needed

G. Estimated cost

Year 1: $ 250,000 Year 2: $ 262,000 Year 3: $ 275,000
Year 4 and beyond: as needed

H. Restoration activity or endpoint addressed

An understanding of the population genetics of affected salmonid populations will be used to guide restoration management decisions including commercial harvest management and sportfish regulations. Genetic monitoring and risk assessment will continue as needed and be used to evaluate any supplemental restoration programs. This continued monitoring and risk assessment is analogous to the process currently being conducted to evaluate supplemental restoration of damaged stocks on the Columbia River by the Northwest Power Planning Council.

I. Relationship to science information needs identified by RPWG

This proposal relates to the first general science information need identified by RPWG. The information generated from this study will improve our understanding of the long-range underlying mechanisms causing injury or limiting populations. The status of wild salmonid populations was a concern prior to the oil spill; the documented damage to these populations further increases the concern and the need to understand the underlying population structure and amount of gene exchange among populations. This proposal will also extend the area of study beyond Prince William Sound for pink salmon.

J. Importance of initiating project in 1992

Reproductively isolated populations are by definition self-recruiting--the adults generally do not stray to repopulate depleted areas. Therefore, basing management decisions on known population structure is critical to facilitate successful restoration. Harvest adjustments, through commercial harvest assessment and regulation of sport fishing seasons and possession limits, must be made upon known population genetic units in order to restore those reproductively isolated units.

Hatchery supplementation of wild pink salmon stocks cannot be contemplated without knowledge of the underlying population structure (see State of Alaska Genetic Policy). To do so would put the unique adaptive advantages of the wild stocks at risk. The same population genetic data will provide baseline for mixed-stock fishery analysis and possibly genetic marking. Genetic marks are now used to manage the harvest of Fraser River pink salmon, for example, and such techniques may ameliorate the hatchery/wild stock management problems exacerbated by the EVOS.

Finally, genetic data is critical for the proper management of the depleted cutthroat trout populations, the northern most populations in the species' range. They may become candidates for protection under the Endangered Species Act because of the importance of such peripheral populations. Therefore, the structure of the stocks is not only need for the reasons described above, but is also a key factor determining the importance of these stocks to the genetic diversity of the species.

It is critical to initiate the study as soon as possible so the resulting data are available for guiding ongoing restoration activities.

K. Link to other NRDA damage assessment or restoration studies

NRDA Fish/Shellfish studies 1-5 documented injury to pink and chum salmon, Dolly Varden, and cutthroat trout in PWS. Several other ADF&G restoration proposals are linked to this proposal and will allow exchange of biological data and sharing of logistics to minimize duplication of effort. These studies include: 1) Weir and ground survey enumeration of pink salmon escapements, 2) Enumeration and coded wire tagging of wild pink salmon fry, 3) Recovery of coded wire tags and otoliths in spawning escapements, 4) Monitoring and recovery of salmon eggs and pre-emergent fry, 5) Monitoring and recovery of Dolly Varden and cutthroat trout, and 6) Monitoring DNA breakages of fish and shellfish populations in Prince William Sound.

RESTORATION SCIENCE PROPOSAL

1992 FIELD SEASON

A. Study Name:

Stock Identification and Population Monitoring of Wild Pink Salmon

B. Injured species to be addressed:

Pink salmon (*Oncorhynchus gorbuscha*). Pink salmon are a key species in the Prince William Sound (PWS) marine ecosystem both as juveniles and adults. Huge spring seaward migrations of pink salmon fry function both as dominant predators on zooplankton populations and as important prey items for other fishes and birds. Millions of adult salmon returning from the high seas to spawn and die provide a unique and vital mechanism for transport of nutrients and energy from feeding grounds in the north Pacific to nearshore waters and upstream areas of PWS.

Wild pink salmon production in PWS has ranged from 10 to 15 million fish in recent years. As much as 75% of the total pink salmon run spawns in intertidal areas. The proportion of intertidal spawning is greatest in streams on the southwestern portion of PWS. Oil from the March 24, 1989, Exxon Valdez Oil Spill (EVOS) was deposited in layers of varying thickness in the intertidal portions of streams utilized by spawning salmon. Salmon eggs deposited in oiled intertidal spawning areas in 1989 and subsequent years have been adversely affected by this contamination. Injuries from spawning ground contamination include increased egg mortality as well as a high incidence of somatic, cellular, and genetic abnormalities in alevins and fry. Emergent salmon fry and smolt from throughout PWS experienced further injuries as they migrated through and reared in areas where oil contamination was greatest. Diminished growth and survival have been demonstrated for salmon which reared in oiled areas. Documented injuries have led to declines in the number, health, and overall fitness of the PWS salmon population and these effects may persist for several years.

C. Principle Investigator(s)/Biometrician(s):

Samuel Sharr, Biologist, Alaska Dept. Fish and Game
Carol Peckham, Biologist, Alaska Dept. Fish and Game
Dan Sharp, Biologist, Alaska Dept. Fish and Game
David Evans, Biometrician, Alaska Dept. Fish and Game

D. Project Objectives:

The goal of this project is to identify, implement, and evaluate methods to restore PWS wild pink salmon stocks injured by EVOS. Although other techniques may be developed, the most effective restoration methods identified at this time is modification of human use of injured wild pink salmon stocks. The commercial fishery is a major factor controlling pink salmon population size and reproductive success. Since PWS wild pink salmon stocks are harvested in mixed stock fisheries dominated by hatchery fish, successful restoration efforts must be based on the State's ability to closely regulate the exploitation of oil impacted wild stocks. A coded-wire tag application and recovery program will provide inseason estimates of stock abundance and timing that will permit fisheries managers to selectively reduce harvests on injured stocks. Tagging information will also provide total return and survival estimates needed to set exploitation rates and assess the success of restoration procedures. Project component objectives are:

1. Sampling and coded-wire tagging of wild pink salmon fry to:

   a. describe abundance and migration timing of wild pink salmon fry from intertidal and upstream portions of representative oiled and control streams;
   b. mark a representative subsample of pink salmon fry from the intertidal and upstream portions of oiled and control streams for later recovery in juvenile and adult sampling programs;
   c. collect samples for documentation of persistent somatic, cytologic, and genetic abnormalities attributable to oil contamination;
   d. determine the feasibility of using otolith banding patterns to distinguish fry originating from upstream spawning areas from those originating from intertidal spawning sites.

2. Recovery of coded-wire tags and otoliths from commercial catches to:

   a. estimate temporal and spatial contributions of tagged wild stocks to PWS commercial and hatchery harvests. (Since coded-wire tagging of hatchery fry is expected to continue independent of the restoration process, these tags will also be recovered from harvests. This data will also be used to enhance restoration efforts directed at wild stocks.);
   b. provide timely inseason estimates of stock contributions to harvests by time and area to fisheries managers so they can closely regulate exploitation of injured wild stocks;
   c. examine the feasibility of using otoliths as a stock identification tool that will complement or replace coded wire tagging. (This objective must also consider the test application of thermal otolith banding to all fry released from two hatcheries in 1992. Therefore, otolith samples collected in 1992 will be used as baseline samples for testing the ability to distinguish hatchery applied thermal marks in 1992 from naturally occurring banding patterns.)

3. Recovery of coded-wire tags and otoliths from spawning populations to:

   a. estimate tag loss and mortality of tagged pink salmon;
   b. determine total return and overall survival of tagged pink salmon stocks, including subpopulations within the same stream tagged in intertidal and upstream zones. (To be accomplished, this objective will require tag recovery data from catches.);
   c. compare growth and survival of pink salmon returning to oiled and unoiled spawning sites, and to upstream and intertidal spawning sites within the same stream, using otoliths collected from tagged pink salmon;
   d. examine effects of egg and fry densities, fry migration timing, nearshore zooplankton abundance, and juvenile growth and survival upon adult survival;
   e. collect samples for documentation of pervasive somatic, cytologic, and genetic abnormalities in adults returning to oiled streams.

E. <u>Project Methods</u>:

Project component methods are as follows:

1. Sampling and coded-wire tagging.

   Wild pink salmon fry from both oiled and non-oiled areas will be enumerated and a random subsample tagged with coded-wire tags. Tags will be applied at rates which allow sufficient recoveries from harvests and spawning populations for estimating numbers of returning adults from each tag release group by area and time period. Nine wild pink salmon stocks, including the six examined in NRDA F/S Study 3, will be tagged.

Five of these stocks are from oil contaminated streams. The remaining four are from uncontaminated streams.

2. Recovery of code-wire tags and otoliths from commercial catches.

   Coded-wire tag recoveries from commercial and hatchery harvests will be based on a sampling design stratified by processor, area, and time. For each time and area specific stratum, 15% of the pink salmon catch will be scanned for fish with clipped adipose fins (indicating presence of a tag). Catch sampling will be done at all processing facilities which handle large numbers of PWS pink salmon. Samples will be processed and data analyzed to estimate stock contribution within five days of the sampling date. Otoliths will be removed from a subsample of tagged pink salmon and processed so banding patterns can be examined. This information will be used to determine whether otoliths can serve as a useful stock identification tool. Otolith samples collected in 1992 will also be used to determine whether hatchery applied thermal marks can be distinguished from naturally occurring banding patterns.

3. Recovery of coded-wire tags and otoliths from spawning populations.

   Tags will be recovered from the spawning population of each tagged wild stock. At each of the nine study streams, crews will enumerate daily passage of pink salmon through a weir. Daily ground surveys of each stream will also be conducted to count fresh carcasses and scan them for missing adipose fins (indicating the presence of a tag). Streams in the vicinity of study streams will also be sampled to determine whether tagged pink salmon have strayed. Otoliths will be removed from a subsample of tagged pink salmon and processed so banding patterns can be examined. This information will be used to compare growth of pink salmon returning to oiled and unoiled spawning sites, as well as to upstream and intertidal spawning sites within the same stream.

F. Duration of the project:

The persistence of oil contamination levels which contribute to sub-lethal injuries to pink salmon is not known nor is it certain how long documented sub-lethal effects, such as genetic damage, may persist in the population. Therefore, salmon populations should be monitored until oil induced effects no longer cause observable reductions in survival. A minimum of two years will be required to determine whether even and odd year cycles have recovered. Progress reports will be filed annually and a final report will be submitted in the year following the final field season.

G. Estimated cost (per year):

1.	Sampling and tagging -	$ 900,000
2.	Recovery of tags and otoliths from catches -	$1,000,000
3.	Recovery of tags and otoliths from spawners -	$ 230,000
	Total -	$2,130,000

H. Restoration activity or endpoint to be addressed:

This project will ensure wild pink salmon stocks injured by EVOS will be protected and restored through modification of human use. Adjustments to harvests will be made based on stock abundance and timing estimates provided by this project in order to minimize exploitation of damaged wild stocks in mixed stock fisheries. This project will monitor the effectiveness of this restoration technique as well as the recovery of populations from sub-lethal damages such as cytologic and cytogenetic abnormalities.

I. Relationship to science information needs identified by RPWG:

This study relates to both the general and specific needs identified by RPWG. Since tagged pink salmon will be recovered at the juvenile as well as the adult stages, our understanding of long-range underlying mechanisms which limit salmon survival will be vastly improved. Furthermore, by studying a species which plays such an important role in the ecosystem, as a predator and prey organism as well as an energy transfer agent, we will be monitoring the health of the entire ecosystem.

In relation to specific needs, tags applied and recovered in this proposed project will provide stock specific timing and distribution data critical to restoration of damaged wild pink salmon stocks through manipulation of human use. Tag recoveries will also provide information on genetic mixing of populations and shed light on the genetic isolation of intertidal and upstream spawners.

J. Importance of initiating the project in 1992:

Salmon stocks from oiled streams in southwestern PWS are subjected to extreme fishing pressure in fisheries targeting on hatchery runs. This exploitation may be great enough to drive EVOS damaged stocks to critically low levels and impede the natural recovery process. Without this project, stock specific timing and distribution data will not be available, and fisheries managers will be unable to control harvests with enough accuracy and precision to protect damaged stocks from overexploitation. Failure to begin this project in 1992 will also prevent continued monitoring of the health of these populations and hinder our understanding of factors limiting their survival and recovery.

K. Link to other NRDA damage assessment or restoration studies:

This project is a logical continuation of Restoration Study 8 and NRDA F/S Study 3. Wild stock streams in this study are a subset of streams examined in NRDA F/S Studies 1 and 2. These streams are also a subset of streams included in other restoration proposals for enumerating adult escapement, monitoring egg and fry survival, improving instream salmon spawning habitat, improving early marine survival of wild pink salmon fry through rearing techniques, genetic identification of wild stocks, and monitoring of recovery from genetic damage in wild stocks. This project has links to existing Cooperative Fisheries and Oceanographic Studies sponsored jointly by the University of Alaska, Alaska Dept. of Fish and Game, and local aquaculture associations. Existing and proposed salmon projects have been carefully integrated to maximize our ability to monitor natural recovery at all accessible pink salmon life history stages. This project will greatly improve our understanding of factors affecting salmon survival.

Confidential Attorney Work Product

Restoration Science Study Proposal
1992 Field Season

A. Name of study.

Monitoring DNA breakages of fish and shellfish populations in Prince William Sound

B. Injured species to be addressed.

Several fish and shellfish populations in Prince William Sound were negatively impacted by the Exxon Valdez oil spill (EVOS). Pink salmon (Oncorhynchus gorbuscha) escapement in 1989 was 82% of the historic odd year average due to intense exploitation in non-oiled areas where commercial fishing was allowed. Egg survival, egg-to-preemergent fry survival, and early marine fry growth of pink salmon was greater in non-oiled areas than in oiled areas. Reduced growth may have lowered fry-to-adult survival in fry exposed to oil.

A significantly higher proportion of Pacific herring (Clupea harengus) larvae from oiled areas showed cytogenetic damage, and these larvae had significantly more physical deformities than those from non-oiled areas. Mortality of Dolly Varden charr (Salvelinus malma) and large cutthroat trout (Oncorhynchus clarki) was 32% and 57% greater, respectively, and growth of cutthroat trout was 68% slower in oiled areas than in non-oiled areas. Spot shrimp (Pandalus platyceros) injuries included reduced recruitment, relative abundance, and fecundity. A high occurrence of gill lesions, indicative of exposure to hydrocarbons, was also documented in shrimp from oiled sites.

C. Principal investigators.

James E. Seeb, Ph.D., Principal Geneticist, FRED Division, ADFG
James J. Hasbrouck, Ph.D., Biometrician II, FRED Division, ADFG

D. Project objectives.

Our goal is to provide technical services and expertise to monitor the genetic effects of chromosome breakage on animal populations inhabiting Prince William Sound. Sublethal petrochemical-related DNA damage caused by the EVOS may reduce performance and fertility, effects which could have major implications in restoring populations damaged by petrochemical toxins. We will use flow cytometry to detect cytogenetic effects via DNA breakages and to monitor the purging of damaged DNA in populations impacted by the EVOS. The objective of the study is to evaluate the short-term and long-term effects of genetic damages at the population level and to monitor the genetic recovery of pink salmon, herring, cutthroat trout, Dolly Varden, and spot shrimp. In providing this technical expertise, samples from other impacted animal populations [e.g. groundfish (Sebastes spp.), harlequin ducks (Histrionicus histrionicus), pigeon guillemots (Cepphus columba), river otters (Lutra canadensis)and sea otters (Enhydra lutris)] could also be analyzed.

E. Project methods.

Blood, gametes, and other tissue (e.g. liver, heart, and muscle), depending on taxa, will be collected from individuals in oil impacted and non-oiled areas. Pink salmon populations will be monitored during various stages in their life history by sampling a) eggs and preemergent fry from intertidal and freshwater zones of streams, b) outmigrating pink fry at oiled and non-oiled streams weired to apply coded-wire tags, c) tagged fry during the early marine phase of life, and d) tagged adults returning to their natal streams. Samples will also be collected from larval and adult herring at two oiled and one non-oiled site, from adult Dolly Varden and cutthroat trout at three oiled and two non-oiled systems, and from adult spot shrimp at four oiled and three non-oiled sites.

Samples will immediately be cryoprotected, frozen on liquid nitrogen, and later stored at -80°C. Replicates (3-5) of 10,000 cells from each sample will be analyzed with a flow cytometer to assess fluorescence intensity, a measure of DNA content. Standard chicken erythrocyte samples will be analyzed as an internal control for each individual. DNA histograms and coefficient of variation values can then be calculated and statistically analyzed to detect differences in DNA breakage.

F. Duration of project.

Pink salmon populations should be sampled for 6 years (3 generations each of odd and even year cohorts); herring populations sampled 4-6 years; and Dolly Varden, cutthroat trout, and spot shrimp populations sampled 4 years.

G. Estimated cost per year:

$150K year 1; $103.5K year 2; $110K year 3; $115.5K year 4; $121.6K year 5; $128.8K year 6

H. Restoration activity or endpoint addressed.

The restoration endpoint is identification of populations with no detectable DNA damage due to the EVOS, populations not recovering from petrochemical-related genetic damages, and populations with continued sublethal chronic exposure to petrochemical toxins.

I. Relationship to science information needs identified by RPWG.

This study will supply technical expertise in monitoring the genetic recovery of populations composing aquatic and terrestrial communities in Prince William Sound. Such efforts have broad ecological ramifications in recovery of ecosystems and food webs. This project will provide an integral component in evaluating the effectiveness of other restoration studies. Finally, key species (e.g. spot shrimp, groundfish, pigeon guillemots, oystercatchers, sea otters) can be monitored as indicators of continued chronic hydrocarbon contamination of the intertidal and subtidal regions.

J. Importance of initiating project in 1992.

Flow cytometry technology was not readily available during the damage assessment phase. Implementation of this study in 1992 is critical to establish the baseline to monitor genome restoration or continued chronic exposure to petrochemical toxins. This baseline data will allow detection of genetic injuries affecting other proposed restoration efforts.

K. Link to NRDA or restoration studies.

This study utilizes results from NRDA studies and will provide an important technical service to restoration studies. Field samples will be collected in conjunction with ongoing NRDA and proposed restoration studies. Morphologic and environmental variables measured in these studies will be related to results from this study.

Current NRDA and proposed restoration studies will continue to monitor pink salmon populations at the egg and preemergent fry stages [NRDA Fish/Shellfish (F/S) Study 2], to coded-wire tag hatchery and wild stock populations (NRDA F/S Study 3), to recover tagged fry during the early marine portion of their life history (NRDA F/S Study 4), and to enumerate adult wild stock escapements (NRDA F/S Study 1). Other NRDA and restoration projects are proposed to monitor herring (NRDA F/S Study 11), cutthroat trout and Dolly Varden (NRDA F/S Study 5), and spot shrimp (NRDA Subtidal Study 5). In addition, a genetic study (Assessment of genetic stock structure of salmonids for restoration planning monitoring) has been proposed.

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Confidential Attorney Work Product

RESTORATION SCIENCE PROPOSAL
1992 FIELD SEASON

Study name:

Salmon stock separation using otolith banding patterns and microchemistry

Injured species to be addressed:

Pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon are a critical part of the ecosystem in Prince William Sound (PWS). The Exxon Valdez oil spill (EVOS) deposited various amounts of oil in intertidal habitats utilized by spawning pink and chum salmon. Up to 75% of the pink and chum salmon spawning occurs in intertidal areas. The proportion of spawning that is intertidal is highest in streams that flow into southwestern Prince William Sound. Salmon eggs from 1988 and all subsequent brood years that were deposited in oiled intertidal spawning areas in western PWS have been contaminated and adversely affected by oil from the EVOS. Emergent salmon fry and smolt from throughout PWS were also damaged when they migrated through and reared in areas where oil contamination was greatest. Injuries from spawning ground contamination include increased mortality of eggs and higher incidence of somatic, cellular, and genetic abnormalities in alevins and fry. Diminished growth and survival have been demonstrated for salmon fry and juveniles which reared in oiled areas of PWS. The observed injuries have lead to declines in numbers, health, and overall fitness of salmon populations in PWS and those effects may persist for many years.

Principal investigator(s) and lead agency(s):

Mark Willette, Area Biologist, FRED Division, ADFG, Cordova
Kenneth Severin, Research Associate, Dept. Geology and Geophysics, University of Alaska Fairbanks
James Hasbrouck, Biometrician, FRED Division, ADFG, Anchorage

Project objectives:

The goal of this project is to develop a practical method for identifying intertidal and upstream spawning salmon from different streams. Salmon eggs in the intertidal zone are exposed to changes in intragravel water temperature and chemical composition with each tidal cycle. Salmon eggs in upstream spawning habitats are exposed to different changes in intragravel water temperature associated with weather patterns. Individual streams or groups of adjacent streams likely possess a unique chemical signature resulting from the geology of the drainage basin. Preliminary results from F/S Study #4 suggest that these thermal and chemical signatures are recorded in the fishes' otoliths.

Understanding population limiting factors requires the ability to identify discrete populations throughout the life history of the organism. Analysis of otolith banding patterns and microchemistry will allow a significant refinement of our ability to study population limiting factors at several life history stages. Homing and straying can be examined much more readily than with coded-wire tagging, because all individuals from the home stream carry a unique mark. Information on homing and straying is essential to determine whether individual streams support reproductively isolated groups of animals. The match or mismatch of fry outmigration timing with optimal growth conditions in the ocean strongly affects the size of adult returns. Monitoring the outmigration timing of intertidal and upstream spawning populations presently involves operation of two weirs on each stream. Analysis of otolith characteristics will allow estimation of fry production from intertidal and upstream habitats without the need to operate two weirs. Studies of the early marine growth and fry-to-adult survival of upstream and intertidal spawning populations will also be greatly facilitated by otolith analysis. This project will focus on the following objectives:

1. Describe natural banding patterns and microchemistry in otolith samples collected from intertidal and upstream areas of streams included in proposed egg/fry dig and wild fry coded-wire tagging studies.

2. Perform a discriminant analysis to determine the set of variables that best reveals differences among the individual spawning habitats and streams.

3. Estimate the number of fry outmigrating from intertidal and upstream spawning habitats at proposed wild fry coded-wire tagging sites.

4. Estimate the size of the adult return to intertidal and upstream habitats in streams included in proposed egg/fry dig and wild fry coded-wire tagging studies.

Project methods:

Otolith samples will be collected from the intertidal and upstream areas of streams included in proposed egg/fry dig and wild fry coded-wire tagging studies. These sites include 15 oiled and 15 control streams. Additional samples may be collected to estimate variability in banding patterns and microchemistry in areas not covered by the egg/fry dig and wild fry coded-wire tagging projects. Otolith thin sections will be prepared at the FRED Division Limnology Laboratory in Soldotna. A Biosonics Image Analysis System will be used to collect pixel luminance data along three radius lines drawn from the focus to the hatch check on each otolith. Principal components analysis will be used to isolate the dominant pattern of variability along the three lines. The elemental chemistry of otoliths will be determined by Dr. Ken Severin with a Cameca SX-50 wavelength dispersive electron microprobe. The spatial resolution achieved by the microprobe is 5-10 um which is more than adequate to analyze the portion of the otolith laid down during the egg stage. A discriminant analysis will performed on the luminance and elemental composition data to determine the set of variables that best reveals differences among the individual spawning habitats and streams.

Otolith samples will be collected from the commercial catch and escapements in conjunction with the proposed coded-wire tag recovery project. Sampling design and sample tracking procedures are presently being developed as part of a planned otolith mass-marking program in Prince William Sound. Rapid otolith processing techniques are being developed by ADFG in Juneau. Otolith samples collected for analysis of natural banding patterns will be channeled into the system being established for the mass marking program. Luminance data will be collected from each otolith at the Juneau laboratory. Samples will then be sent to Fairbanks for elemental analysis by Dr. Ken Severin. Discriminant function analysis will be used to separate the fish from intertidal and upstream habitats and individual streams or groups of streams.

Duration of project:

The first two years of this project will focus on developing processing and analytical techniques and estimating stock-specific production rates at proposed egg/fry dig and wild fry coded-wire tagging sites. Depending on initial results the project may be expanded and continue for several years until pink and chum salmon populations in PWS fully recover from the EVOS.

Estimated cost: $500,000

Restoration activity or endpoint to be addressed:

The endpoint of this project will be a sampling program and analytical technique that can be used to study factors limiting salmon populations and used as a stock separation tool to reduce exploitation rates on damaged wild stocks.

Relationship to science information needs identified by RPWG:

This project will provide a tool for the study of limiting factors affecting discrete populations at several life history stages. Our understanding of the mechanisms regulating salmon populations will be greatly improved. This understanding will enable us to determine appropriate and effective restoration techniques.

Importance of initiating project in 1992:

Initiation of this project in 1992 will accelerate the evaluation and development of otolith analysis as a stock separation tool. Because this methodology may affect the direction of several other restoration projects, it is important that this project begin as soon as possible.

Link to other NRDA damage assessment or restoration studies:

The results from this study will affect nearly every other restoration study proposed for pink and chum salmon. The proposed pink salmon escapement enumeration projects focus on accurately estimating escapement to achieve optimum escapement goals for each stream. Otolith analysis will provide estimates of the productivity of populations utilizing upstream and intertidal spawning habitats. This information will enable refinement of escapement goals for each stream. The proposed pink salmon coded-wire tagging and population monitoring projects focus on estimating population limiting factors affecting discrete stocks and stock specific harvest management. Otolith analysis may be a practical alternative to coded-wire tagging that provides more information at a lower cost.

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Confidential Attorney Work Product

RESTORATION SCIENCE PROPOSAL

1992 FIELD SEASON

Study Name:

Evaluation of wild-hatchery salmon stock interactions during the early marine period

Injured species to be addressed:

Pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon are a critical part of the ecosystem in Prince William Sound (PWS). The Exxon Valdez oil spill (EVOS) deposited various amounts of oil in intertidal habitats utilized by spawning pink and chum salmon. Up to 75% of the pink and chum salmon spawning occurs in intertidal areas. The proportion of spawning that is intertidal is highest in streams that flow into southwestern Prince William Sound. Salmon eggs from 1988 and all subsequent brood years that were deposited in oiled intertidal spawning areas in western PWS have been contaminated and adversely affected by oil from the EVOS. Emergent salmon fry and smolt from throughout PWS were also damaged when they migrated through and reared in areas where oil contamination was greatest. Injuries from spawning ground contamination include increased mortality of eggs and higher incidence of somatic, cellular, and genetic abnormalities in alevins and fry. Diminished growth and survival have been demonstrated for salmon fry and juveniles which reared in oiled areas of PWS. The observed injuries have lead to declines in numbers, health, and overall fitness of salmon populations in PWS and those effects may persist for many years.

Principal Investigator(s):

Mark Willette, Area Biologist, FRED Division, ADFG, Cordova
James Hasbrouck, Biometrician, FRED Division, ADFG, Anchorage

Project objectives:

Hatcheries release approximately 600 million juvenile salmon into PWS annually. Large numbers of hatchery fry may reduce the fry-to-adult survival of damaged wild stocks and inhibit wild stock restoration efforts. Two mechanisms may function to reduce the fry-to-adult survival of damaged wild stocks. First, large numbers of hatchery fry may affect the feeding, growth, and predation rates of wild and hatchery fry equally. In this case, the feeding, growth, and predation rates of the two groups will not differ, but wild fry will be negatively impacted by the presence of hatchery fry. Second, large numbers of hatchery fry may affect the feeding, growth, or predation rates of wild and hatchery fry differently. Negative interactions of this type are most likely to occur when hatchery fry are consistently larger than wild fry. This project will focus on the following objectives:

1. Determine the impacts of fry density on prey size composition and stomach fullness, condition, and growth rate of fry.

2. Determine whether size, condition, stomach fullness, growth rate, and prey size composition of fry are significantly different between hatchery and wild fry captured in mixed schools.

3. Determine whether the frequency of occurrence of hatchery and wild fry in the stomachs of predators captured near mixed fry schools are significantly different.

Project methods:

The sampling design for this project will utilize the natural distribution of salmon fry schools. Results from NRDA F/S Study #4 indicate that high and low fry densities persist in different nursery areas for periods of a week or more. Ten replicate sampling areas will be selected in areas of high and low fry density. A pairwise comparisons will be made between areas of high and low fry density. Particular sample sites within paired high and low fry density groups will be selected for similarity of water temperature, zooplankton density, average current speed, beach gradient, and macrophyte coverage. Mixed schools of hatchery and wild fry are often found adjacent to hatcheries and in the southwest passages of PWS. A stratified design will be employed for sampling mixed schools. Sample strata will be based on water temperature, zooplankton density, average current speed, beach gradient, and macrophyte coverage.

Fry density will be estimated with a side-scan sonar operated from a skiff. Small mesh beach and purse seines will be used to capture fry. The abundance of epibenthic prey will be estimated from replicate samples taken with an epibenthic sled or pump. The abundance of pelagic zooplankton will be estimated from replicate samples taken with a 0.5 m ring net towed vertically from 20 m depth. The condition of fry will be evaluated from length-weight regression parameters. Fry wet weight will be estimated after the viscera have been removed. Fry stomach contents weight will be estimated by the product of prey frequency and average weight. Fry growth rate will be estimated for weekly time periods by the distance between each seven increments along a standard otolith radius line. A Biosonics image analysis system will be used to collect luminance profile data from juvenile salmon otoliths. Predator abundance will be estimated from catches in variable mesh monofilament gill nets set adjacent to fry nursery areas. Gill nets will be checked at two hour intervals to minimize prey digestion. Stomach contents will be immediately removed and otoliths extracted. Induced and natural otolith banding patterns and otolith microchemistry will be used to identify hatchery and wild fry otoliths removed from predator stomachs.

Duration of the project:

This study will continue for 3-5 years depending on project results. The effects of hatchery fry on wild fry will likely differ from year to year depending on zooplankton abundance, water temperature, wild fry outmigration timing, and predator abundance.

Estimated costs: $600,000

Restoration activity or endpoint to be addressed:

Project results will be used to determine whether hatchery fry releases inhibit wild stock restoration efforts. Increased hatchery production has been followed by a general decline in wild stock abundance. This decline may be due to changing environmental conditions, but further study is needed to firmly establish the cause. It is necessary that this potential problem be investigated to insure that salmon restoration efforts are effective.

Relation to science information needs identified by RPWG:

This project will provide information on a mechanism that may be limiting the size of wild stock salmon populations in PWS. Project results will further contribute to our understanding of the juvenile lifestage and its effects on salmon population dynamics. This project will also provide information on the ecological role of juvenile salmon and other forage fishes in PWS that will be useful for evaluation of restoration methods.

Importance of initiating project in 1992:

This project should be initiated as soon as possible because results will affect other restoration projects. However, it would be very difficult to initiate this project in 1992 without an immediate commitment of funding.

Link to other NRDA damage assessment or restoration studies:

Evaluation of hatchery-wild stock interactions will be greatly facilitated by otolith mass marking, and analyses of otolith microchemistry and natural banding patterns. These techniques will allow identification of hatchery and wild fish in predator stomachs. Recoveries of coded-wire tagged fry released from streams with and without fry rearing will provide information of fry migration routes and growth rates. The early marine mortality rates of genetically damaged stocks will be estimated from samples collected for cytogenetics studies.

A. Prince William Sound Mines and Canneries Hazardous Site Assessment

B. Recreational resource impacts associated with increase use of Prince William Sound.

C. Carol Huber, Chugach National Forest; Chris Roe, Bureau of Mines

D. Inventory abandoned mine and cannery sites throughout Prince William Sound. Approximately 200 sites are known within the Sound on Federally administered lands. Identify on site hazards to the public and environment. Potential environmental contaminants such as PCB's, mercury, other heavy metals, and petroleum products are suspect on many of the sites. In addition physical hazards such as open mine shafts, rotten internal timbers within shafts, vertical shafts, partially caved and unstable adits, poor mine ventilation, collapsing wood frame structrues such as stamp mills, and abandoned explosives are known to exist at mine sites within the Sound. The inventory of such hazards would be followed up with recommendations to protect the public and environment.

E. In 1991 the Forest Service and Bureau of Mines cooperatively began to survey abandoned mine and cannery sites in Prince William Sound. Inventory methods include literature research, certified mine examiners visiting each site and recording hazards found at those sites, and development of remediation measures for those hazards found. Sites were accessed by helicopter and boat during the summer field season. All sites investigated in 1991 showed sign of recent public visitation. Most of the sites are popular hiking and recreation areas for the general public.

F. Initial examinations are preliminary to determine the scope of the problem. The preliminary investigations would take two to five years to complete depending on intensity of survey. Utilizing results of these surveys mitigation of environmental and physical hazards could be developed. This project would be considered the first phase of determining the extent of the problem to lead into on-site cleanup.

G. $100,000 per year. Costs include:

30 days Contract Vessel @ $1000/day $30,000
13.3 hours Helicopter @ $750 /hr $10,000
Crew of 3 @ $600/day for 60 days $36,000
Overtime/travel/housing/supplies $14,000

H. Enhance recreation experience and opportunities at ruins that attract visitation in Prince William Sound.

I. This project would be linked to any recreation development proposed for Prince Willaim Sound or public education designed to increase visitation to the area.

J. As a result of increased awareness of Prince William Sounds resources by people involved in the oil spill clean up, Damage Assessment process, or news information about the Sound, visitation to hazardous mining ruins has increased. This has resulted in a management need to deal with hazardous sites that was not present before the oil spill. As public recreation increases in the Sound the probability of injury from hazards at the mine and cannery sites will increase. The environmental contaminants, if removed will lessen the total amount of these types of contaminants within the Sound.

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Title: COASTAL HABITAT COMPREHENSIVE INTERTIDAL MONITORING PROGRAM

Injured species to be addressed: Key elements of the intertidal community

Principal Investigator: Dr. Raymond C. Highsmith, Coordinator
Institute of Marine Science
University of Alaska Fairbanks
Fairbanks, AK 99775-1080
(907) 474-7836

Co-Principal Investigators:

Dr. Mike Stekoll (Algal Studies)
University of Alaska
Juneau Center for Fisheries and Ocean Sciences
11120 Glacier Highway
Juneau, Ak 99803
(907) 789-4579

Dr. M. Dale Strickland & Dr. Lyman L. McDonald (Statistical Cons.)
WEST, Inc.
1406 S. Greeley Highway
Cheyenne, Wyoming 82007
(307) 634-1756

Dr. Willard Barber (Fish Studies)
School of Fisheries & Ocean Sciences
University of Alaska Fairbanks
Fairbanks, AK 99775-1080
(907) 474-7177

Lead Agency: USFS, Univ. of Alaska Fairbanks, National Park Service (tentative)

INTRODUCTION

The intertidal portion of the Coastal Habitat Damage Assessment Study was designed to measure the effects of the *EXXON Valdez* Oil Spill (EVOS) on marine invertebrates, fish, and plants at the community level. The study encompassed all three geographic regions affected by the oil and contributed greatly to the understanding of the ecology of these communities. The basic design of the studies provided inductive statistical inferences of damage to the entire universe of oiled habitats because of the random selection of sites within habitat categories. Thus, the results of these studies can be applied in the assessment of damage to other components of the community including higher trophic levels of interest because of economic or aesthetic considerations. In addition to damage assessment on a regional basis, experiments in Herring Bay on Knight Island provided more detailed basic information on specific sites and the impact of oil on relationships between organisms. These experiments helped focus regional inventories and analyses of regional data.

A major criticism of most studies on the oil effects is that very few pre-spill studies had been made of coastal habitat in

Prince William Sound, Cook Inlet-Kenai Peninsula and the Kodiak Island-Alaska Peninsula. These regions are highly variable. Jacqueline Michel of Research Planning, Inc., stated in the October 1991 Issue of the *Scientific American*, "Everyone can find data to support his or her position." In spite of the lack of pre-spill data, the matched pair design of our Intertidal Damage Assessment study allowed detection of significant oil effects by controlling for spatial and temporal variation such as the confounding effects of major natural climatic events. We believe our study design is the only one based on scientific sampling of sites from all impacted regions for the purpose of estimating oil effects with statistical measures of accuracy and precision. Our study may be the only one not subject to Michel's criticism.

This proposal is designed to monitor selected invertebrates, fish and plants in the intertidal community so that community recovery from oil effects and response to any future perturbations can be measured. In addition, knowledge of the population dynamics of these organisms is a necessary element in recovery studies of higher trophic level organisms (i.e., birds, mammals, fish) which depend on intertidal organisms for food and the intertidal area for habitat. Study sites will include the Herring Bay experimental sites (per instructions, the renewal proposal for Herring Bay experiments will be submitted in late Nov.) and certain habitat categories from the stratified random sample of oiled and control sites studied for the last 2-3 years. Emphasis will be placed on organisms that showed statistically significant oil effects and/or are important elements of the intertidal community. The basic design of the Coastal Habitat Damage Assessment Study has been retained so that regional recovery can be monitored and evaluated by statistical procedures. Thus, issues of community condition and recovery will not be clouded by spatial variation and natural temporal fluctuations in the environment.

OBJECTIVES

The overall objective of the study is to conduct a comprehensive monitoring program of intertidal communities in the area impacted by the EVOS. To be comprehensive, the study will include oiled and matched control sites, from which we have a valuable historical record of post-spill data, in all three regions impacted by the oil spill (PWS, Cook Inlet/Kenai Peninsula, Kodiak/Alaska Peninsula), and a variety of habitats (sheltered rocky, coarse textured, estuaries). Within these sites, we will focus on the recruitment and population dynamics of key species as determined by their role in the community (indicator species, spatial dominants, annual vs perennial algae, grazers, predators).

METHODS

The basic study design implemented in the Coastal Habitat Damage Assessment Study will be maintained as a means of monitoring the recovery of randomly selected oiled sites compared to their matched controls. Statistical inferences comparing a specific oiled site with its control will be made by appropriate statistical tests based upon subsamples within each site. These tests will include standard parametric and non-parametric tests, as required, for the scientific hypotheses formulated concerning faunal and floral parameters indicative of community condition.

A subset of sites studied during the Coastal Habitat Damage Assessment Study will be used for the monitoring study. For site selection procedures and general approach to intertidal studies, see Coastal Habitat Study #1, Phase I and Phase II, for 1990 and 1991. We propose to monitor three oiled sites and three matched control sites for sheltered rocky, coarse textured, and estuarine habitats in all three regions (PWS, CIK, KAP). As the flora and fauna change seasonally due to recruitment, growth and mortality, each site will be visited twice per season. Field methods will be simplified from the SOPs given in the study plans mentioned above. We will utilize a repeated measures design for floral and faunal censuses in existing permanent quadrats at our oiled and control sites to track recovery. To analyze interannual recruitment variability, supplemental quadrats will be cleared each year (sheltered rocky only). Key organisms will be identified and counted in the field and the data recorded on-site. To focus efforts, only important members of functional groups such as spatial dominants, grazers, and predators will be studied. Examples from these groups include *Fucus*, barnacles, mussels, limpets, *Nucella* and *Leptasterias*. *Fucus*, *Nucella*, and *Leptasterias* are also of interest because they lack dispersal phases in their life histories. Minor constituents of the fauna and flora will not be studied. For large but less abundant organisms that play a role in structuring the intertidal community, such as predatory seastars, 2-m wide swaths parallel to our permanent transects will be surveyed. The identity, number and size of the animals will be recorded. Samples will not be collected, other than for hydrocarbon analyses and for such activities as mussel histology and growth and limpet growth. Low intertidal fish will be collected, where present, for a variety of measurements that would not be practical in the field. Data will be collected directly in the field by experienced personnel, eliminating the need for extensive photography and subsequent cataloging and analyses of thousands of slides. By eliminating the need for extensive laboratory sample analyses, data analysis can proceed immediately after the field work.

For the habitat classifications studied, statistical inferences to the universe of oiled sites within the habitat class can be made because of the random selection of oiled sites. It is anticipated that these statistical inferences will be made by using Fisher's Procedure for combining significance levels from the comparison of matched pairs.

DURATION

The study should be conducted for a minimum of five years.

ESTIMATED COST

Equipment and remaining supplies purchased for the Coastal Habitat Damage Assessment Study will be used for this project. In addition, personnel trained on the Damage Assessment Study will participate in the monitoring work. The budget given below includes continuation of the Herring Bay restoration studies initiated in 1991 (proposal to be submitted in late November per instructions). Because the Herring Bay restoration studies and the monitoring study proposed here will use some of the same logistic support and have the same principal investigators and administrative personnel, we did not separate out the budgets. The budget given below does not include the cost of hydrocarbon analyses.

We are negotiating with the National Park Service (Dr. Gail Irvine) to work collaboratively on this project, particularly with regard to sites within the Kenai Fjords and Katmai National Parks. We have not had time to work out details but a possible arrangement would be for the Park Service to provide logistic support (or funds for logistic support) and we would supply trained personnel.

<u>Budget</u> (3/1 - 9/30/92):

University of Alaska:		
Salaries and benefits		1,070,040
Logistics		609,500
Travel		40,000
Equipment		22,500
Supplies		22,500
Indirect costs (20%)		352,908
	TOTAL	$2,117,448
WEST, Inc.*		
Statistical consulting		$74,376

*Separate contract with USFS

RELATIONSHIP TO SCIENCE INFORMATION NEEDS IDENTIFIED BY RPWG

The guidance provided by the Oil Spill Restoration Planning Office was followed by considering the following needs when preparing this proposal:

1. Improve understanding of the long-range underlying mechanisms causing injury or limiting populations.

Intertidal organisms and habitats are key components of the marine environment affected by the EVOS. The organisms represent primary producers, grazers and predators, many of which provide forage for both marine and terrestrial animals at higher trophic levels. The intertidal zone also provides important habitat for various life stages of a variety of organisms. Knowledge of the dynamics of this community is an essential element in understanding the population dynamics of vertebrates, such as shore birds or otters, inhabiting the coast. For example, if a shorebird population declined, it would be essential to have data on the condition of prey populations and the habitat in order to identify or at least eliminate possible causes. The proposed study is designed to provide information necessary to understand the coastal community and its dynamics.

2. Focus beyond Prince William Sound.

The intertidal damage assessment study was designed to measure damage throughout the area affected by the EVOS. Baseline data exist for oiled sites and control sites for the entire area and it is important to maintain basic data on this important component of the coastal system. Our monitoring proposal retains a system-wide focus.

3. Emphasize broader ecological rather than species-specific approaches.

Intertidal monitoring is designed to look at important elements of the intertidal community by focusing on important habitats and a complex of species which showed significant effects of the EVOS and are expected to illustrate recovery from those effects and/or are important components of this community. The expertise and experimental approach is in place to address the intertidal community. It is essential to communicate with scientists needing population and community information from intertidal studies for application to studies of other community components such as higher vertebrates.

4. Analyze the linkages between predators and prey.

The intertidal study is designed to provide statistically defensible estimates of abundance and distribution of intertidal organisms. Data can be analyzed by functional group such as primary producer, filter feeder, grazer, or predator. More specific analyses can also be made, such as the abundance of *Nucella* spp. relative to mussel or barnacle prey. Not only will these data be useful in estimating damage due to the EVOS but they will provide estimates of natural variation in the system and will allow for rapid assessment of future disturbances, especially those that specifically impact certain species or trophic groups. The study is designed to also provide data on elements of the intertidal community which may not have been affected by oil but represent important components of the community. Many intertidal species represent important prey for marine or terrestrial vertebrates and linkages to relevant studies should be developed.

5. Monitor ecosystem recovery.

This study is primarily concerned with monitoring recovery of components of the intertidal community which demonstrated effects of the EVOS. However, the community approach will provide data which will allow studies of higher trophic levels to interpret changes in the dynamics of those populations and differentiate between recovery responses on oiled sites and responses to natural environmental fluctuations in habitat (prey) on the control sites. A key to identifying and tracking oil effects and recovery is maintenance of the treatment/control design.

6. Synthesize the effects of environmental disturbances (e.g., logging) on EVOS-injured species.

Pathways for effects on populations/communities will likely involve habitat changes. Monitoring of recovery of the intertidal community on oiled and control sites will help partition the effects of oil and other environmental perturbations, both man-caused and natural.

7. Monitor the fate of weathering oil, including in mussel beds.

Sites included in the Coastal Habitat study contain mussel beds representative of the area affected by the EVOS, e.g., the sheltered rocky and coarse textured sites. These mussel beds were sampled in proportion to availability by the methodology used. Data obtained include density and biomass, growth rates, age-frequency distribution, and reproductive condition. Samples were also analyzed for hydrocarbon content. Continued monitoring of these beds by the same methodology is planned. In addition, monitoring of mussel beds on coarse textured pocket beaches, which may be prone to retaining oil, of the protected rocky habitat sites was conducted in 1989 and will be reinstated into the sampling protocol. For these sites, hydrocarbon analyses should be done on samples of sediment from under the mussels. Monitoring mussel beds associated with our randomly chosen sites will allow statistical extrapolation of the results. We recommend focusing the oiled mussel bed studies in Herring Bay, in conjunction with studies of oystercatchers and other predators on mussels.

IMPORTANCE OF INITIATING PROJECT IN 1992

To properly document the events and timecourse of recovery, a continuous record is needed. The sites to be monitored have been studied since 1989 or, in some cases, since 1990 in order to determine the extent of oil spill damage and to develop estimates of recovery rate. It is critical that a continuous historical record be maintained at oiled and matched control sites so that natural variability and fluctuations can be distinguished from oil spill impacts.

LINK TO OTHER NRDA DAMAGE ASSESSMENT OR RESTORATION STUDIES

This study basically represents a continuation of the Coastal Habitat Damage Assessment study, and utilizes the knowledge gained at representative sites throughout the spill region to initiate a long-term recovery monitoring program. The budget includes funding for continuation of restoration studies initiated in Herring Bay in 1991 (proposal to be submitted in late November). We also plan to collaborate with the National Park Service (Dr. Gail Irvine) in conducting intertidal studies in the Kenai Fjords and Katmai National Parks (see Budget section). This collaboration could result in adding a few sites to the study, which would strengthen the overall monitoring effort.

66

A. Project Name

Prince William Sound Resource and Oil Spill Interpretation

B. Injured Species

All plant and animal life affected by the oil spill

C. Principal Investigator and Lead Agency

Steve Hennig, Glacier Ranger District, Chugach National Forest

D. Project Objectives

The objective of this project is to provide current information to a large number of people from all over the world about the oil spill, the many injured species, results of the various studies, efforts underway for restoration and where and how people can use/recreate in the Sound.

Information will be disseminated from the Begich, Boggs Visitor Center, the MV Bartlet and the Glacier Ranger District Office, Girdwood.

A combination of brochures, displays, videos and personal contacts would be used to present the information.

E. Project Methods, including technical feasibiltiy

A combination of methods will be used depending on the location.

The first method, and possible to implement immediately, is to provide information at the Begich, Boggs Visitor Center and aboard the VV Bartlet through personal contacts and programs on the oil spill, injured resources, restoration activities and recreation use in Prince William Sound. Specific programs on topics can be prepared and ready for use by the tourist season, 1992.

Programs at the Vistor Center, the most visitied place in the State of Alaska, will reach a large number of people with factual information on resources and oil spill related activities. Programs aboard the MV Bartlet will provide much the same information while traveling through Prince William Sound between Whittier, Valdez and Cordova.

Topics for programs, displays and presentations could include a historic perspective of the oil spill and clean-up, information on specific plant and animal species affected by the spill, damage assessment results, restoration projects and current recreation opportunities in Prince William Sound.

Brochures and displays are just as feasible but will take a little longer to prepare. Brochures can be distributed from almost any location with emphasis on the Glacier Ranger Station in Girdwood and the Begich, Boggs Visitor Center. A major display will be developed for the Begich, Boggs Visitor Center focusing on the oil spill and its affect on the resources of Prince William Sound and the people who live and use the Sound.

F. Duration of the Project

This project is proposed as a long-term, on going, project to continue as long as there is interest in the oil spill or the restoration activities; estimate 10 years minimum.

G. Estimated Cost (1991 dollars)

Calendar Year	1992	$ 198,000	Staffing, housing & design/fabrication/ printing of brochures and displays
	1993	198,000	Staffing, housing & design/fabrication/ printing of brochures & displays
	1994	153,000	Staffing, housing & design/fabrication/ printing of brochures & displays
	1995	108,000	Staffing, housing & design/fabrication/ printing of brochures & displays
	1996	83,000	Staffing, housing & design/fabrication/ printing of brochures & displays
		83,000	This is the annual estimated cost for the last 5 years

H. Restoration Activity or Endpoint to be Addressed

This proposal is intended to to provide accurate information and educate people on all aspects of the Exxon Valdez oil spill, the clean-up effort and the effect on the resources and people of Prince William Sound.

I. Link to Other NRDA Damage Assessment or Restoration Studies

This proposal is linked to all damage assessment and restoration studies. While many animal or plant species were directly or indirectly affected by the oil spill, it is the concern and interest of people about these effects that links this proposal to damage assessment and restoration activities.

J. Importance of Initiating Project in 1992

People visiting the Begich, Boggs Visitor Center and Prince William Sound aboard the MV Bartlet are still very interested in the facts of the oil spill, the known effects and what projects or activities are on-going to restore the damage done as well as learn about the safety measures in place to prevent another accident. These people are receptive to information because the incident is still relatively recent. With a receptive audience, it is easier to get more information to them on the spill, clean-up, damage assessment and restoration activities.

MOSS LANDING MARINE LABORATORIES
CALIFORNIA STATE UNIVERSITY FRESNO. HAYWARD. SACRAMENTO. SAN FRANCISCO. SAN JOSE. STANISLAUS

P. O. BOX 450
MOSS LANDING . CA USA
95039-0450
(408) 633-3304

8 November 1991

Stan Senner
Oil Spill Restoration Planning Office
437 E Street, Suite 301
Anchorage, Alaska 99501

Dear Mr. Senner,

Please find enclosed a copy of our proposal in response to your memorandum "Restoration Science Needs and Preparation of Proposals for 1992."

We think our intertidal work should be among the best that the RPWG will receive, especially on a per dollar basis (our budget for two years was roughly $60,000, including overhead from both the University of Alaska and Moss Landing Marine Labs). Initially we sampled upper intertidal Fucus assemblages to describe damage and recovery following different cleaning intensities, and also permanently marked tarred areas to determine weathering rates. We used correlative data to develop hypotheses about the causes of variable Fucus recovery, and initiated a three factor field experiment to test the hypotheses. We've continued monitoring sites, and did some transplant experiments to test one possible restoration technique. The upper Fucus zone is not recovering. This zone represents a large portion of the intertidal habitat in Prince William Sound, especially where the shore has a gentle slope. We would now like to use our results to develop restoration studies that make sense biologically and are economically feasible. Our carefully designed trial restoration experiments will help answer both academic and applied questions.

We look forward to your response.

Sincerely,

Andrew De Vogelaere   Michael S. Foster

Dr. Andrew De Vogelaere and Dr. Michael S. Foster

Proposal to the
Oil Spill Restoration Planning Office
1992 field season

Overview

The upper intertidal zone in Prince William Sound is dominated by the brown alga Fucus gardneri. Much of this zone was heavily oiled and intensely cleaned during the *Exxon Valdez* oil spill, and our studies indicated that it will not recover soon. This extremely high intertidal habitat normally harbors a number of associated invertebrates and is commonly used by terrestrial organisms. Based on our results, we propose a trial of three restoration methods for this habitat. We also propose to continue ongoing studies on the underlying mechanisms of high intertidal Fucus recovery. The proposal is presented as a new versus continued study even though a portion of the proposed work contains a previous study. A new proposal will allow us to streamline our currently circuitous funding route through the University of Alaska, a route that has resulted in frequent crippling delays and hidden indirect costs.

A) Name of study

High intertidal Fucus recovery and restoration following the *Exxon Valdez* oil spill.

B) Injured species to be addressed

Fucus gardneri.

C) Principal investigators and Lead agency

Drs. Andrew P. De Vogelaere and Michael S. Foster
Moss Landing Marine Laboratories
P.O. Box 450 Moss Landing, CA 95039
(408) 633-3304 FAX (408) 753-2826

Lead agency: In the past it has been the EPA, this may or may not be appropriate in the future.

D) Project objectives

The upper half meter of the Fucus zone has not recovered from the *Exxon Valdez* oil spill. Even after three years, we estimate that 10 hectares of rocky shore in Herring Bay alone are still nearly barren, while control areas average 80 percent cover of Fucus. This high intertidal habitat is unique because it is almost always exposed to air. This means that it is a harsh environment for recruitment and recovery, but also important to shorebirds and terrestrial organisms that frequent the intertidal habitat. We propose to study the underlying mechanisms limiting Fucus populations and test restoration methods. Our project objectives are:

1) Perform an analysis of cost vs. benefit for three restoration techniques: (a) a trickle irrigation system, (b) a biodegradable substratum modifier, (c) and cobble assemblage transplants.

2) Continue monitoring a field experiment on the causes of variable recruitment in the high rocky intertidal zone.

3) Continue monitoring permanently marked rocky shore sites where natural weathering of tar is taking place.

4) Continue monitoring recovery at sites categorized as intensely cleaned, less intensely cleaned, and controls.

E) Project methods

1) Restoration

A) *Trickle irrigation system* . Our preliminary results (see appendix A) indicate that Fucus survivorship is higher and growth is faster in moist conditions. We would enhance the moisture on upper intertidal substrata by placing an inexpensive PVC trough at the upper fringe of the upper Fucus zone. The trough would be designed to fill with sea water at high tide, and drain slowly to the region below to modify this otherwise harsh environment. Areas with and without humidity enhancement troughs would be compared for the number of Fucus recruits and their growth rates.

B) *Biodegradable substratum modifier*. Our preliminary results (see appendix A) indicate that Fucus recruitment is mainly in cracks as well as other moist habitats. Large (one inch diameter) removable/biodegradable (i.e. hemp) ropes with cobble anchors will be used to enhance catchment crevices and moisture. The ropes will be stretched across the high intertidal zone parallel to shore. They will create crevices where they contact the substratum, and increase moisture by absorbing seawater at high tide and releasing it slowly as the tide falls. This should provide a second method for enhancing conditions for recruitment and growth of Fucus. Again, replicate areas with and without the biodegradable substratum modifier would be compare for the number of Fucus recruits and their growth rates.

C) *Cobble assemblage transplant.* Last season we transplanted individual Fucus plants, but their survivorship was poor (appendix A). The highly exposed microenvironment and modified stipe orientation seem to have caused the mortality. Transplanting entire cobbles with mature Fucus assemblages may be the innovative solution to the transplant mortality problem. Cobble orientation is simple to maintain and groups of Fucus plants create their own moist microhabitat during low tides. Cobbles would be transplanted from unoiled areas and wedged into cracks at restoration sites. Their survivorship and ability to "seed" surrounding areas with recruits will be monitored.

These restoration techniques are technically feasible, and biologically sound according to our preliminary results. They are also simple and inexpensive, and so could be easily used for large scale restoration projects. The time it takes to deploy the restoration methods, the cost of the materials, and the enhanced recruitment and growth of Fucus will be analyzed in a cost/benefit format for future management decisions.

2-4) Continuing studies

2) *Variable recruitment experiment.* We are currently running a three factor (rugosity, canopy shading, and presence/absence of local adults) field experiment on the recruitment of Fucus. This experiment will provide more definitive tests of our tentative hypotheses that are based on correlations. Funding for an additional season is essential for the experiment to run through the high recruitment and growth period of the early spring.

3) *Weathering of tarred rocky shores.* Permanently marked tarred areas resulting from Exxon Valdez oil have been followed photographically through time. This information is essential for answering questions about the natural weathering rates of oil in Prince William Sound.

4) *Monitoring recovery of the high Fucus zone.* In the first two years (appendix A and B), recovery of Fucus and associated organisms was extremely slow. Knowing recovery rates is important to management decisions concerning effects and need for restoration.

These studies (2-4) are all in progress, so they have already been determined as technically feasible.

F) Duration of the project (number of seasons)

Two field seasons, spring and summer of 1992 and 1993.

G) Estimated cost	Year 1	Year 2
Boat charter	$ 28,000	$ 28,000
Travel	$ 12,600	$ 12,600
Equipment/supplies	$ 16,450	$ 500
Salary	$ 24,000	$ 24,000
Indirect costs	$ 28,125	$ 22,590
total	$ 109,175	$ 87,690

H) Restoration activity or endpoint to be addressed

The restoration activities for the un-recovered upper rocky intertidal zone are tests of two habitat modifiers and a transplant method (described above) expected to increase the recovery of Fucus. The endpoints addressed are numbers of two year old recruits vs. unmanipulated controls for the habitat enhancement studies, and recruits around and survivorship of adults after two years for the transplanted cobbles study. If these methods are successful, their relative merits will be evaluated as cost vs. benefit analysis.

I) Relationship to science information needs identified by RPWG

The following are RPWG science information needs addressed by this proposal: improved understanding of long-range underlying mechanisms limiting populations (p. 1, RFP), monitoring ecosystem recovery (p. 1, RFP), and monitoring the fate of weathering oil (p. 2, RFP). We would like to reiterate that the upper Fucus zone appears to be the most prominent habitat in need of restoration work.

J) Importance of initiating project in 1992

It is important to initiate restoration studies while the areas still need restoration. It is unclear how long the upper Fucus will need restoration work but, given lack of recovery so far observed, it is logical to initiate restoration as soon as possible. The continuing studies should be done in 1992 to finish previously initiated experiments and continue monitoring recovery.

K) Link to other NRDA damage assessment or restoration studies

This proposal is developed directly from the results of a current NRDA study (appendices A and B). We have also been coordinating with Drs. Mike Stekoll and Raymond Highsmith, who have initiated other intertidal studies in Herring Bay. Their work has focused on lower intertidal regions than ours, but their studies have provided data on Fucus zygote availability and Fucus growth rates of relevance to our studies. We believe that our unique restoration techniques, rare tar weathering data, and method for categorizing cleaning intensity will complement other NRDA studies to assist in current and future damage assessments and restoration decisions.

Appendix A:

Preliminary conclusions from a final report (in preparation, due December 1991) to the EPA.

1) Three years after the *Exxon Valdez* oil spill and clean-up effort, the percent cover of Fucus and number of Fucus recruits in the upper half meter of its tidal range is significantly lower in cleaned versus control sites (percent cover differs by 80 % and recruits by 60 per 100 cm^2).

2) Trends in the data strongly indicate that cleaning intensity slowed Fucus recovery.

3) Fucus recruitment was negatively correlated with smooth rock surfaces and substrata covered with tar, and positively correlated with crevices. This appears to be a response to moisture and being held in place, and not a refuge from grazing.

4) Tar deposits in the high intertidal zone are weathering rapidly, and bare rock is now present at most of the permanently marked tar areas.

5) Fucus recruitment is positively correlated with the local presence of adult plants (source of zygotes and moisture), but significantly lower under adult canopies versus adjacent open areas.

6) Percent survival of transplanted Fucus individuals of two sizes and to two tidal heights was significantly lower than that of un-manipulated control plants.

7) While settlement of Fucus zygotes in the high intertidal zone may be frequent (L. Deysher, personal communication), survivorship of recruits appears to be episodic, and growth is slow. One field season in Prince William Sound is not adequate to study the factors affecting upper intertidal Fucus recovery parameters.

Appendix B

December 1990

Status Report:

FUCUS RESTORATION PROJECT

(University of Alaska, Fairbanks contract No. 53-0109-9-00276 Mod #4)

Prepared by

A.P. De Vogelaere
&
M.S. Foster

Moss Landing Marine Laboratories
P.O. Box 450
Moss Landing, CA 95039

SUMMARY

This is a report on our initial (September 15-24, 1990) field work in Herring Bay, Prince William Sound, Alaska. The objective of our project is to understand the causes of variation in Fucus recovery relative to cleaning techniques and microhabitats in areas affected by the Exxon Valdez oil spill in Prince William Sound. An understanding of Fucus recovery should suggest possible restoration techniques for this dominant intertidal alga. Over a nine day period, high intertidal sites that were subjected to different cleaning intensities (no oil, oil/intense cleaning, oil/less intense cleaning) were sampled for all species, and a series of factors (grazer species and abundance; presence/absence of local Fucus adults; substratum type, slope, and relief) were correlated with the abundance of Fucus recruits. The abundances of most, but not all species, in oiled and cleaned sites were significantly different from un-oiled areas (different: Fucus, Littorina sitkana, L. scutulata, Limpets, tar; not different: Balanus glandula, species richness). There were strong trends indicating that higher cleaning intensity slowed recovery of Fucus, but high between site variability precluded statistically significant results. The preferential substratum for new Fucus recruits was fine rock cracks. No recruits were found growing on high intertidal tar. The presence of adult Fucus plants was positively correlated with local Fucus recruitment. This preliminary study provides a solid background for field experiments to begin in spring, 1991.

OBJECTIVES

The general objectives of this study are to understand the causes of variation in Fucus recovery in areas affected by the Exxon Valdez oil spill in Herring Bay, Prince William Sound, and to document the extent and magnitude of natural recruitment of Fucus in areas subjected to different intensities of cleaning.

INTRODUCTION

The alga Fucus gardneri (Silva) forms large beds throughout the rocky intertidal zone of Prince William Sound. Its canopy ameliorates this harsh habitat, providing food and a place to live for a wide range of intertidal as well as open ocean and terrestrial species. Fucus recovery varied between sites after the Exxon Valdez oil spill. By understanding the causes of this variation, methods to enhance Fucus restoration should become clear. Additionally, by comparing recovery in areas where the intensity of cleaning differed, we are assessing the relative benefits of effectively removing oil versus Fucus recruitment potential.

While some observations were made on the exposed coast at the mouth of Herring Bay, Knight Island, all quantitative data were collected within the bay (Figure 1). This report is on preliminary survey work done during September 15-24, 1990. The correlative data in this report will be used to design field experiments to be done in spring, 1991.

METHODS

Cleaning Intensity Versus Recovery

Three site treatment categories (based on cleaning intensity) were chosen: (1) Controls- no oil and no cleaning (2) Intensely cleaned- no distinct continuous oil band on the high intertidal zone, apparently severely damaged mid intertidal zone (based on number of Fucus holdfast remnants and maturity of present Fucus plants) (3) Less intensely cleaned- distinct oil band on the high intertidal zone, apparently healthier mid-intertidal Fucus. Though it is impossible to pin-point intertidal clean up history at the scale of meters, available ADEC shoreline assessment information indicates that our intensely cleaned category of sites received relatively higher pressure and warmer water cleaning. The sites all had similar wave and wind exposure.

Sampling was accomplished in two replicate sites of each cleaning intensity category. A transect tape was laid across each study site at the + 8-9 ft tidal mark in the high Fucus zone. Tidal height was found using a stadia rod, line level, and tidal charts. Five 50 x 50 cm quadrats were placed randomly along each transect tape. In each quadrat, percent cover was estimated by identifying species which came in contact with a pin lowered at 16 points delimited by evenly spaced cross-hairs in the quadrat. Macro-grazers and individual Fucus plants were also counted and the quadrat was photographed.

Some areas were permanently marked to monitor recovery on tar versus directly adjacent cleaned rock in the high Fucus zone. Thirty-five pairs of tar and non-tar areas were marked with numbered tags epoxied to the rock, recruitment on tar was noted, and photographs were taken. In the future these same areas will be re-sampled.

Microhabitat Correlates With Fucus Recruitment

In addition to different cleaning intensities, many microhabitat factors could cause variable Fucus recruitment. The following data were also collected in the above quadrats to correlate with the abundance of Fucus recruits: slope of the quadrat, presence/absence of conspecific adults (> 15 cm) within one meter of the quadrat, and visual percent cover estimates of substratum relief categories (smooth, cracks, high relief). Finally, the length and attachment substratum (smooth rock, crack in rock, tar, barnacle) was noted for 10 Fucus plants closest to the upper left corner of each quadrat.

Deviations From The Proposed Research Plan

We did not arrive in Prince William Sound until the last weeks of the field season because of funding delays. As a result of the time and foul weather constraints, we were not able to do quantitative work at exposed sites, sample the mid Fucus zone, or obtain as many replicate sites as proposed. However, enough information was collected to make some statistically significant conclusions about the effects of cleaning intensity on recovery in the high Fucus zone (where recovery seems slowest), and correlations indicated which factors should be considered for next seasons recruitment experiments.

Data Analysis

The data were analyzed with standard figures and statistical methods. To test for differences between cleaning treatments on individual species, an analysis of variance was used in which sites were nested within treatments. Replicate sites within treatments were pooled for the figures when no statistically significant difference was found between sites. The assumption of equality of variances was addressed with Cochran tests and the data were transformed (arcsin on % cover, square root on counts) when necessary before performing the analyses. The more simple tests are described with the results.

RESULTS

Cleaning Intensity Versus Recovery

Oil and different cleaning intensities influenced Fucus abundance, but the effects were variable on the other common high intertidal species (Figure 2 and Table 1). As might be predicted, more intense cleaning effectively resulted in less tar on the intertidal, and no oil was found in the controls (Figure 2a, Table 1). The percent cover of Fucus was much higher in the controls than in the cleaned sites because of the characteristic large canopies formed in mature stands. There was no difference in Fucus cover between the two cleaning intensities (Figure 2b); however, there tended to be more individuals recruiting into less intensely cleaned sites (Figure 2c). There are no statistical differences in treatment effects for Fucus densities because of the high site variability (Table 1). Balanus glandula rapidly colonized the oiled sites and seems to have recovered (Figure 2d, Table 1). Littorina sitkana and limpets were more abundant in the control sites (Figures 1e,g), while L. scutulata was more abundant in the oiled and cleaned sites (Figure 2f). The number of species sampled were not significantly different between controls and oiled sites (Figure 2h, Table 1). This was surprising compared to other oil spill studies, and is probably a result of the generally low diversity in this high Fucus zone. Abundances of less common species at each site are listed in Appendix 1.

Microhabitats And Fucus Recruitment

The number of Fucus recruits was strongly correlated with substratum relief and presence/absence of local adults, but the correlation with grazer densities was poor. Most of the Fucus recruits (<5 cm) were found growing in fine rock cracks, and none were growing on tar in the high intertidal zone (Figure 3). Visual estimates of cover indicated that the rank of available substratum was, from highest to lowest: smooth rock, tar, cracks in rock, and barnacles. The number of Fucus recruits in cleaned sites was significantly higher if adult conspecifics (> 15 cm) were within one meter of the quadrat (Figure 4, t test, $p << 0.01$). The rest of the factors correlated poorly with the number of Fucus recruits in the cleaned sites (Littorina sitkana, $r = -0.3$; L. scutulata, $r = 0.04$; all limpets combined, $r = 0.4$; slope, $r = 0.02$). However, it appears that intermediate slopes have more abundant recruits than steep or flat slopes (Figure 5). Qualitative field observations also indicated that fresh water runoff and wave exposure also influence recruitment or subsequent growth.

CONCLUSIONS AND CONTINUING STUDIES

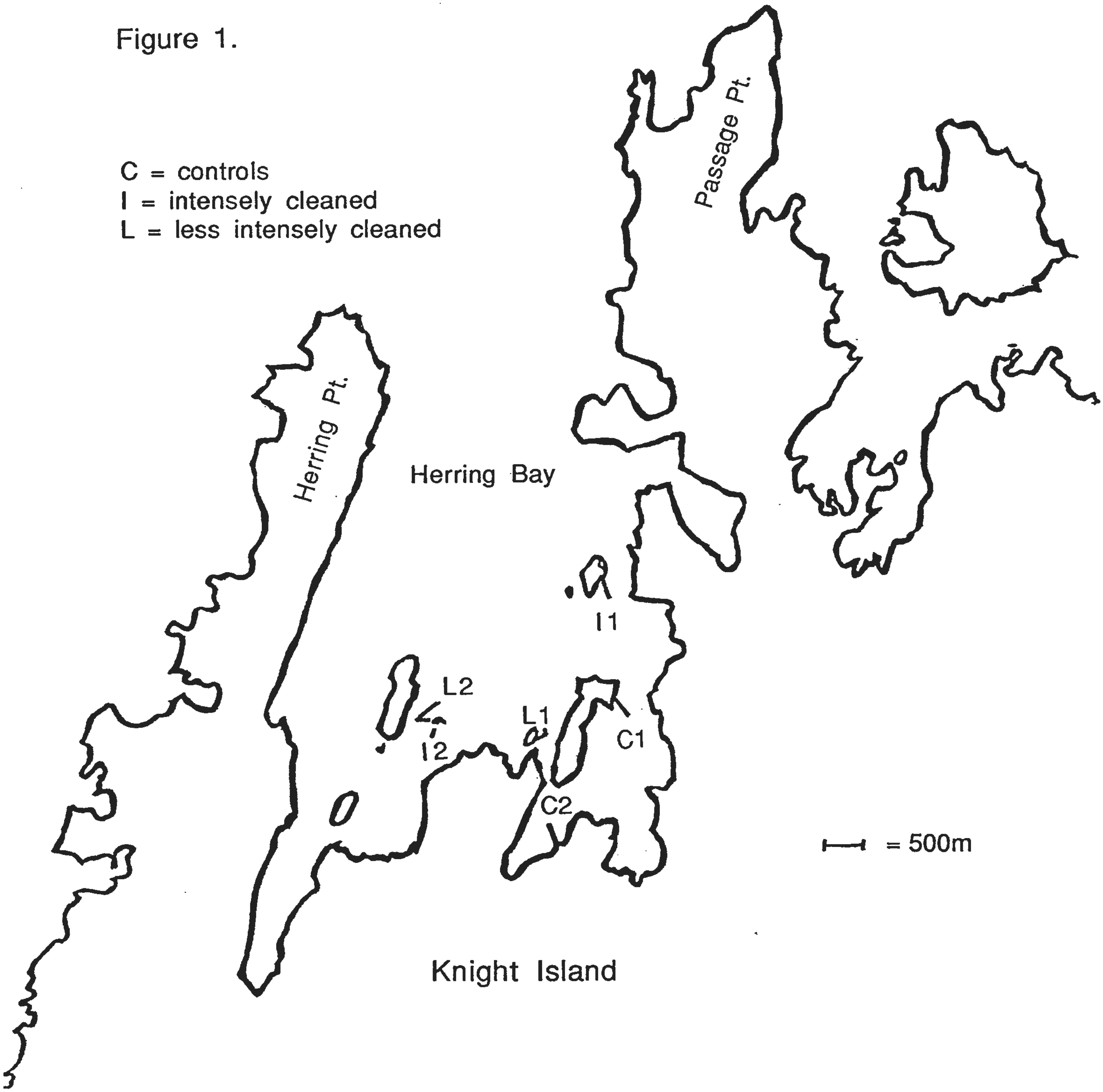
Several conclusions can be made from this initial phase of our study of the high Fucus zone in protected sites of Knight Island, Prince William Sound: oiled and cleaned sites had significantly lower percent cover of Fucus and fewer limpets, while having greater abundances of Littorina scutulata than un-oiled areas; the more intensely cleaned sites had significantly less tar; there were some strong trends indicating that higher cleaning intensity slows recovery of Fucus, but the differences were not statistically significant; new Fucus recruits were more abundant in rock cracks and not found on tar; and the presence of adult Fucus enhanced local recruitment.

In Spring 1991, we will continue to monitor recovery on the permanently marked pairs of tar patches and adjacent cleaned areas. Based on the results of this preliminary study, we plan to set up field experiments to test the effects of substratum relief, substratum slope, local adults, and wave exposure on already present Fucus juveniles and new recruits. Additionally, we will initiate Fucus covered boulder transplant experiments between and within sites as a possible restoration method.

Table 1. Data manipulations and statistical results.

	ANOVA Results		Scheffe A Posteriori test	Cochran test for heteroscedasticity
	Treatment effect	Replicate site effect	Control (C) Intense clean (I) Less clean (L) different than (*)	homoscedasticity (=) heteroscedasticity (//) arcsin transformation (a) square root transfomation (x) no transformation (0)
% Tar	p<<0.01	None	C * I; C * L; I * L	=, a
% Fucus	p<<0.01	None	C * I; C * L	=, a
# Fucus	None	p<0.05	None	=, 0
% Balanus	None	None	None	=, 0
# Littorina sitkana	None	P<<0.01	None	//, x
# Littorina scutulata	p<0.01	None	C * L	=, x
# Limpets	p<0.05	None	C * I; C*L	=, x
# Species	None	None	None	=, 0

Figure 1.


C = controls
I = intensely cleaned
L = less intensely cleaned
Passage Pt.
Herring Pt.
Herring Bay
I1
L2
L1
C1
I2
C2
= 500m
Knight Island

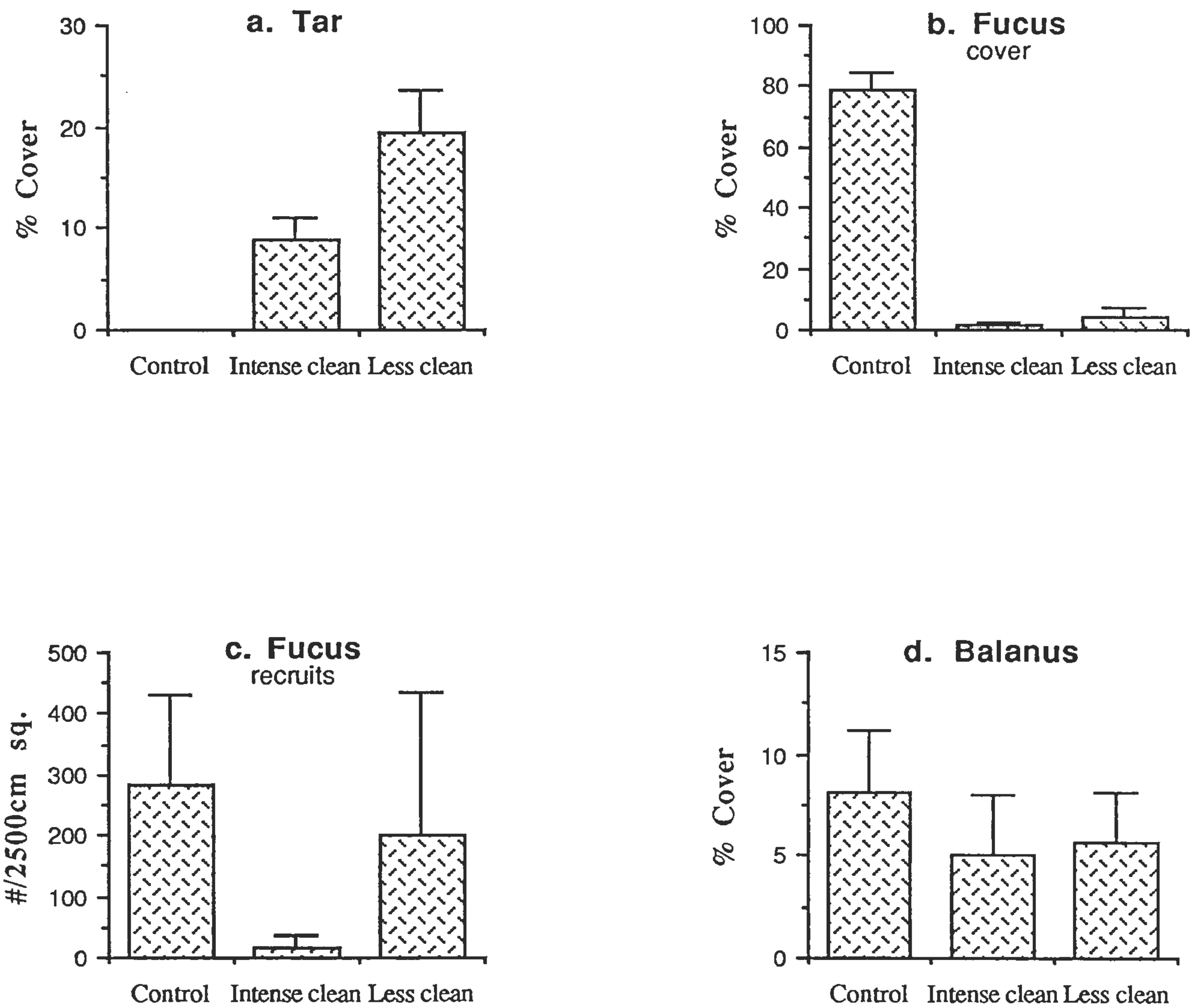


Figure 2. Cleaning intensity effects on (a) % tar (b) % Fucus (c) # Fucus (d) % Balanus. Abundance values are means + 1 S.E.[n = 10 except for # Fucus where n = 2 because site differences (Table 1) made pooling inappropriate].

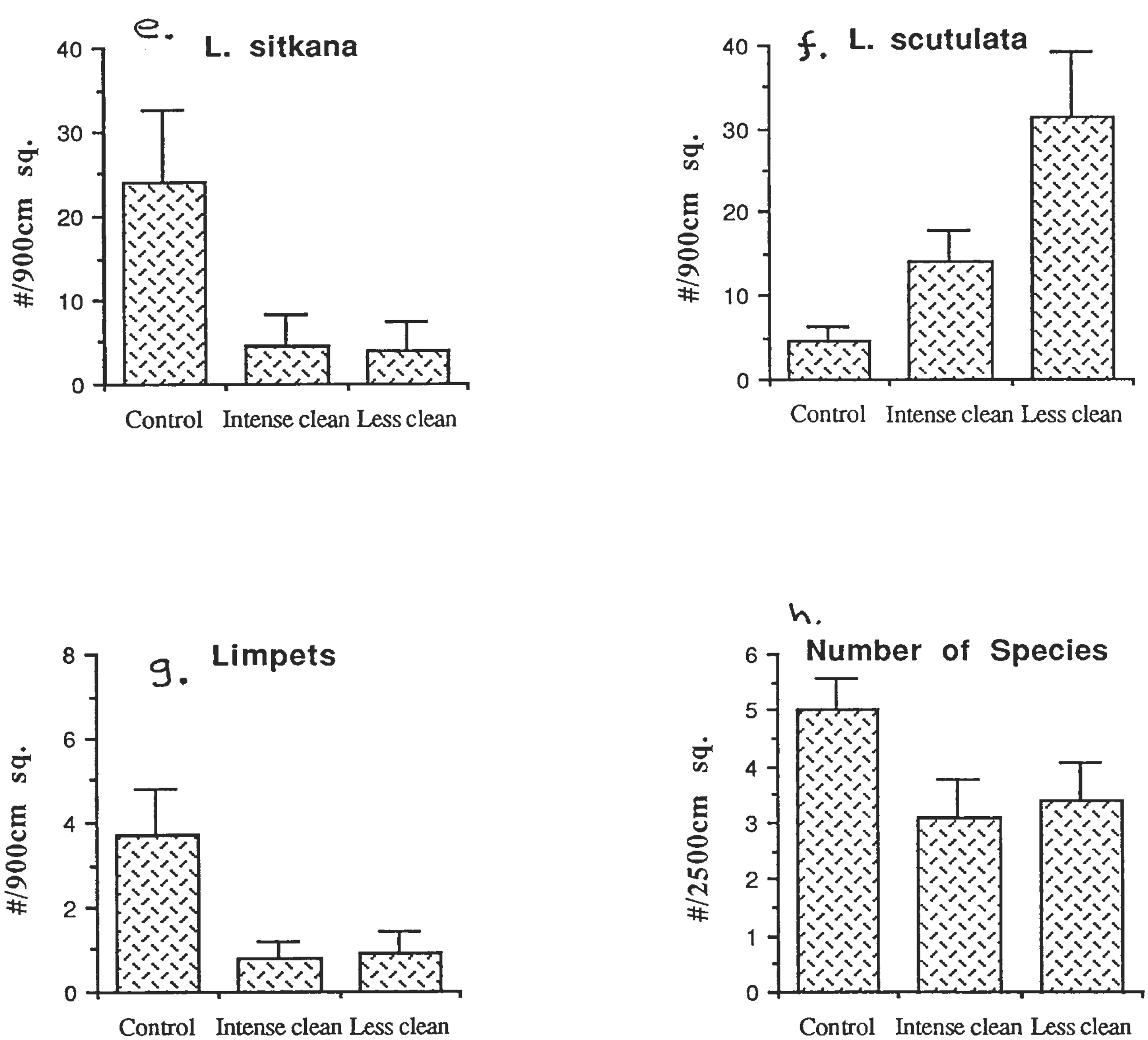


Figure 2 (continued). Cleaning intensity effects on (e) Littorina sitkana (f) L. scutulata (g) # limpets (f) # species. Abundance values are means + 1 S.E. [n = 10 except for L. sitkana where n = 2 because site differences (Table 1) made pooling inappropriate].

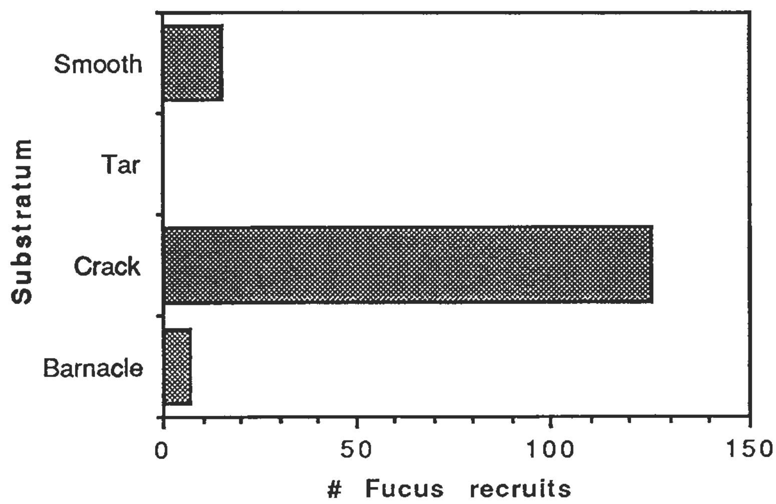


Figure 3. Substratum affects on Fucus recruits (<5 cm) from all sites combined. Smooth and crack indicate rock substratum relief.

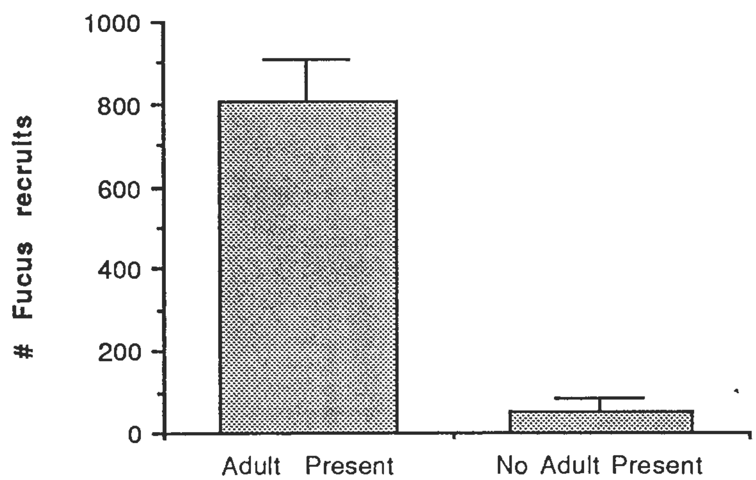


Figure 4. New recruits are more abundant when adults are within one meter of the sample area (means + 1 S.E., 50 x 50 cm area).

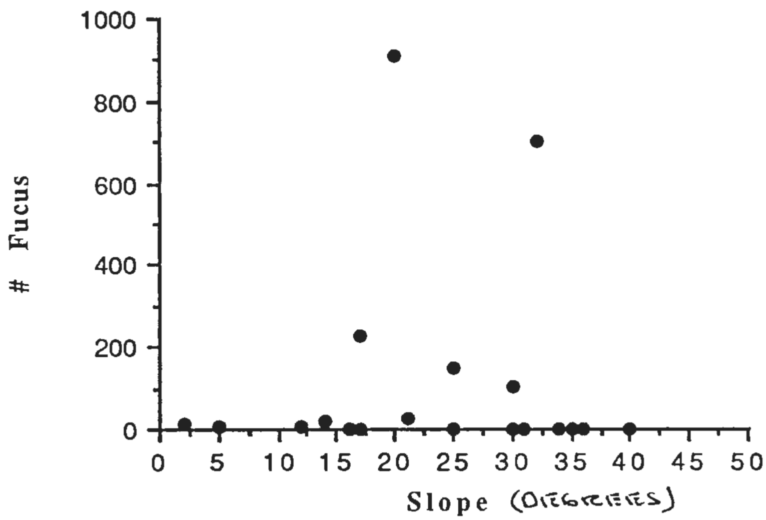


Figure 5. Correlation between Fucus recruits (<5cm) and substratum slope in cleaned sites. Note that the highest values are located at intermediate slopes.

Appendix 1. Descriptive statistics for all species sampled in control, intensely cleaned, and less intensely cleaned sites.

	Control 1		Control 2	
Species	**mean**	**S.E. (n = 5)**	**mean**	**S.E. (n = 5)**
% *Fucus gardneri*	76.25	10.09	82.50	5.69
% *Balanus glandula*	12.50	5.20	3.75	1.52
% Green lichen	0	0	1.25	1.24
% Brown crust	0	0	1.25	1.25
% Red crust	1.25	1.24	1.25	1.24
# *Littorina sitkana* /900 cm^2	18.80	6.68	29.20	2.97
# *Littorina scutulata* /900 cm^2	3.00	1.30	6.40	2.62
# *Tectura persona* /2500 cm^2	5.00	1.60	1.80	0.80
# *Lottia pelta* /2500 cm2	0.40	0.24	0.20	0.20
Pagurus spp.	present		0	0
Amphipods	present		0	0

	Less Intense Clean 1		Less Intense Clean 2	
% Tar	26.25	7.71	10.00	2.48
% *Balanus glandula*	5.00	2.32	6.25	4.81
% *Cthamalus* spp.	0	0	2.50	2.50
% *Mytilus edulis*	0	0	1.25	1.24
% *Gloeopeltis* sp.	0	0	5.00	3.62
% *Leathesia* sp.	0	0	1.25	1.24
% Brwon crust	0	0	1.25	1.24
# *Littorina sitkana*	7.80	1.82	0.40	0.40
# *Littorina scutulata*	42.8	12.70	20.00	5.95
# *Tectura persona*	0	0	1.40	0.67
# *Lottia pelta*	0	0	0.40	0.24

Appendix 1 (continued).

Species	Intense Clean 1		Intense Clean 2	
	mean	S.E. (n = 5)	mean	S.E. (n = 5)
% Tar	12.50	3.40	5.00	2.32
% *Balanus glandula*	10.00	5.05	0	0
% *Fucus gardneri*	2.50	1.52	0	0
% *Neorhodomella aculeata*	0	0	1.25	1.24
% *Gloeopeltis* sp.	0	0	1.25	1.24
% Brown crust	5.00	3.62	1.24	1.25
% Red crust	1.25	1.24	0	0
# *Littorina sitkana* /900 cm^2	6.80	1.79	1.20	1.19
# *Littorina scutulata* /900 cm^2	19.00	7.15	9.00	2.31
# *Tectura persona* /2500 cm^2	0	0	0.40	0.40
# *Lottia pelta* /2500 cm2	0.80	0.37	0	0
Juvenile limpets	0.20	0.20	0.20	0.20
Paguras spp.	0	0	Present	

MICHAEL S. FOSTER

Resume - October, 1991

dress: Moss Landing Marine Labs, P.O. Box 450, Moss Landing, Ca.
95039-0450 (408) 755-8658 FAX: (408) 753-2826

Birthdate: Sept. 4, 1942 SS# 550-54-9835

Education
B.S. Physical Science, Stanford University, 1964
M.A. Education, Stanford University, 1965
Ph.D. Biology, University of California, Santa Barbara, 1972

Positions and Honors
Assistant Professor of Biological Sciences, California State University, Hayward. 1972-76
Associate Professor of Marine Science, Moss Landing Marine Laboratories and San Jose State University. 1976-80
Research Fellow, University of Melbourne, Melbourne, Australia. 1980-81
Professor of Marine Science, Moss Landing Marine Laboratories and San Jose State University. 1981-present
Visiting Professor, Stanford University. 1989
Fellow, California Academy of Sciences.
Editorial Board, Journal of Phycology and Marine Ecology Progress Series.
President, Western Society of Naturalists. 1990
Secretariat, Western Society of Naturalists, 1991-

esearch Interests
Marine ecology with emphasis on the community ecology of macroalgae and the effects of oil pollution on nearshore marine communities.

Selected Publications

1971 Foster, M., Neushul M., and Charters, A. The Santa Barbara oil spill I. Initial quantities and distribution of pollutant crude oil. Environmental Pollution 2: 97-113

1971 Foster, M., Neushul, M., and Zingmark, R. The Santa Barbara oil spill II. Initial effects on littoral and kelp bed organisms. Environmental Pollution 2: 115-134

1975 Foster, M. Algal succession in a Macrocystis pyrifera forest. Marine Biology 32: 313-29

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1982 Foster, M. Factors controlling the intertidal zonation of Iridaea flaccida (RHODOPHYTA). Journal of Phycology 18: 285-94

1984 Reed, D. and Foster, M. The effects of canopy shading on algal recruitment and growth in a giant kelp forest. Ecology 65: 937-948

1986 Schiel, D.R. and Foster, M.S. The structure of subtidal algal stands in temperate waters. Oceanography and Marine Biology Annual Reviews 24: 265-307

1988 Foster, M.S., De Vogelaere, A.P., Harrold, C., Pearse, J.S., and Thum, A.B. Causes of spatial and temporal patterns in rocky intertidal communities of central and northern California. Memoirs of the California Academy of Sciences 9: 1-45.

1990 Foster, M., Tarpley, J. and Dearn, S. To clean or not to clean: the rationale, methods, and consequences of removing oil from temperate shores. Northwest Environmental Journal 6: 105-120

1990 Foster, M. Organization of macroalgal assemblages in the northeast Pacific: the assumption of homogeneity and the illusion of generality. Hydrobiologia 192: 21-33

1991 Foster, M. and Schiel, D. Restoring kelp forests. In: G. Thayer (ed.), Proceedings of the NOAA Symposium on Restoring the Nation's Marine Environments. NOAA Technical Report (in press).

Curriculum vitae

Andrew P. De Vogelaere

Address:
Moss Landing Marine Laboratories
P.O. Box 450
Moss Landing, CA 95039
(408) 633-5856, mes. 633-3304

Citizenship: United States of America
Social Security No: 571 55 1942
Date of Birth: 9 November 1961

Education

1991. PhD in Biology. University of California, Santa Cruz.

1988. MS in Marine Science. Moss Landing Marine Laboratories.

1983. BA in Biology. University of California, Berkeley.

Research Experience

1991 (ongoing). Research Associate, Moss Landing Marine Laboratories.
1991 (ongoing). Research Coordinator, Elkhorn Slough National Estuarine Research Reserve.
1991 (since 1989, ongoing). Recovery from an oil spill, Olympic National Park, Washington. Experimental design and field supervisor, Minerals Management Services/Kinnetic Laboratories Inc.
1991 (since 1990). Effects of the clean-up techniques and restoration of intertidal organisms after the Exxon Valdez oil spill. Co-principal investigator, Environmental Protection Agency.
1991 (since 1984). Effects of size and severity of disturbance on the recovery of a rocky intertidal assemblage. Principal investigator, Minerals Management Service.
1991 (since 189). Using natural oil seeps to study questions associated with accidental oil spills. Student grant, Myers Oceanographic and Marine Biology Trust.
1991 (since 1984). Study of the rocky intertidal communities of central and northern California. Field sampler and taxonomist for invertebrates and algae, Minerals Management Service/Kinnetic Laboratories Inc.
1988 (and 1984). A baseline study before and after the introduction of sea otters to San Nicolas Island. Volunteer field biologist, U. S. Fish and Wildlife.
1986. Long-term monitoring of subtidal communities. Diver, Monterey Bay Aquarium, Kelp Project.
1986. Sea Otter project: quantifying soft bottom invertebrate communities of Kodiak Island, Alaska. Diver, U.S. Fish and Wildlife.
1985. Subtidal kelp forest survey of the Big Sur Coast, California. Field assistant and cook, Marine Mammal Commission.
1983. Studies on optimal culture conditions for agar extraction from the red alga Gelidium coulteri. Honors thesis, University of California, Berkeley.

Teaching Experience

Instructor:
1989. Intertidal Organisms. Associate in Biology. University of California, Santa Cruz.
1988. Rocky Coastline: An Introduction To The Organisms. Instructor in Recreation Department. University of California, Santa Cruz.

Teaching Assistant:
1991. Probability, Sampling and Experimental Design. Department of Marine Sciences. University of California, Santa Cruz.
1990. Intertidal Organisms. Department of Biology. University of California, Santa Cruz.
1989. Probability, Sampling and Experimental Design. Department of Marine Sciences. University of California, Santa Cruz.
1987. Evolutionary Morphology of Land Plants. Department of Biology. University of California, Santa Cruz.
1986. Invertebrate Zoology. Department of Biology. University of California, Santa Cruz.
1986. Evolutionary Morphology of Land Plants. Department of Biology. University of California, Santa Cruz.
1986. Population Biology. Moss Landing Marine Laboratories.
1985. Advanced Marine Ecology. Moss Landing Marine Laboratories.

Other Academic Activities

-Symposium chair: "Disturbance and Community Structure" Western Society of Naturalists 1991.
-Chair of contributed paper session:"Algal Ecology" Western Society of Naturalists. 1990.
-Student Body President. Moss Landing Marine Laboratories. 1986.
-Editor and founder of "MLML Monthly", a monthly newspaper at Moss Landing Marine Laboratories. 1985-1986.
-Editor for "Young Scientist."

Memberships

American Association for the Advancement of Science
American Society of Zoologists
Ecological Society of America
National Association of Underwater Instructors (NAUI)
Sigma Xi
Western Society of Naturalists

Selected Publications

A. Dissertation and thesis

De Vogelaere, A. P. 1991. Disturbance, succession, and distribution patterns in the rocky intertidal communities of central California. Dissertation, University of California, Santa Cruz.
De Vogelaere, A. P. 1987. Rocky intertidal patch succession after disturbance: effects of severity, size and position within patch. Masters Thesis, San Francisco State University/Moss Landing Marine Laboratories.

B. Papers

Foster, M. S., A. P. De Vogelaere, J. Oliver, J. S. Pearse and C. Harrold. (in press). Intertidal and littoral ecosystems of the northeast Pacific. A.C. Mathieson and P. Nienhuis (editors). Ecosystems of the World, Vol. 24: Intertidal and littoral ecosystems. Elsevier Scientific Publishing Company, Amsterdam.

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De Vogelaere, A. P. (submitted). Effects of disturbance severity and size on succession: a rocky intertidal example and general applications.

De Vogelaere, A. P. (submitted). Quantifying patchy patterns in a central California mussel assemblage and a re-evaluation of the fugitive species hypothesis.

De Vogelaere, A. P. (manuscript complete, waiting for the symposium). Description of patchy distribution patterns with a quadrat variance method: tests from a rocky intertidal mussel bed. Proceedings of the second international temperate reef conference, New Zealand.

De Vogelaere, A. P. (in preparation). Manipulating oil from natural seeps to study disturbance effects on a rocky reef. Target: Journal of Experimental Marine Biology and Ecology.

C. Abstracts of conference presentations

De Vogelaere, A.P. 1990. Quantifying algal patchiness in a central California mussel assemblage: a test of the fugitive species hypothesis. Western Society of Naturalists. p. 29.

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De Vogelaere, A.P. 1985. Effects of size, intensity, and edges of clearings on early rocky intertidal succession. Western Society of Naturalists. p. 27.

D. Photographs

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De Vogelaere, A.P. 1988. Cover Photo. Bulletin Of The Ecological Society Of America Volume 69 No. 2.

E. Reports

De Vogelaere, A. P. and ABA Consultants. 1991. Elkhorn Slough Bibliography. Prepared for the Elkhorn Slough National Estuarine Research Reserve. 26pp.

De Vogelaere, A. P. and M. S. Foster. 1990. Status report: Fucus restoration project. Prepared for the Environmental Protection Agency, University of Alaska, Fairbanks contract No. 53-0109-9-00276 Mod #4. 13pp.

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STATE OF ALASKA
DEPT. OF FISH & GAME
OSIAR

P.O. BOX 880
500 WATER STREET
CORDOVA, AK 99574

TELE # (907)424-5900 FAX # (907)424-5910

TO: STAN SENNER
SIMPSON BLDG 276-7178

DATE: 13Nov91

FROM: C. MONNETT & L ROTTERMAN
CORDOVA

No. OF PAGES 8

MESSAGE: HERE ARE TWO SEA OTTER PROPOSALS. THANKS FOR TAKING A LOOK AT THEM.

RESTORATION SCIENCE PROPOSAL: 1992 OIL SPILL YEAR

Study name:

Evaluation of sea otter population recovery rates and processes in Prince William Sound.

Injured species:

Sea otter (Enhydra lutris). As many as 15000 sea otters inhabited Prince William Sound before the Exxon Valdez oil spill (EVOS). Of those species in the spill zone at the time of the spill, the sea otter was one of the most obviously impacted. It has been estimated that 3500-5500 sea otters died in Prince William Sound due to acute exposure to crude oil. Many of the affected individuals were pregnant adult females, and hence, recruitment to the population was lost, in addition to the direct loss of the females.

Data from damage assessment studies indicates that damage to the population continues. Most importantly, the over-winter survival of weanlings (young of the year after they have become independent of their mother) born in 1990, a year after the spill, was strikingly lower in the western sound than in the eastern sound. Thus, for at least 2 years, 1989 and 1990, recruitment in the western sound has been extremely low. With such effects on recruitment, the population may still be declining, rather than recovering. Additionally, in 1989 nd 1990, adult female sea otters in the oiled area were in poorer verall body condition than those in the east. Pups in the oil spill region had a higher incidence of cardiac and ocular pathologies. Preliminary analyses of clinical blood parameters indicated that sea otters in the western sound exhibit a higher incidence of symptoms of organ damage, possible anemia, and other blood abnormalities. Evaluation of literature on other animals suggests that these health problems may become progressively worse with time.

Other damage assessment studies have demonstrated continuing injury to key sea otter prey species. Such damages may be directly linked to some of the injuries detected in the sea otter population. For example, contamination and/or reduction of the mussel population could have important effects on weanling sea otters, whose diving abilities are limited and who depend heavily on mussels over their first winter.

Principle investigators:

Lisa Rotterman, Ph.C., Research biologist
Charles Monnett, Ph.D., Research biologist

Organization:

Prince William Sound Science Center, Cordova, Alaska.

Project objectives:

The survival rate of weanling sea otters in western Prince William Sound was exceptionally low during the winter of 1990-91. Thus, it does not appear that the sea otter population is recovering rom the effects of the EVOS. This study is designed to measure the current rate of recruitment of sea otters to the Prince William Sound population as well as to document physiological and environmental factors that affect the rate and process of recovery. Specifically, we propose to :

1. Evaluate and compare the health of sea otter pups in habitat effected by EVOS with that of individuals in adjacent habitat using the following criteria: gross physical exams, analysis of hematology and blood chemistry, analysis of toxicology and body growth rates.

2. Enumerate survival rates of pups during the last months of dependency and during the first winter following weaning; compare rates for sea otters in habitat effected by EVOS with that for individuals in adjacent habitat.

3. Use necropsy and toxicology results to evaluate the underlying physiological and environmental mechanisms causing injury or death to animals in this and the previous damage assessment studies.

4. Test the non-competing hypotheses that the increased rate of mortality observed in weanling sea otters in areas affected by EVOS is correlated with direct exposure to EVOS related toxins transmitted to sea otters through prey or with secondary effects such as insufficiency of suitable prey.

5. Based on the results of 1-4, comparison of baseline data from previous studies, and integration of data on adult survival rates from pre- and post-spill studies, determine whether the population is recovering, determine the probable course of recovery, and estimate the time until the population will be fully recovered. We will also obtain data on the recolonization of heavily oiled areas vacated by the spill.

Project methods:

1. One hundred dependent sea otter pups will be surgically implanted with radio-transmitters during July - October 1992, using methodology described previously in damage assessment study Marine Mammal Study # 6. We are focusing on the pup and weanling stages because it appears that the low overwinter survival rate of weanlings is the critical period limiting recovery. Hence, the best design and implementation of restoration activities must start with a thorough understanding of this life history stage, the habitat requirements of weanlings and the environmental and physiological reasons for the high mortality rate.

   Fifty pups will be instrumented in habitat affected by EVOS whereas, 50 will be instrumented in adjacent habitat. Twenty-five additional radio-transmitters will be allowed to run continuously in a 100° F solution of physiological saline as a control against transmitter failure. During instrumentation, pups will be given complete physical exams and specimens will be taken for blood and toxicological analysis. Following release pups will be visually inspected using boats or aircraft every 2 days in order to ascertain current status (dependent versus independent, alive versus dead, and location) and to facilitate recovery of unspoiled carcasses for necropsies.

2. In addition to visual observations from aircraft, individual sea otters will be observed weekly for 50 foraging dives to determine the source and type of prey being utilized. For each of the most common prey species (composing 80% of the individuals diet by caloric content), samples will be taken from the 3-5 most commonly used feeding sites for toxicological analysis. It is anticipated that samples will be divided between intertidal and shallow, subtidal areas. When necessary, samples will be collected by using SCUBA. Prey sampling could be accomplished in collaboration with ADF&G and/or NMFS shellfishery biologists to ensure that data collection is comparable to the more extensive surveys being conducted by those scientists.

3. Data from this study will be integrated with survivorship data from previous pre-spill and post-spill studies to estimate the time and course of recovery of the sea otter population.

Duration: Because of biological constraints this study must span 2 oil-spill years: July 1992-August 1993.

Estimated cost: $750,000 if toxicology, pathology and prey sampling are included; $500,000 for instrumentation, monitoring and recovery of carcasses, alone.

Restoration activity or endpoint to be addressed:

Habitat degradation due to factors such as the presence of oil on the water or in the substrate of feeding areas, contaminated prey, or to a lowered carrying capacity due to negative effects on prey species, is more likely to have measurable effects on those segments of a population that have the most difficulty surviving under normal circumstances. In sea otters , this segment of the population is the weanling class. A thorough understanding of the effects of the oil spill on the population of sea otters in Prince William Sound, its long-term and short-term recovery prospects, and the steps necessary to be taken to enhance the rate of recovery cannot be achieved without understanding the effects on the recruitment phase of the population.

The results of this research would help determine: a) whether and where site-specific cleanup activities might be advantageous; b) whether there were particular types of habitat or specific areas where future disturbance (e.g., due to logging, fishing, mariculture, etc.) should be minimized to enhance survivorship; and c) when the population has recovered sufficiently, so that further restoration activities are no longer warranted.

Relationship to science information needs identified by RPWG:

This study addresses general needs identified by the RPWG in that research specifically addresses the underlying mechanism and root cause of observed high rates of mortality among weanling sea otters in habitat affected by EVOS. It specifically attempts to relate mortality to qualitative and indirectly to quantitative changes in important prey species. Specific to identified sea otter needs this study integrates data taken since the EVOS with data from previous years studies in Prince William Sound. It focuses on a critical life stage and seeks to understand the physiological mechanism leading to a pattern of increased mortality during that life stage. Additionally, since the sea otter is a top predator and may function as a keystone species in many subtidal and intertidal communities, restoration efforts aimed at monitoring and hastening its recovery aid in the full restoration of these communities to their natural states.

Importance of initiating project in 1992:

Current evidence suggests that the sea otter population in Prince William Sound may still be declining due to the effects of the EVOS. It is crucial to determine to what extent recruitment continues to be affected, and hence, when and how quickly the population might begin to recover. With such information, and the information that will be collected on specific sites, restoration activities such as acquisition of the timber rights on adjacent uplands, focussed beach cleanup activities, etc., will be most effective with regards to sea otter restoration and the restoration of the ecological community.

Link to other NRDA damage assessment or restoration studies:

This study provides data for use in a proposed study related to identifying habitat critical to sea otters in Prince William Sound. It also permits evaluation of the longevity of injury observed in 1989 and 1990 and should provide insight into the underlying causes of the injuries observed to date.

RESTORATION SCIENCE PROPOSAL: 1992 OIL SPILL YEAR

Study name:

Identification and prioritization of critical habitat for sea otters in Prince William Sound.

Injured species:

Sea otter (Enhydra lutris). As many as 15,000 sea otters inhabited Prince William Sound (PWS) before the Exxon Valdez oil spill (EVOS). Of those species in the spill zone at the time of the spill, the sea otter was one of the most obviously impacted. It has been estimated that 3500-5500 sea otters died in Prince William Sound due to acute exposure to crude oil. Many of the affected individuals were pregnant adult females, and hence, recruitment to the population was lost, in addition to the direct loss of the females.

Data from damage assessment studies indicates that damage to the population continues. Most importantly, the over-winter survival of weanlings (young of the year after they have become independent of their mothers) born in 1990, a year after the spill, was strikingly lower in the western sound than in the eastern sound. Thus, for at least 2 years, 1989 and 1990, recruitment in the western sound has been extremely low. With such effects on recruitment, the population may still be declining, rather than recovering. Additionally, in 1989 and 1990, adult female sea otters in the oiled area were in poorer overall body condition than those in the east. Pups in the oil spill region had a higher incidence of cardiac and ocular pathologies. Preliminary analyses of clinical blood parameters indicated that sea otters in the western sound exhibit a higher incidence of symptoms of organ damage, possible anemia, and other blood abnormalities. Evaluation of literature on other animals suggests that these health problems may become progressively worse with time.

Other damage assessment studies have demonstrated continuing injury to key sea otter prey species. Such damages may be directly linked to some of the injuries detected in the sea otter population. For example, contamination and/or reduction of the mussel population could have important effects on weanling sea otters, whose diving abilities are limited and who depend heavily on mussels over their first winter.

Principle investigators:

Charles Monnett, Ph.D., Research biologist
Lisa Rotterman, M.S., Ph.C., Research biologist

Organization:

Prince William Sound Science Center, Cordova, Alaska.

Project objectives:

The sea otter population in Prince William Sound is surely not fully recovered from the effects of the EVOS, and indeed, may still be declining due to the spill. This may be the result of latent effects from oil contamination at the time of the EVOS and/or due to chronic contamination due to exposure to weathered oil still in the habitat, including uptake through prey species. In order to direct and to enhance the effectiveness of activities that might be undertaken to restore the PWS sea otter populations, we propose to:

1. Identify units of habitat used by sea otters in Prince William Sound during critical life history stages (e.g., pupping, weaning, breeding, overwintering, and haulout areas);
2. Identify critical habitat assemblages, that is, areas used for different purposes by the same group of individuals;
3. Prioritize these areas and assemblages with regard to their importance to the sea otter population(s) so that the most productive areas are identified;
4. Provide an analysis of the effect of future cleanup and habitat protection activities on sea otter population recovery;
5. Identify perturbations that are likely to occur within the oil spill zone and that would also be likely to further damage, or slow the recovery of, the Prince William Sound sea otter population;
6. Produce an atlas of sea otter habitat use in eastern and southwestern Prince William Sound;
7. Based on 1-5, provide detailed recommendations about whether and where habitat protection measures (including acquisition or protection of habitat) and/or further cleanup should occur to hasten the recovery of the sea otter population.

Project methods:

Proposed research is based upon standard methodologies of sea otter research, most of which have been used by the authors over the past 8 years. The keystone of the approach is to study individuals to gain information about population patterns and processes. The proposed research takes advantage of both existing data (including pre-spill data) and previous investment made pursuant to damage assessment studies which are being abandoned or severely curtailed. These damage assessment studies resulted in the instrumentation of large numbers of adult females and pups in the oil spill zone. Continuing to monitor these individuals will provide much of the biological information necessary to meet the objectives of this restoration proposal. While the methodology is similar to that undertaken for damage assessment work, the objectives of the proposed work are considerably redefined. Specific measures that would be taken in order to identify and prioritize the critical habitat units include the following:

1. Obtain data on patterns of habitat use by adult female and young sea otters by monitoring those animals implanted with radio transmitters since the T/V Exxon Valdez oil spill. Identify concentration points for sea otters during fixed-wing aircraft radio-tracking flights. Supplement radio-telemetry observations with those of shore or boat based observers directed at determining sex and functional composition of sea otter groupings at identified aggregation points.
_. From direct visual observations on radio-instrumented sea otters obtain data on site specific habitat utilization. For example, we expect to determine which portions of habitat are most

important to sea otters for mating, pupping, pup rearing, weaning, hauling out and feeding.

3. Obtain direct data on the patterns and causes of mortality of adult and juvenile sea otters within the study area in order to discriminate habitat units in which sea otter population processes are normal from those in which processes appear to be negatively affected as a result of the oil spill and related activities.
4. In order to evaluate the quality of habitat units in greater detail, and to determine whether a need exists for cleanup activities with reference to sea otter requirements: capture, recapture, weigh, measure, closely examine, tag, and obtain blood samples for blood chemistry and hydrocarbon analyses from sea otter pups in the oil spill zone. Capture work will concentrate on those areas receiving high usage (as identified through the telemetry information) and those areas that were heavily oiled but that are now being recolonized by sea otters (identified through monitoring of radioed animals and surveys (see below)).
5. Integrate movement and habitat utilization from pre- and post-spill telemetry and capture studies with toxicology data, and with the data to be collected as part of this study.

Duration: We believe the proposed objectives can be accomplished in wo years, with some preliminary analysis being available in one year.

Estimated cost: Year 1 - $450,000; Year 2 - $350,000

Restoration activity or endpoint to be addressed:

This study will provide information directly relevant to determining what active restoration efforts are likely to be effective in hastening the recovery of the PWS sea otter population, and where such activities should occur. Specifically, this study will result in the identification of those areas that are most critical to the health and recovery of the sea otters in Prince William Sound, and conversely, in the identification of those areas that are not productive (e.g., due to contamination or destruction of sea otter prey, etc.). Additionally, this study provides information about the course of recovery and recolonization, and hence, provides information useful for determining the status of the population over time.

Relationship to science information needs identified by RPWG:

This research will provide information critical to understanding and monitoring ecosystem recovery. Sea otters have been described as a keystone species of the marine nearshore community because their predation on marine invertebrates may determine the composition, abundance, and relative diversity of invertebrates in the areas they inhabit. Because of this, and relatedly because they prey on a multitude of intertidal and subtidal species, the sea otter serves as an important indicator species of ecosystem health. This research irectly addresses the identified goal of synthesizing the effects of ıvironmental disturbances on EVOS-injured species, and extends this goal by providing a summary of disturbances that are scheduled to occur in the near future that may negatively impact the sea otter population. The proposed research activities provides information on the geographic distribution of damages, and proposes to extend the capture of sea otters into areas most heavily impacted by the spill. The data to be gained from the capture and recapture work will provide data directly relevant to understanding the physiological mechanisms underlying the continuing decline in the population.

__Importance of initiating project in 1992__:

In order to take advantage of the sea otters that were instrumented with radiotransmitters in 1989 and 1990, this research must be carried out in 1992. By the summer of 1993, most of the radios being carried by the animals will no longer be broadcasting.

__Link to other NRDA damage assessment or restoration studies__:

We have submitted a second restoration proposal entitled "Evaluation of sea otter population recovery rates and processes in Prince William Sound." Data on instrumented pups from this study would provide additional data to be used in the determination of use and priority of different habitat and areas to sea otters. As noted, data from post-spill studies will also be integrated in this study, including data on movements, habitat utilization and toxicological burdens of adult females and males, dependent pups, and weanlings. Additionally, any data available from studies of sea otter prey studies would be complementary to the study proposed herein, by providing information about the supportiveness of various areas in which sea otters are observed.

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RESTORATION RESEARCH AND MONITORING PROPOSAL

Title:

Stable carbon isotopic analyses of EVOS derived carbon in intertidal organisms.

Injured species to be addressed:

There is considerable interest in understanding (1) the potential long-term problems associated with continued oiling of mussel beds and (2) the possible transfer of petroleum residues to consumer species. For these reasons, *Mytilus edulis* was chosen as one organism on which to concentrate stable isotope analyses. Mussels are filter feeders and their body carbon should represent the isotope signal of particulate organic carbon. Limpets (Lottiidae) will also be analyzed for their stable carbon isotope ratios. These organisms are grazers in the intertidal zone and should have isotope ratios representing a macrophytic carbon signal. These two organisms should represent the carbon isotope signals of the two major sources of carbon to the intertidal zone of rocky sheltered beaches in regions away from large freshwater/terrestrial inputs.

Principal Investigators:

Raymond C. Highsmith and Susan M. Saupe, University of Alaska Fairbanks. Lead Agency: USFS.

Project Objectives:

The objective of this study is to use stable isotope techniques as an indicator of petroleum derived carbon in the tissues of intertidal organisms, namely mussels and limpets. The actual concentrations of hydrocarbon molecules within organisms near spill areas (0-400 ug/g, NRDA data and National Academy of Sciences 1985) are not high enough to detect with stable carbon isotope methods and can easily be measured using the standard GC/MS look for incorporation of the isotopically light (C-13 depleted) carbon originating from long-term exposure to hydrocarbon molecules; and thus integrates the ingestion of oil-derived carbon within the turn-over time of the tissue. Isotopically light carbon can be introduced to the organism either by direct ingestion and metabolism of hydrocarbons or by incidentally filtering out or grazing on bacteria that are associated with high concentrations of hydrocarbons on the beach. This technique has the potential advantage of detecting petroleum derived carbon for situations in which high concentrations of hydrocarbon molecules are absent in tissues but rather the carbon is introduced via a bacterial/meiofaunal pathway. The overall objective is to compare the isotope ratios of organisms on oiled sites to those on control sites and look for relative differences of these ratios.

Project Methods:

In recent years, stable carbon isotopes have become increasingly useful as natural tracers of carbon flow in a variety of systems where more than one carbon source is available to the food-web and the isotope ratios of the carbon end-members are distinct (See review by Fry and Sherr 1984). The premise of using carbon isotopes to trace carbon through animal food webs is based on the different stable isotope ratios plants have depending on the metabolic pathway used in carbon fixation (O'Leary 1981). The isotope ratio of source carbon is conservatively transferred through a food web, with a slight enrichment in the heavier isotope per trophic step (DeNiro and Epstein 1978). Consequently, the stable carbon isotope ratio of an organism reflects that of its diet.

If a particulate organic carbon (POC) end-member is mainly marine derived phytoplankton, the stable isotope ratio is isotopically distinct from marine macrophytes (-20 to -25 ^{0}/oo vs -15 to -18 ^{0}/oo, respectively). In the intertidal zone of most sheltered and exposed rocky beaches in the PWS/CIK/KAP regions, POC and macrophytes are the two major carbon sources, with the possible addition of macrophytic carbon to total POC. Petroleum-derived carbon is isotopically distinct from either of these two carbon end-members, with EVOS crude having an isotopically "light" value less than -28 o/oo (Dave Shaw, pers. comm.). Stable carbon isotopes have been used in past studies to look at the inputs of petroleum derived carbon to ecosystems, both as a pollutant (Calder and Parker 1968) and as a natural seep (Spies and DesMarais 1983). The chronic exposure to oil in these two situations affected the isotopic values of the POC and/or organisms. We propose to test stable isotope ratios to monitor the entrance of isotopically light carbon into the tissues of intertidal organisms on beaches with exposure to high concentrations of EVOS crude oil.

During the 1989, 1990, and 1991 field seasons of the CHIA project, mussels and limpets were collected for survivorship and growth determinations. These samples were preserved by freezing immediately after collection. They were thawed in order to take measurements and for identification purposes and then refrozen. Unlike the quadrat data that was collected, they are not contaminated with formaldehyde which would interfere with the natural stable carbon isotope signal. These archived samples could provide information on the stable carbon isotope signals in the tissues of mussels and limpets from oiled and control sites for 5 months, one year, and two years after the oil spill. Additional collections would be made during the 1992 field season in conjunction with the sampling efforts of the Coastal Habitat intertidal monitoring project (proposed).

In 1992, mussels and limpets will be collected from oiled/control pairs that have been sampled during the past three field seasons. These organisms will be removed from their shells, soaked in 10% HCl to remove any carbonate contamination, rinsed with distilled water, rinsed with hexane to remove any oil on the surface of the organism, and left overnight in a 60° C oven to remove the hexane and to dry the samples. Preparation of the samples and measurement of the resultant CO_2 will be done by standard techniques (Boutton et al., 1983), using a temperature of 870°C for combustion and a VG SIRA-9 triple collector mass spectrometer for isotope ratio determinations.

There is a certain amount of variation in stable isotope ratios in a non-polluted natural system. These variabilities occur both temporally and spatially. We will do comparisons between sites that are well matched, in close physical proximity and thus exposed to the same carbon inputs. To further enhance consistency, the sites will be sampled within a short time period of each other. Thus, relative comparisons can be made between sites that were heavily oiled and associated control sites.

Duration of the project:

The duration of this project would depend on the results of the intitial sample analyses. If the technique is useful for monitoring the incorporation of hydrocarbon derived carbon into mussels and limpets, other organisms could be similarly monitored in the future. Initially, this proposal is for the 1992 field season and for the analysis of samples during the fall and winter of 1992.

Estimated Cost:

The supplies required for this sampling effort are minimal. Collections would be made on sites that are visited by the Coastal Habitat intertidal monitoring crew and would require less than one hour of one person's time per site. The samples will be processed through the Stable Isotope Laboratory at the University of Alaska, Fairbanks. An estimated 800 total samples from the 1989, 1990, 1991, and 1992 collections will be analyzed.

Budget:

Salaries and benefits	12,000.00
Contracts	28,000.00
Supplies	500.00
Subtotal	40,500.00
Overhead	8,100.00
Total	48,600.00

Restoration activity or endpoint to be addressed:

Estimation of hydrocarbon derived carbon incorporated into tissues of invertebrate species that are important prey of sea otters and/or marine birds.

Relation to science information needs identified by RPWG:

This study fits under the general needs category outlined by the RPWG "Monitor the fate of weathering oil in mussel beds" and under the more specific coastal habitat categories to "assess the quantity, chemical status, and oil underlying mussel beds" and "monitor contamination over time."

Importance of initiating project in 1992:

This project should be initiated in 1992 in order to provide a yearly collection of samples from the 1989 through 1992.

Links to other NRDA studies:

This study would be directly linked to the Coastal Habitat Injury Assessment study on invertebrates in the intertidal zone. The data collected for this study could supplement data collected for mussels on growth, survivorship, and histology. Limpet isotope data could be correlated with that of growth and survivorship. The coastal habitat study has three years of sample collections and resulting data for intertidal mussels and limpets. This information would provide a framework on which to base the data obtained from this isotope study.

The NRDA samples collected for hydrocarbon analyses by GC/MS or UVF will be useful for interpreting the stable carbon isotope date obtained on mussels in this study.

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Harlequin Duck Restoration Project in Prince William Sound: Proposal for 1992

Project ID Number:

Written by: David W. Crowley, B.S., Assistant Investigator

As directed by: Dr. Samuel M. Patten, Principal Investigator

Leading Agency: Alaska Department of Fish and Game
Division of Wildlife Conservation

Cooperating Agency: U.S. Fish and Wildlife Service

Date of Proposal: November 20, 1991

INTRODUCTION

Harlequin ducks are both residents in and winter migrants to Prince William Sound (PWS), Alaska, feeding in intertidal zones and breeding along coastal mountain streams. The Exxon Valdez Oil Spill of March 24, 1989 (EVOS) heavily impacted the Harlequin duck population in western PWS. The NRDA Harlequin Study in the EVOS area has observed nearly complete reproductive failure, patchy Harlequin distribution, and unusual plumage coloration on many individuals (Patten 1991, Jarvis pers. comm.) during 1990 and '91. Ingestion of hydrocarbons through the food chain and massive disturbance associated with oil spill cleanup response at breeding locations are probable causes of reproductive failure (Patten 1991).

The impaired status of Harlequin populations in the EVOS area of western PWS necessitates managing for stable or increasing populations in northern, eastern, and southern (referred to as "eastern") PWS with the intent of eventual recolonization of western PWS. Identification of undisturbed Harlequin nesting streams and important habitat along those streams in eastern PWS is required. Protection of breeding habitat through the acquisition of undisturbed riparian corridors within timber sale areas may be essential for restoration of breeding Harlequins in the EVOS area.

The Harlequin Duck Restoration Feasibility Study in 1990 documented brood sightings and determined characteristics of Harlequin breeding streams. The Restoration Project in 1991 surveyed and trapped 35 streams, only 9 of which were used by breeding Harlequins. We located and documented hydrological and vegetative characteristics for 5 nests and 16 broods. Much time was expended on streams that we believed had breeding potential but that did not attract Harlequins. Capture and telemetry techniques were refined. Coastline surveys for breeding pairs, molting flocks and broods provided baseline data on population and production.

OBJECTIVES FOR 1992

These objectives supplement those listed in the Harlequin Duck Project Report (p. 5) attached. Rather than restate all objectives, the following are refined or additional goals for 1992: breeding stream and nesting habitat analysis (A below); determining productivity (B); and coastline surveys (C).

A. 1) Increase sample size of nests from 5 to 20 and complete the catalog of all breeding streams in the study area. Continue vegetation and hydrology analysis on these streams.

2) Investigate further the Two Moon Bay timber sale, determine use by Harlequins.

B. 1) Increase sample size of breeding hens, clutches and broods to determine breeding potential.

2) Determine hatching success.

3) Determine #broods/total hens and #broods/breeding hens to calculate productivity.

4) Determine brood survival.

C. Replicate boat surveys completed in 1991, thereby doubling the sample size of coastline survey observations in 1992. Improve technique to avoid disturbing Harlequins.

METHODS FOR 1992

The objectives proposed above require the following additional or refinement of methods listed in the Harlequin Duck Restoration Report (pp 9-13) attached. These are proposed respectively to the above objectives.

A. 1) Capture efforts will concentrate on known breeding streams and will commence 2 weeks earlier than last year. An additional boat will be used for trapping work in 1992. We will also use air charters and spike camps to more efficiently trap remote streams. We will use a transceiver at stream mouths recording arrival and departure of incubating and brood-rearing hens to determine diurnal movements and develop more time-efficient trapping schedules.

2) Trap and walk Irish Creek (adjacent to harvested area), request cooperation of fisheries crew present to document Harlequin sightings.

B. 1) In addition to radio-tagging, mark captured hens with colored leg bands or nasal disks so that if radios are shed early or malfunction, hens can still be identified and included in sample.

2) Return to last years nests, and revisit 1992 nests . Use Mayfield method to determine total nesting success.

3) Increase efforts to capture and mark all Harlequins using a stream to determine number of breeding pairs, total number of hens, total number of breeding hens that produced a clutch, and nesting density along a stream corridor.

4) Improved radio-mounting technique and stronger radio antennae, combined with color marked hens will allow tracking of broods through time.

C. Repeat coastline surveys initiated in 1991 on the same dates when possible. Outfit workers with quality optics so that number, sex-ratio, and breeding pairs can be discerned without disturbing ducks from offshore rocks and estuaries.

DURATION AND SCOPE

Field work in 1992 will begin May 15 and continue through the end of August. An additional third season is planned. The study is investigating the breeding ecology of Harlequin ducks in Prince William Sound in undisturbed habitat, with emphasis on breeding stream, nest site and molting habitat. This information will be used to manage an undisturbed Harlequin population for the restoration (through eventual recolonization) of the impaired population in the oil spill area.

EXPECTED RESULTS

Our results will include a catalog of Harlequin breeding streams and intertidal molting sites in Prince William Sound, important vegetative and hydrological characteristics of nest sites and streams described in a hierarchical system, and a model of such characteristics to predict potential breeding streams and nesting habitat in Prince William sound and other coastal communities. We will also provide population and productivity estimates and replicable survey techniques. Recommendations of riparian buffer strips and seasonal logging activities will be presented in a management plan for protection of Harlequin breeding habitat.

COST

6 techs., 1 crew leader, 1 supervisor	170K
Travel/ Per Diem	25K
Air charters (telemetry and logistics)	10K
Field supplies/equipment	35K
Radio-tracking, limnological equipment	35K
Total	275K

ALTERNATIVES CONSIDERED

No Action in 1992: Small sample sizes will not allow statistical analysis of current habitat data. Potential habitat degradation in breeding areas within timber sales could impede restoration despite our efforts of 1991.

Alternative proposals: 1) Expand the study to investigate the effects of logging on breeding Harlequins in Southeast Alaska, Kodiak, Afognak Island or other areas of the North Gulf Coast where timber harvest has occurred in Harlequin breeding habitat. Select anadromous fish streams possessing characteristics documented in 1991 by this study, on pre-harvested, current harvests and post-harvested watersheds. Determine Harlequin use of and productivity on these streams. This information would be important to restoration. Logistics and equipment would considerably increase cost but techniques would be the same. 2) Determine effects of the oil spill on Prince William Sound wintering and resident Harlequins by winter trapping and banding, blood work and radio-tracking to breeding areas throughout the state.

Preliminary Status Report of the Harlequin Duck Restoration Project in Prince William Sound

Project ID Number:	
Written by:	David W. Crowley, B.S., Assistant Investigator
As directed by:	Dr. Samuel M. Patten, Principal Investigator
Field Technicians:	Charles Hastings, Michael Knehr, John Kristopeit, Jon Syder, Paul Twait, David Vandenbosch
Leading Agency:	Alaska Department of Fish and Game Division of Wildlife Conservation
Cooperating Agency:	U.S. Fish and Wildlife Service
Date initiated:	May 2, 1991
Date of Report:	November 20, 1991

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EXECUTIVE SUMMARY

Harlequin ducks continue to be effected by the Exxon Valdez oil spill (EVOS) in western Prince William Sound, experiencing the second consecutive year of an essentially complete reproductive failure in the oil spill area in 1991 (Patten 1991). Kuchel (1977) stated that several consecutive years of very low production or damage to winter habitat could completely eliminate a local Harlequin population. Harlequin ducks are highly philopatric to breeding and wintering areas; repopulation would occur slowly by random wanderings from other areas. Restoration of this Harlequin population requires knowledge of undisturbed breeding, feeding and molting habitat.

Information on Harlequin ducks, which are unique, stream-nesting specialists throughout their North American range, is limited, particularly for coastal breeding Harlequins. The Harlequin Duck Restoration Project was designed to collect habitat information necessary for an effective policy of restoration and management of Harlequin populations in coastal communties. The primary objectives of this project were to document undisturbed nesting habitat and determine potential impacts of timber harvest on Harlequin reproduction. This study in eastern PWS, where Harlequins are reproducing normally, also acts as a control case for the Natural Resources Damage Assessment (NRDA) Harlequin Study in the EVOS area, where reproduction is reduced or nonexistent.

The initial field season in 1990 documented breeding streams and developed a Harlequin breeding stream profile. The wariness of Harlequin ducks required development of innovative capture and radio-tracking techniques during the 1991 season. We captured 23 Harlequins in mist nets suspended over 14 suspected nesting streams and outfitted 14 hens with radio transmitters. By radio-tracking hens into coastal mountains, we located and recorded habitat for 5 Harlequin nests, representing the first successful attempt to locate nests of coastal-breeding Harlequins. We developed a hierarchical system to document vegetation, hydrology and topography of riparian, aquatic and forest habitat and implemented it during 1991. Our discovery of Harlequin hens' exclusive use of mature and old growth forest in Prince William Sound for nesting has important implications for management of habitat in Harlequin breeding areas scheduled for logging.

Extensive boat surveys were conducted along 350 miles of coastline from Valdez to Cordova. These were repeated 3 times to locate breeding Harlequins in the spring, molting flocks in mid-summer and broods in late summer. We documented habitat for 55 molting sites (occupied by approximately 1200 Harlequins), observed 14 broods and located 4 previously unknown breeding streams.

The NRDA Harlequin Project in the EVOS area has documented that Harlequins failed to reproduce in 1990 and 1991. Probable causes

are direct mortality of returning females, sublethal effects of hydrocarbon ingestion through the food chain, and massive disturbance to Harlequin breeding areas by clean-up and monitoring activities conducted in response to the EVOS (Patten 1991). The distressed status of the Harlequin population in the oil spill area necessitates protection and management of populations in eastern PWS for restoration purposes. As a result of these findings, Harlequins duck hunting was closed during the 1991 waterfowl season in PWS. Acquisition of undisturbed riparian corridors within timber sales may be essential for restoration and recolonization of Harlequin populations.

OBJECTIVES

These objectives are revised from Patten (1990b).

A. Locate, identify and describe Harlequin nesting streams in Prince William Sound.

B. Identify habitats used by nesting Harlequins by documenting topographic, hydrologic and vegetative characteristics at nest sites.

C. Identify other Harlequin breeding habitat parameters such as distance from nest to coast, distance from nest to stream and physical features of nest sites.

D. Construct a model that predicts potential Harlequin nesting streams and high quality habitat along those streams using the characteristics identified in objectives B. and C.

E. Measure Harlequin breeding productivity by identifying clutch size, hatching success and duckling mortality.

F. Document sightings of Harlequin duck breeding behavior including pair-bonding, nest prospecting, nesting, and brood-rearing in eastern PWS to provide a study control for the NRDA Harlequin Project in the EVOS area.

G. Determine width of forested buffer strips required to protect Harlequin breeding sites from the effects of timber harvest in Prince William Sound.

INTRODUCTION

The <u>Exxon</u> <u>Valdez</u> Oil Spill of March 24, 1989 (EVOS) heavily impacted the Harlequin duck (<u>Histrionicus</u> <u>histrionicus</u>) population in western Prince William Sound (PWS). The NRDA Harlequin Study in the EVOS area has observed nearly complete reproductive failure, patchy Harlequin distribution, and unusual plumage coloration on many individuals (Patten 1991, Jarvis pers. comm.). Harlequins forage in the intertidal, consuming a wide variety of invertebrates including blue mussels (<u>Mytilus</u> <u>edulis</u>). Established blue mussel beds may continue to discharge hydrocarbons for years, possibly causing ongoing sublethal contamination of Harlequin populations. Massive disturbance associated with oil spill cleanup response at breeding locations has also contributed to reproductive failure (Patten 1991).

The impaired status of Harlequin populations in the EVOS area of western PWS necessitates protection and management of populations in northern, eastern, and southern (all referred to as "eastern" unless specified) PWS. Patten (1990b) and this study have documented successful Harlequin reproduction in 1990 and '91 in unoiled, eastern PWS. Protection of breeding habitat could best be accomplished through the acquisition of undisturbed riparian corridors within timber sale areas. This acquisition may be essential for eventual recolonization of breeding Harlequins in the EVOS area.

Project History

Prior to the 1991 field season little was known about habitat requirements of Harlequin ducks breeding in PWS. Harlequins are among the least understood waterfowl species in North America. State and federal biologists attending the EVOS restoration planning meeting (April 1990) placed a priority rating on identification of breeding habitat requirements of Harlequin ducks. This subsequent project represents the first effort to study the specific nesting and brood-rearing habitat requirements of Harlequin ducks in Alaska. This knowledge is mandatory to develop an effective policy of restoration and management of Harlequins in PWS.

In 1990 a concentration of breeding Harlequins was located in northeastern Prince William Sound (Patten 1990b). This area was not impacted by the Exxon Valdez oil spill. However, mature and old growth forest habitat favored by Harlequin ducks and timber investors is currently scheduled for logging. Potential impacts of timber harvest on breeding Harlequins may be portrayed with a better understanding of breeding ecology.

Protection and management of riparian ecotones is now recognized as critically important in areas of disturbance (Petts 1990). By regulating the flow of nutrients and materials between upland forest and stream ecosystems, riparian ecotones maintain specific aquatic habitat required by fish and invertebrates (Petts 1990, Petterjohn and Correll 1984). Aquatic-terrestrial ecotones sustain biological diversity over a short period of time by providing habitat diversity (Risser 1990, Petts 1990). Should surrounding ecosystems undergo dramatic changes by timber harvest, protected riparian habitat may sustain bio-diversity over the long term by maintaining minimal populations of species once common in the undisturbed habitat, by providing corridors for recolonization (Petts 1990, Koehler et. al. 1975), and by maintaining quality aquatic habitat for such obligate stream breeders as fish and Harlequin ducks.

Because the Harlequin is an riparian breeder in PWS, clear-cutting surrounding forest and riparian habitat could theoretically eliminate breeding from those streams. Buffer zones left adjacent to streams could satisfy breeding habitat requirements of Harlequin ducks. Maintaining the current level of Harlequin brood production on a stream once its watershed has been harvested would indicate that the ecotone within the buffer zone is continuing to function (ie. maintaining terrestrial and aquatic habitat). Conversely, a decrease in productivity could indicate that wider buffer zones are needed. Wallen (1987) suggested that the Harlequin be considered an indicator of pristine ecosystems both because of sensitivity to human disturbance and nutritional importance to Harlequins of invertebrates considered to be biological indicators of healthy streams.

A riparian ecotone is in large part determined by its adjacent forest and stream ecosystems. As an interfacing system between relatively stable ecosystems, a riparian ecotone is sensitive to change (Risser 1990, Petts 1990, Wiens et. al. 1985). Changes that occur despite preservation of buffer zones after the adjacent forest ecosystem has been harvested could potentially lower reproductive success on that stream. For example, increased movment of sediments through an ecotone could lower invertebrate and spawning salmon numbers (Frissell et. al. 1986) thus reducing the amount of forage available for Harlequin broods. The protection of critical breeding habitat within timber sales in northeastern PWS is an important component of the restoration of Harlequin ducks. Currently, 66 ft (28.8 m) buffer strips are required by the State Forestry Act to protect spawning habitat in anadromous salmon streams on private timber holdings in PWS (Martin Maricle, ADNR, pers. comm.). Determining width of buffer zones required to protect Harlequin breeding habitat from degradation and human activity disturbance is an objective of this project.

Other studies on breeding Harlequins indicate their sensitivity to human disturbance (Cassirer and Groves 1990, Wallen 1987, Kuchel 1977, Bengtson 1972). Reproductive failure resulting from human disturbance could potentially occur even with intact riparian buffer zones should logging activities take place during the nesting season. In addition to timber harvest, other impending development activities such as aquaculture, mariculture and hydroelectric projects along Harlequin breeding and molting areas in Prince William Sound could impede recovery from the EVOS (Patten 1990b).

Harlequin Life History

Throughout their range Harlequin ducks breed and feed along turbulent mountain streams, displaying considerable diving expertise as they forage for invertebrates in rushing water. Breeding and non-breeding Harlequins in Iceland migrate up interior rivers in the spring (Bengston 1966, 1972). Non breeding ducks congregate at "clubs" (community loafing sites), remaining on the rivers until the molt in July. Non-breeding and post-breeding males and some non-breeding hens then migrate back to sea, rejoining Harlequin males that had remained at coastal streams for breeding Bengtson 1966, Bellrose 1980).

Breeding hens conceal nests under dense brush, windfalls, tree roots and in rock crevices within the riparian ecotone (Bellrose 1980, Bengtson 1966, Inglis et al. 1990). Average clutch size in Iceland is 5.5 (Bengston 1966), with 1 egg laid every 2 days. Icelandic Harlequin hens are quite attentive to the nest during the 28 - 30 day incubation period (Bellrose 1980, Bengston 1966). Brooding and non-breeding hens remain on inland and coastal rivers until ducklings are nearly fledged. Bengtson (1966, 1972) and Bengtson and Ulfstrand (1971) concluded that Harlequin ducks in Iceland nested on any stream with enough food and nesting cover, but that invertebrate food resources were a more important limiting factor than cover on inland streams.

Invertebrate productivity on breeding streams may be less important to Harlequins ducks in eastern PWS. Unlike interior Harlequins of Iceland (Bengtson 1972), Wyoming (Wallen 1987), and Montana (Kuchel 1977), coastal-nesting Harlequins fly downstream from nests to intertidal estuaries to forage (Dzinbal and Jarvis 1982, Bengtson 1972). Harlequins consume small mussels, clams, snails, chitons and limpets in the intertidal before the arrival of spawning salmon. Brood-rearing on coastal streams corresponds with the anadromous salmon run. Drifting salmon roe provides an easily obtainable and nutritious food source for broods and non-breeding Harlequins in lower stream reaches and estuaries during July and August (Dzinbal and Jarvis 1982).

Harlequin breeding pairs and non-breeding females are conspicuous on or near estuaries and lower reaches of nesting streams from mid-May to mid-June in PWS. Non-breeding males also feed on estuaries but are more likely observed on offshore rocks, small islands and headlands in PWS. Dzinbal and Jarvis (1982) reported much loafing but relatively low feeding activity around this exposed rocky habitat. Post-breeding males join non-breeders on offshore rocks for molting in mid-June. Harlequin hens and broods, often in groups of mixed age classes and non-breeding "aunts", remain on breeding streams until broods are nearly fledged in late August. Breeding streams, intertidal and marine areas used by Harlequins are all important during the breeding season and should therefore be regarded as critical habitat in restoring and managing Harlequin ducks in PWS.

Mean brood size in non-oiled areas of PWS during 1990 was 3.1 ducklings/brood (Patten 1990b). Boat surveys initiated in 1971 by the USFWS indicated a resident population in PWS of approximately 6000 Harlequin ducks, supplemented in the winter by an additional 4000 migrants (Patten 1990b, Isleib and Kessel 1973).

STUDY METHODOLOGY

Study Area

The restoration project crew (4 - 6 workers) was stationed in Olsen Bay, Port Gravina, approximately 30 km northwest of Cordova. The study area consisted of all streams, estuaries and coastline from Cordova to Valdez and limited areas of Hinchinbrook and Hawkins Islands. Our study area was positioned outside the limits of the oil spill. The NRDA Harlequin staff (2 - 4 workers) was based in Herring Bay, Knight Island, in the oil spill area.

Harlequin Capture

We began an intensive capture effort in late May on streams presumed to be used by breeding Harlequins. We selected streams for investigation based on previous brood sightings, presence of mated pairs on estuaries during Spring surveys, and on a breeding stream profile developed from previous brood sightings (Patten 1990b) listed in Table 1. We captured Harlequins during their nest prospecting, egg-laying and incubation periods by suspending mist nets (by Avinet, Inc., Dryden NY) over potential breeding streams (Dzinbal 1982, Wallen 1987) from 5 to 200 m upstream from estuaries. Harlequins fly within 0.5 - 1.5 meters of the stream surface at mid-channel and were usually captured during twilight hours as they flew to and from estuaries. Initially, fast-flying Harlequins burst through mist nets of lighter gauge mesh (2 ply 2-3/8" mesh, # 8N-110/2), but were adequately restrained in stronger nets. Large, long-handled landing nets were useful in scooping ensnared Harlequins from streams; ducks often struggled free of lighter mist nets as we approached within 1 or 2 meters.

We attempted to use a net-gun (Coda Enterprises, Mesa, AZ) to capture Harlequins roosting on rocky shores and islands. This method was not effective because of the limited range of the net-gun (<10 m) and wariness of Harlequins towards approaching boats.

All captured Harlequins were weighed, measured and banded with a USFWS leg band as indicated in Table 2. Blood was drawn from each Harlequin to determine physiological condition. Samples are being analyzed by Pheonix Laboratories (Pheonix, Arizona). All Harlequin hens regardless of breeding status were fitted with a small radio transmitter.

Radio Telemetry

A radio transmitter weighing 4.5 g (built by Advanced Telemetry Systems; Isanti, Minnesota) with a lithium battery pack was epoxy-glued to the base of the tail retrices of each hen captured on breeding streams. The transmitter was nearly covered by uppertail coverts with only the whip antennae exposed. Quinlan and Hughes (1990, cited in Patten 1990b) used a similar method to locate the nest of a marbled murrelet (a diving seabird) in old growth forest habitat. By using this attachment technique, we avoided changes in feeding and reproductive behavior (Perry 1981, Sorenson 1989 and Korschgen et al. 1984), and feather wear or loss (Gilmer et al. 1974, Greenwood and Sargeant 1973, Perry 1981) induced by back packs and neck collars. We considered implanting radio transmitters but the required invasive surgery and reduced effective range (Korschgen et al. 1984) added complexity and unacceptable risk.

We radio-tracked incubating hens initially via Supercub airplane with twin 4 element Yagi antennae to determine general location of incubating hens. We then followed up on foot using Telonics receivers (model # TR-4) and 4 element portable Yagi antennae. Our ability to readily locate nesting hens was hampered by distances of nests from the coast, difficult terrain and radio signal reflection off surrounding mountains. Most incubating hens required 10 - 15 hours (round-trip) of tracking on foot to locate. These expeditions were often repeated when trackers pinpointed a nesting hen on the opposite bank of an unfordable torrent. Once found, nest locations and habitat data were recorded on data forms (see Breeding Habitat below).

Reproduction

Harlequin eggs were counted, weighed, measured and candled to determine approximate stage of incubation (Weller 1956). This was often done in cool, rainy weather. We minimized egg handling time and covered nest bowls with down and a hat while doing habitat work to reduce cooling and to keep the eggs dry. We will return to these nests during the 1992 field season to count membranes or addled eggs to determine hatching success. The Mayfield method (Klett and Johnson 1982) will be used to determine nesting success.

Productivity data and breeding behavior observations from the Harlequin Duck Restoration Project are also being used as a study control for the NRDA Harlequin Study. The NRDA team compared characteristics of Harlequin nesting streams in the restoration study area to streams in the EVOS area and consulted a breeding stream profile (Patten 1990b, listed in Table 1) to identify potential (or historical) breeding streams in western PWS. We initially proposed capturing and placing radios on 60 breeding Harlequins hens in the EVOS area and on 60 breeding hens in unoiled eastern PWS for comparison of productivity and habitat utilization. Harlequins in the EVOS area did not use estuary or stream habitat during the breeding season (see Study Results, Reproduction below). As a result Harlequins were not captured and objectives for the NRDA project were revised to examine causes of reproductive failure in wetsern PWS.

Breeding Habitat

Because the structure and dynamics of stream habitat are determined by the surrounding watershed (Osborne and Wiley 1988), Frissell et. al. (1986) and Lotspeich and Platts (1982) recommended integrating both aquatic and terrestrial habitat characteristics of streams into a hierarchical system of classification. We have developed a model similar to that of Frissell et. al. (1986), but one specifically designed to provide both a general classification of breeding streams and to delineate specific Harlequin nesting habitat within a stream reach. Figure 1 indicates system levels, boundaries of each level, and variables that characterize habitat features within system levels. Variables in the LANDFORM, STREAM and SEGMENT systems are determined from topographic (1:63,360), geological, and vegetation maps. The lower hierarchical levels (of higher resolution) REACH, POOL/RIFFLE and MICROHABITAT are documented in the field by completing data forms shown in Tables 3 and 4.

The advantages of using a hierarchical system of classification reported by Frissell et. al. (1986) are that: 1) the number of variables to be recorded at lower levels in the hierarchy is reduced since many are already recorded in the upper levels; 2) it maintains organization of data while allowing the integration of data from a variety of sources and levels of resolution; and 3) it permits selection of the level of resolution that is most appropriate in meeting project objectives and budgets. For example, it might be determined through a principal components analysis that only the variables Substrate (of POOL/RIFFLE system level) and mainland (LANDFORM level) are necessary in predicting potential nesting streams. The presence of boulder runs at the MICROHABITAT system level (determined in the field) may predict use by Harlequin broods, but so might the presence of steep sideslopes at the SEGMENT level (determined from topographic maps) since boulders most often reach the stream channel by landslides (Frissell et. al. 1986). By determining important characteristics and levels of resolution we can construct a model to aid in the inventory of Harlequin nesting streams required in pre- and post-impact studies.

Hydrology

Oswood and Barber (1982) developed a diagrammatic mapping technique to predict habitat quality and fish abundance on streams in southeastern Alaska. They selected habitat features important to spawning adult and resident juvenile salmonids, measured the features using a flowmeter, meter-stick and meter-tape, and mapped the features to scale. Areas (m^2) were determined using planimetry or a digitizing computer. Consistency of results among work crews, logistics and time constraints were considered in the development of their technique (Oswood and Barber 1982).

We are using a variation of Oswood and Barbers' (1982) technique to record stream features important to Harlequin ducks at the MICROHABITAT system level since Harlequin hens and anadromous salmon share many habitat requirements. We measured a 30 meter stream plot adjacent to each nest site, mapping the stream characteristics listed in Table 3. Classes of stream habitat at the MICROHABITAT level are being developed from the proportion of area of each feature in the plot and tested using a Chi-square analysis for frequency of selection (Zar 1984, Neu et. al. 1974).

Vegetation

We began a detailed analysis of riparian vegetation on Harlequin nesting streams in PWS during 1991. In addition to serving as a flow regulator between ecosystems, vegetation provides protection from unfavorable weather conditions and cover from predators, both important to nesting waterfowl (Bellrose 1980, Bengtson 1972). We collected data for each of 4 tiers of vegetative characteristics at nest sites located in 1991: 1) Dominant climax species of area at nest elevation (Area); 2) plant species composition within a 30 m^2 plot around nest site (Vicinity); 3) plant species composition within a 10 m^2 plot of the nest bowl (Nest Site); and 4) plant species composition over the nest bowl (Cryptic Nest Cover). Determining percent species composition for the most abundant 3 plant species at each of the 4 levels allows us to test frequency of selection of habitat classes using a Chi-square analysis. Randomly selected 30 m^2 plots along nesting streams will be used to analyze utilization vs. availability of riparian habitat (Neu et. al. 1974, Byers et. al. 1984).

We are comparing vegetative, aquatic and topographic characteristics (listed in Tables 3 and 4) of nesting streams and an equal number of non-nesting streams using a discriminant analysis (Patten 1990) and a principal components analysis followed by stepwise regression (M. Wilms, USFWS, pers. comm., Kleinbaum et. al. 1988). These procedures will determine which characteristic, or suite of characteristics are most important to breeding Harlequins.

Coastline Surveys

During the last 2 weeks of May, 1991, approximately 350 miles of unoiled coastline and estuaries from Cordova to Valdez were surveyed for Harlequin flocks and breeding pairs. Similarly, NRDA surveyed coastline and estuaries in the EVOS area. Surveys were repeated in late June through early July in both study areas to locate and document important molting habitat, and were repeated again in August for brood documentation. We also surveyed all coastline and estuaries in Port Gravina bi-weekly throughout the season to document changing Harlequin numbers, sex ratios, molt chronology, appearance of broods and preferred habitat.

Harlequin surveys were conducted from 2 skiffs; a 22 ft fiberglass boat powered by a 225 hp outboard, and an 18 ft fiberglass boat with a 90 hp outboard. One crew member piloted the boat near the coastline, islands and offshore rocks, and in intertidal estuaries. A second researcher using 8 - 10x binoculars recorded Harlequin numbers, sex when possible, location, habitat, tide and weather conditions. To save time on extensive surveys we quickly scanned shoreline habitat known to be avoided by Harlequins, concentrating our search on more classic habitat. This method was validated by more thorough, bi-weekly Port Gravina surveys, where the occurrence of Harlequins in apparent unfavorable habitat, such as near vertical cliffs, was extremely rare.

All coastal habitat in Port Gravina was recorded on 1:63360 U.S.G.S topographic maps so that a utilization-availability test can be conducted on Harlequin use of marine habitat (Neu et. al. 1974, Byers et. al. 1984). Marine habitat was placed into the following categories:

- 1e: Boulder or bedrock islands, unvegetated, that remain exposed at high tide.
- 1s: Boulder or bedrock islands, unvegetated, that are submerged at high tide.
- 2: Uniform gravel or cobble beaches on mainland or vegetated islands.
- 3: Intertidal estuaries of permanent streams.
- 4: Rocky points off mainland or vegetated islands.
- 5: Vertical or sharply sloping cliffs.

Activity Budgets

Behavioral activities of randomly selected Harlequins were recorded every minute for a minimum of 10 minutes (Dzinbal 1982). We collected morning, afternoon and evening activities for 3 habitats: estuaries (inhabited by hens only at the time), offshore rocks and gravel beaches. Activities (conventional to capitalize) documented included RESTING, FEEDING, PREENING LOCOMOTION, ALERT, and INTERACTIONS (Dzinbal 1982). When possible, behaviors were categorized further. For example HEADNOD, RUSH and NECK STRETCH are agonistic behaviors which fall under INTERACTIONS (Inglis and Torrence 1990).

STUDY RESULTS

Habitat Analysis

5 Harlequin nests were located during June and July, 1991, on high, steep banks of mountain streams in predominantly mature and old-growth spruce-hemlock forest in eastern PWS. Table 5 provides a detailed location of each nest site. Western hemlock (*Tsuga heterophylla*) was much more prevelant than was Sitka spruce (*Picea*

sitchensis) at nest sites. Nests were concealed under Vacccinium, Rosa, fern spp. and hemlock seedlings, on southern exposed, mossy banks. Streams used by nesting hens were fast-flowing, shallow and turbulent, ranging in width at the nest site from 1.5 m to 4 m. Table 6 lists all parameters of the hierarchical system with corresponding habitat data from the 5 nest sites located in 1991. Table 7 lists characteristics and Harlequin breeding status of nesting streams investigated in 1991. For comparison, Table 8 lists the characteristics of suspected non-nesting streams. The following is a further discussion and summarization of breeding stream characteristics.

LANDFORM: Four of the five nests and 7 of 9 breeding streams (defined by presence of nests and brood sightings) were located on the mainland. Two breeding streams were identified on Hinchinbrook Island. However, much more capture and survey effort was expended on mainland streams.

STREAM: Origin of all breeding streams was non-glacial, fed by melt water and precipitation runoff. We did not determine Harlequin use of clear, tributary streams flowing into large, predominantly glacial rivers (such as the Gravina and Rude rivers) because of difficult access through braided, shallow estuaries and unnavigable river channels. We surveyed the lower 1.5 km of the Gravina River once only during a very high tide. No Harlequins were observed on the river nor on the outer estuary which was surveyed regularly. Because of the proximity of coastal mountains to the sea, most non-glacial stream lengths were relatively short, from 2 - 8 km.

SEGMENT: Valley sideslopes were categorized into Enclosing (Encl), Moderate (Mod) and Distant (Dist). Enclosing sideslopes were steep, and rose directly off the stream over most or all of its length. Moderate slopes were generally steep, but did not rise directly from the stream over most of its length. Distant sideslopes were less steep, and were far enough away so that landslides did not affect stream channel or substrate. All sideslopes are heavily forested with exposed bedrock and boulders.

Streams often flowed through deep gorges. Some stream segments contained whitewater rapids and cataracts of such intensity that it was difficult to imagine young Harlequin ducklings surviving the trip from nest to estuary much less remaining together as broods. This could partially explain why we consistently saw clutch sizes of 6 - 7 in nests upstream and broods of 1 - 3 below on estuaries.

REACH: At each nest site we measured a 30 m stream channel plot and determined percent of vegetation species, dominant substrates and hydrological characteristics. Although dense, alder/willow (Alnus crispa/Salix spp.) riparian vegetation was available, often on the opposite stream bank, nests were located on high cut, relatively open banks of hemlock forest. Alder/willow banks were lower, much more subject to flooding and received less direct sunlight because of the dense canopy. Stream banks selected by Harlequin hens were south-facing, well-drained and noticeably dry compared to surrounding rain forest type habitat. Nests were positioned 2 - 5 meters above streams; hens could launch directly into flight from nests.

Although stream banks by Harlequin hens were fairly open, nests were well-concealed under small blueberry (Vaccinium ovalifolium) or rose (Rosa acicularis) shrubs and ferns. Nests were usually positioned on moss-covered rock ledges or crevices but one hen nested on an old, mossy stump 2.0 m off the forest floor. Incubating hens held tightly when approached, usually flushing when we were within 1 m or less of the nest.

POOL/RIFFLE: All nests were located above or very near shallow (<.5 m) fast water. Stream substrate was most often gravel/cobble or cobble/boulder mix resulting in riffles and boulder runs with limited pocketwater. No salmon were observed in streams at nest sites; steeper gradients and waterfalls block passage of spawning salmon generally within 1.5 km of estuaries. The three broods observed while still on streams were in riffles with gravel/ cobble substrate.

MICROHABITAT: This will be a further dissection of POOL/RIFFLE whereby each type of aquatic habitat was measured and mapped to scale. This data will be used to determine proportion of each type within the plot. Analysis will be completed after a larger sample of plots has been obtained.

Reproduction

Harlequins ducks successfully reproduced within the Restoration Project study area in eastern PWS during 1991. We observed a minimum of 49 breeding pairs (many more were mixed in with large flocks) during Spring surveys. One copulation was observed in Olsen Bay on May 11. Average clutch size for 5 nests was 6.2 eggs/clutch. Hatching success was determined for 18 eggs in 3 clutches. All hatched except 2 eggs; 1 from a clutch of 4 and 1 from 7 (89% success). A larger sample will be required in 1992 to determine predation and abandonment. Radio transmitter loss or damage to antennae (hens were able to break off antennae near bases) did not allow relocation of radio-tagged hens with broods on estuaries during 1991 so that duckling mortality for these particular broods is unknown. Average size for 13 Harlequin broods observed in marine habitat was 3.4 ducklings/brood. See Table 9 for comparison of breeding results among this and other Harlequin studies.

A crude estimate of mortality can be calculated by 100 - (average brood/average clutch size)*100. This indicates a duckling mortality rate of 45.2% at 3 - 5 weeks of age. This is almost certainly an underestimate of mortality because loss of entire broods is not known nor included in the calculation. Improved transmitter mounting, stronger antennae and greater number of radio-tagged hens will allow us to determine loss of entire broods as well as survival of individual broods over time in 1992.

Table 10 lists data collected from radio-tagged hens. Of the 14 hens we radio-tagged in 1991, 7 nested or were suspected nesters, 5 did not or were suspected not to breed, 1 possible breeder was killed and devoured by an unidentified predator, and 1 hen was never relocated after capture, possibly because of radio failure or loss. This indicated a minimum hen breeding frequency of approximately 50%.

In contrast to our findings of successful Harlequin reproduction in eastern PWS, extensive boat surveys of estuaries and 121 hours of mist-netting of potential nesting streams revealed a failure of Harlequins to reproduce in the EVOS area. Mated pairs common in eastern lagoons and estuaries were <u>not</u> observed in the EVOS area, nor was nest-prospecting by hens. One brood was observed in the EVOS area in 1991 (Patten, pers. comm.) It was seen on marine habitat in the Bay of Isles in mid-September, 1 month later than when broods of similar age class began appearing in eastern PWS. Four broods were observed on the periphery of the oil spill area (Patten, pers. comm.). No broods were documented in the EVOS area in 1990.

Coastline Surveys

We counted 572 Harlequin ducks during Spring surveys, including 49 pairs, 103 females, and 124 males (our ability to discern between males and females at a distance improved with time). Pairs were observed more often on or near estuaries than were singles. Nearly all Harlequins observed in eastern PWS were on offshore rocks (types 1e and 1s), rocky points (4) or intertidal estuaries.

Preliminary results of mid-season surveys indicate a preference of 1200 Harlequins in 55 molting flocks for rocky points interspersed with gravel/cobble beach and offshore rocks near such beaches. Use of this habitat was much greater than would be predicted by random use of available habitat. Molting areas were along seaward exposed beaches with protection from storms offered only by the rocks themselves. These findings were similar to those of Dzinbal (1982). Loafing rocks generally were 50 - 100% covered with <u>Fucus</u> and 25% - 50% barnacle coverage. Molting areas in eastern PWS appeared rich in other fauna and flora and occurred in fairly shallow water (which is auto-correlated with emergent, offshore rocks), generally less than 15 m deep. Seemingly identical habitat in Port Fidalgo, except that seaward exposure was limited to 1.5 km or less of reach, was nearly devoid of Harlequins. We speculated that areas of exposed coastline had stronger currents or upwellings that carried in deep-water nutrients, than did ports and bays of limited seaward reach.

We located 14 broods of Class 2a - 3 during late August surveys on marine habitat in 1991 (Table 11), all of which were on or very near estuaries of breeding streams. Two broods were observed on stream habitat in July.

Activity Budgets

Preliminary results indicate that male molting flocks on outer rocks and gravel beaches spend much of the day resting or preening. Feeding occurs most often in the morning. Harlequin males fed together in small flocks in shallow (1 - 10 m) water. Dive times averaged 29.3 seconds, resting time 22 seconds, and feeding bouts approximately 35 minutes. Feeding areas of molting flocks were within a short swim (50 m) of favorite loafing rocks or gravel spits. The few agonistic displays between molting males that were recorded occurred over occupation of particularly favorable loafing spots; usually rounded, _Fucus_-covered rocks barely emerged above the tide.

Hen flocks (6 - 16 ducks) present in estuaries from mid-July through August, fed much more than did molting male flocks in their respective habitat. Harlequin hens fed vigorously in fresh water among spawning pink salmon, staying just ahead of the high tide line. A typical feeding bout lasted 15 - 30 minutes. Dives lasted .5 - 2 seconds in water less than .5 m deep. Hens fed by swimming about in riffles "PEERING" repeatedly (submerging bill and eyes beneath the surface) above spawning salmon. When food items were located after much peering, hens made repeated dives to the stream bed, diving to the same spot each time. These small feeding areas (<1 m^2) were temporarily defended against other feeding hens approaching within .5 - 1 m. Intruders were driven off with a RUSH, NECK STRETCH, PECK and a high pitched SQUEAK. Feeding was also accomplished at the surface by skimming and below the surface by tipping-up.

Dzinbal (1982) and Dzinbal and Jarvis (1982) determined that waste salmon roe is nutritionally important to coastal-nesting Harlequins. From our observations we believe that Harlequins were also feeding directly from salmon redds possibly as eggs were being laid. This would explain the hens' sudden interest in and temporary defense of small feeding spots on the stream bed among spawning salmon. Often a hen diving repeatedly at a site would suddenly rush to the surface and "run away" for 1 - 2 meters. Although we could not determine conclusively why these sudden escapes were performed because of limited visibility among spawning fish, hens were possibly being driven off redds by defensive male salmon.

Harlequin hens loafed on emergent rocks and on the stream bank. The grassy bank, well trampled by brown bears (_Ursus arctos_), offered good visibility to roosting hens. Hens sat close together, often in physical contact, along the bank without agonistic behavior as displayed by roosting males. ALERT behavior was telegraphed among hen flocks with HEAD UP and EXTREME HEAD UP. Disturbed harlequins were able to leap directly into flight with less than 1 meter of bank elevation.

STATUS OF HARLEQUIN RESTORATION

A. We located 9 harlequin nesting streams identified by actual capture of nesting Harlequin hens or by observations of broods on estuaries. Vegetative, hydrological and topographical characteristics of each stream were described using the hierarchical model. We require a larger sample size of nest sites, nesting streams, and non-nesting streams to statistically test selection of habitat in order to determine conclusively nesting habitat requirements. We have identified up to 26 suspected non-nesting streams, presented in Table 9. It is unknown, however, if marginally adequate streams may be used intermittently as Harlequin populations fluctuate. For example, Harlequin broods were reported on East and West Olsen Creeks (which share an estuary) in 1990, and we observed the early-Spring use of the estuary by 2 breeding pairs in 1991. After 65 net-hours of capture effort we observed only limited nest prospecting by breeding Harlequins, no nesting and no broods. It is possible that our presence caused breeding hens to nest elsewhere. Classification as non-nesting streams should be made tentatively after the second season of trapping and brood surveys.

B. We documented hydrological, vegetative and topographical characteristics at five nest sites. One nest was constructed during the previous breeding season, was located approximately 10 m from a current nest and was almost certainly used by that same hen since Harlequins are highly philopatric (Wallen 1987).

C. We recorded other breeding parameters of Harlequins including distance to the coast, distance from the stream and physical features of 5 nest sites.

D. We have developed a working hierarchical structure in which to describe breeding habitat. A larger sample size is required before statistical tests can be applied (see A. above).

E. We have obtained limited data on productivity including clutch size for 5 nests, observation of 14 broods on marine habitat (productivity indicator for Harlequins) and female breeding frequency of approximately 50%. An increase in overall sample size will improve accuracy of our current data. Our data thus far are similar to those reported in the literature (Table 9).

F. Documented sightings of Harlequin duck breeding behavior including courtship, copulation, nest prospecting, location of 5

Harlequin nests and 16 broods in eastern PWS during 1991 indicate that Harlequins successfully reproduced in the restoration study area in 1991. Harlequins essentially failed to reproduce in the EVOS area in 1990 - '91.

G. Petts (1990) stated that the most important parameter to be determined for effective management of land-water ecotones is the minimum size (i.e. width) required to sustain both riparian habitat and function of this habitat as a flow regulator between systems. Petterjohn and Correll (1984) reported that 50 m of riparian forest habitat removed most of the excess nutrients and pollutants from overland and throughflow water in an agricultural watershed. Cassirer and Groves (1990) observed Harlequin broods more often on undisturbed streams away from roads and human activity in National Forests of northern Idaho. They also coincidentally recommended a 50 m undisturbed riparian corridor, visual isolation, and limited human activity during the breeding season to minimize impacts of timber harvest.

We located Harlequin nests within 25 m of streams or small tributaries to streams. Current required buffer strips of 28.8 m may provide enough nesting habitat, but would not visually isolate nesting hens from human disturbances associated with logging. Buffer strips are only required on anadromous fish streams; 3 of the five nests located in 1991 were on very small tributaries (1 - 1.5 m wide, .25 m or less deep) where buffer strips would not be required. We tentatively conclude that 50 m buffer strips would adequately protect Harlequin nesting habitat but believe that human and machinery disturbances associated with logging would be a much more serious hindrance to reproducing Harlequins than would lack of nesting habitat. Harlequin ducks in Iceland, Greenland, North Slope of the Brooks Range, Siberia and Aleution Islands do not nest in old growth forest, but do require adequate streamside vegetation ranging from dwarf birch (Betula nana) to Salix spp (Bengtson 1972, Bellrose 1980).

Most streams within the Two Moon timber sale in Port Fidalgo were probably not used by breeding Harlequins, although 2 pairs were present in Two Moon Bay in late May. Irish Creek (Irish Cove, adjacent to Two Moon Bay) appeared of adequate size for breeding Harlequins but an ADF&G Commercial Fisheries crew monitoring a wier site was present all summer. This could potentially have caused enough disturbance to discourage breeding Harlequins from nesting on the stream.

The identification of Harlequin habitat requirements by this project is an important first step toward management of riparian ecotones within timber sales in PWS. The inventory of breeding streams and identification of nesting and brood rearing habitat on those streams will providing a model to aid in identification of potential nesting streams in western PWS and in other coastal Harlequin populations. The detail with which we document vegetation and hydrology at the Microhabitat, Pool/riffle, and Reach levels will be highly useful in determining specific areas of vulnerability to impacts of timber harvest (Desaigues 1990). This effort, combined with surveys for estimating population size and productivity, will also provide a record of pre-harvest conditions that will be valuable in post-impact assessment of habitat condition and population trends (Cassirer and Groves 1990, Oswood and Barber 1982). Subsequent management decisions based on this information can be applied to western PWS, Southeast Alaska in areas of extensive timber harvest, and the northeastern coast of North America where in 1990 the Harlequin duck was placed on the list of endangered species by the Canadian Wildlife Service.

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Table 1. Characteristics of 9 known breeding streams selected by Harlequin hens for nesting and brood-rearing in Prince William Sound, Alaska.

Stream Characteristics[a]
10 - 30 m wide at mouth
Extensive intertidal areas in estuary
Moderate gradient
Discharge rate: 1.5 - 7.0 cu. m/sec
Depth .3 - .5 m
Elevation at onset: 750 ft
Clear, not turbid
Substrate: large stones, boulders
Stream length: 5 - 8 km
Forest: Mature Spruce-hemlock
Spawning salmon species: Pink, Chum

[a]From Patten (1990b)

Table 2. Data collected from captured Harlequin Ducks in Prince William Sound, Alaska, 1991.

CAPTURED HARLEQUIN DUCK DATA FORM

Harlequin Duck Restoration Project, Prince William Sound, Alaska

Bird #:______________

IDENTIFICATION

Sex: F M
Age: AHY FY AFY
Unknown
USFWS
Band#:______________
Species: ____________
(if not HARL)

LOCATION

Stream: ____________
Bay: ____________
Estuary: Y N
Roosting: Y N
Sbstrt: BE BO CO SA
SO LI VE
Comment:

PLUMAGE

Coverts: Trapezoid
Rounded
Tail tips: Pointed
Forked
Worn
Brood Patch: Y N
Appearance: G Poor
Oiled

CAPTURE CONDITIONS

Time:______________
Date:______________
Sky: CLD PTCL CLR
Precip: NONE FOG MIST
DRZL RN SNW
Tide: INCO OUTG HIGH LOW

CAPTURE METHOD

Mist Net
Net Gun
Decoy Trap
Comment:

MEASUREMENTS

Weight:__________g
Tarsus:__________mm
Left or rght
Culmen:__________mm
Wingcord:__________mm
Left or rght
10th Prm:__________mm

BIRD CONDITION

Cloaca distended: Y N
Keel Depth: None Slight
Comments:

RADIO TELEMETRY

Frequency:
Date/Time released:
Behavior after release:

BLOOD SAMPLES

Taken: Y N
I.D.#:

COMMENTS:

Table 3. Aquatic data collected at Harlequin nest sites in Prince William Sound, Alaska in 1991.

HARLEQUIN DUCK NESTING HABITAT: STREAM DATA FORM

Harlequin Restoration Project, Prince William Sound, Alaska

DATE:	BROOD SIZE:
TIME:	HEN I.D.#:
LOCATION:	FREQ:

Mark location on map

MAP TO SCALE 30 m STREAM PLOT[a]: 1 at nest site, 2 random w/in .5 km

STREAM CHARACTERISTICS		**DESCRIPTIONS**
TA	Total Area	Measure of stream size since length is constant
SS	Shallow Fast	Area of water <.5m deep, velocity <.3m/s.
SF	Shallow Fast	Area of water <.5m deep, velocity >.3m/s.
DS	Deep Fast	Area of water >.5m deep, velocity <.3m/s.
DF	Deep Fast	Area of water >.5m deep, velocity >.3m/s.
BR	Boulder Run	Area of DF water with boulder induced turbulence.
FD	Forest Debris	Area of logs, branches in and over streams.
RV	Ripariation Veg	Area of over-hanging vegetation.
UN	Undercut Bank	Area of undercut stream bank.
PW	Pocketwater	Area of SF or DF water creating small pools.
BW	Backwater	Area of slack water off main stream channel.
FA	Falls	Area of waterfalls > 1m high, include plungepools.
LO	Loafing Sites	Number emergent, slightly submergent boulders.

STREAM VARIABLES[b]

SUBSTRATE

- BE Bedrock
- BO Boulder (>30cm)
- CO Cobble (8-30cm)
- GR Gravel (.2-8cm)
- SA Sand
- SI Silt

CHANNEL TYPE

- ME Meander
- BR Braided
- ST Straight
- CU Curved

TURBIDITY

- CL Clear
- ST Slight turbid
- TU Turbid

ORGANISMS

Salmon present: Y N
Species:
Spawning: Y N

HYDROLOGY

Stream length:
Dist. to estuary:
Width at nest site:
Discharge at mouth:

TOPOGRAPHY

Gradient:
Altitude at origin:
Aspect:
Stream order:

COMMENTS:

[a]Compiled, in part, from Oswood and Barber (1982).
[b]Compiled, in part, from Cassirer and Groves (1990).

Table 4. Terrestrial data collected at Harlequin nest sites in Prince William Sound, Alaska in 1991.

HARLEQUIN DUCK NESTING HABITAT: TERRESTRIAL DATA FORM[a]

Harlequin Restoration Project, Prince William Sound, Alaska

DATE:
TIME:
LOCATION:
Mark location on map

BROOD SIZE:
HEN I.D.#:
FREQ:

NEST SITE HABITAT: Complete 1 for 30 m, 1 for 10 m plots.

NEST SUBSTRATE

BE Bedrock
BO Boulder (>30cm)
CO Cobble (8-30cm)
GR Gravel (.2-8cm)
SA Sand
SI Silt
LI Litter/vegetation

LANDFORM

MN Mainland
IS Island
PE Peninsula
SB Streambank
- UN Undercut
- VE Verticle
- SL Sloping

FL Floodplain

NEST BOWL MATERIAL

GS Grasses
DO Down
VE Vegetation

UNDERSTORY (ht<1m)

Sp1:________________%________
Sp2:________________%________
Sp3:________________%________
Veg Density: HE MOD SP

OVERSTORY (ht>1m)

Sp1:________________%________
Sp2:________________%________
Sp3:________________%________
HEV MOD SPARSE

CRYPTIC NEST COVER

RO Rock crevice
TR Tree cavity
DF Deadfall
VE Vegetation
% Species:

Measure Distance To:
STREAM:____________
FOREST:____________
HARVEST:___________

AREA HABITAT

SPRUCE-HEMLOCK FOREST
(specify if not S-H)

OG Old growth
MA Mature
IM Immature
PO Pole
SA Sapling
SE Seedling

HARVEST STATUS

UN Unharvested
RH Recent (<10 yr)
OH Old harvest (>10yr)
SG Second growth
BU Buffer width:
CL Clear-cut no buffer

BANK COMPOSITION
(list species and % on back)

TR Trees
SH Shrubs
TS Tree/shrub mosaic
GF Grass/forb
DE Debris
SA Sand
SI Silt
GR Gravl/cobbl/bould
BE Bedrock
RO Roots

TOPOGRAPHY: Altitude:______ Slope:______ Aspect:_______

[a]Compiled, in part, from Cassirer and Groves (1990).

Table 5. Locations of 5 Harlequin duck nests on coastal, mountain streams in Prince William Sound, Alaska in 1991.

Hen I.D.#	Stream Name	Location	Alaska Stream Catalog Number	Latitude[a] Longitude	Elevation
EPWS0891[b]	Beartrap	Beartrap Bay Port Gravina	221-30-10480	60°46'30" 146°28'00"	220 m
EPWS1991	East Cove	Jack Bay Valdez Arm	221-50-11230	61°00'30" 146°34'45"	100 m
EPWS2091	East Cove	Jack Bay Valdez Arm	221-50-11230	61°00'15" 146°34'15"	175 m
EPWS2191	Hinchinbrook (near Nuchek)	Port Etches Hinchinbrook Island	None	60°15'30" 146°28'00"	220 m

[a]Determined from 1:63369 USGS topographic maps.
[b]Two nests were found at this location, 1 current and 1 from a previous breeding season. Because Harlequins are highly philopatric, these were presumably constructed by the same hen.

Table 6. Hierarchical description of Harlequin duck breeding streams and habitat from 5 nests located in 1991 in Prince William Sound, Alaska.

System Level			# Nests	# Broods	# Streams
LANDFORM	Mainland		4	13	6
	Peninsula		0	1	1
	Island		1	1	2
STREAM	Origin	Glacial:	0	0	0
		Runoff:	5	15	9
	Topography	Slope:	4 - 13%, Mean 8%		
		Aspect:	5 SW, 2 E, 1 NW, 1 W		
		Length:	2.0 - 8.5 km, Mean 5.0 km		
	Geology		"Dominantly coarse, rubbly deposits associated with steep-sloped mountains with high percentage of exposed bedrock" (Karlstrom et. al. 1964).		
SEGMENT	Stream order[a]:		1 - 3, Mode 2		
	Valley sideslopes:		7 Enclosing, 2 Moderate		
	Stream discharge at mouth:		1.5 - 7.0 cu.m/sec[b]		
	Stream width at mouth:		1.5 - 10 m, Mean 6.4		
	Climax vegetation:		Mature to old growth coastal Spruce-Hemlock forest		
REACH	Channel slope:		5.3 - 30%, Mean 17.4%		
	Channel pattern:		Straight or curved, no meanders		
	Bank vegetation:		Tree shrub mosaic to trees only		
	Bank configuration:		Sloping (45 - 90°), 1 - 5 m high		
	Nest site vegetation:		Western hemlock, *Vaccinium*		
	Cryptic nest cover:		*Vaccinium* or hemlock seedlings		
	Distance to coast:		1.25 - 2.75 km, Mean 2.15 km		
	Nest to stream:		1.5 - 22 m. 2 m most common.		
POOL/RIFFLE	Fish species:		No fish near nest sites		
	Dominant hydrology:		Shallow fast		
	Stream width at nest:		1.5 - 5 m		
	Dominant substrate:		Gravel and cobble		
MICROHABITAT	Proportion of each substrate type listed in Table 4.				

[a] Rating of size based on number of tributaries contributing to segment (Cole 1983).
[b] From Table 1 (Patten 1990b).

Table 7. Harlequin duck breeding streams, identified by trapped hens or presence of broods, investigated in Prince William Sound, Alaska during 1991.

STREAM NAME	A.S.C.[a] #	LENGTH Km	% SLOPE	BASIN ASPECT	WIDTH(m) AT MOUTH	LAND FORM	SIDE SLOPES	# TIMES SURVEY[b]	# NET HOURS	# HENS TRAPPED	# NESTS FOUND	# BRDS
Beartrap	10480	7.0	8	SW	10	Main	Encl	25	47	5	2	3[c]
Constantine	18150	8.5	4	SW	unkw	Isl	Encl	1	0	0	0	1
Duck	11160	2.0	7	SW	7	Main	Encl	6	0	0	0	1
East Jack Cove	11230	3.5	6	NW	4	Penn	Encl	12	18	2	2	2
Fish Bay	10950	3.5	13	E	4	Main	Mod	3	0	0	0	2
Hinchinbrook	none	2.0	11	SW	1.5	Isl	Encl	2	0	0[d]	1	N/A
Rain	10450	6.0	7	W	4	Penn	Mod	14	9	0	0	2
Sheep	10360	7.0	6	SW	10	Main	Encl	10	22	3	0	3[c]
Stellar	11530	6.0	11	E	8	Main	Encl	14	53.5	3	0	2
	MEAN:	5.0	8		6.4			TOTAL:	149.5	13	5	16
	STDEV:	2.4	2.9		3.1							

[a]Alaska Stream Catalog number.
[b]Number of times each stream was surveyed, an index of effort. Visits range in duration from 3 minutes to 10 hours.
[c]One of these broods was sighted on the stream so is not included in productivity calculations.
[d]This hen was captured twice on Nuchek Creek though the streams do not meet except at low tide in the outer estuary. She apparently used the larger Nuchek to travel into the hills, then flew several hundred meters through or above the forest to the nest site on Hinchinbrook creek.

Table 8. Coastal streams determined not to be used by breeding Harlequin ducks during 1991 in Prince William Sound, Alaska through surveying and trapping at stream mouth.

STREAM NAME	A.S.C. #	LENGTH Km	% SLOPE	BASIN ASPECT	WIDTH(m) AT MOUTH	LAND FORM	SIDE SLOPES	# TIMES SURVEYED	NET HOURS	HARLEQUIN SIGHTINGS
St. Matts	221-30-10560	3.5	13	SW	4	P	M	19	23	none
East Olsen	221-30-10516	7.5	12	S	4	M	M	25	32	1 pair, 1 hen,
West Olsen	221-30-10517	5.5	9	S	5	M	M	25	35	2 pr nearby, Spring
Control	221-30-10520	5	13	SE	4	P	M	22	24	Aug. hen flock; 13
West Cove	221-40-11212	5	13	N	4	P	E	5	4	6 pr nearby, Spring
2 Moon	221-40-10735	2	2	N	3	P	D	5	10	4 pr nearby, Spring
Irish	221-40-10760	4	7	N	5	P	D	5	0	none
Whalen	221-40-10800	7	13	W	8	P	D	5	0	1 pr in bay, Spring
Surf	221-20-10380	7	9	SE	3	P	D	8	0	2-6 near all summer
Close Sheep	221-20-10370	4	13	SE	2	P	E	3	0	molting flock nearby
GravinaRock	221-30-10410	4.5	4	NW	2	P	D	10	0	molting flock nearby
'Ganzer	221-30-10430	2	22	NW	1.5	P	E	10	0	molting flock nearby
RottenHumpy	221-30-10440	2.5	23	NW	2	P	E	10	0	molting flock nearby
StMattSeep	221-30-10540	5	13	S	2	P	M	9	0	none
SahlinFalls	none	4.5	20	SE	4	M	E	6	0	none
Comfort	221-30-10460	4	17	W	5	P	M	11	0	1 hen, mid-late Aug
Koppen	221-20-10350	5.5	20	SW	3	M	M	7	5	none
Gravina	221-20-10450	15	9	W	15	M	D	5	0	none
Nuchek	228-60-18120	8.5	5	SW	4	I	D	3	11.5	1 hen captured[a]
East Nuchek	228-60-18110	4.5	5	SW	2	I	D	1	3	none
Native	221-30-10470	3.5	9	W	4	M	M	10	0	3-4 near all summer
Indian	221-50-11170	6.5	18	S	7	P	M	4	5	none
LittleShark	221-30-10420	0.5	8	NW	1.5	P	M	9	0	molting flock nearby
Little Ole	221-30-10513	1.5	29	S	2	P	M	9	0	molting flock nearby
West Olsen	221-30-10530	1.5	38	E	1.5	P	E	9	0	none
Little Bear	221-30-10490	1.5	21	SW	1.5	M	E	9	0	none
	MEAN:	4.7	14		3.8			TOTAL:	150	
	STDEV:	2.9	8		2.8					

[a]This hen nested on Hinchinbrook Creek, Table 8.

Table 9. Summary of Harlequin duck breeding productivity in northeastern Prince William Sound, Alaska during 1991 and comparison to other Harlequin populations[a].

Investigator	Year	Location	%Male Sex Ratio	Mean Clutch Size	Hatch Success	Mean Fldged Brood Size	% Duckling Mort
This study	1991	PWS, AK	55	6.2	89%	3.4	>45
Dzinbal	1982	PWS, AK	60	---	---	2.5	---
Bengtson	1972	Iceland	56	5.7	87%	2.8	45
Kuchel	1974	Wyoming	62	---	---	3.9	---
Wallen	1987	Montana	50	---	---	---	---
Cassirer	1990	Idaho	---	---	---	3.0	---

[a]The estimates presented are intended only as a comparison of production amoung studies and were not necessarily derived using the same method or parameters.

Table 10. Harlequin hens captured and radio-tagged in northeastern Prince William Sound during 1991.

Hen I.D. #	Brood Patch	Disten Cloaca	Capture Date	Nest Located Date	Stream Name	Breeding Status[a]	Approx. Hatch Date	Clutch Size	Radio Locations: Date and habitat[b]
01	No	N/A	6/2	N/A	Beartrap	Unknwn	N/A	N/A	Mortality 6/6-S
05	No	Yes	6/5	No	Beartrap	Nonbrd	N/A	N/A	7/1, 7/2, 7/9, 7/11-M
08	Yes	N/A	6/5	7/6	Beartrap	Breeder	7/6	7	7/7-S; 7/9-M
09	Yes	Yes	6/6	No	Beartrap	Breeder	Unkwn	Unkwn	7/17-M
10	N/A	N/A	6/6	No	Beartrap	Nonbrd	N/A	N/A	7/1, 7/9-M
13	Yes	Yes	6/11	No	Sheep	Breeder	7/7	Unkwn	7/9, 7/10-S
14	No	No	6/11	No	Sheep	Nonbrd	N/A	N/A	7/9, 7/17-M
15	Yes	N/A	6/12	No	Sheep	Breeder	7/8	Unkwn	7/7, 7/10-S; 7/9-M
16	Yes	N/A	6/19	No	Stellars	Nonbrd	N/A	N/A	6/25, 8-8-M
17	No	No	6/20	No	Stellars	Nonbrd	N/A	N/A	6/22-S; 6/29-M
18	No	Yes	6/21	No	Stellars	Unkwn	N/A	N/A	None
19	No	Yes	6/20	6/25	East Cove	Breeder	7/4	7	8/6-S; 8/8-M
20	Yes	No	6/24	6/27	East Cove	Breeder	7/10	4	8/5-S
21	Yes	Yes	7/2	7/3	Hinchinbrook	Breeder	7/6	6	N/A

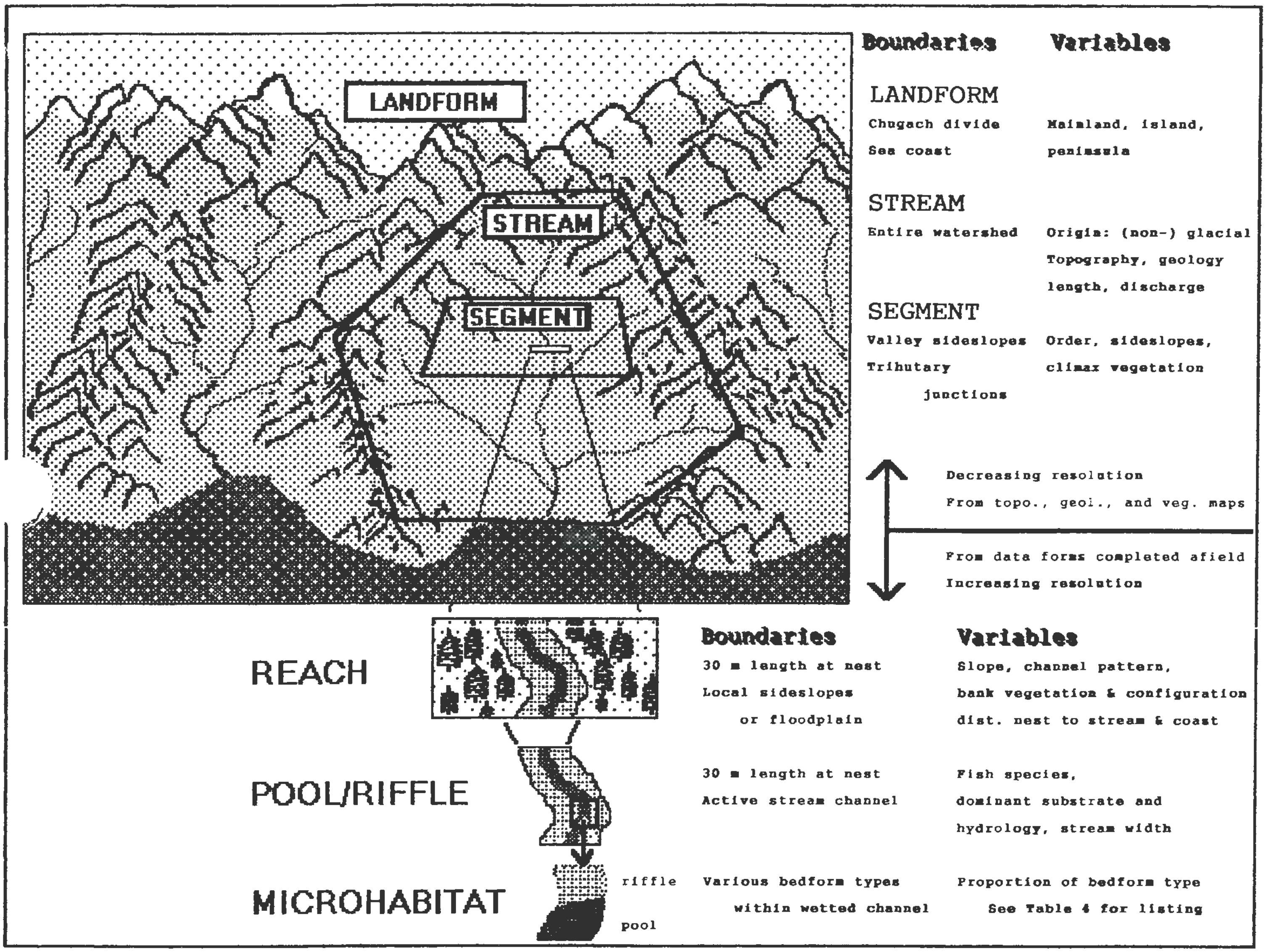
[a] Breeding status was determined when nests were not located by a combination of factors including presence of brood patch, distended cloaca, and subsequent relocations.

[b] Habitat: S = upstream, assumed to be at nest site; M = marine, including estuaries.

Table 11. Brood observations recorded during 1991 in Prince William Sound, Alaska.

Location	A.S.C	Date	# Young	Age Class	Habitat	Hen ID#
Beartrap	10480	7/7	7	Ia	Nest Bowl	EPWS0891
Beartrap	10480	8/14	2	IIa	Estuary	N/A
Beartrap	10480	8/18	1	IIc	Estuary	N/A
Constantine	18150	8/7	8	IIa	Estuary	N/A
Duck River	11160	8/4	1	Ic	Estuary	N/A
Fish Bay	10950	8/19	2	IIc	Estuary, Bay	N/A
Fish Bay	10950	8/19	4	IIIa	Estuary, Bay	N/A
Jack Bay	11230	8/20	4	IIc	Estuary	N/A
Jack Bay	11230	8/20	6	IIb	Estuary	N/A
Rain	10450	8/22	1	IIc	Estuary	N/A
Rain	10450	8/22	2	IIIa	Estuary	N/A
Sheep	10360	7/10	2	Ia	Stream riffle	EPWS1391
Sheep	10360	8/15	3	IIc	Estuary	N/A
Sheep	10360	8/15	4	IIIa	Estuary	N/A
Stellar	11530	8/20	2	IIc	Estuary	N/A
Stellar	11530	8/20	5	IIb	Estuary	N/A

Figure 1. Diagram of hierarchical system levels for description and classification of stream habitat in Prince William Sound.



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STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF PARKS AND OUTDOOR RECREATION
Office of History and Archaeology

WALTER J. HICKEL, GOVERNOR

3601 C STREET, Suite 1278
ANCHORAGE, ALASKA 99503
PHONE: (907) 762-2622

MAILING ADDRESS:
P.O. Box 107001
ANCHORAGE, ALASKA 99510-7001

November 20, 1991

3500-1 VOS, CERCLA. Restoration

Subject: Restoration Proposal

Stan Senner
Oil Spill Restoration Planning Office
437 E. Street, Suite 301
Anchorage, AK 99501

Dear Mr. Senner:

Attached is a proposal to do restoration work on five archaeological sites on State land which have been damaged as a result of the EXXON Valdez Oil Spill. Three of the sites have been examined for damage under the joint Federal/State damage assessment contract administered by the U.S. Forest Service. An interim report of results of that study has been submitted to the Forest Service. The other two sites were examined by this office and an interim report will be submitted to ADF & G by November 27. If you have questions please contact me or Douglas Reger, 762-2622.

Sincerely,

Judith E. Bittner

Judith E. Bittner
State Historic Preservation Officer

cc Mark Fraker, ADF & G
Art Wiener, DNR

JEB/DR

11/19/91

State Archaeological Restoration Project

Dr. Douglas R. Reger, Principal Investigator
Office of History and Archaeology
Division of Parks and Outdoor Recreation
Department of Natural Resources

Injured Resource: Coastal archaeological sites

Project Objective: The objective of this restoration project is to recover through archaeological excavation, data to mitigate the damage from response related activities and from incorporation of petroleum based carbon into the datable material in sites. It is the data within archaeological sites that makes them important and appropriate methods of mitigating damages includes collection of comparable data. Precedent for this concept is set by the National Historic Preservation Act of 1966 and its implementing regulations, 36 CFR, Part 800, and by the Archaeological Resources Protection Act and implementing regulations.

Project Methods: The methods proposed are: 1) to excavate portions of oil contaminated sites to provide diagnostic (time specific) artifacts to verify radiocarbon dates and 2) to obtain data from physically damaged sites to replace lost data. Oil invaded sites, AFG-098 and SEL-215, will be partially excavated in intertidal areas in aligned blocks or trenches. Emphasis on thicker deposits for stratigraphic data will allow comparison dating and establishing area chronologies. Radiocarbon samples will also be collected to monitor accuracy of radiocarbon dates. Both sites contain exposed intertidal cultural deposits which have been subjected to some degree of oiling. A study conducted on the effect of petroleum hydrocarbon contamination of radiocarbon dating process suggests that cleaning samples prior to dating does not eliminate skewed results.

Physically disturbed sites, SEL-178, SEL-129, and AFG-046, will be partially excavated in large blocks to obtain maximum activity information. The excavated blocks will be located in the areas of disturbance with emphasis placed on mapping artifact distributions and aboriginal activity areas. SEL-178 and SEL-129 were both eroded by response related activities and the former was used as a re-fueling station for helicopters. AFG-046 was cleaned initially without required monitors and vandalized. The excavation units will be distributed on the sites where erosion has occurred and in thicker deposits to aid reconstruction of cultural chronology.

Project Duration/Cost: The field phase of restoration will require two field seasons. Analysis will require the intervening nine months and an additional nine months after completion of field work. The overall project will require two years minimum from start to finish. The first year of restoration work costs have been estimated at $350,000 and has been submitted as a FY93 restoration budget request. Year two estimates are approximately $300,000. FY93 (Archaeological Restoration Year 1) estimates, broken down by budget category are: Personal services- $216,300, Travel- $38,000, Contractual- $88,000, Commodities- $5,000, Equipment- $3,000.

Restoration Goal: The goal of this archaeological restoration project is to collect data from damaged archaeological sites to reconstruct the culture history of the area. Such data normally are collected by academic, agency or other researchers investigating well defined questions about the resource. Such investigations are discouraged in the Valdez Oil Spill area however because sites have been physically damaged or contaminated by oil. Academic researchers will typically spend precious research time and money in areas where results are more reliable.

One of the benefits of establishing a reliable archaeological chronology will be to provide management agencies a measure for determining significance of other sites in the area. Agencies lacked that ability at the time oil from the EXXON Valdez began fouling beaches and sites were damaged. The restoration project will also help characterize the types of sites in the areas that might be expected.

Data collected through this process will provide the information necessary to educate the public about the importance of the cultural resources of the area and demonstrate what kinds of scientific information will be lost if sites are further vandalized.

The restoration excavations proposed here fall within the limits of the restoration goals identified by the Archaeological Steering Committee and the Restoration Planning Work Group. The sites identified here include only those on state land.

MEMORANDUM

STATE OF ALASKA
DEPARTMENT OF FISH AND GAME

TO: Mark Fraker
OSIAR
Anchorage

DATE: November 18, 1991

THRU:

TELEPHONE: 456-5156
FAX: 452-6410

FROM: Kathy Frost KJF
Marine Mammals Biologist
Wildlife Conservation
Fairbanks

SUBJECT: Harbor Seal
Progress Report-
Restoration Study

Enclosed is the annual progress report for the harbor seal restoration study entitled "Habitat use and behavior of harbor seals in Prince William Sound, Alaska." This report describes April and September 1991 field work during which satellite transmitters were attached to four harbor seals in Prince William Sound, and the results of preliminary analyses of data obtained from these PTTs.

I think the prognosis for future work is excellent. We have demonstrated that catching seals in PWS is possible, if not always predicatable or easy. We have a much better understanding of the personnel and logistics support that are necessary and of the capabilities and limitations of the netting technique. Some data were received from all four: three of the four remained near Seal Island where they were tagged; the other seal tagged in Herring Bay moved over 90 km away, and then returned to the original location.

The PTTs attached in early September were a simplified version of those that failed last April. They were reconfigured to transmit location and histograms of dive depth and duration on a single geolocational channel, in contrast to the more complex 5-channel configuration of the first two PTTs. Dive profiling features that required multiple data-only channels were eliminated.

By initiating this study with a two-phase pilot project that entailed only a few PTTs, we hope to have solved any major problems before we begin the full-scale study in 1992. This project has and will continue to benefit greatly from the fact that large numbers of similar PTTs are being attached to sea lions and fur seals this year and next. By the time we order the 20 PTTs for the 1992 field season, modifications based on sea lion and fur seal work should be in place. We have also benefited by having PTTs on four spotted seals in northern Alaska.

In summary, I am optimistic about the future of this project. I think that with what we learned in our first year pilot program and improvements that are being made in the PTTs, we will be able to make significant progress in our understanding of harbor seals during 1992. I think this project will provide us with valuable information about the movements and dive patterns of seals in Prince William Sound.

If you have any questions or want to discuss anything in the report, feel free to give me a call.

cc w/ enclosure: Don Calkins

Exxon Valdez Oil Spill Restoration Science Study
1991 Progress Report

Title: Habitat Use, Behavior, and Monitoring of Harbor Seals in Prince William Sound

Project Leader: Kathryn J. Frost

Lead Agency: Alaska Department of Fish and Game

Cooperating Agencies: NOAA/National Marine Fisheries Service
Texas A & M University
University of Alaska

19 November 1991

I. EXECUTIVE SUMMARY

Field work was conducted in April and September 1991 to attach satellite-linked transmitters (PTTs) to harbor seals (Phoca vitulina). Objectives were to investigate haulout use and at-sea behavior in order to identify important habitats as a guide to restoration activities.

Seals were captured by entangling them in specially constructed nets set near their haulouts. Nine animals were caught. PTTs were attached to three animals at Seal Island and one in Herring Bay. The length of time during which PTTs were received by the satellites ranged from 3 to 67 days. In spite of the premature failure of the PTTs, numerous locations and dive depths were obtained.

Two seals at Seal Island in April were equipped with VHF radiotags as well as PTTs. A combination of location data from the two sources indicates that the animals stayed in the vicinity of Seal Island at least through June. The seal tagged at Seal Island in September also stayed in the area for the short period that the PTT was functional. In contrast, the seal that was tagged in Herring Bay left that area and swam at least 100 km to spend a period of seven days near the Yale Glacier in College Fiord. It then returned to where it was tagged in Herring Bay.

Data on depth of dives showed that some harbor seals in Prince William Sound make dives deeper than 250 m, and therefore may do much of their feeding on the bottom. One seal concentrated its diving in the 51-150 m depth range. The sample size is currently too limited to say whether differences are individual or seasonal.

Continued development and testing of previous and new types of PTTs should produce units that will be more reliable and will provide longer records for each seal tagged. In 1992, PTTs should be attached to a larger sample of seals from more locations in order to gather data on harbor seal behavior, movements, and habitat use.

II. INTRODUCTION

The semi-enclosed waters of Prince William Sound (PWS) provide very good habitat for harbor seals and other marine mammals. Several thousand seals occur in PWS, where they are commonly seen hauled out on rocks, reefs, beaches, and glacial ice. Harbor seals are used for subsistence by residents of coastal communities such as Tatitlek, Chenega, and Cordova. Tourists and recreational users of PWS enjoy watching and photographing harbor seals. They, like other marine mammals, are protected by provisions of the Marine Mammal Protection Act. Because of a population decline that is going on in PWS and other parts of Alaska, it is possible that protective legislation may be invoked to provide for conservation and recovery of harbor seals.

Harbor seals were impacted by the Exxon Valdez oil spill (EVOS) in PWS. They encountered oil in the water and on haulouts. Early in the spill several fetuses, pups, and older animals were found dead in the impacted area. Studies conducted as part of the Natural Resources Damage Assessment (NRDA) program documented a substantial decline in the number of seals in oiled areas.

The number of seals in PWS had been declining prior to the EVOS. Twenty-five haulout sites in eastern and central PWS have been used to monitor trends in abundance since 1984. The mean number of seals in the trend count area during late summer surveys declined by 40% between 1984 and 1988, from 1,796 seals to 1,058 seals, a rate of about 10% per year (Pitcher 1989). Subsequent to the spill, the population decline continued at about the same rate at unoiled locations. However, at oiled sites the decline was much greater. From 1988 to 1990 harbor seals in the oiled portion of the trend count area declined 35%, compared to 13% in unoiled areas (Frost 1990).

Because of the decline in harbor seals, which was exacerbated in the area impacted by the EVOS, it is particularly important to understand what factors are limiting the population. Given the ongoing decline we cannot assume that the number of seals in oiled areas will return naturally to pre-spill levels. It is necessary both to continue monitoring population trends and to identify and appropriately manage areas of particular biological significance in order to augment recovery. Most of the information currently available on harbor seals in PWS consists of counts of animals on haulouts during pupping and molting. While these data are essential for monitoring changes in overall abundance, they are not adequate for determining what is causing the seal population to decline, or for designing conservation and management measures to facilitate recovery and ensure its future health. There is no information available on site fidelity, movements between haulout sites, seasonal changes in hauling out patterns, habitats used for feeding, or feeding behavior.

Recently developed satellite-linked telemetry can be used to gather information on these important aspects of harbor seal biology. Miniature platform transmitter terminals have created opportunities to monitor location and diving behavior of marine mammals (Mate 1986, 1989; Hill et al. 1987; Stewart et al. 1989; R. Merrick personal communication). The PTTs transmit to a satellite-based Doppler positioning system that calculates locations and tracks movements of animals with considerable accuracy. When combined with appropriate environmental sensors and microprocessor hardware and software, other information about an animal's environment and behavior can be transmitted to the satellite.

III. METHODS

Efforts in 1991 concentrated on developing techniques and equipment for live capture of seals. PTTs were attached to a small number of seals to evaluate tag performance and to determine baseline values for parameters such as depth of dive and dive duration. This information will be used to program tags with appropriate default values and threshold levels such that they will gather and store the maximum amount of useful data.

Field work was conducted during 15-19 April and 9-13 September. Personnel (Table 1) were transported to the study sites aboard a 10 m chartered vessel from Valdez and a 13 m volunteer vessel from Cordova. The primary area of operations included northern Knight Island, Seal Island, and Applegate Rocks.

Seals were caught by entanglement in nets set near their haulouts. Nets were approximately 100 m long and either 3.7 or 7.4 m deep with standard floats and lead lines. The size of openings ranged from 10 to 15 cm (20-30 cm stretch mesh). Nets were set from a 5 m Boston Whaler as close as possible to areas where seals were hauled out and where it was likely that seals would become entangled as they went in the water in response to the presence of people and boats. A 4 m Zodiac raft was used to help maneuver the net. Once the net was set it was tended by people in both the Whaler and the Zodiac. When seals became entangled they were brought into the boats or to shore, cut free from the tangle net, and put into hoop nets (large stockings made of 1 cm mesh soft nylon webbing).

In some cases seals could be physically restrained during handling and tagging. Larger animals were sedated with a mixture of ketamine and diazepam administered intramuscularly at standard doses (Geraci et al. 1981). Each seal was weighed, measured, and tagged in both hindflippers with individually numbered plastic tags. Approximately 50 cc of blood was drawn from the extradural intervertebral vein.

Larger seals were selected for attachment of satellite-linked PTTs. Transmitters (approximate size 15 cm x 15 cm x 3 cm) were attached to the mid-dorsal surface of the seal by gluing with epoxy resin (Fedak et al. 1984; Stewart et al. 1989). Some seals were also equipped with small (3 cm x 3 cm x 5 cm) VHF radiotags that were glued on the top of the head.

Data were acquired from the ARGOS satellite receiving system and analyzed using software provided by the manufacturer of the transmitters. Each PTT transmitted geographical locational information to a polar-orbiting satellite whenever it was hauled out or when it surfaced sufficiently long for transmission to occur and the satellite was positioned to receive the signal. Units were equipped with built-in programmable microprocessors that collected and summarized data for periods when animals were diving and stored it for later transmission, as has been done for crabeater seals (Lobodon carcinophagus) and Steller sea lions (Eumetopias jubatus) (Hill et al. 1987; R. Merrick, personal communication). These data were stored in six hour blocks and transmitted to the satellite once the six hour period was complete. Data from four periods were stored in memory providing at least a 24 hour window for transmission before the data were lost. Dive data were summarized as histograms in depth bins of 0-50 m, 51-100 m, 101-150 m, 151-200 m, 201-250 m, and over 250 m, and duration bins of 0-120 seconds, 121-240 seconds, 241-360 seconds, 361-480 seconds, 481-600 seconds and over 600 seconds. Temperature sensor data was also reported.

IV. RESULTS

During the April field work, weather was generally cold and windy, with rain and snow. Winds of 20-25 knots prevented any seal capture attempts on 15 and 16 April. On 17-18 April we attempted to catch seals in the short arm of Bay of Isles and at Seal Island and Applegate Rocks. On 19 April four seals were caught at Seal Island (Table 2). Flipper tags were attached to and blood samples were taken from all four seals. The two largest animals had PTTs and VHF tags attached to them. All animals were released in healthy condition.

Seals number 96 and 97 (PTT numbers 14096 and 14097) went back into the water at Seal Island at about 1420 hours Alaska Standard Time on 19 April. Signals from the head-mounted VHF tags were monitored from both animals for about 30 minutes as they dove and moved offshore.

Only two location fixes were received for seal 96. At 0649 hours on 21 April signals indicated that it was at Seal Island. A position obtained at 1114 hours on 8 May showed the seal to be at sea approximately 6 km west-northwest of Seal Island. Occasional transmissions were received from the PTT through 0916 hours on 25 June, but no other locations were determined. A total of 275 dive depths were received at intervals during 21 April-20 June (Table 3). Most of the dives were in the depth range from 51 to 100 m. No dives deeper than 200 m were recorded. Most dives were six minutes or less in duration; only 10 of 245 dives were 6-8 minutes long, two were 8-10 minutes long, and one was recorded as longer than 10 minutes.

After it was released, seal 97 was not located until 24 April. Eleven locations were obtained from 0615 hours on 24 April through 0731 hours on 26 April. All those fixes showed the animal to be on or within 0.9 km of Seal Island. The last transmission from the PTT was received at 0922 hours on 26 April. No dive depth data were received from seal 97. Dive durations were received for 31 dives on 20-21 April. Twenty-four dives were less than six minutes long, six were 6-8 minutes, and one was 8-10 minutes.

Because seals 96 and 97 were also equipped with VHF radio transmitters it was possible to verify their status and location from aircraft and boats. During the period from late April through late June they were regularly hauled out at Seal Island, especially at low tide (K. Frost, unpublished; S. Rainey, personal communication). They were not found anywhere else but Seal Island until late August when seal 97 was located at Port Chalmers. With the aid of the radio transmitters both seals were located and observed from boats on 23 May. At that time the satellite-linked PTTs were still attached properly and appeared undamaged.

Weather conditions were generally windy during September field operations. On 10 September we attempted to capture seals in Herring Bay. On 11 September four seals were caught at Seal Island (Table 2). Two small seals were blood sampled and released. One large seal was blood sampled, flipper tagged, and had a PTT attached. A fourth seal was accidentally drowned in the net, and blood and tissue samples were taken from it. On 12 September we caught one seal in Herring Bay (Table 2) and took blood samples, and attached flipper tags and a PTT. On 13 September we attempted to capture seals at Seal Island, but operations were terminated due to strong winds.

Seal number 66 (PTT number 11466) went back into the water at Seal Island at 1120 hours on 11 September. Eight location fixes were received from 0242 through 1820 hours on 12 September. Two of those locations show the seal on Seal Island while the other six indicate that the animal was 0.4-3.8 km from the island. No other fixes were obtained, although transmissions were received by the satellite until 0922 hours on 14 September. Dive data were received from seal number 66 during 12-14 September (Table 4). Of a total of 307 dives recorded, 89% were in the depth range of 0-150 m and 10% were to depths greater than 200 m. Most (89%) of the dives were six minutes or less in duration; six were longer than ten minutes.

Seal number 67 (PTT number 11467) was released into the water in Herring Bay at 2215 hours AST on 12 September. Five location fixes were received from 2338 hours on 12 September through 0913 hours on 13 September, three of them adjacent to the haulout where the seal had been captured and the other two approximately 1.8 km away. No other locations were obtained until 1347 hours on 15 September, at which time the seal was in College Fiord after having travelled a minimum distance of 90 km (Figure 1). Forty-nine location fixes were obtained from 1708 hours on 15 September through 1406 hours on 22 September, all of which showed the seal to be in the upper part of College Fiord, usually near the Yale Glacier. At 1546 hours on 22 September signals indicated that the seal had moved southward down College Fiord, traveling a distance of 26 km in 1 hour and 40 minutes. At 0848 hours on 24 September the seal was located in Herring Bay, and all subsequent location fixes showed it in the Bay. The last transmission was received at 0751 hours on 8 October. Dive data were obtained from seal 67 on 13-15 September while it was apparently feeding in the region between Knight Island and College Fiord (Table 5). Of a total of 429 dives, 98% were to depths of 0-150 m. Most (92%) of the dives were six minutes or less in length; one was longer than ten minutes.

V. DISCUSSION

Work conducted in April and September 1991 demonstrated that it is possible to live capture harbor seals in PWS. Nine seals were captured in seven days of actual capture operations. Poor weather prevented capture attempts on some days and made operations marginal on others.

The areas at which we worked were rocky and had very clear water, and it was difficult to set nets in such a way that there were no openings that the seals could find and escape through. Many seals were temporarily encircled but were able to swim around the end of the net or under it where the lead line left openings alongside boulders. Nonetheless, by selecting areas with specific characteristics and developing a detailed knowledge of those areas it was possible to catch seals with some regularity. Certain modifications to equipment and procedures as indicated in the recommendations section would result in greater capture success.

The procedures used for handling seals and attaching PTTs were very satisfactory. Animals that were handled did not seem unduly stressed and appeared to behave normally following release. The attachment of PTTs seemed very secure and there is no evidence that they were shed before the annual molt. Four PTTs were attached to spotted seals (*Phoca largha*) in the Chukchi Sea during 4-7 August 1991 using identical procedures. Three of the four transmitters were still providing data in mid-November, more than 100 days after attachment (K. Frost and L. Lowry, unpublished data).

The relatively short functional periods of the PTTs that we attached to harbor seals appear to have been due to equipment failure. Since the PTTs were not recovered it is not possible to determine exactly why they failed. Similar problems have occurred with PTTs attached to Steller sea lions. Two sea lion PTTs were recovered after they had stopped making contact with the satellite; one had a damaged antenna and the other had a battery leak (R. Merrick, personal communication). The tag manufacturer is continuing to evaluate PTT performance and problems. In addition, a new 0.5 watt circuit board has been developed, and is being packaged in a way that should eliminate some of the problems with prior tags. The new 0.5 watt PTTs have been tested in the laboratory and are currently deployed on Pribilof fur seals (Callorhinus ursinus) and Steller sea lions.

In spite of problems with PTT failures, the first year of this study demonstrated the utility of satellite-linked telemetry for studying harbor seals in PWS. Data from the satellite tags in conjunction with the VHF tags showed a high degree of haulout site fidelity during the spring-summer period for seals tagged at Seal Island. In contrast, the seal tagged in Herring Bay in September made a long distance movement and spent a period of seven days near the glaciers at the head of College Fiord, 100 km away from the location where it was tagged. Perhaps most remarkable was the fact that the seal then returned directly to Herring Bay. Dive depth information indicate that harbor seals are capable of diving in excess of 250 m, which means they can reach the bottom in most parts of PWS near their haulouts. The seal tagged at Seal Island in spring made fewer deep dives than the one tagged in the fall. This could be either an individual or a seasonal difference. The dives of the seal that moved from Herring Bay to College Fiord were mostly relatively shallow, but a few exceeded 200 m.

While most of the location fixes showed the seals to be relatively close to the haulouts, depth of dive information indicates that some feeding occurs farther away. For example, seal number 66 tagged at Seal Island made 23 dives in the 201-250 m depth range and 7 dives deeper than 250 m. According to bathymetry on charts, the nearest area where water depths exceed 200 m is 8 km to the east of Seal Island. To reach water deeper than 250 m the seal would have had to swim at least 21 km to the east, to an area very near the vessel traffic lanes used by tankers outbound from PWS. This demonstrates the utility of both location and depth of dive information for examining at-sea distribution and habitat use.

VI. RECOMMENDATIONS

In 1992 satellite-linked PTTs should be attached to more seals in more areas in order to gather data on movements within PWS and between PWS and adjacent areas. In addition to the Seal Island-Knight Island area, consideration should be given to capturing seals in eastern PWS (Port Gravina and Sheep Bay), northern PWS (College Fiord or Unakwik Inlet), southwestern PWS (Dangerous Passage and Icy Bay), and the Copper River Delta. A total of 20 PTTs should be attached, divided between spring and fall. Based on results with 0.5 watt PTTs that have recently been deployed on fur seals and sea lions and ongoing studies with 1 watt transmitters on spotted seals, a decision should be made as to what type of unit to deploy on PWS harbor seals in 1992.

Future capture operations should use three small boats. The boat used for setting the net should be a minimum of 6 m long so that it can carry two 100 m long sections of net. The other two boats should be used to assist in maneuvering the net and tending it to ensure that all captured seals are quickly detected and removed. Nets should be constructed of 20-25 cm stretch mesh and should have relatively light lead lines.

In addition to the studies described above, it is essential to continue tracking the trend in abundance of PWS harbor seals. Recovery, either natural or as a result of restoration efforts, should be monitored through annual fall counts of index sites as described in Pitcher (1989) and Frost (1990). Counts through 1991 have been conducted as part of the NRDA study program. Future surveys should be done annually in conjunction with the harbor seal restoration program.

VII. LITERATURE CITED

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Table 1. Participants in field activities conducted in Prince William Sound, April and September 1991.

Name	Affiliation
Kathryn Frost	ADF&G
Lloyd Lowry	ADF&G
Jon Lewis	ADF&G
Fred Weltz	Cordova resident and fisherman
Kate Wynne	University of Alaska Sea Grant Program (April only)
Brent Stewart	Hubbs Marine Research Institute (April only)
Pam Tuome	Alpine Veterinary Clinic (April only)
Randy Davis	Texas A & M University (September only)
Dennis McAllister	ADF&G (September only)

Table 2. Harbor seals captured during field activities conducted in Prince William Sound, April and September 1991.

Date	Location	Sex	Weight	PTT #	Flipper Tag #s
19 April	Seal Island	M	80 kg	14096	645/646 green
19 April	Seal Island	F	42 kg	14097	643/644 green
19 April	Seal Island	F	31 kg	none	639/640 green
19 April	Seal Island	F	32 kg	none	641/642 green
11 Sept.	Seal Island	M	89 kg	11466	178/179 green
11 Sept.	Seal Island	M	23 kg	none	none
11 Sept.	Seal Island	M	34 kg	none	none
11 Sept.	Seal Island	F	30 kg	none	none
12 Sept.	Herring Bay	F	70 kg	11467	176/177 green

Table 3. Diving pattern of harbor seal number 96 in the vicinity of Seal Island, Prince William Sound, 21 April through 20 June 1991.

Depth (m)	Number of dives in depth interval 0300-0900 hours	0900-1500 hours	1500-2100 hours	2100-0300 hours	Total	Percent
0-50	25	2	5	2	34	12
51-100	87	15	11	29	142	52
101-150	40	7	6	36	89	32
151-200	2	0	0	8	10	4
201-250	0	0	0	0	0	0
> 251	0	0	0	0	0	0

Table 4. Diving pattern of harbor seal number 66 in the vicinity of Seal Island, Prince William Sound, 12-14 September 1991.

Depth (m)	Number of dives in depth interval 0300-0900 hours	0900-1500 hours	1500-2100 hours	2100-0300 hours	Total	Percent
0-50	85	12	25	58	180	59
51-100	9	8	22	15	54	18
101-150	0	24	4	8	36	12
151-200	0	6	0	1	7	2
201-250	0	0	21	2	23	7
> 251	0	0	5	2	7	2

Table 5. Diving pattern of harbor seal number 67 in northeastern Prince William Sound, 13-15 September 1991.

Depth (m)	Number of dives in depth interval					
	0300-0900 hours	0900-1500 hours	1500-2100 hours	2100-0300 hours	Total	Percent
0-50	41	84	60	94	279	65
51-100	0	19	36	1	56	13
101-150	0	22	61	1	84	20
151-200	0	2	3	0	5	1
201-250	0	0	3	0	3	<1
> 251	0	0	2	0	2	<1

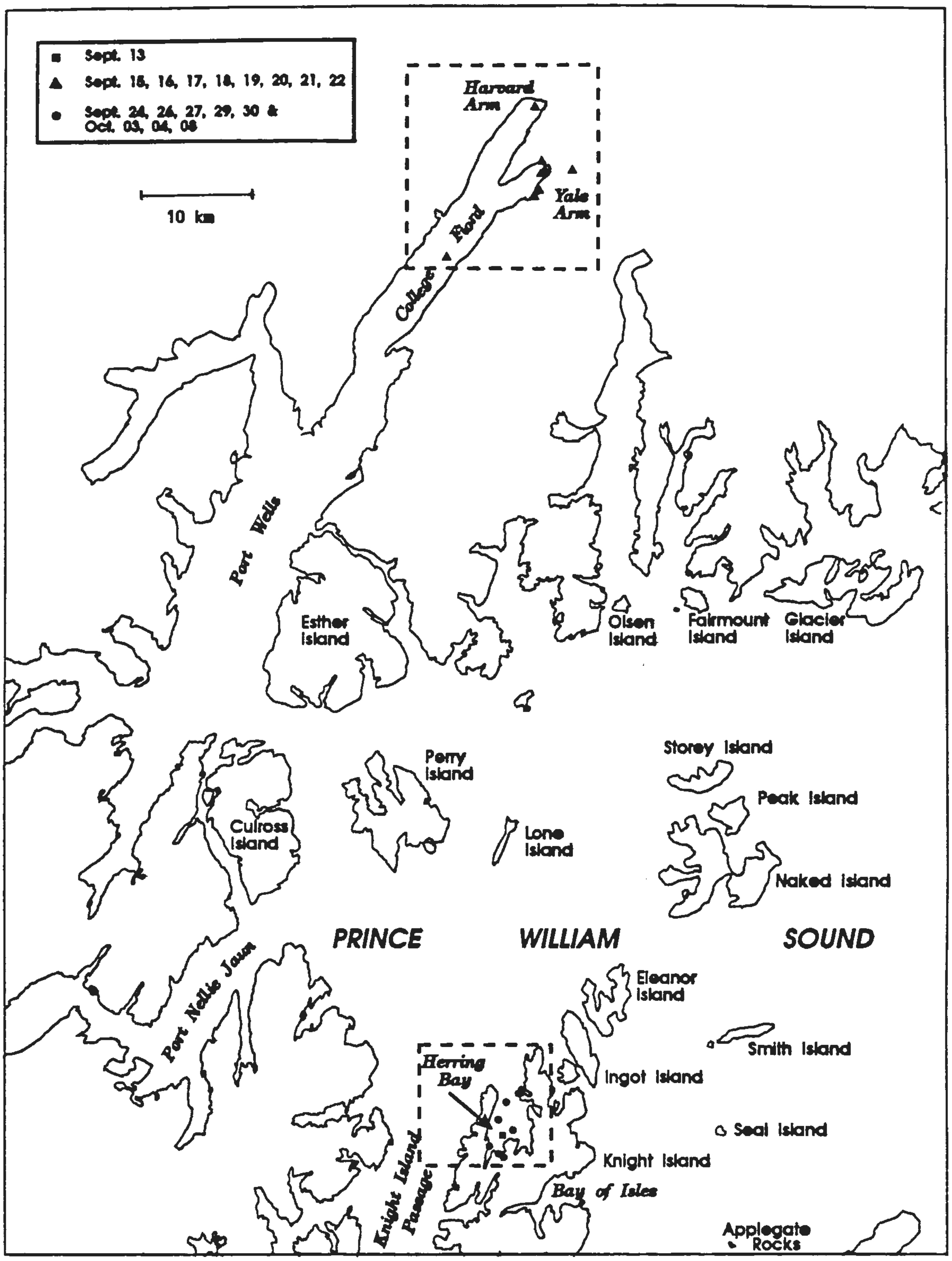

Figure 1. Map of Prince William Sound showing location fixes for seal number 67 in Herring Bay and College Fiord, 13 September-8 October 1991. Only one location per day is shown.

Progress Report

Habitat Use and Behavior of Harbor Seals in Prince William Sound, Alaska September 1991

Field work was conducted from September 9-13, 1991, in central Prince William Sound. The objective of this trip was to catch and attach satellite transmitters to three harbor seals in order to determine feasibility of a larger scale tagging project in 1992 and to provide preliminary data on distribution and movements of seals in autumn. This was the second of two tagging efforts to be conducted in 1991.

This was a cooperative effort among several agencies and individuals. The following personnel participated in field activities:

Personnel	Affiliation	Involvement
Kathy Frost	ADF&G	Principal investigator,project coordination, seal catching, tagging, logistics
Lloyd Lowry	ADF&G	Permits and coordination, seal catching and tagging
Jon Lewis	ADF&G	Seal catching and tagging, logistics
Dennis McAllister	ADF&G	Seal catching and tagging, logistics
Randy Davis	Texas A&M University	Seal catching, tagging, blood sampling
Fred Weltz	Cordova fisherman	Seal catching and tagging, logistics support

Other cooperators who contributed to the project but were not present in the field included: Tom Loughlin and Dick Merrick, National Marine Mammal Laboratory/National Marine Fisheries Service, who allowed ADF&G to use their permit to tag seals, contributed data acquisition time from Service ARGOS for the pilot project, and offered advice on methodology and PTT specifications; and Kate Wynne, Alaska Sea Grant Marine Advisory Program, who helped procure seal catching nets.

Frost and Lowry departed Valdez for Knight Island in central Prince William Sound on September 9th via the *F/V Inga Kristine*, a chartered 36-ft vessel. They were met there by Lewis and McAllister, who travelled from Whittier in a 17-ft ADF&G Boston Whaler. Davis and Weltz traveled from Cordova to Knight Island in the F/V *Dancing Bear* and met the *Inga Kristine* on the evening of September 9th in Louis Bay. Field activities were as follows:

Date	Location	Weather	Activity and Comments
9/9	Louis Bay	Windy, stormy	No activity; gale winds
9/10	Herring Bay	Windy, overcast; low tide at 0903	Reconnaissance; net deployed several times but unsuccessful
9/11	Seal Island	Light breeze; low tide at 0939	Ten seals hauled out; set net across cove; caught 4 seals, tagged 1 with PTT; blood from others
9/12	Seal Island, L. Smith, Applegate, Herring Bay	Calm, sunny, warm; low tide at 1016	No luck at any of haulouts, seals spooky; set net at twilight in Herring Bay; caught 1 seal and tagged with PTT
9/13	Seal Island	Windy, rough; low tide at 1052	< 10 seals hauled out, all went in water; set on seals in water, all got away; too rough to continue

Only two seals were tagged within the 5 days during which vessels and personnel were available, instead of the intended three. This was largely due to stormy weather on 2 of 5 days and the wary nature of the seals. We are still developing and refining capture techniques.

At Seal Island, seals were caught by setting a net near the haulout to block access to the water and entangle the seals as they tried to escape. The nets were deployed at high speed across the cove where the seals were hauled out, from a platform mounted over the stern of the Whaler. One net was 19-cm (7.5") stretch mesh, multifilament twine, 7.3 m (24 ft) deep x 91.4 m (300 ft) long with lead and cork lines. The other was 20.3 cm (8") stretch mesh, 3.7 m (12 ft) deep x 87.8 m (288 ft) long. Personnel jumped into the water and dragged the ends of the net to the shore. Three seals became tangled in the net. They were placed in stocking or "hoop" nets. All were measured, weighed, and blood was collected. The largest male was tagged with a satellite PTT. The other two seals were released without tags since they weighed 23 kg and 34 kg and were considered too small to easily carry the satellite package. One other small seal weighing 30 kg was entangled in the net and drowned. This seal was necropsied and samples taken for tissue hydrocarbon analysis and blood work. We believe that risk of future mortalities can be minimized by decreasing the weight of the lead line on the capture nets.

At Herring Bay, the shallow (3.7 m deep) net was deployed near the main haulout on a falling tide at twilight. Investigators departed the immediate area and obvserved the net from shore.

Approximately 15 minutes after deployment, an adult female swam into the net and became entangled. She was disentangled and, since it was rapidly becoming dark, taken to the *F/V Inga Kristine* for tagging. We believe that using stationary nets that are set at twilight and closely monitored promises to be an effective and efficient way to catch seals.

The seals selected for tagging were an adult male and adult female. Measurements (in centimeters), weights (pounds) and tag numbers were as follows:

Sex	Length	Weight	PTT #	Flipper tags
Male	161	88.6	11466	178,179 green
Female	139	70.5	11467	176,177 green

Blood was collected from both seals in EDTA, heparinized, and red-top tubes and centrifuged within a few hours after tagging. Blood or serum was provided to Randy Davis (Texas A&M University) and Mike Castellini (University of Alaska) for physiological analyses, Brendan Kelly (University of Alaska) for genetics studies, and Randy Zarnke (ADF&G) for virology studies.

The female was tagged without sedation. The male required sedation with ketamine and valium (diazapam). Satellite PTTs were attached to the middle of the back. The hair was first thoroughly dried and cleaned with acetone. Devcon 5-minute epoxy was used to glue nylon netting, which anchored a thin metal baseplate, to the pelage. The PTT was then bolted to the baseplate and the nuts secured with epoxy. Each seal required approximately one hour to tag.

Data were received from both PTTs during the 10 days following tagging. Through September 18th, multiple locations had been received for each seal. Both remained near the locations where they were caught; the male at Seal Island and the female in Herring Bay. For both seals, approximately 90% of their dives were to depths less than 100 m. Two to 6% of the dives were greater than 200 m.

Progress Report

Habitat Use and Behavior of Harbor Seals
in Prince William Sound, Alaska
April 1991

Field work was conducted from April 15-19, 1991, in central Prince William Sound. The objective of this trip was to catch and attach satellite and VHF transmitters to two harbor seals in order to determine feasibility of a larger scale tagging project in 1992. This was the first of two tagging efforts to be conducted in 1991. The second will be conducted in September.

This was a cooperative effort among several agencies and individuals. The following personnel participated in field activities:

Personnel	Affiliation	Involvement
Kathy Frost	ADF&G	Principal investigator, project coordination, seal catching, tagging, logistics
Lloyd Lowry	ADF&G	Permits and coordination, seal catching and tagging
Jon Lewis	ADF&G	Seal catching and tagging, logistics
Kate Wynne	AK Sea Grant Marine Advisory Program	Seal catching and tagging
Brent Stewart	Hubbs Sea World Research Institute	Seal catching, tag attachment, previous experience with PTTs
Pam Tuomi	College Village Animal Clinic	On-site veterinarian, seal sedation, blood collection
Fred Weltz	Cordova fisherman	Seal catching and tagging, logistics support

Other cooperators who contributed to the project but were not present in the field included: Tom Loughlin and Dick Merrick, National Marine Mammal Laboratory/National Marine Fisheries Service, who allowed ADF&G to use their permit to tag seals, contributed data acquisition time from Service ARGOS for the pilot project, provided two VHF radios, and offered advice on methodology and PTT specifications; Randy Davis, Texas A&M University, who interfaced with the PTT manufacturer and ordered and coordinated delivery of the PTTs; and Robin Brown, University of Oregon Marine Science Center, and Steve Jeffries, Washington Department of Wildlife, who provided seal-catching nets.

Frost, Stewart, and Tuomi departed Valdez for Bay of Isles in central Prince William Sound on April 15 via the F/V Inga Kristine, a chartered 36-ft vessel, accompanied by Lowry and Lewis in a 17-ft ADF&G Boston Whaler. Inclement weather delayed arrival at Bay of Isles until the afternoon of April 16. Wynne and Weltz traveled from Cordova to the Bay of Isles in the F/V

Dancing Bear and met the Inga Kristine on the evening of April 16. Field activities were as follows:

Date	Location	Weather	Activity and Comments
4/16	Bay of Isles (Short Arm)	Ice and slush in bay; cold (32-34 F)	Reconnaissance; few seals present; no good location to net seals
4/17	Bay of Isles (Short Arm)	Cold, windy, overcast; low tide at 0956	Only 4 seals present; poor location; net deployed but unsuccessful
4/18	Seal Island	Cold, foggy, rain, calm; low tide at 1044	Only 6 seals hauled out, all went in water; set on 1 seal in water, seal swam around end and got out
4/18	Applegate Rocks	Same as above	< 20 seals hauled out, all went in water; set on 10-12 seals in water, all got away
4/19	Seal Island	Calm, sunny, warm; low tide at 1137	35 seals hauled out in cove; set net across cove; caught 4 seals, tagged 2 with PTTs and VHF radios

Seals were caught by setting a net near the haulout to block access to the water and entangle the seals as they tried to escape. The net (8-12" stretch mesh, multifilament twine, 24 ft deep x 50 ft long with lead and cork lines) was deployed at high speed across the cove where the seals were hauled out, from a platform mounted over the stern of the Whaler. Personnel jumped into the water and dragged the ends of the net to the shore. Six or more seals were surrounded and/or tangled in the net. Four were placed in stocking or "hoop" nets (two for tagging and two as back-ups). The others were disentangled and released. The four seals that were retained were measured, weighed, and blood was collected. The two largest were tagged.

The seals selected for tagging were a subadult female and an adult male. Measurements (in centimeters) and tag numbers were as follows:

Sex	Length	Girth	PTT #	VHF #	Flipper tags
Female	122	87	14097	990	643,644 green
Male	158	113	14096	802	645,646 green

Blood from both seals was collected in EDTA tubes. Blood was centrifuged and smears were made approximately 4 hours after tagging.

The subadult female was tagged without sedation. The male required sedation with ketamine and valium (diazapam). Satellite PTTs were attached to the middle of the back. The hair was first thoroughly dried and cleaned with acetone. Devcon 5-minute epoxy was used to glue nylon netting, which anchored a thin metal baseplate, to the pelage. The PTT was then bolted to the baseplate and the nuts secured with epoxy. Small VHF transmitters were glued to the top of the head to serve as a backup for locating the seals. The entire operation, including catching and tagging, was completed in approximately four hours.

Since tagging, both seals have been observed visually. In early May, personnel associated with cleanup activities at Seal Island saw a "seal with an arrow on top of its head." It is unknown which of the two seals this was. On May 23, the female was seen hauled out at Seal Island by Don Calkins of ADF&G. He saw the male in the water near Seal Island the following day. Both PTTs were still attached and the antennas were intact. The VHF radios were also attached and transmitting strong signals. A Cordova fisherman reported seeing a seal "with a funny antenna" on its head near Seal Island in early June. The VHF signals of both seals have been heard on multiple occasions from April to June:

Date	Seal	Time	Tide	Location	Activity
4/26	Male	1120	High	Near Applegate	Diving
4/27	Male	1444	High	Near Applegate	Diving
4/30	Female	0803	Low	Seal Island	Hauled out
	Male	0805	" "	Seal Island	Hauled out
5/3	Female	1340	1/2 in	<1/2 mi S of Seal I	Diving
	Male	1345	" "	<1 mi W of Seal I	Diving
5/6	Female	1430	Low	Near Seal Island	Diving
	Male	1433	" "	Seal Island	Hauled out
5/12	Male	1730	Low	Seal Island	Hauled out
	Female	1736	" "	Near Seal Island	Diving
5/13	Female	0620	Low	Near Seal Island	Diving
	Male	0625	" "	Near Seal Island	Diving
5/22	Female	1300	Low	Seal Island	Hauled out
5/22	Male	1300	Low	Seal Island	Hauled out
5/23	Female	1700	Low	Seal Island	Hauled out
	Male	" "	" "	Near Seal Island	Diving
5/24	Male	0600	Low	Near Seal Island	Diving
6/1	Male	1100	Low	Near Seal Island	Diving
	Female	" "	" "	Near Seal Island	Diving

Data were received from both PTTs during the first few days following tagging. Through April 26, we had obtained a single location for the male. He was at Seal Island during the early morning of April 21. We obtained 11 locations for the female from April 24-26. All were at or near Seal Island. Data have not been received from ARGOS for the month of May. Dive profiling and dive summary features are not working for either seal. Some histogram data have been received and are being analyzed at this time.

PROPOSAL FOR RESTORATION SCIENCE STUDY
1992 FIELD SEASON

Name of Study

Recovery Monitoring of Hydrocarbon-Contaminated Subtidal Marine Sediment Resources.

Injured Species to be Addressed

Subtidal sediments.

Principal Investigators and Lead Agency

Charles O'Clair
Stanley Rice

Auke Bay Laboratory
National Marine Fisheries Service
National Oceanic and Atmospheric Administration

Project Objectives

1) Determine occurrence, persistence, depuration and chemical composition of petroleum hydrocarbons in and from subtidal sediments,

2) Continue to provide marine sediment data to assist agencies in mass balance calculations of the fate of oil in the marine environment, and

3) Continue to provide marine sediment data to assist researchers in following recovery of deep benthic biological resources.

Project Methods

1) Subtidal sediments will be collected from six depths (mean lower low water (MLLW, 0) and 3, 6, 20, 40, and 100 m below MLLW) at 21 (10 oiled and 11 unoiled) locations in Prince William Sound. This study would involve one sampling trip in July 1992 when 21 locations will be visited and sampled.

2) Collections at 3, 6, and 20 m will be made by divers on 30 m transects laid along the appropriate isobath. Three samples, each a composite of 8 subsamples, will be collected from random locations on this transect.

3) Samples taken depths below 20 m will be collected by Smith-McIntyre Grab. Three grabs will be collected at each depth. Four subsamples will be removed at random locations within each

grab. The subsamples will be combined to make one sample from each grab.

4) All samples will be taken from the surface (top 0-2 cm) of the sediment column. All sampling utensils will be made of either glass or stainless steel and appropriately cleaned between collection of each sample or subsample. Sampling jars will be baked at 440°C or rinsed with methylene chloride prior to use. The jars will be fitted with a teflon-lined cap.

5) Samples will be kept in coolers with ice immediately after collection and will be frozen as soon as possible.

6) Guidelines as developed by the NRDA Hydrocarbon Technical Committee will be consulted on matters pertaining to sample collection (with labeling), chain-of-custody, chemical and data analysis.

Duration of Project

Somewhat dependent upon recovery rates of target sediments, but not thought to exceed three to five years.

Estimated Cost

Oil Year 4 - $480K
Oil Year 5 - $530K
Oil Year 6 - $585K

The cost of the vessel assumes that cooperating agencies such as the University of Alaska Fairbanks will sample the same sites at the same time for recovery of hydrocarbon-degrading bacteria and deep benthos. If these projects do not go forward, the costs of the vessel will be reduced by half.

Restoration Activity or Endpoint to be Addressed

The monitoring of recovery of subtidal sediments (particularly depositional sediments) contaminated by oil from the EXXON Valdez spill will provide information on temporal changes in the levels of petroleum hydrocarbons which will be useful to the interpretation of results obtained by other restoration studies.

Relationship to Science Information Needs Identified by RPWG

The NRDA Subtidal Study Number 1 documented injury to subtidal sediments to a depth of 20 m at a minimum of 10 sites in Prince William Sound in 1989 and Spring 1990.

This study addresses the need to monitor ecosystem recovery as articulated in RPWG's Science Information Needs and Priorities - Oil Year 4. It addresses the specific need to continue to assess (monitor) the quantities, chemical state, persistence and depuration of oil in or from key intertidal and subtidal habitats.

Importance of Initiating Project in 1992

If this study is delayed beyond 1992, an opportunity will be lost to fully document the timecourse of recovery which may deprive other restoration studies of data useful to interpretation of their results.

Link to Other Damage Assessment or Restoration Studies

This study is linked to other restoration science studies that require documentation of weathering and depuration of residual petroleum hydrocarbons from subtidal sediments, particularly those studies following recovery of birds and mammals that forage on or come in contact with contaminated subtidal sediments.

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DRAFT

Proposed project title: Natural recovery of subtidal species in Prince William Sound

Usha Varanasi, Principal Investigator

Damaged resources: Subtidal fish and invertebrate species

Problem and Importance: There has been extensive and continuing exposure of subtidal fish species to oil in and around Prince William Sound following the EVOS, as documented in Progress Reports from F/S 24 (OY 1 &2) and ST 7 (OY3). Exposure is generally decreasing with time in species examined in these studies, but could still be documented in OY3. 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. This project proposes to continue to document the rate and extent of the natural recovery of subtidal fish species from oil exposure following the EVOS. In addition, it is presumed that there has been concomitant exposure of subtidal invertebrate species, including crustaceans and bivalve molluscs. The exposure of subtidal invertebrates to oil needs to be assessed, and such assessment would be done under this proposal.

Samples from benthic fish species taken during OY2 showed some evidence of alterations in parameters associated with reproduction, and some evidence of altered histology. However, there are few samples which can be analyzed to assess the potential for these effects to have occurred during OY1. It is therefore necessary to carry out limited assessments of the effects of known exposure to Prudhoe Bay crude oil on 1) indicators of exposure and 2) biological processes in species indigenous to Prince William Sound, in order to allow a realistic interpretation of the data obtained during OY1. Such limited investigation will be critical both for interpretation of data obtained under the current NRDA and Restoration processes and for evaluation of potential for injury resulting from future oil spill events.

Implementation and Methods: Bile, liver, and muscle from demersal fish species which have shown and/or continue to show exposure to oil will be sampled. Subtidal invertebrate species will also be sampled. Representative sediment samples will be taken from each benthic sampling site for subsequent chemical analysis. All samples will be analyzed for presence of oil and/or oil-derived products by recently developed rapid screening techniques. Several of these techniques are described in the Detailed Study Plans for F/S 24 (OY 1 &2) and ST 7 (OY3). The use of these screening techniques has been shown to be very cost-effective, and also to result in the timely acquisition of data. Limited laboratory studies will be done in which fish and invertebrate species indigenous to Prince William Sound are exposed to known amounts of Prudhoe Bay crude oil, followed by analysis of tissues by both rapid screening and detailed chemical analysis. The potential for biological effects (e.g. reproductive dysfunction, histopathological alterations) to occur at these doses will also be assessed.

Products: Estimation of rates of natural recovery of subtidal fishes and invertebrates from oil exposure. Progress and Final reports containing timely assessments of exposure of these species to petroleum-derived compounds and accompanying effects of exposure. The results of laboratory exposure studies will assist in interpretation of data obtained during current and past NRDA projects, and will be useful in evaluating both planned and implemented restoration projects in these species..

Tasks:

Screening for PAH metabolites in bile of subtidal fish (up to 400)

Analysis of cytochrome P4501A in livers of subtidal fish (up to 400)

Screening for oil derived compounds in tissues of subtidal invertebrates (up to 200)

Screening for oil derived compounds in subtidal sediments (up to 50)

Exposure of indigenous species to PBCO and measurement of oil-derived compounds by screening techniques, and assessment of biological effects.

Total funding required: $230K (estimate, does not include vessel support)

Products: Estimation of rates of natural recovery of subtidal fishes and invertebrates from oil exposure. Progress and Final reports containing timely assessments of exposure of these species to petroleum-derived compounds and accompanying effects of exposure. The results of laboratory exposure studies will assist in interpretation of data obtained during current and past NRDA projects, and will be useful in evaluating both planned and implemented restoration projects in these species..

Tasks:

Screening for PAH metabolites in bile of subtidal fish (up to 400)

Analysis of cytochrome P4501A in livers of subtidal fish (up to 400)

Screening for oil derived compounds in tissues of subtidal invertebrates (up to 200)

Screening for oil derived compounds in subtidal sediments (up to 50)

Exposure of indigenous species to PBCO and measurement of oil-derived compounds by screening techniques, and assessment of biological effects.

Total funding required: $230K (estimate, does not include vessel support)

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PROPOSAL FOR RESTORATION SCIENCE STUDY
1992 FIELD SEASON

Name of Study:

Recovery Monitoring of Intertidal Oiled Mussel Beds in Prince William Sound and the Gulf of Alaska Impacted by the Exxon Valdez Oil Spill.

Injured Species to be Addressed:

Intertidal sediments and mussels.

Principal Investigators and Lead Agency:

Coordinating Principal Investigator: Stanley Rice, NOAA/NMFS

Participating Principal Investigators:
Malin Babcock, Pat Rounds, NOAA/NMFS
TBN, ADEC
TBN, ADNR
TBN, Other interested agencies

Project Objectives:

1) In cooperation with ADEC and other interested agencies, determine the intensity of petroleum hydrocarbon contamination of mussel tissue, mussel byssal thread mats, and underlying sediments, at oiled mussel beds identified by ADEC.

2) Determine biological impacts of oiled mussel beds on mussels, and the recovery potential of remediation options.

3) Evaluate the recovery of mussels in oiled mussel beds through comparison with historically monitored mussels.

Project Methods:

1. Petroleum Hydrocarbon Contamination of Oiled Mussel Beds

The intensity of petroleum hydrocarbon contamination of oiled mussel beds will be determined by measuring amounts of petroleum derived hydrocarbons in mussel tissue, in mussel byssal thread mats, and in underlying sediments. A total of 95 samples of these matrices were collected from 13 sites in 1991, of which 24 samples have been analyzed. Results of analyses of these 24 samples indicated very high petroleum contamination levels, with aromatic hydrocarbon contamination levels reaching 4.5 ppm in mussel tissues and 48 ppm in underlying sediments. The remaining 61 of these 95 samples collected in 1991 will be analysed to further define the geographic extent of oiled mussel beds, as will an additional 90 samples of mussel tissue, mussel byssal threads, and underlying sediments collected in triplicate from 10 sites in 1992. The proposed number of sites sampled in 1992 may be adjusted pending recommendations of other participating investigators.

2. Recovery of Biological Function and Condition

The impact of oiled mussel beds on biological function and condition of mussels will be studied to evaluate the biological capacity of mussels in oiled beds to recover if left alone, or following some cleaning attempt of the underlying substrate. Several biological parameters (e.g., condition index, byssal thread production, reproductive index, reproductive histology, lipid content, growth) will be determined 6 times in 1992 at each of three oiled and two unoiled sites. Bioavailability of persistent petroleum hydrocarbons in intertidal substrates will be examined by transplanting mussels from clean control sites to oil contaminated sites. Mussels and underlying substrates will be sampled initially and at 7 and 30 d, for hydrocarbons and biological parameters. Recovery potential of contaminated mussels will be determined by monitoring depuration of mussels transplanted from oil contaminated sites to clean control sites after depuration periods of 7 and 30 d. Study sites will be selected in association with ADEC and ADNR and on the basis of chemical analyses of sediment and mussel samples collected during the 1991 multi-agency survey of contaminated mussel beds. The 3 oiled sites studied will be selected from those sampled under element 1 above; the two unoiled sites will be the control sites monitored in element 3 below. These methods have been thoroughly validated, and should provide an objective basis for remediation decisions.

3. Hydrocarbon Monitoring

This study will continue intertidal baseline mussel and sediment hydrocarbon monitoring, begun in 1977, and continued under NRDA Project CH1B (1989-1991) and Recovery Monitoring Study No. 11 (1991). Five sites will be sampled once in 1992 (late May). Mussels and sediments will be collected as described in CH1B study plans 1989-1991. In addition, mussel byssal thread mats will be collected at each site. Two of the 5 sites will be control sites at Olsen Bay and at Siwash Bay, and the remaining 3 sites will be selected from CH1B monitoring sites established in 1989 that were heavily impacted by oil. The two control sites will also serve as control sites for element 2 above. These monitoring sites will provide a reference for evaluating results of elements 1 and 2 above.

Duration of Project

Somewhat dependent upon recovery rates, but not thought to three years.

Estimated Cost

Oil Year 4 - $500K
Oil Year 5 - $550K
Oil Year 6 - $600K

Restoration Activity or Endpoint to be Addressed

In spite of their large biomass and their importance in marine and estuarine food webs, no NRDA study was undertaken focusing on post-spill changes in mussel biomass, condition index, growth or reproductive function in relation to oiling. Relatively high levels of total aromatic hydrocarbons (4.5 ppm in mussels, 48 ppm in substrates) in oiled mussel beds in 1991 suggest that oiled intertidal substrates have the potential to continue to contaminate mussels and trophically linked predator species. The effects of three years of continual hydrocarbon contamination on the biology and health of mussels and their ability to recover needs to be addressed, because of the key role that mussels play in marine dependent food-chains.

The relationships among substrate hydrocarbons, tissue hydrocarbon burdens, and continuing biological effects are critical to our understanding of recovery processes in affected intertidal habitats, particularly mussels and their predators. The most likely impacted predator species, identified by several NRDA projects, are the harlequin duck, black oystercatcher, and juvenile sea otter. Post-spill reproductive failure of the harlequin duck population and continued high mortality of juvenile sea otter in Western Prince William Sound may be linked to ingestion of hydrocarbon contaminated mussels. Restoration proposals for these species must consider the level of residual contamination and the biological condition of their primary food (mussels). Depuration rates of contaminated mussels moved to clean sites will provide an indication of potential recovery rates that could be achieved if further remediation were implemented. Periodic sampling of contaminated substrates and mussels in 1992 and beyond will establish the pattern of persistence and/or depuration and provide information useful in evaluating the need for restoration projects designed to remove or clean contaminated mussel beds and associated sediments.

Relationship to Science Information Needs Identified by RPWG

This project addresses RPWG's stated need to shift emphasis to broader ecological rather than species specific approaches, and the need to assess the quantity, chemical status and persistence of oil in intertidal habitats underlying mussel beds and link predators to abundance, availability and quality (level of residual contamination) of intertidal prey.

<u>Importance of Initiating Project in 1992</u>

Elimination of this study significantly reduces our understanding of the rate of recovery of impacted intertidal habitats. Delay in implementing this study also significantly reduces the information base upon which a decision will be made to remove or clean contaminated mussel beds and associated sediments.

This project exists as the only project to have sampled key intertidal habitats for hydrocarbon content prior to the <u>EXXON Valdez</u> oil spill. These baseline hydrocarbon data, then, will provide the target against which partial or complete recovery will be judged.

<u>Link to other NRDA Damage Assessment or Restoration Studies</u>

Mussels, *Mytilus trossulus*, were sampled by several NRDA (COHAB 1A, SUBTIDAL 1, SUBTIDAL 3, SUBTIDAL 4) projects following the <u>EXXON Valdez</u> oil spill, chiefly as indicators (sentinels) of hydrocarbon contamination.

DRAFT

Proposed project title: Monitoring recovery of intertidal and nearshore subtidal species in Prince William Sound

Usha Varanasi, Principal Investigator

Damaged resources: Intertidal and near subtidal fish and invertebrate species

Problem and Importance: Recent assessment (Alan J. Mearns, HMRAD, personal communication) of oiled shorelines in Prince William Sound has shown evidence of significant differences in distribution of oil and oil derivatives between treated oiled shorelines, nontreated oiled shorelines (e.g. set aside sites), and nonoiled shorelines. These distribution differences appear to be reflected in hydrocarbon contamination of several invertebrate species, based on limited analyses. There has been little study of the exposure to oil and possible biological effects associated with such exposure in intertidal and nearshore subtidal fish species (such as juvenile rockfish, juvenile salmon, and blennies), especially as such exposure might be affected by shoreline treatment. This study proposes to document the extent of recovery of intertidal and nearshore subtidal fish species from oil exposure, and to expand the analyses of oil and oil derivatives in intertidal and nearshore subtidal invertebrate species. The proposed work should be able to help make the important determination of whether treatment of shorelines by aggressive cleaning techniques effected either increased or decreased exposure to oil in intertidal and nearshore subtidal biota.

Implementation and Methods: This project will be carried out in conjunction with and will be complementary to the "Prince William Sound Long-term Shoreline Ecological Monitoring Program" proposed by Alan J. Mearns, HMRAD. Through the use of recently developed rapid screening techniques, this program will substantially increase the assessment of oil exposure in intertidal and nearshore subtidal biota.The additional samples to be collected are bile and tissue samples from selected species of intertidal and nearshore subtidal fish, and sediment samples from several depths along transects at study sites. Replicate samples of invertebrate tissues for rapid screening analyses may also be taken.

Both sediment and fish bile will be screened for the presence of oil-derived compounds, using recently developed technology as described in the Detailed Study Plans for Subtidal 7 and Subtidal 4. Induction of cytochrome P450 (e.g. MFO) will also be measured in fish liver samples as described in the Detailed Study Plan for Subtidal 7. In addition to their use in fish and sediment samples, the screening techniques will be adapted for use on invertebrate tissue samples to the extent possible. The use of such screening methodology has been shown to be very cost-effective, and also to allow the rapid acquisition of data. Such timeliness should be highly desirable for assessing the efficacy of planned restoration efforts in any of these species, and will also allow a rapid estimation of natural recovery rates of impacted species.

Products: Progress and Final reports, containing assessments of extent and rate of natural recovery of intertidal and nearshore subtidal biota, together with assessment of effectiveness of shoreline treatment methods with respect to oil distribution and fish and invertebrate exposure.

Tasks: Screening for PAH metabolites in bile of intertidal and subtidal fish (up to 400)

Analysis of cytochrome P4501A in livers of intertidal and subtidal fish (up to 400)

Screening for oil derived compounds in tissues of intertidal and subtidal invertebrates (up to 200)

Screening for oil derived compounds in intertidal and subtidal sediments (up to 200)

Total funding required: $240K plus $60K for additional vessel support

PROPOSAL FOR RESTORATION SCIENCE STUDY
1992 FIELD SEASON

Name of Study

Mussel Tissue and Sediment Hydrocarbon Data Synthesis

Injured Species to be Addressed

Intertidal and subtidal sediments and mussels.

Principal Investigators and Lead Agency

Stanley Rice
Jeffrey Short

Auke Bay Laboratory
National Marine Fisheries Service
National Oceanic and Atmospheric Administration

Project Objectives

1) Synthesize all restoration science data resulting from chemical analyses for petroleum hydrocarbon concentrations in intertidal and subtidal sediments and in mussels.

Project Methods

This project will examine hydrocarbon data generated by restoration science projects in the context of minimal consistency and reasonableness for their PI's expectations, and for minimal consistency and reasonableness across all projects. These activities will provide a basis for noting significant trends among restoration science projects, which will be summarized, defended and reported. Products will include data evaluations that will be provided to each participating PI, and data synthesis products such as tables, graphs, and maps, showing global trends of petroleum hydrocarbons across all projects.

Duration of Project

Three to Five years.

Estimated Cost

Oil Year 4 - $100K
Oil Year 5 - $110K
Oil Year 6 - $120K

Restoration Activity or Endpoint to be Addressed

Various restoration science projects have collected sediment and mussel samples for hydrocarbon analyses to determine recovery rates by documenting declines in hydrocarbon levels over time. The resulting hydrocarbon data must be reviewed for consistency and reasonableness so that conclusions based on these hydrocarbon data are defensible.

Relationship to Science Information Needs Identified by RPWG

This project is undertaken at the suggestion of the Management Team and Chief Scientist. Its purpose is to provide a mechanism for the evaluation and review of sediment and mussel tissue hydrocarbon data within the context of the originating restoration science projects, and to compare hydrocarbon results across all projects. The procedures used for hydrocarbon sample collection and analysis incorporate methods for detecting extraneous contamination from field or laboratory sources, as well as for determining the quality of the data produced. These methods include collection and analysis of field blanks, analysis of various quality control materials to determine analytical precision and accuracy, analysis of spiked samples to evaluate recovery, etc. Within the analytical laboratories, these quality assurance efforts are designed to detect aberrations and faults with no knowledge of the history of the samples; the samples themselves are analyzed blind within the analytical laboratories.

After hydrocarbon data are released from the analytical laboratories, it is still necessary to evaluate these data within the context of the project for which samples are collected. It is both reasonable and highly desirable to determine whether released hydrocarbon data are internally consistent for each project, as the initial phase of interpreting these data. In particular, it is of great interest to determine whether the distribution of samples determined to be contaminated is at least minimally consistent with the expectation of the project's principal investigator, as opposed, say, to a random distribution among samples collected which might suggest randomization of sample labels. It is also of interest to determine whether the precision of data for a project varies dramatically and inexplicably depending, say, on which particular laboratory performed the analysis, or on whether a sample was analyzed in a certain batch.

Importance to Initiating Project in 1992

It is appropriate to analyze data as it is generated and not wait until a backlog has accumulated. Problems that are identified early in the overall program tend to remain small and are more easily solved.

Link to Other NRDA Damage Assessment or Restoration Studies

A parallel project focuses on all NRDA analytical data.

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PROPOSAL FOR RESTORATION SCIENCE STUDY
1992 FIELD SEASON

Name of Study

Recovery Monitoring of Intertidal and Nearshore Subtidal Communities Impacted by the EXXON Valdez Oil Spill and Associated Clean-up.

Injured Species to be Addressed

Shoreline biota including clam beds, shoreline and shallow subtidal eelgrass beds, particularly heavily treated shorelines.

Principal Investigators and Lead Agency

Alan Mearns, Project Director
Hazardous Material Response and Assessment Division
National Oceanic and Atmospheric Administration

Jonathan Houghton (procurement dependent)
Pentec Environmental, Inc.
Edmonds, Washington

Dennis Lees and Howard Teas (procurement dependent)
ERC Environmental and Energy Services Co.
San Diego, California

Jacqueline Michel (existing contractor)
RPI International, Inc.
Columbia, South Carolina

Charles Henry (existing contractor)
Louisiana State University
Baton Rouge, Louisiana

Objectives

In general, to monitor recovery of intertidal and shallow subtidal communities, particularly those habitats receiving intensive cleaning following the EXXON Valdez oil spill.

Project Methods

Survey Specifications

Two - three cruises in 1992 (one planned now).

Minimum 27 sites:

Three shoreline types to be sampled: 3 rocky, 3 boulder cobble, 3 mixed soft.

Minimum 3 treatment types per shoreline type: unoiled, oiled-treated, oiled untreated.

Sampling approach:

Ten - 0.25 m2 epibiota quadrats per transect, 2-3 transect (elevations), July and September (species abundance, % cover).

Five - six infaunal cores and four 0.25 m2 excavations per mixed-soft transect (clams).

Growth: tag/recovery of clams and keystone molluscs (Nucella, littorines, mussels).

PAH (35) in one sediment composite per transect.

Minimum 9 eelgrass beds with focus on total integrated seed production.

Analysis of Deferred 1991 chemistry, infauna, histology, growth samples

Inter-laboratory PAH intercalibration.

Estimate of total potential impacted shoreline.

Products:

1992 Final (peer reviewed) report, March, 1993, with minimum 3 year time series (4 for geomorphology/ total PHC in shore sediments)

Duration of Product

Somewhat dependent upon recovery rates, but thought to be three or more years.

Estimated Cost

Total (complete program) funding required: $800 - $850K
Partial funding ($600K) to come from other sponsors.

Anticipated Funding (1992 Restoration Science Program):
Oil Year 4 - $250K, Oil Year 5 - $430K.

Scope with 1992 Restoration Science Program share: Include boulder-cobble sites, eelgrass; complete two cruises.

Restoration Activity or Endpoint to be Addressed

Understanding and predicting natural recovery is key to evaluating restoration alternatives. Since July 1990, NOAA's

HMRAD has monitored shoreline and subtidal marine life at up to 28 unoiled, oiled and treated sites in Prince William Sound (Houghton et al, 1991). Our primary goal has and always will be to develop information useful to making future oil spill clean-up decisions that best protect marine resources. However, the information gathered during past, ongoing and proposed future monitoring studies also has direct relevance to restoration including additional clean-up. The most damaged intertidal and shallow subtidal community resources in Prince William Sound are at those sites given high pressure/ hot water treatment. Our hypothesis is that clams and other keystone plant and animal species at these sites may take many more years, perhaps a decade, to fully recover. By contrast, untreated or lightly treated sites have suffered less damage, and the biota at many of these sites are already structurally similar to unoiled control sites. Further, oil appears to be more concentrated in sediments at low and shallow subtidal elevations at heavily treated sites, whereas at sites receiving no treatment or mild treatment, remaining oil is largely concentrated in sediments at upper elevations. Thus, the fate of oil and rate of depuration will be different between these sites.

Relationship to Science Needs Identified by RPWG

This proposal addresses RPWG's stated need to improve understanding of the long-range underlying mechanisms causing injury or limiting populations. Such information is necessary to support effective restoration actions. This proposed project also addresses the need to assess the quantity, chemical status and persistence of oil in intertidal and shallow subtidal habitat and links predators to abundance, availability and quality (level of residual hydrocarbon contamination) of intertidal prey.

Importance of Initiating Project in 1992

If the proposed project is deferred, valuable information on rates of recovery as well as intermediate (successional) stages of recovery in both set-aside as well as treated sites would be lost. This exists as the only study to systematically monitor recovery of oiled and treated intertidal and shallow subtidal habitats.

Link to other NRDA Damage Assessment or Restoration Studies

Sediments and contaminated molluscs may serve as continuing sources of hydrocarbons to dependent components of the marine food web (e.g., fish sea otter, marine birds, etc.) and subsistence fisheries. Altered habitat (algal cover, attached fauna) may continue to provide inadequate protection for fishery stocks, their reproductive products and prey for fish and wildlife. Recovery may have begun but several more years of intensive study will be needed to predict when recovery will be complete.

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Hydrocarbon Analyses of Mussels and Substrates/Sediments Collected From Prince William Sound, 1991: A Special Survey of Oiled Mussel Beds.

Malin M. Babcock
NOAA/NMFS/Auke Bay Laboratory
11305 Glacier Highway
Juneau, Alaska 99801-8626

COOPERATING AGENCIES:

AK Department of Environmental Conservation
AK Department of Natural Resources
AK Department of Fish & Game
NOAA/National Marine Fisheries Service
Environmental Protection Agency

DATE: 4 November 1991

BACKGROUND

In accordance with THE *Exxon Valdez* Oil Spill Restoration Planning Work Group's recommendations and Management Team's concurrence, we surveyed potential intertidal sites that had been identified by cooperating agencies as candidates for inclusion in a special reconnaissance of oiled, densely packed mussel (*Mytilus trossulus*) beds. Of concern was continual re-oiling, or chronic contamination of mussels and subsequent transfer of petroleum hydrocarbons through the food chain to birds and mammals. Main criteria for sampling was the presence of oil, either in the substrate underlying the mussels or presence of oil immediately upslope from such mussel beds; and the presence of moderately to densely packed mussel beds. Secondary criteria was close proximity of an anadromous salmon stream (of particular interest because of nesting of waterfowl). Substrates/sediments and mussels and substrates/sediments were collected from sites that met these criteria.

FIELD COLLECTIONS

The initial survey, 27-29 June 1991, resulted in the collection of samples from 8 sites (Table 1, Figure 1). During the August survey we visited and ground truthed 6 sites, flew over an additional 5 sites but did not land, and sampled 1 site. Four sites were actually sampled in September and another on surveyed. Surveys in August and September were coordinated with ongoing field collections under NRDA/Restoration-Recovery Studies S1 and

Ch1B. Of the 13 sites sampled, the present report covers completed analyses of mussels and substrates/sediments from the 8 sites sampled in June (Table 1).

At least 30 mussels/pooled sample were randomly collected along a 30 meter transect line laid through the densest portion of the mussels bed. The line was laid generally parallel to the water line but, on some sites, was curved to fit beach morphology. Triplicate samples were collected at all sites.

Pooled substrates/sediments were collected from substrates immediately underlying the mussel bed. Eight to ten subsamples were pooled for each of the triplicate samples. At some sites it was difficult to obtain a good representation of the underlying substrate/byssal thread mat; at these sites, sediment was sampled immediately upslope from the mussel bed itself. Field/equipment blanks were also taken at each site.

Sampled were immediately cooled, transported and frozen within 3-4 hours of collection. Standard NRDA Chain-of-Custody procedures were followed throughout.

ANALYTICAL ANALYSES

GC/MS analyses for petroleum hydrocarbons was performed on at least one pooled mussel samples and pooled substrate samples from all sites (Table 1). In some cases, duplicates were analyzed. Standard *Exxon Valdez* NRDA QA/QC guidelines were followed throughout the field sampling procedures, processing and analytical procedures.

All data analyzed to date is presented in Table 2 - 5 and Figures 2 - 4.

Aromatic Hydrocarbons. Mussels from the Bay of Isles site and the site at the northeast end of Latouche Island showed the highest contamination of aromatic hydrocarbons - 4.9 and 3.5 parts per million ($n = 2$ for both sites), respectively (Figure 2). Mussels from 5 sites (Elrington Isl., Fleming Isl., Eleanor Isl., Disk Isl., and Bainbridge Isl.) showed concentrations of total aromatic hydrocarbons between 0.1 and 0.5 parts per million and from Evans Isl - <0.1 ppm.

Substrates from Bay of Isles and NE Latouche Island had total aromatics hydrocarbons at levels 10x the levels (48.0 ppm and 15.5 ppm, respectively) in mussels collected from the same sites (Figure 3). Substrate hydrocarbon levels at Eleanor Isl. were also quite high - 25.8 ppm. Fleming Isl. substrate levels were intermediate - 4.4 ppm. The remaining sites showed total aromatic hydrocarbon levels <1.0 ppm.

The pattern of aromatic hydrocarbon groups present in both mussels and substrates/sediments generally reflects that shown in Prudhoe Bay crude oil (See Figure 2 for PBCO distribution of aromatic hydrocarbons groups).

Alkane Hydrocarbons. Total alkane hydrocarbons and phytane were highest in mussels from the Bay of Isles and NE Latouche (31.4 and 23.0 ppm, respectively) (Figure 4) and were between 2.0 and 10.0 ppm at all other sites. The presence of phytane followed a similar pattern except that it was totally absent from Eleanor Island and Evans Island [the Eleanor Island data for alkanes in mussels is currently being verified]. For those 4 sites where data is available on substrates, alkanes and phytane follow the general pattern as shown for mussels.

SUMMARY AND COMMENTS

Bay of Isles and NE Latouche Island were the most contaminated of the sites for which data is available. Petroleum hydrocarbons, both aromatic and alkane fractions, were consistently high in both mussels and substrates from these sites. The least contaminated sites were those on Bainbridge and Evans Island. Of the intermediately contaminated sites (Elrington Isl., Fleming Isl., Eleanor Isl. and Disk Isl.), Eleanor Island samples need to be verified. This site is on a tombolo with an extremely low gradient; has a densely packed, extensive mussel bed, and the visible oil was quite aromatic when the substrate was disturbed.

A possible source of underestimation of hydrocarbons available to birds and mammals, is the method of processing mussels in the laboratory. Standard processing technique calls for shucking the mussels in a manner that contaminants on the outside of the shell are rigorously excluded from the tissue being analyzed. In the case of predation by fish, birds and mammals, this technique does not represent the true hydrocarbon load being ingested. This is possibly illustrated by the samples collected from Eleanor Island where the substrates showed aromatic hydrocarbons at levels 2 orders of magnitude higher that those shown for the mussel tissue itself. Aromatic hydrocarbon content in substrates from Bay of Isles and NE Latouche Island was also substantially higher than shown in mussels from these same sites.

Laboratory techniques in subsequent hydrocarbon analyses of mussels and substrates from contaminated sites should address this situation during the analytical processing procedure.

Table 1. Sites sampled during mussel bed surveys in Prince William Sound, Alaska, 1991. Triplicate samples of pooled mussels and underlying substrates along with field blanks were collected.

SITE	GEN. LOCATION	BEACH SEG. #	DATE COLLECTED	# ANAL	TO BE ANALYSED
Bay of Isles	E. Knight Island	KN136	27 June	4	2
Eleanor Isl.	S.W. Eleanor Isl.	EL013A	27 June	4	2
Elrington Isl.	N.E. Elrington Isl.	ER020B	28 June	4	2
Evans Island	N.W. Evans Island	EV017	28 June	2	4
Fleming Isl.	N.W. of Evans I.	Fl004A	28 June	2	4
Bainbrige Isl.	Bay in N.W. Bainbridge	BA006C	28 June	2	4
Disk Island	N. of Knight Isl.	DI067A	29 June	2	4
Latouche Island	N.E. Latouche Isl.	LA015E	29 June	4	2
Foul Bay	N. of Main Bay	MA002A	07 Aug.	0	6
Herring Bay	Knight Island	KN0300	06 Sept.	0	6
Herring Bay	Knight Island	KN113B	06 Sept.	0	6
Chenega Island	N.E. Chenaga Island	CH010B	07 Sept.	0	6
Evans Island (mussels only)	N.E. Evans Island	EV900A	08 Sept.	0	3

Summary: There have been 24 samples analyzed under the NRDA process. Yet to be analyzed are 51 samples plus 13 field blanks - for a total of 64 samples. The total cost for these analyses is estimated to be $50432.00.

Table 2. Individual aromatic hydrocarbon compounds, means of selected aromatic groups, and total aromatic hydrocarbons of mussels from oiled mussel bed survey, Prince William Sound, 1991. All concentrations are in ng/g dry weight.

SITE	BAY OF ISLES	BAY OF ISLES	LA-TOUCHE	LA-TOUCHE	ELRING-TON ISL.	ELRING-TON ISL.	ELEANOR ISL.	ELEANOR ISL.	FLEMING ISL.	DISK ISL.	BAIN-BRIDGE	EVANS ISL.
BEACH SEGMENT #	KN0136A	KN0136A	LA0015E	LA0015E	ER0020B	ER0020B	EL0013A	EL0013A	FL0004A	DI0067A	BA0006C	EV0017A
SAMPLE ID	214001	214002	214105	214106	214020	214021	214012	214013	214034	214047	214040	214027
COMPOUND												
Naphthalene	12.2	9.1	9.1	7.2	4.8	4.9	8.0	3.8	6.2	4.3	3.0	5.1
2-methylnaphthalene	3.3	3.1	3.8	3.5	2.1	2.6	2.9	1.6	3.2	3.0	2.1	2.5
1-methylnaphthalene	6.7	2.2	9.1	5.4	4.4	3.0	6.9	4.0	6.3	5.1	3.7	4.2
2,6-dimethylnaph.	0.0	4.1	11.2	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C-2 naphthalenes	14.0	20.6	56.0	11.0	5.6	4.2	13.7	10.7	14.9	5.1	7.9	2.9
2,3,5-trimethylnaph.	4.2	9.5	22.4	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0
C-3 naphthalenes	37.5	68.3	158.7	6.5	4.9	5.5	13.1	14.0	4.6	3.5	4.4	0.0
C-4 naphthalenes	49.1	97.8	189.6	25.2	2.1	1.4	6.0	5.6	0.0	0.0	0.0	0.0
Biphenyl	3.4	2.4	11.0	4.6	17.1	8.5	1.2	1.5	3.1	6.5	12.5	5.4
Acenaphthylene	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	1.2	0.0	0.0
Acenaphthene	3.9	3.8	2.8	0.0	0.0	2.5	2.0	1.9	1.6	1.6	1.6	1.6
Fluorene	2.6	2.3	3.9	0.0	0.0	0.0	0.0	2.1	2.0	0.0	0.0	1.0
C-1 fluorenes	8.6	19.3	32.3	2.0	3.4	0.3	4.6	2.4	5.1	1.7	3.8	3.9
C-2 fluorenes	152.4	84.5	129.1	25.3	12.1	10.3	4.9	9.1	4.3	44.7	3.1	2.7
C-3 fluorenes	137.1	171.5	176.5	49.6	23.1	30.1	5.0	5.8	20.9	4.2	0.0	3.0
Dibenzothiophene	4.6	4.2	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C-1 dibenzothioph.	57.0	76.1	121.0	11.3	2.5	2.5	3.1	6.4	2.6	0.9	1.4	0.0
C-2 dibenzothioph.	275.5	399.7	449.5	81.4	17.6	17.1	11.6	19.2	14.8	4.5	6.4	0.0
C-3 dibenzothioph.	702.7	930.3	868.2	203.9	31.2	32.0	12.1	29.3	29.2	15.7	16.0	3.9
Phenanthrene	20.7	21.2	34.2	10.9	10.2	10.2	13.5	10.5	11.0	9.0	9.3	10.9
1-methylphenanthrene	23.6	54.5	42.9	0.0	7.7	8.1	3.8	3.6	3.1	0.0	2.0	0.0
C-1 phenanthr/anthr	139.1	124.9	210.8	13.6	16.4	11.8	12.9	12.9	11.5	2.6	4.8	1.1
C-2 phenanthr/anthr	492.0	574.2	757.6	149.1	62.0	53.5	32.4	45.0	40.3	18.6	16.5	1.3
C-3 phenanthr/anthr	862.5	1130.2	1097.7	310.3	88.3	67.7	40.3	141.2	64.0	36.3	15.6	0.0
C-4 phenanthr/anthr	406.6	479.8	434.9	129.4	19.8	18.8	2.3	17.0	14.0	11.2	1.9	0.0
Anthracene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fluoranthene	8.8	21.4	9.1	0.0	11.1	2.7	3.0	14.1	2.2	2.4	6.9	2.6
Pyrene	10.8	21.8	18.4	10.6	11.3	2.2	3.5	11.8	2.6	2.6	2.8	2.1
C-1 fluoranth/pyr	154.7	289.3	154.7	46.1	6.3	6.2	0.8	6.0	7.2	3.5	0.1	0.3
Benz-a-anthracene	5.4	6.5	0.0	1.8	1.0	1.1	1.6	1.4	2.1	0.9	0.9	6.3
Chrysene	119.4	146.4	117.3	39.3	16.5	15.8	9.5	11.1	16.9	10.1	5.3	0.0
C-1 chrysenes	209.3	264.9	209.9	62.9	21.2	19.8	11.3	16.1	24.4	13.2	5.1	0.0
C-2 chrysenes	223.5	257.1	266.3	89.2	25.2	19.0	14.6	33.4	41.0	30.0	18.8	10.2
C-3 chrysenes	107.2	126.2	112.9	56.0	10.8	1.5	2.9	6.4	13.8	0.6	0.0	0.0
C-4 chrysenes	27.9	33.3	26.3	7.7	6.8	7.1	6.6	5.2	6.9	2.9	4.7	0.2
Benzo-b-fluoranth.	18.4	18.9	13.7	7.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzo-k-fluoranth.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzo-e-pyrene	32.4	42.1	32.3	10.0	5.8	0.0	0.0	0.0	0.0	0.0	0.0	2.0
Benzo-a-pyrene	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Perylene	36.4	0.0	0.0	0.0	11.9	0.0	0.0	0.0	0.0	0.0	5.3	3.5
Indeno-123-cd-pyrene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dibenzo-a,h-anthr.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzo-g,h,i-perylene	6.2	6.2	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL AROMATICS	4348	5455	5718	1372	450	357	240	444	367	238	158	70
SUM NAPHTHALENES	117	205	436	50	17	16	41	37	26	13	15	8
SUM PHENANTHRENES	1921	2330	2535	613	197	162	101	226	141	78	48	13
SUM DIBENZOTHIOPH.	1040	1410	1449	297	51	52	27	55	47	21	24	4
SUM FLUORENES	301	278	342	77	39	41	15	19	32	51	7	11
SUM CHRYSENES	687	828	733	255	81	63	45	72	103	57	34	10

Table 3. Individual alkane hydrocarbons, total alkanes, and UCM (unresolved complex mixture) from mussels sampled during oiled mussel bed survey, Prince William Sound, 1991. All concentrations are given in ng/g dry weight.

SITE	BAY OF ISLES	BAY OF ISLES	LA-TOUCHE	LA-TOUCHE	ELRING-TON ISL	ELRING-TON ISL	ELEANOR ISL.	ELEANOR ISL.	FLEMING ISL.	DISK ISL.	BAIN-BRIDGE	EVANS ISL.
BEACH SEGMENT #	KN0136A	KN0136A	LA0015E	LA0015E	ER0020B	ER0020B	EL0013A	EL0013A	FL0004A	DI0067A	BA0006C	EV0017A
SAMPLE ID	214001	214002	214105	214106	214020	214021	214012	214013	214034	214047	214040	214027
COMPOUND												
ALKANE, C10-	73.2	105.6	0.0	0.0	82.0	56.2	96.3	98.0	85.5	0.0	67.0	0.0
ALKANE, C11-	75.3	82.6	40.1	32.9	31.6	7.2	0.0	0.0	32.9	8.6	23.2	27.7
ALKANE, C12-	59.5	0.0	43.5	27.7	0.0	23.2	0.0	0.0	0.0	29.6	22.7	0.0
ALKANE, C13-	133.8	0.0	159.0	87.6	0.0	0.0	0.0	0.0	0.0	50.7	43.4	0.0
ALKANE, C14-	20.2	0.0	196.9	265.5	17.0	21.6	0.0	14.7	0.2	136.8	147.6	0.0
ALKANE, C15-	221.3	211.1	630.9	573.9	266.5	344.0	135.5	339.3	282.2	390.4	486.7	219.3
ALKANE, C16-	25.7	101.0	148.1	154.9	94.7	157.2	0.0	164.3	130.1	143.6	264.1	94.4
ALKANE, C17-	560.0	291.1	2035.8	527.4	563.2	683.8	842.5	786.9	1246.4	434.9	309.0	293.9
PRISTANE	1306.7	1443.5	1771.8	722.4	1741.1	2487.9	1028.6	876.8	1331.6	787.2	833.5	292.0
ALKANE, C18-	0.0	0.0	790.4	156.7	0.0	106.9	0.0	0.0	168.8	84.2	70.1	54.1
PHYTANE	782.0	758.8	1083.0	308.6	126.2	118.0	0.0	0.0	180.8	84.9	53.7	0.0
ALKANE, C19-	176.4	0.0	497.7	74.2	62.2	64.8	0.0	0.0	171.4	52.1	41.0	29.3
ALKANE, C20-	101.0	97.2	509.4	44.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ALKANE, C21-	0.0	0.0	207.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ALKANE, C22-	254.1	266.5	253.4	191.6	80.5	69.1	0.0	0.0	288.4	89.0	62.6	0.0
ALKANE, C23-	166.3	172.2	150.3	59.2	41.3	50.6	0.0	0.0	0.0	48.9	37.0	0.0
ALKANE, C24-	370.1	481.7	276.1	130.9	107.1	93.3	0.0	0.0	55.2	109.5	50.6	0.0
ALKANE, C25-	496.0	532.8	355.6	159.6	100.8	238.8	0.0	0.0	102.6	117.6	121.1	43.1
ALKANE, C26-	268.0	257.7	147.0	43.5	45.3	52.7	0.0	0.0	132.2	17.9	10.4	0.0
ALKANE, C27-	368.6	643.9	238.4	437.6	115.3	80.7	0.0	0.0	184.2	101.9	111.3	127.6
ALKANE, C28-	375.9	621.0	343.8	0.0	174.8	185.2	0.0	0.0	0.0	314.8	55.0	0.0
ALKANE, C29-	282.7	319.9	346.3	288.9	70.8	96.6	0.0	0.0	0.0	150.1	83.9	0.0
ALKANE, C30-	440.8	524.4	357.0	465.7	0.0	164.6	0.0	0.0	0.0	192.0	0.0	0.0
ALKANE, C32-	0.0	0.0	198.7	176.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ALKANE, C34-	0.0	0.0	267.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOT. ALKANES	24482	21450	47117	15718	7386	9082	3857	4034	9604	8532	5029	2251
[UCM]	155153	152992	191069	87437	23756	0	0	0	0	34847	0	7071

Table 4. Individual aromatic hydrocarbon compounds, means of selected aromatic groups, and total aromatic hydrocarbons in substrates/sediments from oiled mussel bed survey, Prince William Sound, 1991. All concentrations are in ng/g dry weight.

SITE	BAY OF ISLES	BAY OF ISLES	LA-TOUCHE	LA-TOUCHE	ELRING-TON ISL	ELRING-TON ISL	ELEANOR ISL.	ELEANOR ISL.	FLEMING ISL.	DISK ISL.	BAIN-BRIDGE	EVANS ISL.
BEACH SEGMENT #	KN0136A	KN0136A	LA0015E	LA0015E	ER0020B	ER0020B	EL0013A	EL0013A	FL0004A	DI0067A	BA0006C	EV0017A
SAMPLE ID	214005	214006	214101	214102	214016	214017	214008	214009	214030	214043	214037	214023
Naphthalene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-methylnaphthalene	11.95	313.03	0.00	62.73	0.00	0.00	60.58	0.00	1.26	0.83	0.00	0.00
1-methylnaphthalene	0.00	254.38	0.00	29.09	0.00	0.00	114.92	0.00	0.00	0.05	0.00	0.00
2,6-dimethylnaph.	246.76	1173.36	53.90	240.02	0.09	0.24	411.75	88.33	2.42	0.96	0.00	0.03
C-2 naphthalenes	1475.10	5750.36	331.51	1346.15	3.57	3.38	2673.21	717.73	18.63	9.39	0.00	0.47
2,3,5-trimethylnaph.	458.44	1385.49	114.63	382.96	1.28	0.74	674.90	259.05	5.85	0.83	0.23	0.64
C-3 naphthalenes	2807.31	8997.63	675.62	2220.22	7.42	3.62	4194.31	1602.48	49.92	6.13	1.70	2.36
C-4 naphthalenes	1349.79	4661.48	188.86	830.54	12.33	7.31	1718.13	758.13	116.24	8.84	4.81	2.96
Biphenyl	0.00	8.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acenaphthylene	12.75	40.96	0.00	0.00	0.00	0.00	20.19	0.00	0.00	0.00	0.00	0.00
Acenaphthene	0.00	18.21	0.00	0.00	0.02	0.09	0.00	0.00	0.00	0.18	0.05	0.06
Fluorene	45.36	136.83	8.89	55.84	0.04	0.34	106.90	17.34	1.35	0.38	0.02	0.11
C-1 fluorenes	445.13	1274.69	91.76	334.66	1.98	0.95	648.53	225.51	32.47	3.23	0.45	0.56
C-2 fluorenes	662.86	2119.53	101.96	432.70	7.98	5.29	833.21	428.86	127.84	9.45	0.86	1.20
C-3 fluorenes	633.49	2126.48	97.74	427.28	12.95	8.59	899.28	480.53	261.81	19.27	0.14	0.87
Dibenzothiophene	186.51	426.89	54.91	225.77	0.38	0.27	417.13	140.17	4.93	0.43	0.09	0.31
C-1 dibenzothioph.	1054.93	2746.68	277.23	901.38	5.67	2.70	1563.49	686.05	82.41	4.94	0.39	0.91
C-2 dibenzothioph.	2297.04	6507.75	526.41	1693.35	35.15	21.46	3234.89	1768.54	550.12	33.82	1.27	2.29
C-3 dibenzothioph.	2259.20	6598.64	483.70	1476.78	61.96	37.91	3113.66	2023.22	868.09	72.16	1.38	2.50
Phenanthrene	209.87	584.54	35.77	278.87	0.00	0.00	438.66	69.29	3.25	0.00	0.00	0.00
1-methylphenanthr.	273.92	892.04	83.91	410.98	1.88	0.61	547.49	172.53	12.85	0.64	0.00	0.00
C-1 phenanthr/anthr	1680.01	4432.70	464.95	1540.73	10.71	5.69	2493.56	973.20	115.40	7.89	0.32	2.01
C-2 phenanthr/anthr	2851.63	8155.64	662.14	2118.56	42.68	25.14	4100.78	2103.78	606.81	36.74	1.21	3.88
C-3 phenanthr/anthr	2656.87	8145.99	505.65	1806.78	75.70	48.08	3716.51	2336.06	1077.17	91.96	2.14	4.24
C-4 phenanthr/anthr	552.14	1733.44	91.80	289.43	30.34	21.36	635.24	527.91	339.46	43.60	0.00	0.05
Anthracene	15.56	41.15	0.00	13.68	0.31	0.29	27.98	12.49	1.65	0.00	0.00	0.44
Fluoranthene	0.00	0.00	0.00	7.47	0.03	0.00	21.22	0.00	0.00	0.00	0.00	0.74
Pyrene	34.97	170.31	4.24	29.49	2.18	1.31	68.14	13.13	0.00	1.28	0.00	0.39
C-1 fluoranth/pyr	322.58	1108.79	51.84	177.67	28.15	20.77	578.14	305.73	214.53	39.95	0.33	3.58
Benz-a-anthracene	0.00	0.00	0.00	0.00	0.63	0.44	0.00	0.00	0.00	0.80	0.06	0.00
Chrysene	231.82	669.05	41.61	136.87	30.08	24.44	318.24	229.68	0.00	40.14	0.34	3.31
C-1 chrysenes	509.46	1516.67	64.24	221.38	58.74	49.06	571.28	502.37	0.00	71.42	1.92	3.50
C-2 chrysenes	508.63	1590.18	103.46	275.52	71.34	60.31	719.50	544.57	0.00	87.34	1.34	5.59
C-3 chrysenes	280.11	893.97	50.33	137.35	50.15	53.14	341.62	316.86	0.00	83.25	0.48	4.98
C-4 chrysenes	68.73	274.75	15.46	19.42	25.02	28.48	85.24	50.91	0.00	38.70	0.49	2.48
Benzo-b-fluoranth.	30.55	93.96	0.00	21.40	5.98	5.21	50.75	35.47	0.00	6.26	0.78	1.56
Benzo-k-fluoranth.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Benzo-e-pyrene	71.79	175.83	22.05	40.79	16.99	16.76	95.87	73.15	0.00	18.64	0.97	2.22
Benzo-a-pyrene	0.00	0.00	0.00	0.00	2.26	2.27	0.00	0.00	0.00	2.28	0.00	0.46
Perylene	0.00	10.24	0.00	0.00	1.90	1.65	0.00	0.00	0.00	2.28	0.00	1.08
Indeno-123-cd-pyrene	0.00	0.00	0.00	0.00	1.02	1.57	0.00	0.00	0.00	1.29	0.15	0.39
Dibenzo-a,h-anthr.	0.00	0.00	0.00	0.00	1.45	1.60	0.00	0.00	0.00	1.85	0.00	0.00
Benzo-g,h,i-perylene	12.74	35.89	0.00	7.41	5.01	5.96	19.88	16.47	0.00	5.61	0.65	1.41
TOTAL AROMATICS	23725.4	72432.8	5066.7	17450.5	611.4	466.2	34380.5	17218.7	4477.9	750.3	22.6	57.6
SUM NAPHTHALENES	6090.6	20795.0	1310.6	4779.9	24.6	15.1	9260.6	3337.4	190.6	25.2	6.7	6.4
SUM PHENANTHRENES	7950.5	23052.3	1760.3	6034.4	159.4	100.3	11384.8	6010.2	2142.1	180.2	3.7	10.2
SUM DIBENZOTHIOPH.	5797.7	16280.0	1342.3	4297.3	103.2	62.3	8329.2	4618.0	1505.5	111.3	3.1	6.0
SUM FLUORENES	1786.8	5657.5	300.3	1250.5	23.0	15.2	2487.9	1152.2	423.5	32.3	1.5	2.7
SUM CHRYSENES	1598.7	4944.6	275.1	790.5	235.3	215.4	2035.9	1644.4	0.0	320.9	4.6	19.9

Table 5. Individual alkane hydrocarbons, total alkanes, and UCM (unresolved complex mixture) from substrates/sediments sampled during oiled mussel bed survey, Prince William Sound, 1991. All concentrations are given in ng/g dry weight.

SITE	BAY OF ISLES	BAY OF ISLES	LA-TOUCHE	LA-TOUCHE	ELRING-TON ISL	ELRING-TON ISL	ELEANOR ISL.	ELEANOR ISL.	FLEMING ISL.	DISK ISL.	BAIN-BRIDGE	EVANS ISL.
BEACH SEGMENT #	KN0136A	KN0136A	LA0015E	LA0015E	ER0020B	ER0020B	EL0013A	EL0013A	FL0004A	DI0067A	BA0006C	EV0017A
SAMPLE ID	214005	214006	214101	214102	214016	214017	214008	214009	214030	214043	214037	214023
ALKANE, C10-					0.0	0.0				0.0	0.0	0.0
ALKANE, C11-					0.0	0.0				0.0	0.0	0.0
ALKANE, C12-					0.0	0.0				0.0	0.0	0.0
ALKANE, C13-					17.4	4.2				0.0	0.0	0.0
ALKANE, C14-					25.3	34.2				9.6	0.0	0.0
ALKANE, C15-	D A T A				80.8	128.3	D A T A			85.2	0.0	2.4
ALKANE, C16-					147.1	45.4				78.0	1.1	5.6
ALKANE, C17-					243.2	53.3				116.9	1.6	16.4
PRISTANE			L O S T		352.0	196.7			L O S T	186.0	19.7	95.5
ALKANE, C18-					284.0	35.0				37.5	1.4	13.5
PHYTANE					218.5	68.3				122.3	2.6	13.4
ALKANE, C19-					105.0	59.3				43.0	2.9	14.7
ALKANE, C20-					100.6	90.6				22.1	0.9	21.7
ALKANE, C21-					34.4	73.0				30.7	1.6	23.1
ALKANE, C22-					126.3	95.8				51.3	2.5	29.5
ALKANE, C23-					99.2	92.2				47.4	2.5	30.4
ALKANE, C24-					154.9	132.3				99.3	0.6	33.4
ALKANE, C25-					125.3	89.0				41.2	0.0	24.8
ALKANE, C26-					114.0	58.8				32.1	0.0	14.1
ALKANE, C27-					168.3	137.9				84.7	1.7	72.1
ALKANE, C28-					71.5	45.8				70.6	0.0	9.1
ALKANE, C29-					70.2	56.9				17.5	0.0	29.6
ALKANE, C30-					113.5	101.7				74.2	323.2	15.9
ALKANE, C32-					136.9	150.4				92.8	0.0	30.7
ALKANE, C34-					193.1	205.0				143.0	0.0	51.6
TOT. ALKANES					9798	9026				8625	352	2052
[UCM]					18502	39107				36565	1854	12266

Figure 1. Prince William Sound, Alaska sites sampled, June, August and September, 1991, during oiled mussel bed surveys.

▲ = samples taken

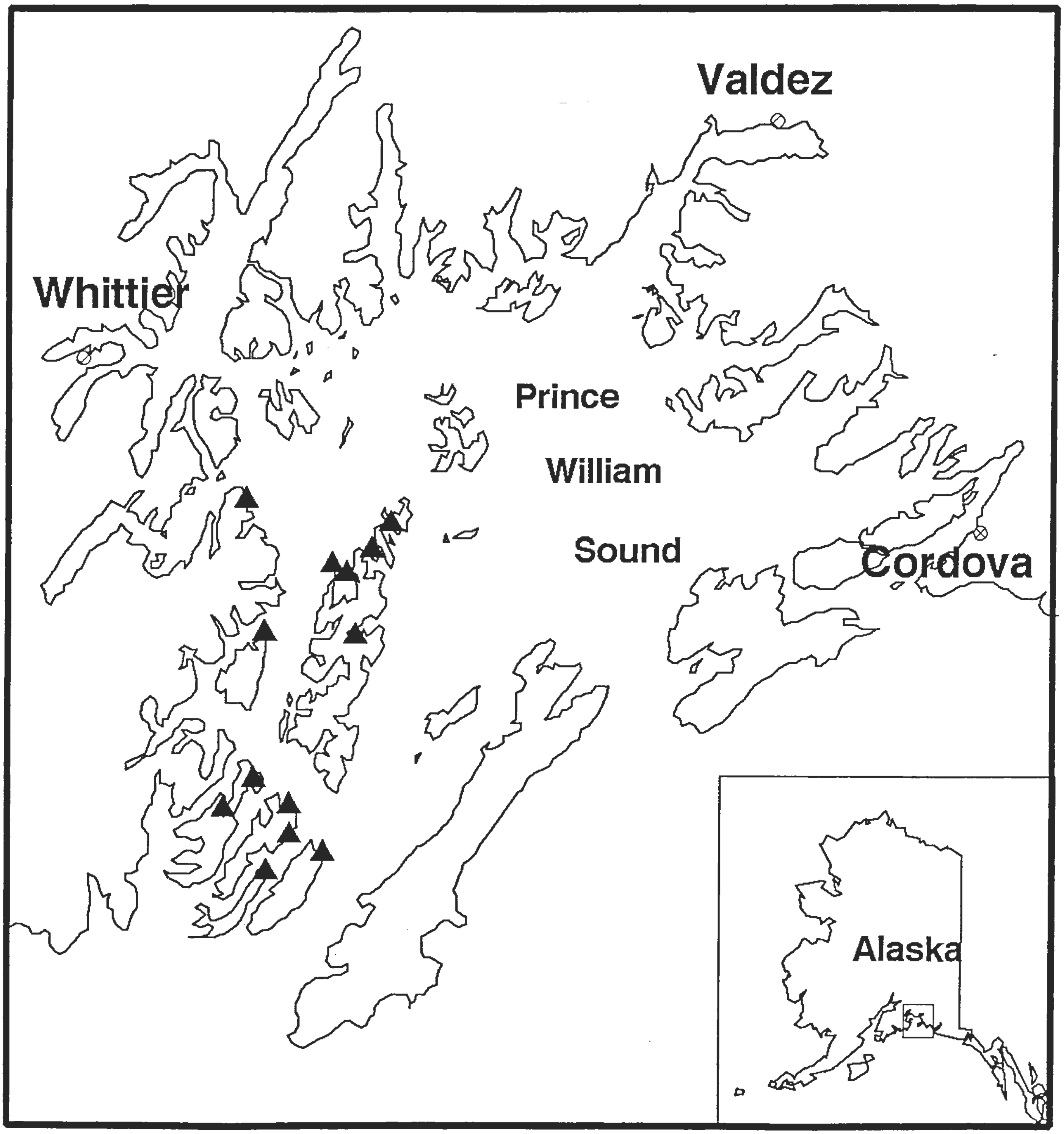


Figure 2. Total aromatics hydrocarbons and selected hydrocarbon groups in mussels sampled in Prince William Sound, June, 1991. Sums of aromatic hydrocarbon groups in Prudhoe Bay crude oil. * = avg. 2 samples; T = total; S = sum.

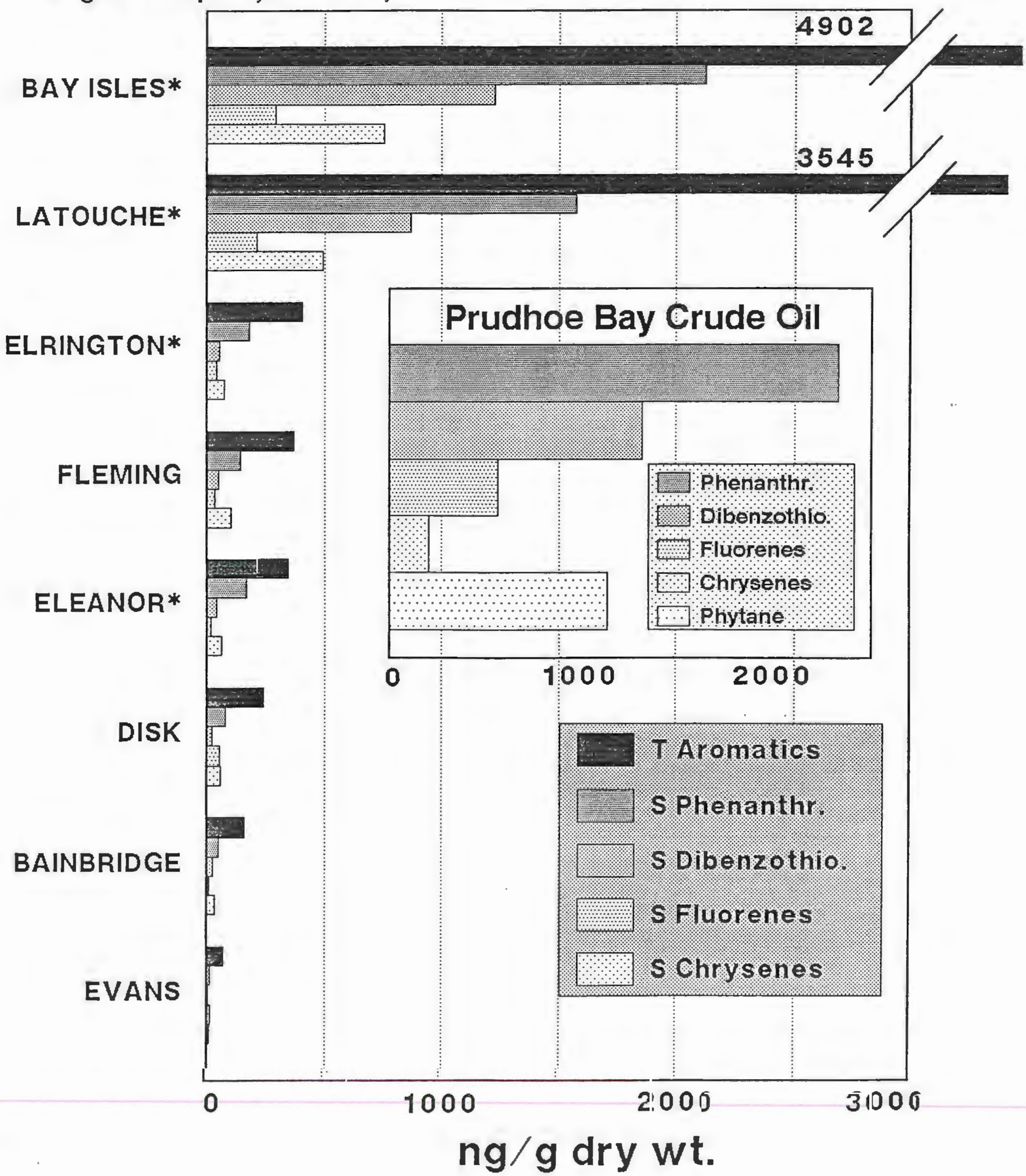


Figure 3. Total aromatics hydrocarbons and selected hydrocarbon groups in substrates sampled in Prince William Sound, June, 1991. * = avg. 2 samples; T = total; S = sum.

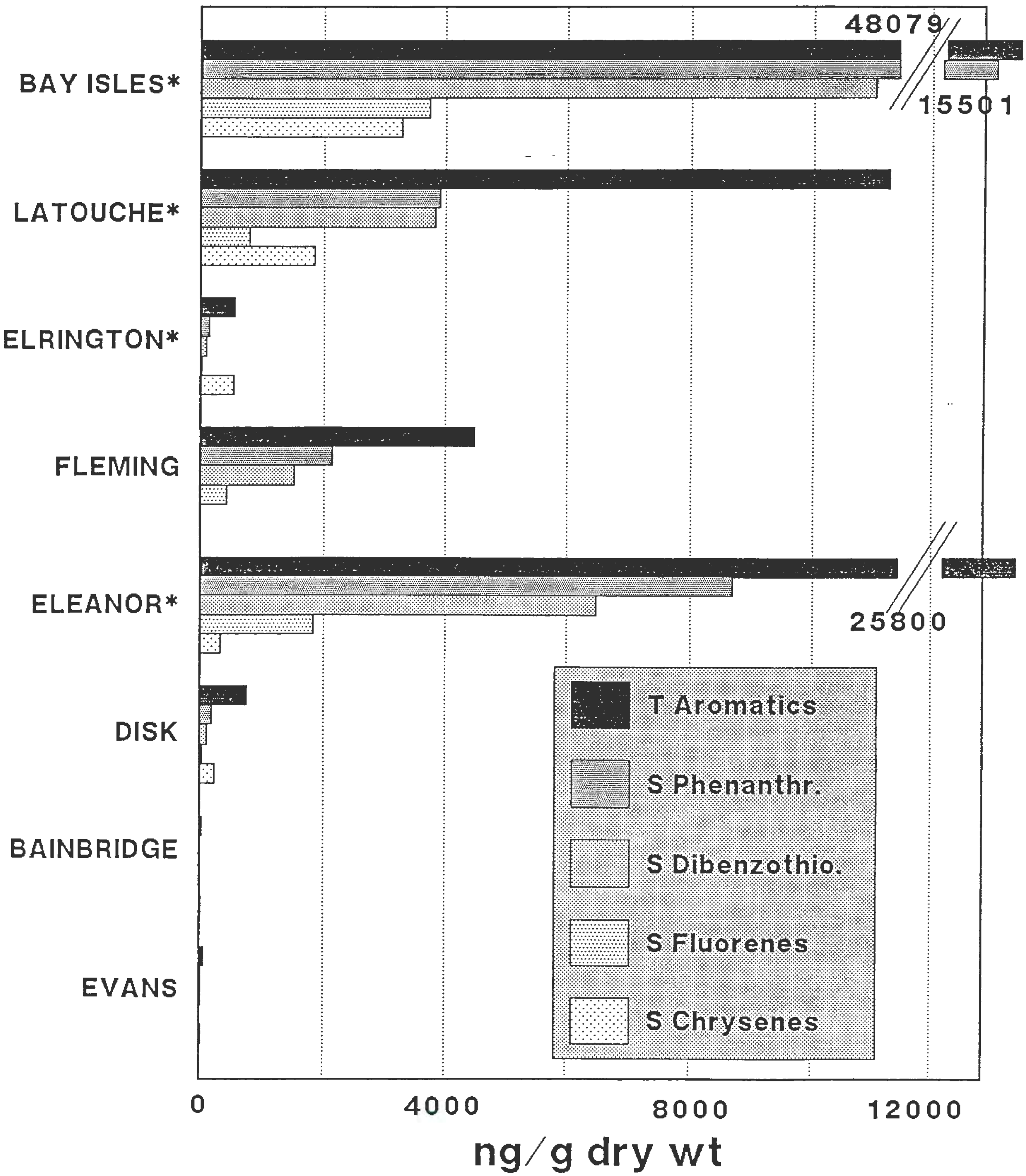
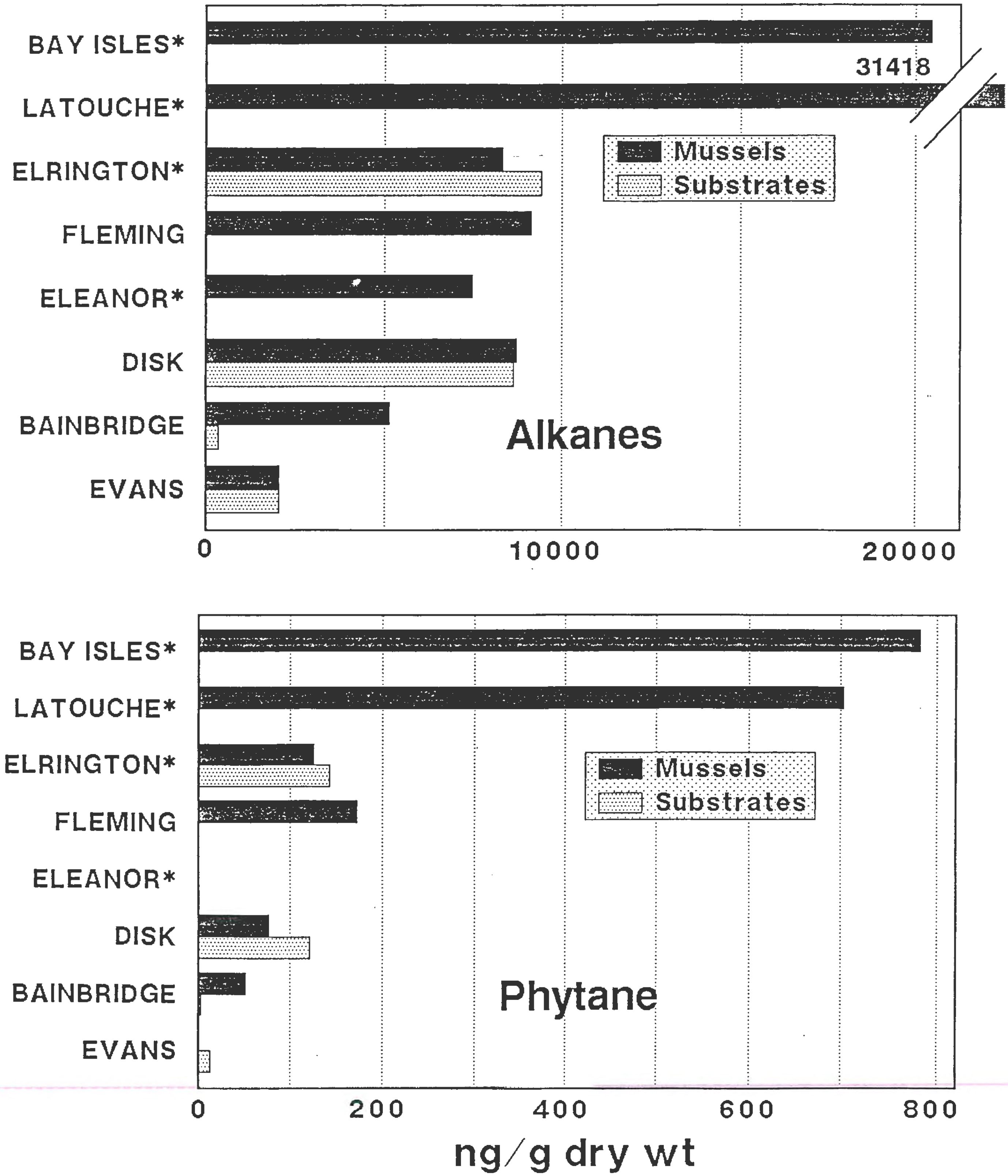


Figure 4. Total alkanes and phytane in mussels and substrates from Prince William Sound, June, 1991. Alkane fraction from several sites (substrates only) lost during processing. * avg. 2 samples.



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Killer Whale Monitoring and Habitat Studies

Study ID Number: Marine Mammals Study Number 6

Project Leader(s): Marilyn E. Dahlheim and Thomas R. Loughlin

Lead Agency: National Oceanic and Atmospheric Administration

Cooperating Agency(ies): Federal: None
State: None

Cost of Proposal: $ 219.5K

Dates of Study Plan: 1 April 1992 through 31 March 1993
(Year 2).

Marilyn E. Dahlheim
Marilyn E. Dahlheim, Ph.D.
Project Leader

Thomas R. Loughlin
Thomas R. Loughlin, Ph.D.
Project Leader

Howard W. Braham
Howard W. Braham, Ph.D.
Organization Leader

Joanne Wejak
Joanne Wejak
Financial Officer

Alaska Fisheries Science Center
National Marine Mammal Laboratory
7600 Sand Point Way N. E., Bin C15700
Seattle, Washington 98115-0070
206/526-4045

4 November 1991

INTRODUCTION

Photographs of individual killer whales occurring in Prince William Sound were collected from May to September 1989 and 1991 to assess the potential impacts of the Exxon Valdez oil spill on killer whale life history and ecology. Research vessels traversed over 25,000 nautical miles in search of whales or while photographing whales, reflecting 617 days of field research. An unusually high number of killer whales were reported missing from one of the resident pods named AB pod. In addition to missing whales in this pod, significant changes occurred in the pod's social structure.

Continued monitoring of the status of AB pod in Prince William Sound through photo-identification studies is required to document natural recovery of the injured population. In addition, restoration of killer whales can be enhanced by protecting sensitive habitats, minimizing fishery interactions, reducing or redirecting other human-use impacts, and promoting public education. The designation of habitats has occurred in the United States to protect endangered and threatened pinnipeds and also internationally to protect cetaceans. Recently Robson Bight in British Columbia has been designated as a sensitive habitat for killer whales (Rennie, 1989). It should be understood, however, that little or no quantitative information exists on habitat needs for killer whales in Prince William Sound and adjacent waters on which to base a recommendation to limit or otherwise change human-use activities.

The purpose of this study is to obtain photographs of individual killer whales occurring in AB pod to document natural recovery. Photographs collected will be compared to the National Marine Mammal Laboratory's photographic database for the years 1989 to 1991 to determine if changes continue to occur in whale abundance, pod integrity, and mortality or natality rates. Photo-identification studies have been used with a number cetacean studies and the methods well proven. Investigations will continue on the feasibility of satellite tagging killer whales. Data obtained from tagged whales would be used to determine habitat needs for the species. During 1992, a request to place satellite tags on killer whales will be submitted to National Marine Fisheries Service (Office of Protected Species) to obtain necessary federal permits. Transmitters would be attached to at least three killer whales during the summer of 1993. A delay in the 1992 photo-identifcation field studies could result in the loss of data pertaining to annual killer whale reproductive and mortality rates and would also impact the collection of needed information on habitat requirements for killer whales.

OBJECTIVES

1. To count the number and individually identify killer whales within AB pod.

2. To test the hypothesis that pre- and post-spill killer whale structure and integrity within AB pod have remained constant.

3. To determine killer whale reproductive rates and trends in abundance within Prince William Sound.

4. To identify and describe habitat requirements for killer whales through the use of satelitte tags, a prerequisite to developing realistic restoration options for the species.

METHODS

A. Sampling Methods

1) Enumeration, Pod Structure and Integrity, Reproductive Rates and Trends in Abundance.

Personnel from the National Marine Mammal Laboratory (NMML), Seattle, Washington (Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA/DOC) will develop and coordinate all killer whale research activities associated with restoration studies. Field studies will be conducted by either NMML staff and/or contractors that have recognized expertise in the study areas of concern.

A shore-based camp (equipped with a suitable small boat for whale identification work) or a live-aboard chartered vessel will be used in Prince William Sound to conduct photo-identification studies on killer whales from approximately July to September 1992. Study areas will be similar to those areas worked during our 1989 through 1991 seasons. The camp or vessel would be fully self-contained with necessary items for safety and staffed by at least two biologists. For consistency in data collection, key personnel remain in the field throughout the study period.

Weather permitting, field personnel will spend an average of 8 to 10 hours per day conducting boat surveys searching for AB pod. When encountered, other pods of killer whales should be photographed as well. Specific areas, known for whale concentrations, are investigated first. However, if reports of whales are received from other sources, those areas are examined. If AB pod is not located in "known" areas and opportunistic sighting reports are not available; a general search pattern is developed and implemented. Travel routes typically taken by AB pod will be surveyed. When whales are sighted, researchers stop further search efforts and approach the whales to collect photo-identification information. When whales are encountered, researchers select a vessel course and speed to approximate the animals' course and speed to facilitate optimal photographic positioning.

To obtain a high-quality photograph, an approach within 30-60 meters is required. Photographs are taken of the left side of the whale's dorsal fin and saddle patch. Any high-performance camera system (i.e., Nikon, Canon, Pentax) can be used to collect the data. Motor drives (5 frames/sec) and 300 mm fixed lens are optimal. The camera shutter speed is set to 1/1000th second, or the highest speed possible. The film type should allow for a high shutter speed and good depth of field. For this project the type of film is standardized; black and white Ilford HP5 film (ASA 400), which is taken and developed at ASA 1600. The camera should be held steady and be supported by a shoulder brace if possible. All exposed film during this study will be developed by the same photographic laboratory. Film will be processed throughout the season to allow field personnel to obtain necessary feedback within two weeks of encounters. Proper labelling of exposed film includes date, roll number, photographer's initials, location, species code, and ASA setting. A new roll of film is used for each encounter.

Daily effort logs are maintained each day which will permit 1) quantification of the amount of time searching for whales versus photographing whales, 2) quantification of search effort under different weather conditions; 3) daily vessel trackline, and 4) an estimation of number of vessels/aircraft encountered in the study area.

2) Habitat Requirements

The current sighting data on killer whales does not contain adequate information to allow quantification of critical habitat needs for killer whales. Whale movement patterns are unknown. To more accurately determine habitat use and overall distribution and movements of killer whales, we have explored the feasibility of placing satellite transmitters on Prince William Sound killer whales. Recently, many successful deployments of satellite transmitters on cetaceans and pinnipeds have provided important ecological information and each year brings about major advances in technology. After extensive examination of existing technology, we believe that the technology is available to successfully place satellite tags on at least three whales in Prince William Sound. Year two (1992) will be devoted to the modification of satellite tags for placement on killer whales. In addition, an application will be submitted to obtain the necessary federal permits for this work. If the necessary equipment and permit is obtained in 1992 and we are satisfied with all aspects of the work (delivery system, attachment device, minimal disturbance to whales, etc.), we propose to initiate satellite tagging during the 1993 field season (year three).

B. Data Analysis

1) Photo-Identification Studies

All exposed film of killer whales collected during the 1992 field season will be analyzed for individual identification. Each negative (or prints as needed) is placed under a dissection microscope for identification and notes and sketches are made. Sub-standard photographs (not showing enough detail or improper angle/side) are discarded; thus reducing the probability of mis-matching photographs. Photographs are then grouped by individuals. Each identified whale is then visually compared to the historical photographic database available. Once an individual whale is properly identified, it is relatively easy to identify the pod to which it belongs. Once all photographs are properly entered and evaluated, it is then possible to determine 1) if all members of the pod were present, and 2) if pod structure/integrity is similar to previous years. Missing animals are noted. The stability of resident pods over time is such that if an individual is listed as missing for at least one year; that missing whale is considered dead.

Calves of the year will be noted and their mothers identified. Natality (number of calves per adult female) will be calculated for each pod for each year and comparisons made between resident and transient groups using descriptive statistics. Mortality rates will also be calculated for resident groups. Mortality for transient pods will be calculated when necessary data are available.

2) Habitat Requirements

A progress report will be written assessing the success of obtaining appropriate tags and permits. This would include recommendations for either continuation or cancellation of this aspect of the work.

FUTURE STUDIES

Because killer whale recovery rates are essentially unknown (it may take 25-30 years or more), there is a clear need to continue monitoring population trends for killer whales in the spill area beyond the 1992 field season. Since the historical database was found inadequate to support future decisions to implement restoration (e.g. habitat protection), it is possible that future habitat-use surveys (beyond satellite tagging) would be proposed.

SCHEDULES & PLANNING

A. Data Submission and Archival

No other special reports or additional visual data will be submitted other than those described in the reports.

Reports will be available through the National Marine Mammal Laboratory, Seattle, Washington (Attn: Drs. Dahlheim and Loughlin) summarizing the 1992 studies. Reports are written in a scientific format and contain an Abstract, Title Page, Table of Contents, List of Tables and Figures, Introduction, Materials and Methods, Results, Discussion, and Conclusion/Recommendation Section. Original survey forms, identification cards, daily logs, marine mammal sighting and effort forms are archived at the National Marine Mammal Laboratory. The highest quality photograph for each individual killer whale will be selected and a 2 1/2" by 3 1/2" print will be made for archival purposes.

All documents and materials associated with this monitoring study will be stored at the National Marine Mammal Laboratory, Seattle, Washington under the Alaska Ecosystem Program. Killer whale prints are stored in archival plastic sheets and properly labelled (date/location/photographer). Equipment purchased for the investigations will be properly labelled. Serial numbers will be listed when available. Equipment will be stored in the custody of the Project Leaders at the NMML.

B. Management Plan

<u>NOAA, Alaska Fisheries Science Center, National Marine Mammal Laboratory, 7600 Sand Point Way N. E., Bin C15700, Seattle, Washington 98115 (206/526-4045).</u>

Dr. Marilyn E. Dahlheim, Project Leader
Duties: Project development, research design and implementation. Coordination of, and participation in, field research.

Dr. Thomas R. Loughlin, Project Leader
Duties: Project development and research design.

Ms. Joanne Wejak, Financial Officer
Duties: Administrative officer in-charge of processing financial paperwork associated with research.

Temporary Biologist (x2)
Duties: Laboratory/Field Assistant

<u>NOAA, WASC, Procurement Division, 7600 Sand Point Way N. E., Bldg. 1, Location 22, Seattle, Washington 98115.</u>

Duties: Contract Negotiations and Administration
206/526-6494

BUDGET

A. Costs (in thousands of dollars = K)

	Line 100	200	300	400	500	Total
-Projected Expenses 4/92 - 3/93	58.5	11.0	100.0	20.0	30.0	$219.5K*

PROJECTED EXPENDITURE BREAKDOWN

Line 100 - Salaries

Level	Name	Months	Salaries & Benefits/Month	Total
GM-14	Loughlin	1.0	5,800.00	5,800.00
GS-12	Dahlheim	5.0	4,200.00	21,000.00
GS-09	Assistant	6.0	3,000.00	18,000.00
GS-07	Assistant	6.0	2,275.00	13,650.00
			Total	$58,450.00

Line 200 - Travel

Travel would include trips from Seattle, Washington to Alaska to conduct field research and to Newport, Oregon to consult with experts in the field of telemetry systems. In addition, monies are set aside for travel to Alaska for required restoration meetings.

Total $11,000.00

Line 300 - Contracts

Contracts for photo-identification studies, modification and purchase of satelitte tags for killer whales.

Total $100,000.00

Line 400 - Supplies

Purchase of air time on Service Argos and necessary supplies.

Total $20,000.00

Line 500 - Equipment

Purchase of delivery systems and computers.

Total $30,000.00

GRAND TOTAL $219,500.00

*Killer whales are a highly valued species. The proposed costs are not disproportionate considering the value of the resource.

PERSONNEL QUALIFICATIONS

Curriculum Vitae of Project Leaders is provided (Attachment 1 and 2).

Attachment 1

CURRICULUM VITAE (abbreviated)

Marilyn E. Dahlheim, Ph.D.
National Marine Mammal Laboratory
7600 Sand Point Way N. E., Bin C15700
Seattle, Washington 98115-0070

From 1978 to the present time have participated and designed marine mammal vessel and aerial surveys in Alaskan waters (Bering, Chukchi and North Pacific). Have collected and analyzed acoustical data on whales and seals inhabiting Arctic waters from vessel, ice, and helicopter platforms. Collected data on movements, behavior, and distribution of marine mammals and correlated distributional data on marine mammals with physical environment. Co-chief scientist on USCGC Icebreaker POLAR SEA in charge of shipboard activities and selection of personnel from multidisciplinary fields to define winter habitat of bowhead whales. Helped developed use of passive acoustics as a censusing device to monitor whales. Training of personnel on correct methods of collection and analysis of scientific data. Responsible for reviewing outside research proposals for accuracy of scientific hypotheses and methods. Review of numerous environmental assessments, impact statements, and marine mammal permits. Reviewer for two scientific journals and participation with other governmental agencies regarding solutions to problems arising from increasing oil development and vessel traffic and the acoustical effect on marine mammals. Principal investigator for five consecutive years conducting acoustical research on gray whales in Mexico. Principal investigator gray whale census (three consecutive years). Task leader on killer whale/blackcod fishery interactions in Prince William Sound, including photo-identification research. Task leader for photo-identification studies on killer whales in the Bering Sea (four years). Project leader on NRDA studies 1989-1991 on humpback and killer whales. Representative of the National Marine Mammal Laboratory at international conferences/ meetings; submission/acceptance of independent research proposals. Has published extensively in peer reviewed scientific journals and lay publications.

Attachment 2

CURRICULUM VITAE (abbreviated)

Thomas R. Loughlin, Ph.D.
National Marine Mammal Laboratory
7600 Sand Point Way, NE
Seattle, WA 98115-0070

From 1977 to 1981 was Acting Chief, Research and Management Division, NMFS, Washington, D.C., and was responsible for development, implementation, and coordination of the national research and management program consisting of research into the life history and population dynamics of marine mammals and endangered species. Currently is leader of the Bering Sea/Gulf of Alaska Ecosystem Program, National Marine Mammal Laboratory and is responsible for developing and executing ecosystem based research regarding marine mammal abundance, distribution, trophic relationships, and environmental and fishery data throughout Alaska. Also responsible for the design, supervision, and execution of research addressing marine mammal fishery interactions between foreign and domestic commercial fisheries in Alaska. Has been Chief Scientist on numerous ship and terrestrial research programs spanning fifteen years of marine mammal research along the west coast of North America. Associate Professor (courtesy), Oregon State University, and reviewer for scientific papers submitted to over eleven scientific journals. Has published extensively in peer reviewed scientific journals and lay publications.

SELECTED CITATIONS

The following killer whale articles are pertinent to the studies.

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Matkin, C. O., G. M. Ellis, and E. Saulitus. 1989. Killer Whales in Prince William Sound in 1989 after the _Exxon Valdez_ Oil Spill. Contract report to the National Marine Mammal Laboratory, Seattle, Washington.

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von Ziegesar, O., G. Ellis, C. Matkin, and B. Goodwin. 1986. Repeated Sightings of Identifiable Killer Whales (_Orcinus orca_) in Prince William Sound, Alaska 1977-1983. Cetus, Vol. 6, No. 2, 5 pp.

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IAB 92-33

Proposal Submitted to the Oil Spill Restoration Planning Office

Title: MONITORING MICROBIAL POPULATIONS IN MARINE SEDIMENT AS INDICATORS OF ENVIRONMENTAL DISTURBANCE AND RESTORATION.

Effective: 1 July 1992

Principal Investigator: Institution:	Joan Forshaug Braddock Institute of Arctic Biology University of Alaska Fairbanks, Alaska 99775-0180 (907) 474-7991
Co-Principal Investigator Institution	Edward J. Brown Water Research Center University of Alaska Fairbanks, Alaska 99775 (907) 474-6223

A. **Monitoring microbial populations in marine sediment as indicators of environmental disturbance and restoration.**

B. Injured species to be addressed:

Results affect entire biological system. Results most immediately link with responses of invertebrate populations of both economic and non-economic importance. These invertebrate species then in turn effect higher trophic levels directly.

C. Principal investigator:

Joan F. Braddock, Institute of Arctic Biology, University of Alaska Fairbanks, Fairbanks, Alaska 99775

Edward J. Brown, Water Research Center, University of Alaska Fairbanks, Fairbanks, Alaska 99775.

D. Project objectives:

1. Monitor numbers and activity of hydrocarbon-degrading bacteria in oiled and control sediments. Past results indicate that even in the summer of 1991 where oil was visibly present (primarily in the subsurface sediments) microbial hydrocarbon degrading population numbers and activity were as great as seen in early summer of 1989. By monitoring microbial populations in the shallower sediments (e.g., 3 m) we can trace the mobilization of subsurface oil.

2. Determine whether deeper sediments (e.g., 40 m) at some heavily oiled bays have been adversely impacted by carbon inputs. Other oil spills and invertebrate studies in Prince William Sound show that bays may become anaerobic due to carbon inputs directly from hydrocarbons and from greater than usual inputs of dead plant and animal material as a result of the oil spill. Since carbon is often in short supply in deeper sediments, inputs cause increases in respiratory activities of the microbial populations leading to shifts from aerobic to anaerobic populations. Since petroleum is essentially non-degradable in anaerobic systems this has a direct impact to any oil remaining in these sediments. In addition, the environment becomes inhospitable for higher organisms.

E. Project methods

Approximately 8-12 sites with the most complete historical data from NRDA studies should be monitored (including oiled and reference sites). Microbial sediment samples need to be processed shortly after collection, therefore either ship space is necessary or samples must be collected by a boat capable of reaching sites of interest from Valdez within several hours. Samples could then be processed in laboratory facilities currently available in Valdez. Microbial hydrocarbon-degraders will be measured by the Sheen Screen method (Brown and Braddock 1990). Radiorespirometry will be used to assay the hydrocarbon-oxidation potential of microorganisms in sediment slurries (Brown et al. 1991). To determine if total numbers of bacteria in sediments have increased due to carbon inputs, we will count total numbers by an epifluorescent direct count microscopic technique (Porter and Feig 1980). Population shifts to anaerobic groups of microorganisms will be monitored by enumeration of sulfate reducing bacteria in sediments. Since the oil, particularly in shallower sediments is persisting primarily in the subsurface, more emphasis will be placed on monitoring subsurface sediments. It would be appropriate to have one intensive sampling cruise per summer for the next 5 years. Monitoring the fate and effects of oil in sediments is crucial in identifying the ultimate long-term effects of the oil spill on the ecosystem of Prince William Sound. Logistics for the microbiology study could be fairly costly in themselves, however, if coordinated with other sediment projects the logistical requirements are minimized greatly.

F. Duration of the project:

Results of previous oil spills have found that it can take from 5-10 years for sediments to fully recover. We therefore propose that sediment microbiology should monitored for the next 5 years or until other indicators such as microbial flora and invertebrate f_ return to normal.

G. Estimated cost per year:

This project requires support vessels and divers to collect the sediment samples. This project should be coordinated with other projects with similar requirements. We only list here the budget to cover the microbiological services once the samples are collected. This does not include the cost of vessels or salaries of divers. It does cover the cost of providing personnel to process the samples immediately after collection, to do the appropriate analyses on the samples in the laboratory at UAF and to analyze the data and write reports. This includes personnel wages and benefits, supplies, travel costs, and non-direct costs (at current negotiated 20% rate). Estimated cost per year: $80,000.

H. Restoration activity endpoint to be addressed:

We would like to monitor bacterial populations until the indicators of disturbance return to normal. This includes such factors as recolonization by sensitive invertebrate species.

I. Relationship to science information needs identified by RPWG:

The results of this study will be directly applicable to understanding effects on all species of higher trophic levels.

J. Importance of initiating project in 1992:

Great changes have already been observed in sediment chemistry and biology since the oil spill. These results suggest that the effects of the oil spill may just now be being felt in the deeper sediments. These processes continue on despite the political climate. While there is no longer critical need for multi-cruise years, one cruise per year will allow a monitoring of the long-term harmful effects and the restoration of the sound to healthier conditions.

K. We have been monitoring the total numbers and activity of hydrocarbon degrading bacteria since the summer of 1989 in sediments impacted by the Exxon Valdez oil spill. Assessment of the microbial populations is an essential component of oil spill monitoring since the ultimate fate of spilled petroleum depends to a major degree on the ability of microorganisms to use hydrocarbons as a source of carbon and energy (Leahy and Colwell 1990). We have found that numbers and activity of hydrocarbon-degrading bacteria are very good indicators of petroleum contamination of sediments. This data is particularly useful because results can be obtained within weeks of sampling rather than the long delays associated with chemical analysis. It is essential to be able to understand the effects of a major disturbance such as the oil spill to monitor its effects at the lowest trophic levels.

References:

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COASTAL HABITAT RESTORATION STUDIES - 1992 Renewal

Title: HERRING BAY EXPERIMENTAL AND MONITORING STUDIES

Principal Investigators: Raymond C. Highsmith, Coordinator
Institute of Marine Science
School of Fisheries and Ocean Sciences
University of Alaska Fairbanks
Fairbanks, AK 99775-1080
(907) 474-7836

Michael S. Stekoll
Juneau Center for Fisheries and Ocean Sciences
School of Fisheries and Ocean Sciences
University of Alaska Fairbanks
11120 Glacier Highway
Juneau, AK 99803
(907) 789-4579

Co-Principal Investigators:

Anthony J. Hooten
Coastal Resource Assoc. and
Institute of Marine Science
School of Fisheries & Ocean Sci.
University of Alaska Fairbanks
Fairbanks, AK 99775-1080

Peter van Tamelen
Oregon State University and
Juneau Center for Fisheries and Ocean Sciences
University of Alaska Fairbanks
11120 Glacier Highway
Juneau, AK 99801

Larry Deysher
Coastal Resource Associates
2270 Camino Vida Roble, Suite L
Carlsbad, CA 92009

Lyman McDonald and
Dale Strickland
WEST, Inc.
1406 S. Greely Highway
Cheyenne, Wyoming 82007

INTRODUCTION

Experiments conducted at Herring Bay and throughout the EVOS impact area over the last two years clearly indicate that one of the consequences of the oil spill and resultant clean-up activities was serious damage to intertidal algal and invertebrate populations. The Herring Bay experiments were designed to examine the impact of oil on relationships between and among intertidal invertebrates and plants, and to monitor recovery of intertidal communities over the long term. Experiments conducted in Herring Bay to date substantiate experimentally the nature and magnitude of damage to the intertidal community due to oil and clean-up efforts. As examples, the perennial brown alga, *Fucus gardneri*, which can constitute up to 90% of the biomass of intertidal algae, was adversely affected, especially in the upper intertidal zone. *Tectura persona*, a limpet species also found in the upper intertidal, showed lower population densities at oiled sites than at matched control sites. Results from these monitoring programs and other experiments indicate that it may be several years before the upper edges of the *Fucus* beds are restored by natural means, and invertebrate populations return to pre-spill levels.

The Herring Bay experiments were designed to elucidate the dynamic aspects of intertidal community recovery and to facilitate long-term monitoring of recovery events. We propose to continue to monitor some of these experiments and to extend and refine others from the 1990 and 1991 field seasons. The major goal of the studies is to understand what factors limit the recolonization of the intertidal by dominant species, such as perennial algae, and to predict recovery rates in a variety of habitats.

PROPOSED STUDIES

1. Population Dynamics

The overall condition of the *Fucus* population in the intertidal will continue to be assessed by periodically revisiting the population dynamics plots established in 1990. This experiment will continue to follow the status of various size classes of *Fucus* plants. It is of special interest to determine whether recruitment of smaller plants will be successful in affected areas.

For invertebrates, density and size class measurements of limpets (Lottiidae), the periwinkle *Littorina sitkana*, the dog whelk *Nucella* spp., and the six-armed starfish, *Leptasterias hexactis* will continue. Limpets were chosen for study because of their role as grazers in structuring algal communities. The other species were selected because they do not have a swimming dispersal phase in their life histories and may be poor dispersers.

In 1990, five pairs of sheltered rocky and coarse textured sites were selected in Herring Bay. Eighteen permanent 20 X 50 cm plots were randomly established across the length of each site at three tidal levels. In 1991, one pair each of protected rocky and coarse textured sites was added for additional invertebrate sampling. The plots are examined periodically and the number of *Fucus* plants counted and size frequency determined. Reproductive status and condition of the plants are also recorded. For invertebrates, limpets, *Littorina sitkana*, *Nucella* spp. and *Leptasterias hexactis* are counted, and 5 individuals of each species are measured within a 1 m semicircle adjacent to each quadrat.

2. *Fucus* Studies

<u>Growth Rates</u>

Measurements on growth rates of individually marked *Fucus* plants were initiated in 1991. The data did not indicate a difference in growth rates between the oiled and control sites during the summer. These plants need to be remeasured in the spring to determine if differences in growth rates occur over the winter. Following these plants over the summer of 1992 will provide two years of seasonal growth rate data, plus winter growth. The annual growth information stratified by size classes will be needed to project recovery rates of areas devoid of plants. The disappearance of tagged plants during the year will also provide a measure of mortality rates, an important parameter for population modeling.

Egg Release Rates and Egg Survival

The data from previous experiments in Herring Bay indicate that a crucial event to successful recolonization by *Fucus* is the survival of newly fertilized eggs that are deposited on and in the intertidal substrate. Egg capture studies in 1991 showed that the numbers of released eggs and subsequent survival of the juvenile plants are significantly depressed at oiled sites in the mid to upper intertidal zones. We propose to continue these studies over the next field season to determine how long the sites will take to recover to normal egg release rates. The settling plates developed last year worked extremely well in capturing eggs and allowing them to be easily counted.

We propose to extend the egg capture study to investigate not only the numbers of eggs that are released over the summer, but also to determine the factors that are conducive to egg survival. Results from last season's seeded plate study indicate that newly settled *Fucus* eggs and *Fucus* embryos are susceptible to high mortality from herbivory, desiccation, erosion by waves and the whiplash of adult plants. We hypothesize that the availability cracks of the proper size and depth in the rock substratum will be a key to the survival of embryonic *Fucus* plants. To investigate the contribution these various factors have alone, and in combination with oiled surfaces, a fully factorial experiment will be conducted. Settling plates will be fabricated with various sizes and depths of grooves. These grooves will provide greater or lesser protection from grazing and/or desiccation. The width and depth of the grooves will be varied to determine the optimal combination required for both settlement, using unseeded plates, and for growth and survival, using seeded plates. The experiment will examine factors other than crack depth and width. The other factors to be included are: oiling level present on the surface of the plates, herbivory, tidal level, and presence/absence of adult *Fucus* canopy.

The results from this and prior experiments will enable better prediction rates of recovery at beaches with varying rock substrate, desiccation rates, algae canopy and oil exposure.

Remote Monitoring of *Fucus* at Affected Sites

Extrapolation of the oil effects documented on *Fucus* within Herring Bay, as well as similar results from the overall Coastal Habitat study, indicates substantial loss of habitat and productivity in intertidal communities within Prince William Sound.

Consequently, it will be important to quantify the restoration of *Fucus* populations over the entire Prince William Sound area.

The CASI remote sensing studies conducted in Herring Bay during the summer of 1990 showed that *Fucus* populations can be monitored by remote sensing technology. This monitoring technology offers a number of advantages over current site specific techniques now being used. Remote sensing cannot provide the resolution of the present techniques, but it can greatly extend the area being monitored. Also, the digital data produced by this technique are easily transferred to geographic information systems (GIS), and can be related to historical shoreline oiling, or other spatial models.

The 1990 CASI studies in Herring Bay showed that *Fucus* can be easily differentiated from bare substrate, even under marginal weather conditions. The loss of *Fucus* from the upper intertidal habitat created large areas of bare substrate, and the location of these barren regions can be mapped by remote sensing instruments sensitive to radiation in the near infrared region of the spectrum. There are now a number of new, low cost video techniques that would be ideal for sensing the large area of shoreline impacted by the EVOS in Prince William Sound.

This proposal is designed to use Herring Bay as a model to test the more extensive use of this type of monitoring technique in the areas affected by the EVOS. The current Herring Bay studies offer an extensive set of data with which to compare and ground-truth the video techniques for monitoring *Fucus* populations.

3. Invertebrate Recruitment in Herring Bay: Ongoing Studies

Injured species to be addressed:

Barnacle, limpet, and snail recruitment on oiled and non-oiled surfaces. The species selected are identified under the details of each study.

Project Objectives:

Many of the invertebrates that comprise rocky intertidal communities have a planktonic larval phase in their life history. Consequently, understanding larval recruitment contributes important information for predicting restoration rates. Several studies have been initiated since 1990 that examine aspects of recruitment, and are discussed below.

A. Continued monitoring of barnacle and algal recruitment on oiled and non-oiled substrates

In 1990, an experiment was established which examined recruitment of barnacles and algae on oiled and cleaned halves of rocks and oiled and non-oiled tiles. Other recruiting invertebrates, such as limpets and snails were also recorded.

This experiment continued in 1991 and new oiled and non-oiled tiles were also deployed. Six pairs of tarred and cleaned tiles were replaced at each study site, and barnacle and algal settlement on the recovered plates was quantified. Three of the six tile pairs were caged to exclude grazers, such as limpets. Also, three tile pairs were included which were painted black, and served as controls for dark coloration. This experiment was monitored throughout the 1991 season.

Results from 1990 and 1991 showed that recruitment of both barnacles and algae was lower on oiled tiles compared to clean tiles. We propose to continue measuring recruitment on the tile pairs. Barnacles and other invertebrate recruits will be counted and percent algal cover determined.

B. Continued monitoring of juvenile barnacle recruitment on tarred and scraped vertical rock faces:

Since 1990, a second recruitment study has examined whether presence of tar in upper intertidal areas reduces settlement of barnacle larvae relative to cleaned areas within the band of tar. Five pairs of oiled and reference sites with similar features were selected in Herring Bay. At each site, paired 10 X 10 cm plots were randomly established, with one member of each pair scraped and brushed to remove all visible tar. Half of the plots received cages to exclude grazers. The sites were periodically examined for barnacle settlement, as well as germlings of *Fucus*. We propose to continue gathering data on recruitment at these sites as well as on survival of previous recruits.

C. Mussels

An increase in the abundance of mussels at oiled sites was observed by the Coastal Habitat study in 1989 and 1990. This may be explained by certain species of filamentous algae colonizing oiled sites free from grazing pressure. Filamentous algae are preferred settlement sites for juvenile mussels and may have enhanced mussel settlement. The following experiment tests this hypothesis by clearing small areas and excluding all macro-organisms except algae and mussels and then monitoring mussel density over time.

In 1991, two pairs of oiled and control sites with evidence of mussel populations were selected in Herring Bay. At each study site six transect locations were randomly selected following the methods identified for transect selection (1990 SOP). Each treatment was established as follows:

- o a point was established at the 1.6 meter contour (from MHHW) aligned with the randomly selected transect head, using a site level.
- o at each point two 25 X 25 cm clearings were established 1 m apart. The first clearing was designated T1 and the second T2, plots that are to be sampled at two different times.

- o equally spaced 1m from the second clearing, a third and fourth 25 X 25 cm plot was marked but not cleared.
- o these four 25 X 25 cm plots were established for each of the six transect heads. Thus, the number of study plots per site equaled 24.
- o at each cleared plot, a 25 X 25 cm fence of 1/8" mesh steel hardware cloth (10 cm in height) and marine epoxy was constructed around the boundary of the cleared area. Uncleared plots were marked using a rotohammer to anchor screws at the four corners.
- o after establishment of all plots, each site was monitored twice weekly to ensure that all grazers were counted and removed from the fenced plots.

This experiment was conducted throughout the 1991 season, and was left in place over the 1991-92 winter. In spring of 1992 the following procedures are proposed:

- o two time-series samples of algae from each plot will be taken. Using T1 (Time 1) as an example, a square grid (with squares constituting 1 X 1 cm areas) will be placed over the cleared 25 X 25 cm plot and 10 patches of filamentous algae 1 x 1 cm will be randomly selected and algae removed. This same procedure will be applied to the first 25 X 25 cm non- cleared area. Place each subsample in a whirlpak bag and return to the laboratory.

- o count three of the ten subsamples using the coefficient of variance (CV) of the mean procedure identified in the Coastal Habitat SOP. If more subsamples are required, count additional subsamples from the pool of 10 until a CV of 0.10 is achieved. Counting will involve use of a dissecting scope and a hand-held counter.

The results will provide quantitative data on filamentous algal recruitment and abundance in cleared and uncleared sites with and without grazers, and corresponding mussel recruitment.

4. Invertebrate Recruitment: New Studies

A. <u>Recruitment and Reproductive Condition of Oiled Mussels in Herring Bay</u>.

Injured species to be addressed: *Mytilus edulis*

The Restoration and Planning Work Group (RWPG) has identified oiled mussel beds as a major concern for possible restoration efforts. Bio-accumulation of petroleum hydrocarbons through human subsistence use, foraging shore birds and marine mammals has been identified as a concern.

Several mussel beds located in Herring Bay have received varying levels of oiling. Some beds were not oiled. The different mussel beds with their oiled status and known use as forage sites by American Black Oystercatchers and sea otters, present an opportunity to test and monitor the following:

- o sampling of mussels for hydrocarbon concentrations between sites with different oiling histories
- o sampling sediments beneath the mussel bed matrix for hydrocarbon concentrations
- o sampling of mussels for histological analysis (i.e. reproductive condition) between different sites
- o quantification of recruitment between different sites
- o intensity of use of each site by sea birds and sea otters.

Within Herring Bay six sites would be selected that are known forage sites for the American Black Oyster-catcher or sea otters. At each of these sites, a point in the mid-intertidal zone would be selected, and the width of the mussel bed measured. Three 50 X 20 cm quadrats would be selected with a random numbers generator and positioned horizontally along the meter tape. At each sampling plot three separate sample collections of mussels would occur:

1) one sample would be a 10 X 10 cm area in the upper left of the quadrat. All mussels would be removed from this area and placed in sample jars for tissue hydrocarbon analysis, according to the Coastal Habitat program standard operating procedure mussel collections.

2) ten large mussels closest to the upper right corner would be collected and processed according to the Coastal Habitat sampling procedures for mussel histology. These samples would be preserved and shipped to Fairbanks for preparation and sectioning.

3) a third sample collection would be a 10 X 10 cm area in the lower left of the quadrat. A "patch" of the mussels would be removed entirely and placed in a container. This sample would be returned to the field laboratory and sub-sampled for the number of small mussel recruits, using a dissecting scope.

4) a sediment sample will be collected from beneath the mussels in each quadrat for hydrocarbon analysis according the Coastal Habitat SOP for sediment collection

B. Adult barnacle survivorship and growth and juvenile recruitment in tarred zones.

The Coastal Habitat program has studied recruitment of barnacles, *Fucus*, and other invertebrates since 1990. However, identification and tracking of surviving adults has not been a part of this or other studies. Many rocky shorelines along Herring Bay did not receive treatment and retain a tar coating. By monitoring adult growth and survivorship in tandem with juvenile recruitment, understanding community health and recovery in the upper intertidal region will provide data on when oiled populations can be considered equivalent to populations in non-oiled areas.

Injured species to be addressed:

Populations of *Balanus glandula, Semibalanus balanoides*, and *Chthamalus dalli*.

Project Objectives: 1) Measure survivorship and growth of adult barnacles through time in heavily tarred bands along rocky surfaces. 2) Determine recruitment and survival of juvenile barnacles within fixed study plots along the same tarred bands. 3) Compare both measures to non-oiled shorelines similar in features, orientation and exposure. 4) Based on these comparisons, determine when barnacle adults and surviving juvenile recruits on oiled rocky surfaces achieve similar conditions to non-oiled populations.

Project Methods:

Select three rocky sites in Herring Bay that have remained heavily tarred since the spill, yet possess barnacle populations within the tarred band. Also select three matched, non-oiled sites that are similar to each oiled site in slope, wind and wave energy and orientation.

- o The length of each tarred site will be measured and a random numbers generator used to establish six 10 X 20 cm quadrats over the length of the tarred area. The permanent quadrats will be within approximately 1 m of MHHW, where tar bands are the most prevalent. This procedure will be repeated for each unoiled site that best matches the tarred counterpart.

- o count the number of living barnacles greater than 8 mm in test diameter (approx. 1/2 this size for *C. dalli*).

- o count the number of dead barnacle tests greater than 8 mm in diameter.

- o measure test length and height of ten of the closest barnacles on the inside of the lower right corner of the 10 X 20 cm quadrat. A map will be sketched showing the measured barnacles and the order in which they were measured. Also, each barnacle measured will be marked with an indelible marker (or equivalent such as fingernail polish). Using a macro-lens, the quadrat will be photographed and the resulting print will be used for reference in relocating the measured barnacles for remeasurement on subsequent visits.

- o within a 5 X 5 cm area in the upper left corner of each quadrat, count the number of barnacles less than 8 mm in diameter, including recruits.

- o assess survivorship, growth and recruitment over time by revisiting the site pairs at least twice over the course of the summer and three times per year in subsequent years.

DURATION

The monitoring studies presented in this proposal should be conducted for a minimum of five years. The experiments will be reviewed annually and continued, modified, terminated or replaced according to the results.

ESTIMATED COST

The budget for this study was included within the budget submitted with our proposal entitled, "Coastal Habitat Comprehensive Intertidal Monitoring Program". The two studies will share a number of P.I.s and support staff, as well as some logistic support. Consequently, a budget for the two studies together is more economical than budgeting separately for two stand-alone projects.

RELATIONSHIP TO SCIENCE INFORMATION NEEDS IDENTIFIED BY RPWG

This study applies to several of the general needs identified by the RPWG, which were considered when preparing this proposal:

1. Improve understanding of the long-range underlying mechanisms causing injury or limiting populations.

2. Shift emphasis to broader ecological approaches. The studies being conducted in Herring Bay and proposed here are intended to provide data on how structuring mechanisms within the intertidal community were affected by the EVOS and subsequent clean-up activities. The results will have application to communities at similar sites over the EVOS impact area.

3. Analyze further the linkages between predators and prey. We propose to continue studying important intertidal predators and prey, some of which are utilized by higher trophic levels, such as Oystercatchers and sea otters.

4. Monitor ecosystem recovery. The literature identifies lack of monitoring intertidal communities over the long term as a deficiency in understanding effects of oil spills (Teal and Howarth, 1984). Only through continued monitoring of intertidal sites can an estimate of intertidal community impact and recovery status be obtained. Understanding the dynamic aspects of intertidal communities has direct linkage to higher trophic levels that forage in the intertidal.

5. Monitor the fate of weathering oil in mussel beds. We propose to do this.

6. Coastal Habitat. The proposed study addresses some of the needs identified under this heading.

IMPORTANCE OF INITIATING PROJECT IN 1992

Continuing this study in 1992 will capitalize upon the experiments that are already set-up and will contribute to our understanding of interannual variability in such factors as recruitment and winter mortality on oiled and control sites. It is important that a continuous time record be maintained between the matched site pairs, so that impacts from oil can be distinguished from natural variability.

LINK TO OTHER NRDA OR RESTORATION STUDIES

The proposed work is a continuation of both NRDA and Restoration studies initiated in Herring Bay in 1990. The studies are closely linked to the Coastal Habitat Injury Assessment study and to the proposed Coastal Habitat Comprehensive Intertidal Monitoring Program. The proposed studies would also have direct utility to studies of Oystercatchers and sea otters.

REFERENCES:

Teal, J.M. and R.W. Howarth. 1984. Oil spill studies: a review of ecological effects. Environ. Manag. 8: 27-44.

1990 Coastal Habitat Standard Operating Procedures: Phase II.

85-87

Progress Reports

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

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DATE: December 2, 1991

MEMORANDUM FOR: Barbara Iseah

FROM: John Strand

SUBJECT: Additional NOAA/NMFS Restoration Proposal and Revision of Previously Submitted Restoration Proposals

Attached is an additional restoration science proposal submitted by Dr. K. V. Koski of the Auke Bay Laboratory, NOAA/NMFS. Would you see that a copy of this proposal is given to each RPWG member and also to Rebecca for inclusion in the packages being prepared the Management Team and peer reviewers.

Also attached are revised copies of two proposals submitted earlier by Dr. Usha Varanasi of the Northwest Fisheries Center, NOAA/NMFS. These two proposals are now in the A to K format required by RPWG. Would you also see that copies reach RPWG members and also Rebecca. Thanks very much.

Attachments

cc: Byron Morris (w/o attachments)
Bruce Wright (w/o attachments)

Project Proposal

Stream Carrying Capacity For Evaluating Restoration in Prince William Sound

Species Addressed: All stream rearing anadromous species (e.g., coho salmon, Dolly Varden, cutthroat trout, others).

Principal Investigator and Lead Agency: Dr. K V. Koski, NMFS-Auke Bay Fisheries Laboratory.

Project Objectives: (1) determine habitat availability for stream rearing salmonids; (2) determine juvenile salmonid abundance and habitat utilization (i.e., carrying capacity); (3) assess changes in habitat utilization during/following restoration and recovery; (4) identify streams/injured species needing additional restoration; (5) evaluate response of stream rearing fish to "holistic" restoration efforts in PWS; (6) evaluate the importance of the riparian zone in protecting fish habitat (e.g., if the riparian zone is or will be altered by logging, will the recovery of oil-injured species be prolonged?).

Project Methods: A stream classification system developed by the U.S. Forest Service (i.e., channel typing; Paustian et al. 1984) will be used as a tool to standardize stream characteristics for establishing a baseline of habitat and fish abundance (Murphy et al. 1987). Extensive comparison of fish abundance and habitat will be conducted in stream reaches of the 4-6 channel types with the highest fish and riparian values. Study reaches will be distributed among 10-20 watersheds; half on the east (non-oiled) and half on the west (oiled) side of PWS. These watersheds will be sampled for 3 consecutive years to measure annual variability in habitat and fish abundance. Late summer densities of salmonids will be determined in each channel type. Habitat measurements will include pool-riffle-glide characteristics, stream discharge, water quality (temperature, DO, nutrients), and characteristics of large woody debris. With this information, managers will be able to identify differences in stream carrying capacity between oiled and non-oiled areas and the importance of riparian vegetation to fish production. For example, if streams on the west side of PWS are identified as below carrying capacity, regular monitoring of these sites can help determine the effectiveness of restoration efforts. In addition, if some streams are below carrying capacity after initial restoration efforts, monitoring will identify where more restoration effort is needed. A comparison of oiled and non-oiled watersheds and future monitoring will provide a measure of the response of injured species to restoration. Identifying the relationship between fish and habitat by channel type will also show the importance of maintaining riparian vegetation (buffers) along streams; buffers may be equally important in protecting fish and habitat from logging as well as mitigating for stress on recovery of oil-injured species.

Project Duration: 3 years (1992-94) to establish baseline.

Estimated Cost: $175,000/year.

End Point: Provide information on the status and response of rearing anadromous salmonids from comparisons of habitat and fish abundance in streams in oiled and non-oiled areas of PWS.

Relationship to Science information Needs:
* Develop baseline information relating fish abundance and habitat which will provide a better understanding of mechanisms that limit populations.
* Monitor the recovery of species partially dependent upon impacted ecosystems as a measure of the effectiveness of area-wide restoration efforts.
* Identify the effects of other environmental disturbances (e.g., logging) that may impede recovery of some species injured from the EVOS.

Importance for initiating in 1992: No previous baseline information has been established, therefore the effects of ongoing restoration on injured species cannot be evaluated. In addition, logging is underway in PWS and may compound the stress on injured species.

Link to Other Activities: This study could be a cooperative investigation between U.S. Forest Service (Robert Olsen; Steve Paustian) and NMFS.

References:

Paustian, S. J., D. A., Marion, and D. F. Kelliher. 1984. Stream channel classification using large scale aerial photography for southeast Alaska watershed management. [illegible] Symposium on the Application of Remote Sensing to Reso[illegible] Management, May 22-27, 1983, Seattle, WA.

Murphy, M. L., J. M. Lorenz, J. Heifetz, J. F. Thedinga, K V Koski, and S. W. Johnson. 1987. The relationship betwe[illegible] stream classification, fish, and habitat in Southeast Alaska. U.S. Dept. Agriculture, U.S. Forest Service, Wildlife and Fisheries Habitat Management Notes, Tongass National Forest, R10-MB-10.

3.

DRAFT

A. **Study name:** Natural recovery of subtidal species in Prince William Sound

B. **Injured Species:** Subtidal fish, crustaceans, and molluscs

C. **Principal Investigator and Lead Agency:** Usha Varanasi, NOAA, NMFS

D. **Project objectives:** This project proposes to continue to document the rate and extent of the natural recovery of subtidal fish species from oil exposure following the EVOS. In addition, it is presumed that there has been concomitant exposure of subtidal invertebrate species, including crustaceans and bivalve molluscs. The exposure of subtidal invertebrates to oil needs to be assessed, and such assessment would be done under this proposal. Samples from benthic fish species taken during OY2 showed some evidence of alterations in parameters associated with reproduction, and some evidence of altered histology. However, there are few samples which can be analyzed to assess the potential for these effects to have occurred during OY1. It is therefore necessary to carry out limited assessments of the effects of known exposure to Prudhoe Bay crude oil on: 1.) indicators of exposure and 2.) biological processes in species indigenous to Prince William Sound, in order to allow a realistic interpretation of the data obtained during OY1. Such limited investigation will be critical both for interpretation of data obtained under the current NRDA and Restoration processes and for evaluation of potential for injury resulting from future oil spill events.

E. **Project Methods:** Bile, liver, and muscle from demersal fish species which have shown and/or continue to show exposure to oil will be sampled. Subtidal invertebrate species will also be sampled. Representative sediment samples will be taken from each benthic sampling site for subsequent chemical analysis. All samples will be analyzed for presence of oil and/or oil-derived products by recently developed rapid screening techniques. Several of these techniques are described in the Detailed Study Plans for F/S 24 (OY 1 & 2) and ST 7 (OY3). The use of these screening techniques has been shown to be very cost-effective, and also to result in the timely acquisition of data. Limited laboratory studies will be done in which fish and invertebrate species indigenous to Prince William Sound are exposed to known amounts of Prudhoe Bay crude oil, followed by analysis of tissues by both rapid screening and detailed chemical analysis. The potential for biological effects (e.g. reproductive dysfunction, histopathological alterations) to occur at these doses will also be assessed.

F. **Duration of the project:** From two to three sampling seasons. Length of project is dependent on evaluation of results from each sampling year, thus rapid analysis of samples and acquisition of data are stressed.

G. **Estimated cost per year:** $305K, including $75K for vessel costs. Vessel costs may be lower

H. **Restoration activity/endpoint addressed:** Monitoring of natural recovery

I. **Relationship to science needs:** There has been extensive and continuing exposure of subtidal fish species to oil in and around Prince William Sound following the EVOS, as documented in Progress Reports from F/S (OY 1 & 2) and ST 7 (OY3).

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Exposure is generally decreasing with time in species examined in these studies, but could still be documented in OY3. 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. The rates and extent of natural recovery of these species need to be determined.

J. **Importance of initiation in 1992:** Given the continuing nature documented exposure to demersal fishes in Prince William Sound, it is necessa... also continue the monitoring of the recovery process. If a sampling season is miss..., then it may be difficult or impossible to determine the recovery rates if such rates are discontinuous.

K. **Link to other NRDA/Rest studies:** This project derives very strongly ... NRDA projects F/S24 and ST7. There are also significant linkages with ST4.

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DRAFT

A. **Study name:** Monitoring recovery of intertidal and nearshore subtidal species in Prince William Sound

B. **Injured Species:** Intertidal and subtidal fish, crustaceans, and molluscs

C. **Principal Investigator and Lead Agency:** Usha Varanasi, NOAA, NMFS

D. **Project objectives:** This study proposes to document the extent of recovery of intertidal and nearshore subtidal fish species from oil exposure, and to expand the analyses of oil and oil derivatives in intertidal and nearshore subtidal invertebrate species. The proposed work should be able to help make the important determination of whether treatment of shorelines by aggressive cleaning techniques effected either increased or decreased exposure to oil in intertidal and nearshore subtidal biota.

E. **Project Methods:** This project will be carried out in conjunction with and will be complementary to the "Prince William Sound Long-term Shoreline Ecological Monitoring Program" proposed by Alan J. Mearns, HMRAD. Through the use of recently developed rapid screening techniques, this program will substantially increase the assessment of oil exposure in intertidal and nearshore subtidal biota The additional samples to be collected are bile and tissue samples from selected species of intertidal and nearshore subtidal fish, and sediment samples from several depths along transects at study sites. Replicate samples of invertebrate tissues for rapid screening analyses may also be taken.

Both sediment and fish bile will be screened for the presence of oil-derived compounds, using recently developed technology as described in the Detailed Study Plans for Subtidal 7 and Subtidal 4. Induction of cytochrome P450 (e.g. MFO) will also be measured in fish liver samples as described in the Detailed Study Plan for Subtidal 7. In addition to their use in fish and sediment samples, the screening techniques will be adapted for use on invertebrate tissue samples to the extent possible. The use of such screening methodology has been shown to be very cost-effective and also to allow the rapid acquisition of data. Such timeliness should be highly [illegible] assessing the efficacy of planned restoration efforts in any of these species [illegible] also allow a rapid estimation of natural recovery rates of impacted species

F. **Duration of the project:** From two to three sampling seasons. [illegible] project is dependent on evaluation of results from each sampling year [illegible] analysis of samples and acquisition of data are stressed.

G. **Estimated cost per year:** $300K, including vessel costs. Vessel costs may be lower depending on the extent to which this project can coordinate with other [illegible] projects.

H. **Restoration activity or endpoint addressed:** Monitoring of recovery

I. **Relationship to science needs:** Recent assessment (Alan J. Mearns, HMRAD, personal communication) of oiled shorelines in Prince William Sound has shown evidence of significant differences in distribution of oil and oil derivatives between treated oiled shorelines, nontreated oiled shorelines (e.g. set aside sites), and nonoiled shorelines. These distribution differences appear to be reflected in hydrocarbon contamination of several invertebrate species, based on limited analyses. There has been little study of the exposure to oil and possible biological effects associated with such exposure in intertidal and nearshore subtidal fish species (such as juvenile rockfish, juvenile salmon, and blennies), especially as such exposure might be affected by shoreline treatment.

J. **Importance of initiation in 1992:** Recent results from 1991 sampling suggest that exposure to oil remains demonstrable in this habitat, but for how much longer is unknown. In order to determine the rates of recovery of these species, and the extent of oil still left in these habitats, sampling and analyses should be as continuous as possible. Should analyses from 1992 show no demonstrable oil exposure or oil in the habitats, then this study is projected for termination.

K. **Link to other NRDA/Rest studies:** This project is projected to be highly complementary to the "Prince William Sound Long-term Shoreline Ecological Monitoring Program" proposed by Alan J. Mearns, HMRAD. It could also provide complementary data to other NRDA projects, such as injury to juvenile salmon and injury to rockfish.

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Exxon Valdez Oil Spill Restoration Science Study Proposal

Title:	River Otter Restoration Study
Study ID Number:	
Project Leader:	James B. Faro Alaska Department of Fish and Game 34828 Kalifornsky Beach Road Soldotna, Alaska 99669
Assisted By:	R. Terry Bowyer Associate Professor of Wildlife Ecology Institute of Arctic Biology University of Alaska Fairbanks
	J. Ward Testa Research Associate Institute of Arctic Biology University of Alaska Fairbanks
Lead Agency:	Alaska Department of Fish and Game

November 22, 1991

PROJECT OBJECTIVES

A. To determine the continuing sub-lethal effects of exposure to oil on river otters.

B. To identify areas in Prince William Sound that should support high densities of river otters and assess existing use by otters.

C. To determine if genetic diversity has been reduced (bottle-necked) for otter populations exposed to oil and determine the best populations for use in re-establishing diversity through translocation, if necessary.

PROJECT METHOD

A. Blood specimens will be obtained from live captured river otters and assessed for levels of haptoglobins and cytokines, as well as by use of a "standard blood panel". Values for otters within the oiled areas will be compared to those of otters from the non-oiled, control areas. To monitor continued sub-lethal effects or recovery, otters will be captured during the spring breeding season when vulnerability to trapping is highest.

B. A habitat model developed by the impact study will be used to predict areas that should support high density of otters. Areas will then be visited to determine existing otter use through standard techniques of location and assessment of latrine sites.

C. Blood samples obtained from live captured otters will be analyzed to determine their DNA components using mitochondrial DNA sequencing.

D. Length-mass relationships of otters will be monitored on oiled and nonoiled areas to evaluate and compare previously documented weight-losses on oiled sites.

E. Data from capture effort will also provide a crude index to population size via catch per unit effort analyses.

DURATION OF PROJECT

Duration of project in years to be determined by rate of recovery of otter population.

Field work April to mid August 1992.
Data analysis and report writing September to March 1993.

ESTIMATED COSTS

Cost for FY 93 will be $63,000 if half the PI's salary and Bowyer/Testa contracts with UAF are covered by the proposed NRDA budget. If salary costs are not otherwise covered, this project will cost a total of $121,500. Blood samples are proposed to be obtained through a live capture program funded under the FY 92 impact program. Blood samples will fulfill a dual function of identifying and monitoring recovery.

RESTORATION ACTIVITY

Restoration work should continue until the following conditions are met:

1. All high density river otter habitat in Prince William Sound has been catalogued.

2. Use of latrine sites in oiled habitat has returned to comparable levels of those in similar habitat in nonoiled areas.

3. Blood parameters obtained from otter blood samples are not significantly different between oiled versus nonoiled areas.

IMPORTANCE OF INITIATING PROJECT IN 1992

It is essential that the proposed projects go forward in 1992 because we are sampling variables that are expected to change over time. We expect that relating blood haptoglobin levels to length-mass differences will become more difficult as time goes on. Identifying areas of potential oil impacts, and hence, areas requiring restoration would therefore be more difficult. As the noise to signal ratio increases due to time lags, our ability to identify impacted areas decreases, even for areas still requiring substantial restoration. Further, genetic analysis must be completed so that source populations for potential translocation are known prior to restoration. Finally, it is unlikely our research team will remain together without funding for 1992. If we do not go forward now, other commitments will prevent us from ever doing so.

LINK TO THE NRDA DAMAGE ASSESSMENT ON RESTORATION STUDIES

Our proposed restoration project is a direct extension of Natural Resources Damage Assessment for river otters. Our habitat model for predicting otter use of areas, examination of blood values, and assaying length-mass relationships to evaluate weight loss all were developed in our previous studies. All these variables are already known to differ between oiled and nonoiled areas.

TABLE ONE (Con't). STUDIES AUTHORIZED IN 1989, 1990 AND 1991

STUDY CATEGORY		STUDY TITLE	1989	1990	1991
Birds, continued					
	9	Pigeon Guillemots	X		
	10	Glaucous-winged Gulls	X		
	11	Sea Ducks	X	X	X
	12	Shorebirds	X		
	13	Passerines	X	X	
	14	Exposure North Slope Oil	X		
Fish/Shellfish (F/S)					
	1	Salmon Spawning Area Injury	X	X	X
	2	Eggs/Pre-emergent Fry Sampling	X	X	X
	3	Coded-wire tagging	X	X	X
	4	Early Marine Salmon Injury	X	X	X
	5	Dolly Varden Injury	X	X	X
	6	Sport Fishing Harvest & Effort	X		
	7	Salmon Spawning Area Injury, Outside PWS	X	X	*
	8	Egg & Pre-emergent Fry, Sampling Outside PWS	X	X	*
	9	Early Marine Salmon Injury Outside PWS	X		
	10	Dolly Varden & Sockeye Injury, Lower Cook Inlet	X		
	11	Herring Injury	X	X	X
	12	Herring Injury Outside PWS	X		
	13	Clam Injury	X	X	X
	14	Crab Injury	X		
	15	Shrimp Injury	X	X	moved to subtidal

TABLE ONE (Con't). STUDIES AUTHORIZED IN 1989, 1990 AND 1991

STUDY CATEGORY		STUDY TITLE	1989	1990	1991
Economics, continued					
	8	Research Program Effects	X	X	X
	9	Archaeological Damage Quantification	X		
	10	Petroleum Products Price			X
Restoration Planning			X	X	X

* These studies are being funded for the completion of data analysis and final report preparation.

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S T Archaelogy

T S (all gone) Marine Sediments