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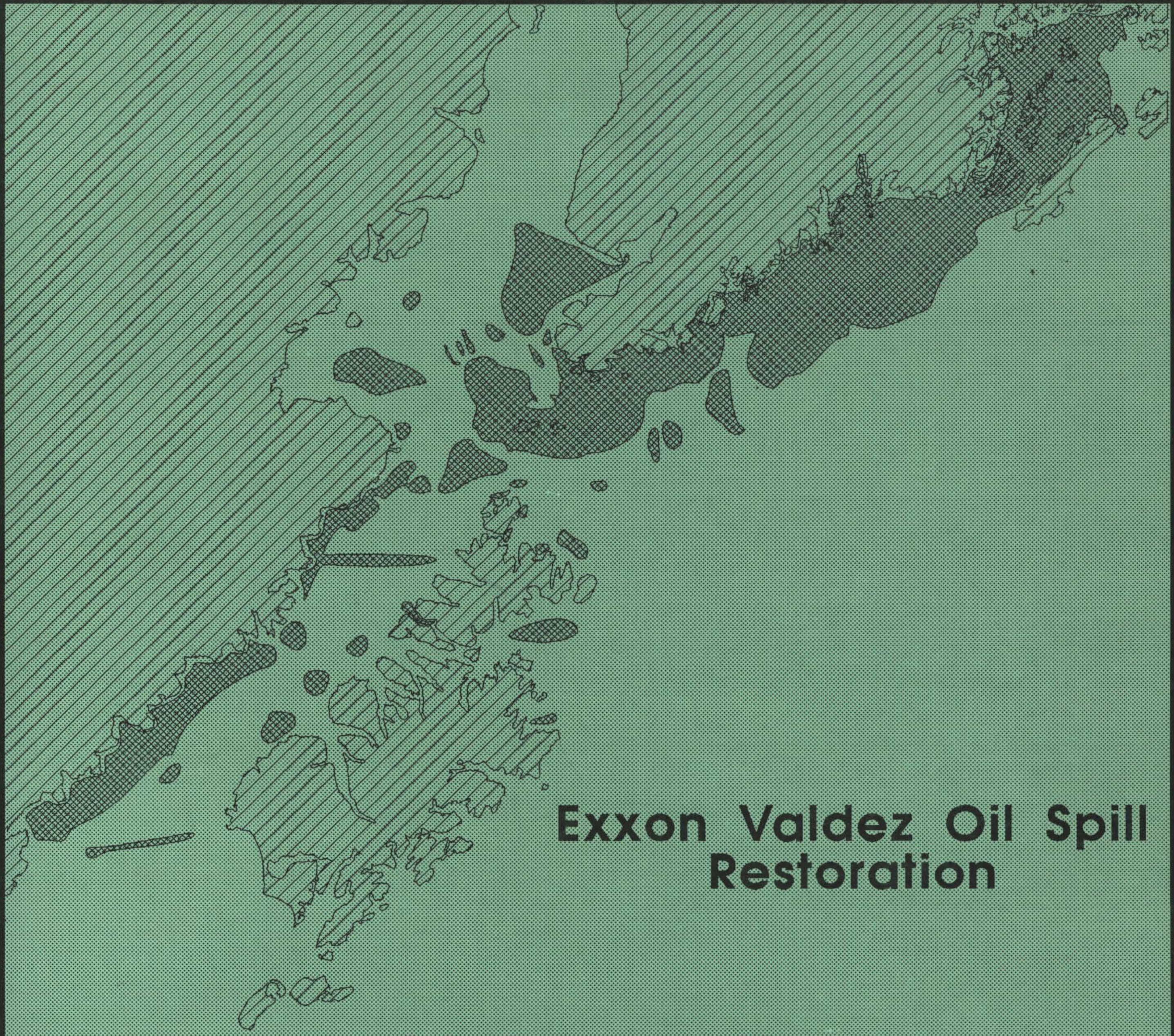

Exxon Valdez Oil Spill Restoration

Volume II
1992 Draft Work Plan

Prepared by:
Exxon Valdez Oil Spill Trustees
645 "G" Street
Anchorage, Alaska 99501
(907) 278-8012

April 1992

State of Alaska: Departments of Fish & Game, Law, and Environmental Conservation
United States: National Oceanic and Atmospheric Administration, Departments of Agriculture and Interior in consultation with the Environmental Protection Agency

April 1992

Dear Reviewer:

In the autumn of 1991 the United States and the State of Alaska settled their claims against the Exxon Corporation and Exxon Shipping Company for natural resource damages from the Exxon Valdez oil spill. Money provided by the settlement will be used to restore the environment of Prince William Sound, lower Cook Inlet, and the Gulf of Alaska. The undersigned six State and Federal Trustees, in consultation with the public, are responsible for determining how restoration funds are to be spent

Exxon Valdez Oil Spill Restoration is a key step in shaping the decision-making process. It is divided into two volumes, which are presented for your review and comment Volume 1: Restoration Framework provides background information and proposes guidelines for the future. The draft Volume II 1992 Draft Work Plan proposes activities that are important to undertake in 1992 prior to the final development of the Restoration Plan. We expect that a work plan will be developed annually, describing the activities the Trustees intend to conduct in each year

These documents are intended to elicit comments and suggestions from you and continue the public "scoping" process for environmental analysis under the National Environmental Policy Act We want to know how you view this process and receive suggestions concerning restoration of the resources and services injured by the oil spill. This planning effort will culminate in the development of the overall Restoration Plan, which will guide the restoration program in the coming years.

We invite your comments on both Volumes I and II of Exxon Valdez Oil Spill Restoration. The issues identified on the tear sheets in each document are intended to facilitate but not limit your comments and suggestions. In order to be considered during the development of the final 1992 Work Plan and draft Restoration Plan, written comments must be received by **June 4, 1992**, at the following address:

Exxon Valdez Oil Spill Trustee Council
645 G Street
Anchorage, Alaska 99501

Questions concerning this document or its distribution should be directed to the Oil Spill Public Information Center, 645 G Street, Anchorage, Alaska 99501, or you may call (907) 278-8008.

We appreciate your interest and look forward to your participation in this important process

Sincerely,

Michael A Barton
Regional Forester
Alaska Region
Forest Service
U S Department of Agriculture

Charles E Cole
Attorney General
State of Alaska

Curtis V McVee
Special Assistant to the Secretary
Office of the Secretary
U S Department of the Interior

Steven Pennoyer
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Alaska Region
National Marine Fisheries Service

Carl L Rosier
Commissioner
Alaska Department of
Fish and Game

John A Sandor
Commissioner
Alaska Department of
Environmental Conservation

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COMMENTS

You are invited to share your ideas and comments with the Trustees. Please use this tear sheet to present your views on the <u>1992 Draft Work Plan</u>. You may send additional comments by letter or participate in a public meeting on the <u>1992 Draft Work Plan</u> and <u>Restoration Framework.</u>

If needed, use the space on the back or attach additional sheets Please fold, staple, and add a postage stamp Thank you for your interest and participation.

Additional Comments:

------------------------------(fold here)------------------------------

Return Address:

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Place Stamp Here

Exxon Valdez Oil Spill Trustee Council
645 G Street
Anchorage, AK 99501

Attn: 1992 Draft Work Plan

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VOLUME II

INTRODUCTION

The March 24, 1989, grounding of the T/V Exxon Valdez in Alaska's Prince William Sound caused the largest oil spill in U S. history. Approximately 11 million gallons of North Slope crude oil moved through the southwestern portion of the Prince William Sound and along the coast of the western Gulf of Alaska (see map, Fig. 1). The spill injured fish, birds, mammals, and a variety of other forms of marine life, habitats, resources, and the services these resources provide. A summary of the injury documented for these resources is contained in Volume I· Restoration Framework, Chapter 4

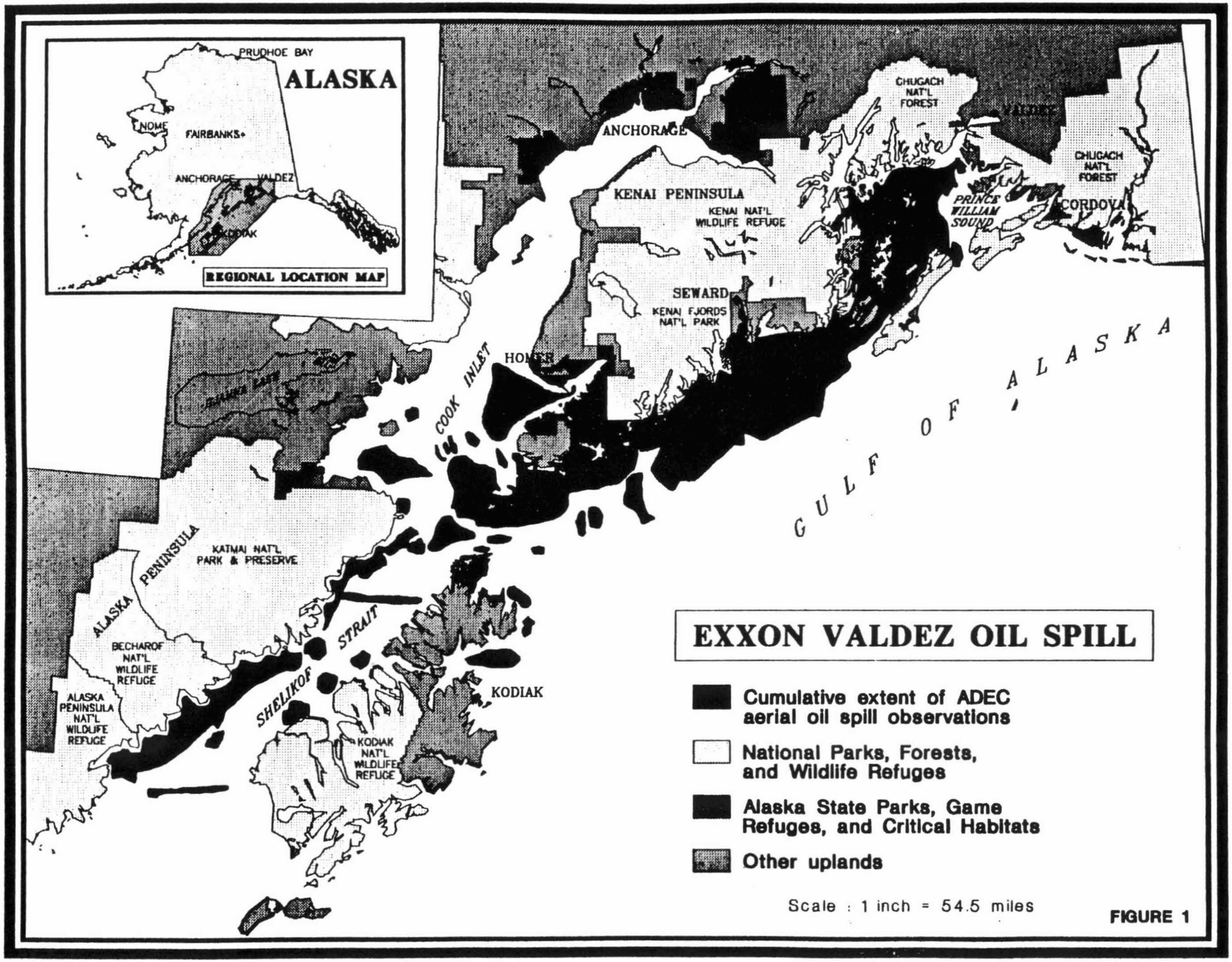
On December 9, 1991, the State and Federal governments and Exxon Corporation agreed to settlement terms of $1 1025 billion for both criminal restitution and civil damage claims Of these monies the State and Federal Trustees will jointly receive up to $900 million from Exxon over the next 10 years. These monies will be used to restore resources and services injured by the spill. Volume 1 Restoration Framework contains details of the settlement and its terms.

The Exxon Valdez Trustee Council is composed of six members, three Federal and three State of Alaska, representing the following Trustees - the Department of Agriculture, the Department of the Interior, the National Oceanic and Atmospheric Administration, Alaska Department of Fish and Game, Alaska Department of Environmental Conservation, and the Alaska Department of Law

The initial $90 million payment from Exxon has been received. Of that amount $53.5 million went to reimburse the governments for previous oil spill expenditures, leaving $36 5 million available for restoration and damage assessment work in 1992 The Trustee Council has tentatively approved expenditure of $17.9 million including $13.9 million for the 1992 Draft Work Plan The remaining $18.6 million has not yet been committed

This document contains Volume II: 1992 Draft Work Plan approved by the Exxon Valdez Trustee Council on February 28, 1992, for public review and comment. The 1992 Draft Work Plan contains descriptions and budgets of projects that are proposed to be conducted this year

The proposed 1992 projects fall into two main categories - Damage Assessment and Restoration. Damage assessment projects are those necessary to complete or support the orderly completion of Natural Resources Damage Assessment (NRDA) studies that were begun after the Exxon Valdez oil spill. Although not all these projects were begun in 1989, some have as many as three years of effort behind them. Most of the proposed damage assessment projects will result in completion of final reports in 1992.


PRUDHOE BAY
ALASKA
NOME
FAIRBANKS
ANCHORAGE
VALDEZ
KODIAK
REGIONAL LOCATION MAP
ANCHORAGE
CHUGACH NAT'L FOREST
KENAI PENINSULA
KENAI NAT'L WILDLIFE REFUGE
PRINCE WILLIAM SOUND
CHUGACH NAT'L FOREST
CORDOVA
SEWARD
KENAI FJORDS NAT'L PARK
HOMER
COOK INLET
GULF OF ALASKA
KATMAI NAT'L PARK & PRESERVE
ALASKA PENINSULA
BECHAROF NAT'L WILDLIFE REFUGE
ALASKA PENINSULA NAT'L WILDLIFE REFUGE
SHELIKOF STRAIT
KODIAK
KODIAK NAT'L WILDLIFE REFUGE
EXXON VALDEZ OIL SPILL
Cumulative extent of ADEC aerial oil spill observations
National Parks, Forests, and Wildlife Refuges
Alaska State Parks, Game Refuges, and Critical Habitats
Other uplands
Scale : 1 inch = 54.5 miles
FIGURE 1

The Restoration projects will provide timely information necessary to support subsequent decisions about restoration options for injured resources. These projects fall into a number of potential restoration options and restoration implementation categories. The companion document to this work plan, Volume I: Restoration Framework, outlines the process by which restoration options will be developed in the future. Categories of restoration projects described in 1992 Draft Work Plan are Technical Support, Recovery Monitoring, Implementation Planning, Manipulation/Enhancement, Habitat Protection Planning, and Management Actions. The goals or purposes of each of these categories are described more fully in the introduction to each of their respective subsections

The 1992 Draft Work Plan is the fourth of a series of plans prepared by the State and Federal Trustees for the Exxon Valdez oil spill. Previous plans that were issued were.

- State/Federal Natural Resources Damage Assessment Plan for the Exxon Valdez Oil Spill, August 1989
- The 1990 State/Federal Natural Resource Damage Assessment and Restoration Plan for the Exxon Valdez Oil Spill
- The 1991 State/Federal Natural Resource Damage Assessment and Restoration Plan for the Exxon Valdez Oil Spill

Each of these previous plans contains descriptions of the damage assessment projects that were proposed and conducted in each of those years.

This 1992 Draft Work Plan has received the approval of the Trustee Council to go forward for public review and comment Many of the proposed projects have elements of work that must be undertaken prior to completion of the public review However, only interim three-month budgets for the proposed projects have been approved by the Trustee Council, and final decisions on funding will not be made until after the review of public comment on this document

1. DAMAGE ASSESSMENT

1A. DAMAGE ASSESSMENT INTRODUCTION

Natural Resource Damage Assessment (NRDA) studies began just days after the Exxon Valdez oil spill on March 24, 1989 In the three years of study efforts prior to the settlement agreement, the Trustees conducted the largest damage assessment program in U. S history. In 1989, the Trustees developed a damage assessment plan incorporating 72 studies in 10 categories. In 1990, 50 studies were undertaken. In 1991, 42 damage assessment studies were conducted. These studies were designed to determine the nature and extent of the injuries, losses or destruction of resources and services, and lost uses of the resources and services The overall cost of this multi-year effort among the Trustees exceeded $100 million.

Now that a settlement has been achieved, it is possible to undertake restoration of the injured resources and services. Damage assessment information provides the base for developing a restoration plan. Injury information will be essential in the identification of restoration opportunities, and, thorough quantification of injury to a particular resource or service will guide decisions on the choices of restoration options to pursue In addition, the body of knowledge gained from the damage assessment will greatly advance our understanding of the impacts from oil spills, and it will be invaluable in the planning and implementation of future damage assessment programs

Most of the damage assessment studies are being brought to a conclusion in 1992 with production of the final reports. These studies are listed as "closeout" studies A few projects in the damage assessment category require continuation because they either support the closeout efforts or need an additional field effort to complete the documentation of resource or service injury Both damage assessment closeout studies and continuation studies are described more fully in the following subsections of the 1992 Draft Work Plan.

1B. DAMAGE ASSESSMENT CLOSEOUT

Most of damage assessment studies are recommended for completion in 1992. Completion dates of final reports will be governed chiefly by the number of samples and amount of data remaining to be analyzed for each project. Although in all instances preliminary reports have been prepared, final reports including comprehensive data syntheses and analyses have not yet been completed for most studies. The preparation of final reports will be essential to understanding the spill-related injuries to resources and services

The preparation and release of final reports on spill injuries will also provide the basis for the first detailed look by the public at the governments' injury assessment. The public's ability to evaluate and suggest restoration measures will be enhanced by the development and release of this information The timing of the public release of the preliminary and final reports will be determined by ongoing third party litigation.

The following pages provide short project justifications for the damage assessment closeout studies. The more detailed descriptions of objectives and methods of these projects were given in the 1991 NRDA Plan, and are not repeated here.

AIR/WATER STUDY NUMBER 1

Study Title: Geographic Extent and Temporal Persistence of Floating Oil from the Exxon Valdez Oil Spill

Lead Agency: ADEC

JUSTIFICATION

The information from this project will help other studies determine oiling conditions at their study sites Overflight information on the location of floating oil from several agencies was used each day to produce a map of oil-on-water conditions Mapping was continued until most of the oil was no longer floating. Some work is needed to finish the maps and prepare a final report.

BUDGET ($K)

Salaries	$13.5
Travel	0.0
Contractual	0.5
Commodities	1.0
Equipment	0 0
Subtotal	15.0
General Administration	2.0
Total	$17 0

ARCHAEOLOGY STUDY NUMBER 1

Study Title: Archaeological Survey

Lead Agency: DNR

PROJECT JUSTIFICATION

This is the closeout project for the 1991 archaeology injury assessment study. The project will complete the analysis of laboratory test results and artifact collections for the state field injury assessment of direct oiling effects on historic and prehistoric site dating. A synthesis of the data from all of the injury assessment studies will be put together and used to set up the basis for restoration decisions. Future restoration projects may include archaeological site protection through enhanced monitoring and law enforcement, data recovery from excavations, museum exhibits using new artifact collections and information, school curriculum units and educational publications for the general public. Archaeological damage assessment studies were not funded until 1991 and thus conclusion of the assessment lags behind other resource studies.

OBJECTIVES

The project includes the following objectives to arrive at an assessment of injuries to archaeological sites and place them in a context to plan for restoration

A Complete analysis of data collected during the State's 1991 field season into a report of scientific findings

B. Compare results of radiocarbon analysis and sediment oiling analysis with cultural chronology generated from 1991 data.

C. Combine results from the federally contracted damage study by the State University of New York (SUNY), Binghampton, with the State study, and the compilation of injury documentation from existing files.

D Based on documented injury, formulate a restoration plan for injured sites.

METHODS

The first four months of the project will conclude the analysis of the data collected during the 1991 field season. Radiocarbon dates and results of sediment analysis to detect petroleum in sites will become available for the damage assessment study during March and

April, 1992. The State report of findings will comply with the Secretary of the Interior's Standards for archaeological reporting. Findings of site injury studies need to be synthesized and determination of injuries completed. Establishing more detailed cultural chronologies for the spill area will allow accurate determination of site importance, a process which was not possible prior to the current studies. The process will include defining why each site is important, how the injury affects the importance of each site, and what kind of action is necessary to maintain that value. The process will result in a restoration plan for injured archaeological sites in the spill area.

Findings from the SUNY-Binghampton survey and modeling study will be incorporated into the spill geographic information system database housed within DNR to be used in future assessments and spill responses. The existing Statewide inventory of historic and prehistoric sites will also be updated.

BUDGET ($K)

Salaries	$ 206.1
Travel	5.1
Contractual	4.5
Supplies	2 2
Equipment	0.0
Subtotal	217 9
General Administration	30 9
Total	$ 248.8

BIRD STUDY NUMBER 2

Study Title: Boat Surveys to Determine Distribution and Abundance of Migratory Birds and Sea Otters in Prince William Sound

Lead Agency: USFWS

PROJECT JUSTIFICATION

Boat-based surveys for migratory birds and marine mammals in the pelagic and nearshore regions of Prince William Sound were conducted following the Exxon Valdez oil spill. Over 120 species of birds and 20 species of mammals have been counted on these surveys. Objectives of the study include determining distributions, estimating abundances, determining differences in bird and mammal abundances between oiled and un-oiled areas, and determining changes in abundances following the spill

Preliminary results indicate that bird populations in Prince William Sound declined since pre-spill surveys for 16 species or species groups including grebes, cormorants, northern pintail, harlequin duck, oldsquaw, scoters, goldeneyes, bufflehead, black oystercatcher, Bonaparte's gull, black-legged kittiwake, Arctic tern, pigeon guillemot, murrelets, and northwest crow More than 30,000 carcasses representing over 90 species of birds were collected from the spill zone in 1989 In addition, both direct and continuing effects of the spill have been demonstrated in NRDA studies on harlequin duck, black oystercatcher, black-legged kittiwake, marbled murrelet, murres, and pigeon guillemot Intensive studies have also revealed evidence of injury to populations of sea otters.

A preliminary report of results has been prepared for this study but comprehensive data synthesis and analysis have not been completed. The preparation of a final report will be essential for understanding the injuries the spill caused to marine birds and sea otters. If this information is not clearly and completely available to those responsible for restoration, it will not be possible to adequately address the restoration needs of the resource.

BUDGET ($K)

Salaries	$	42 2
Travel		0 0
Contractual		0 0
Commodities		0 0
Equipment		0.0
Other Non-Contractual		0.0
Subtotal	$	42 2
General Administration		6 3
Total	$	48 5

BIRD STUDY NUMBER 3

Study Title: Population Surveys of Seabird Colonies in the Spill Area (Murres)

Lead Agency: USFWS

PROJECT JUSTIFICATION

Following the Exxon Valdez oil spill, seabird colonies in Prince William Sound and other areas westward along the spill trajectory were surveyed to determine the immediate effects of the spill Cliff-nesting species such as the black-legged kittiwake and common and thick-billed murres were the primary emphasis of the 1989-90 censuses. Timing of egg laying and productivity were also noted for each of these species. In 1990 and 1991, the major effort was placed on replicate counts of murres in those areas that showed the most drastic changes relative to historical data Study objectives included comparison of pre- and post-spill numbers of breeding colony seabirds within the oiled area and comparison of reproductive chronology and productivity for murres in oiled areas.

As the oil exited Prince William Sound, it passed through areas where large rafts of breeding age murres were congregating around major colonies in preparation for the nesting season The resulting mortality included an estimated 198,000 adult breeding birds, representing 60 to 70 percent of the total breeding population of certain major colonies Extrapolating to include mortality of non-breeders, mortality is estimated to be as high as 300,000 murres. This loss resulted in a major disruption of breeding behavior and phenology resulting in reproductive failure for 1989-91. Significant decreases in the number of murres at nesting colonies in the Exxon Valdez oil spill area were noted in 1989-91 surveys. Murres at all sites associated with oil had either low or no success in producing chicks with either very late egg laying or no egg laying at all in 1989-91

A preliminary report of results has been prepared for this study but comprehensive data synthesis and analysis have not been completed. The preparation of a final report will be essential for understanding the injuries the spill caused to murres, particularly murres breeding in the Exxon Valdez oil spill zone. If this information is not clearly and completely available to those responsible for restoration, it will not be possible to adequately address the restoration needs of the resource

BUDGET ($K)

Salaries	$	56.3
Travel		1 6
Contractual		1 0
Commodities		8.3
Equipment		0.0
Other Non-Contractual		0 0
Subtotal	$	67.2
General Administration		8.5
Total	$	75 7

BIRD STUDY NUMBER 4

Study Title: Assessing the Effects of Exxon Valdez Oil Spill on Bald Eagles

Lead Agency: USFWS

PROJECT JUSTIFICATION

Surveys were conducted following the oil spill to estimate bald eagle numbers and reproductive success of eagles residing in the Exxon Valdez oil spill area. Eagles were radio-tagged and monitored to determine survival, and document movements and exposure to oiled areas. Toxicological tests were conducted on tissue samples, and addled eggs, prey remains, blood, and feathers were collected and analyzed for evidence of hydrocarbon exposure

Preliminary results have shown that oil contamination of the intertidal habitats used extensively by breeding, wintering and migrating bald eagles have resulted in impacts to these birds Conservative estimates of total mortality of bald eagles due to Exxon Valdez oil spill is 553 eagles. Bald eagle nesting surveys revealed a significantly low nest success and productivity in Prince William Sound with approximately 69% of occupied nests failing in 1989 and 43% failing in 1990 A conservative estimate of lost production in 1989 was 133 chicks Hydrocarbon analysis of addled eggs, prey remains, blood, and feathers in 1989 and 1990 indicated exposure. Two of 3 eggshell samples collected in 1989 on the Alaska Peninsula and Kodiak area were exposed to hydrocarbons Concentrations of uric acid in blood serum from adult eagles in oiled areas were higher than those from un-oiled areas in 1989. Eggs collected in 1990 in eastern Prince William Sound also indicated exposure to petrogenic hydrocarbons.

A preliminary report of results has been prepared for this study but comprehensive data synthesis and analysis have not been completed. The preparation of a final report will be essential for understanding the injuries the spill caused to bald eagles If this information is not clearly and completely available to those responsible for restoration, it will not be possible to adequately address the restoration needs of the resource

BUDGET ($K)

Salaries	$ 37.2
Travel	5 0
Contractual	12 0
Commodities	0 0
Equipment	0 0
Other Non-Contractual	0 0
Subtotal	$ 54 2
General Administration	6 4
Total	$ 60 6

BIRD STUDY NUMBER 6

Study Title: Assessment of the Abundance of Marbled Murrelet Sites Along the Kenai Peninsula and Prince William Sound

Lead Agency: USFWS

PROJECT JUSTIFICATION

This study was implemented to assess injury to marbled murrelets from the oil spill. The marbled murrelet population in Prince William Sound has declined from about 300,000 in 1972 to 100,000 in 1989-91. Counts in the Naked Island area in 1989 and 1991 were also lower than counts made from 1978-1980. The length of time between pre-oil surveys and post-oil surveys makes it difficult to determine the contribution of the Exxon Valdez oil spill to this decline.

In Prince William Sound, marbled murrelets comprised 12% of all seabird carcasses retrieved in 1989 following the spill Based on an 8% chance of carcass recovery, an estimated 9,570 murrelets were killed directly by oil in the Exxon Valdez oil spill zone. In addition, apparently healthy murrelets from oiled areas showed signs of petroleum hydrocarbon exposure, whereas murrelets from unoiled areas in Prince William Sound did not show such signs.

A preliminary report of results has been prepared for this study but comprehensive data synthesis and analysis have not been completed. The preparation of a final report will be essential for understanding the injuries the spill caused to marbled murrelets If this information is not clearly and completely available to those responsible for restoration, it will not be possible to adequately address the restoration needs of the resource

BUDGET ($K)

Salaries	$ 21.6
Travel	0.0
Contractual	0 0
Commodities	0 0
Equipment	0 0
Other Non-Contractual	0 0
Subtotal	$ 21 6
General Administration	3 2
Total	$ 24.8

BIRD STUDY NUMBER 7

Title: Assessment of the Effects of Petroleum Hydrocarbons on Reproductive Success of the Fork-tailed Storm-Petrel

Lead Agency: USFWS

PROJECT JUSTIFICATION

Following the oil spill, fork-tailed storm-petrel colonies in the Exxon Valdez oil spill zone were visited to determine reproductive success. The study objectives were to determine if reproductive success was lower than in pre-spill years, assess the impact of crude-oil exposure on reproduction; count the number of adults contaminated by oil; and determine persistence of crude oil in the marine environment by comparing hydrocarbon contamination of petrel stomach oils with pre-spill data on hydrocarbon contamination of petrel stomach oils collected at the same site.

Preliminary results suggest that there was no measurable change in the storm-petrel reproductive success following the spill However, it is difficult to conclude that the storm-petrels have not been impacted by the oil spill until the stomach oil samples have been analyzed. Previous studies established that petrels dosed with oil showed significant decreases in hatching success and chick survival.

A preliminary report of results has been prepared for this study but comprehensive data synthesis and analysis have not been completed. The preparation of a final report will be essential for understanding the injuries the spill caused to fork-tailed storm-petrels. If this information is not clearly and completely available to those responsible for restoration, it will not be possible to adequately address the restoration needs of the resource.

BUDGET ($K)

Salaries	$	6 5
Travel		0.0
Contractual		0 0
Commodities		0 0
Equipment		0 0
Other Non-Contractual		0 0
Subtotal	$	6.5
General Administration		1 0
Total	$	7.5

BIRD STUDY NUMBER 8

Study Title: Assessment of Injuries to Reproductive Success of Black-legged Kittiwakes in Prince William Sound

Lead Agency: USFWS

PROJECT JUSTIFICATION

Black-legged kittiwakes are the most abundant colonial nesting seabird in Prince William Sound. The objectives of this study were to: test for changes in reproductive success of kittiwakes nesting in oiled areas; determine if adult kittiwakes were contaminated by oil; test unhatched eggs and prey delivered to chicks for hydrocarbon content; and identify potential restoration of losses

Preliminary results revealed a significantly lower reproductive success for kittiwakes in oiled areas compared to un-oiled areas, however, analysis is not complete. Kittiwakes were contaminated externally as preliminary results show that 37% of birds observed at oiled colonies had oil on the breast feathers Analysis of hydrocarbon content of kittiwakes, prey samples, and eggs, has not been conducted to date.

A preliminary report of results has been prepared for this study but comprehensive data synthesis and analysis have not been completed and, in some cases, has not been initiated. Data analysis and the preparation of a final report will be essential for understanding the injuries the spill caused to black-legged kittiwakes of Prince William Sound. If this information is not clearly and completely available to those responsible for restoration, it will not be possible to adequately address the restoration needs of the resource.

BUDGET ($K)

Salaries	$ 6.5
Travel	0.0
Contractual	0.0
Commodities	0.0
Equipment	0.0
Other Non-Contractual	0.0
Subtotal	$ 6.5
General Administration	1.0
Total	$ 7.5

BIRD STUDY NUMBER 9

Study Title: Assessment of Injury to Waterbirds Based On the Population and Breeding Success of Pigeon Guillemots in Prince William Sound

Lead Agency: USFWS

PROJECT JUSTIFICATION

Following the Exxon Valdez oil spill, the pigeon guillemot population of Naked, Peak, and Storey islands, located in the center of Prince William Sound, was studied to determine the effects of the spill. The guillemot population has been previously studied, thus pre-spill data was available for comparison The objectives of the study include· determine if the total number of guillemots attending the colonies following the oil spill were significantly different; monitor nesting success and chick growth rates; monitor abundance and type of prey fed to chicks, determine if petroleum hydrocarbons were present in adults, unhatched eggs, dead chicks, and prey items, and identify potential restoration strategies.

Preliminary data analysis suggests that the number of pigeon guillemots attending colonies in the Naked Island area was significantly lower following the oil spill. To what extent this decline was due to an overall decline of the Prince William Sound pigeon guillemot population or to the oil spill is unknown, further analysis is required. However, the most heavily oiled areas at Naked Island were the areas with the largest declines in numbers Reproduction appeared to be similar to previous years, however, sample size was too small to estimate the rate of successful nesting.

A preliminary report of results has been prepared for this study but comprehensive data synthesis and analysis have not been completed and, in some cases, have not been initiated Data analysis and the preparation of a final report will be essential for understanding the injuries the spill caused to pigeon guillemots. If this information is not clearly and completely available to those responsible for restoration, it will not be possible to adequately address the restoration needs of the resource

BUDGET ($K)

Salaries	$ 15.7
Travel	0.0
Contractual	0.0
Commodities	0.0
Equipment	0.0
Other Non-Contractual	0 0
Subtotal	$ 15.7
General Administration	2 3
Total	$ 18.0

BIRD STUDY NUMBER 11

Study Title: Injury Assessment of Hydrocarbon Uptake by Sea Ducks

Lead Agency: ADF&G

PROJECT JUSTIFICATION

The goal of this project was to determine whether the Exxon Valdez oil spill had measurable sublethal effects on six species of migratory and resident seaducks in Prince William Sound and the Kodiak Archipelago. The six seaduck species were harlequin ducks, Barrow's and common goldeneyes, and surf, black, and white-winged scoters. The harlequin ducks are both resident in and winter migrants to the oil spill area. The other species do not breed in the oil spill area but are winter migrants. The postulated mode of sublethal oil exposure to these seaducks was by ingestion of petroleum hydrocarbons through the food chain

Results of biochemical sampling indicate a spectrum of petroleum residues contaminated liver tissue of harlequin ducks and Barrow's and common goldeneyes in western Prince William Sound and south-western Kodiak Island. Concentrations of naphthalene and phenanthrene were found in bile extracts

Results from necropsies indicated that there were a significantly greater number of harlequin ducks in physiologically poor condition (with minimal adipose tissue) in western Prince William Sound and Kodiak than in control sites Other physiological effects included poor plumage condition and lethargy displayed by many individuals

The most important oil spill effect documented by NRDA Bird Study Number 11 was the cessation of harlequin duck reproduction in the oil spill area of Prince William Sound Harlequin ducks, although present in the Exxon Valdez oil spill area of western Prince William Sound, were observed not to form breeding pairs, display courtship behavior, nor seek nest sites. No harlequin broods were observed in the oil spill area in 1990. Only one brood was reported in the oil spill area in 1991 Harlequins reproduced normally in northern, eastern, and southern Prince William Sound in 1990-91.

The mode of sublethal petrochemical exposure to these ducks is highly likely consumption of oiled invertebrate prey items The degree of exposure is related to the foraging areas of the respective species. The zone of maximum oil impact is the intertidal. Harlequin ducks, feeding on a wide variety of invertebrates in the intertidal, appear most exposed Goldeneyes, which feed subtidally, appear moderately exposed, white-winged scoter, feeding on benthic organisms such as scallops in deeper water, appear less exposed.

The goal of this closeout proposal is to produce a final report including food habits analysis and all results of chemical analyses of seaduck proventriculus samples, liver, bile, and histopathology. Pending petroleum toxicology analysis of blue mussels (Mytilus) and other invertebrates from seaduck proventriculus samples will be related to histopathological analyses and to the continued reproductive failure of Prince William Sound harlequin ducks.

	BUDGET ($K)
Salaries	$ 19.5
Travel	0.0
Contractual	0.0
Supplies	0.5
Equipment	0 0
Subtotal	$ 20 0
General Administration	2 9
Total	$ 22 9

BIRD STUDY NUMBER 12

Study Title: Assessment of Injury to Shorebirds Staging and Nesting in Prince William Sound and the Kenai Peninsula

Lead Agency: USFWS

PROJECT JUSTIFICATION

This study was divided into two parts The first part was to estimate the number of spring migrant shorebirds using oil-affected portions of the Prince William Sound Objectives included. estimate the amount of time shorebirds are exposed and number of shorebirds of each species exposed to contaminated beaches, estimate proportion of migrants contaminated, test for differences in feeding behavior; collect tissue samples for analysis and identify contamination pathways in the food chain, and determine nesting success of black turnstones

Part two of the study dealt with black oystercatchers. The objectives of this research were to 1) determine the effects of oiling on the reproductive success of oystercatchers, 2) determine habitat requirements of breeding oystercatchers; and 3) explore how the feeding strategy of oystercatchers may affect populations of invertebrate prey species.

Preliminary results for the shorebird portion of the study revealed that virtually all of the shorebirds were found using sites along Montague Island with heavy herring spawn deposition, these areas were lightly or negligibly oiled More heavily oiled portions of the Prince William Sound probably did not receive a great deal of use by shorebirds. The proportion of birds directly contaminated by oil on plumage is undetermined but probably small Clutch sizes of black turnstones on their western Alaska breeding grounds were reduced relative to pre-spill years, but no direct link could be drawn to the oil spill Samples of prey items and birds have not yet been analyzed to evaluate the degree of contamination via the food chain.

Preliminary analysis revealed that black oystercatchers experienced reduced productivity in Prince William Sound following the oil spill. The relative egg volume of clutches was lower in 1989 Although clutch size, hatching success or fledgling success did not differ, growth rate of chicks was significantly lower in 1991 Additionally, intertidal prey organisms of the oystercatcher experienced diminished productivity and direct mortality

Preliminary reports of results have been prepared for these studies but comprehensive data synthesis and analysis have not been completed and, in some cases, has not been initiated Data analysis and the preparation of a final report will be essential for understanding the injuries the spill caused to shorebirds and black oystercatchers. If this information is not clearly and completely available to those responsible for restoration, it will not be possible to adequately address the restoration needs of the resource.

	BUDGET ($K)	
Salaries	$	18.0
Travel		0.0
Contractual		0.0
Commodities		0.0
Equipment		0.0
Other Non-Contractual		0.0
Subtotal	$	18.0
General Administration		2.7
Total	$	20.7

COASTAL HABITAT STUDY NUMBER 1A

Study Title: Comprehensive Assessment of Injury to Coastal Habitats

Lead Agency: USFS

PROJECT JUSTIFICATION

Preliminary analysis of the coastal habitat data indicate that the intertidal zone was the most severely contaminated habitat within the oil spill area. Recovery in the supratidal is progressing However, recovery in the one and two meter drop of the intertidal zone is still retarded. Natural populations of intertidal organisms were significantly reduced along heavily oiled shorelines throughout the oil impact region Densities of intertidal algae (Fucus), barnacles, limpets, amphipods, isopods, and marine worms were decreased. Although there were increased densities of mussels in oiled areas in 1990, mussels were significantly smaller than mussels in the unoiled areas and the total biomass of mussels was significantly lower. In 1991, mussel densities and biomass were both greater at control sites than oiled sites. Petroleum hydrocarbon accumulation in filter-feeding mussels experimentally placed in oiled areas indicate that oil remains available for uptake by other organisms. In both 1990 and 1991, oiled surfaces retarded settlement by juvenile barnacles when compared to unoiled sites.

Fucus, the dominant intertidal plant, was severely affected by the oil and subsequent cleanup activities In 1991, Fucus densities continued to be depressed at oiled sites, probably due to the poor dispersal capability of this algae The percentage of intertidal areas covered by Fucus was reduced following the spill, and coverage of opportunistic plant species which characteristically flourish in disturbed areas increased In 1991, most algal species showed adverse affects of the oil spill, with only one species being more abundant at oiled sites than control sites The average size of Fucus was reduced, the number of reproductive-sized plants greatly decreased, and the remaining plants of reproductive size decreased in reproductive potential due to fewer fertile receptacles per plant. There was also reduced recruitment of Fucus at oiled sites.

Samples which were collected and sorted from 1989-1991 will be processed and analyzed in 1992. The final analysis of these data will be used to meet the following objectives:

1) Estimate the quantity, quality, and composition of critical trophic levels in moderately and heavily oiled sites relative to non-oiled sites;

2) Estimate hydrocarbon concentrations in sediments and biological samples;

3) Establish the response of populations of intertidal organisms to varying degrees of oiling and subsequent clean-up procedures

4) Extrapolate impact results to the entire spill-affected area;

5) Estimate the rate of recovery of the habitats studied and their potential for restoration, and

6) Provide linkages to other studies by demonstrating the relationships between oil, trophic level impacts, and higher organisms.

BUDGET ($K)

Salaries	$ 0.0
Travel	0.0
Contracts	2,300.0
Supplies	0.0
Equipment	0.0
Subtotal	$2,300.0
General Administration	58.5
Total	$2,358.5

COASTAL HABITAT STUDY 1B

Study Title: Pre-spill and Post-spill Concentrations of Hydrocarbons in Sediments and Mussels at Intertidal Sites within Prince William Sound and the Gulf of Alaska

Lead Agency: NOAA

PROJECT JUSTIFICATION

On March 26, 1989, sampling began at 10 historically established intertidal hydrocarbon baseline sites in Prince William Sound in response to the Exxon Valdez oil spill. Ten additional sites were established in Prince William Sound and on the Kenai Peninsula along the spill trajectory before oiling. These sites were also sampled after oiling to measure the change in hydrocarbon levels in sediments and mussels resulting from the spill

This project has documented that levels of hydrocarbons in sediments and mussels in intertidal areas in Prince William Sound in 1989 before the Exxon Valdez oil spill were similar to concentrations measured by an earlier NOAA/NMFS project (1977-1980) which established a hydrocarbon baseline for sediments and mussels for the same general geographical area

Subsequent sampling in 1989 and 1990 indicates some sites were impacted by crude oil. Preliminary sediment analyses at 3 sites showed impact by Exxon Valdez oil with different patterns of changes in petroleum hydrocarbon (PHC) concentrations over time Mussels from one site had extremely high concentrations of PHCs in 1990 samples while mussels from 4 other sites showed intermediate PHC levels in 1989. There were no detectable aromatic hydrocarbons in mussel samples from 1977-1980 The limited data (from only 25 samples of >300 samples) currently available from 1989-91 samples precludes reliable interpretation at this time.

The goal of the project is to analyze and interpret hydrocarbon data from all samples and produce a final report. The final report for this study will provide data against which recovery and 'return to baseline levels' can be documented Hydrocarbon data generated and analyzed to date is incomplete (i e, there are no data from sites in the Kenai Peninsula available yet) This study furnishes essential background data and is linked directly to other NRDA projects on specific species and to some restoration/recovery Studies; provides topographical continuity to sediment data generated by Subtidal Studies 1 and 3; and complements the large Coastal Habitat Study 1A. This project will produce data that, along with other studies, provides a spatial and temporal distribution pattern of the impact of Exxon Valdez crude oil

	BUDGET ($K)
Salaries	$ 42 6
Travel	1 0
Contracts	0 0
Supplies	1 4
Equipment	0 0
Subtotal	$ 45.0
General Administration	6.4
Total	$ 51 4

FISH/SHELLFISH STUDY NUMBER 1

Study Title: Salmon Spawning Area Injury

Lead Agency: ADF&G

PROJECT JUSTIFICATION

This project will complete the analysis of data from NRDA and restoration studies designed to improve the accuracy of wild pink salmon escapement estimates. Data analyses from ten weirs and more than 40 selected streams in the vicinity of each weired stream will be completed and summarized. Estimates of aerial survey bias and stream life from 1990 and 1991 studies represent a major advance in escapement estimation procedures. Results will dramatically improve past and future escapement estimates in Prince William Sound and will lead to more accurate and precise stock specific fisheries management. The commercial fishery in Prince William Sound is of major economic importance and also plays a major role in regulating populations of salmon in Prince William Sound Wild stocks which were injured by the Exxon Valdez oil spill play a major role in the Prince William Sound ecosystem and are frequently intercepted in mixed stock fisheries dominated by hatchery fish. Accurate and timely estimates of spawning escapements are critical for biologists who seek to ensure reproductive success for wild populations by manipulating fisheries Data analyses completed by this project will enable fisheries managers to improve inseason escapement estimates and identify escapement shortfalls Injured wild populations may be protected and restored if escapement shortfalls can be quickly identified and corrected by selectively reducing harvests in areas where exploitation of injured stocks might occur.

BUDGET ($K)

Salaries	$ 51 3
Travel	1 7
Contractual	1 2
Supplies	2 1
Equipment	0 2
Subtotal	$ 56 5
General Administration	7 8
Total	$ 64.3

FISH/SHELLFISH STUDY NUMBER 2

Study Title: Egg/Pre-emergent Fry Sampling

Lead Agency: ADF&G

PROJECT JUSTIFICATION

The goal of this project is to complete analyses and report results of a study to quantify effects of the Exxon Valdez oil spill on salmon eggs and fry. Results from this study show some of the more significant injury to salmon yet demonstrated. Injury includes significantly increased egg mortality and high incidences of somatic, cellular, and genetic abnormalities in alevins and fry from oiled streams. Summarization and publication of these results is important for the completion of damage assessment and for the planning of future activities.

BUDGET ($K)

Salaries	$ 21 8
Travel	1 7
Contractual	0 8
Supplies	1 6
Equipment	0 1
Subtotal	$ 26 0
General Administration	3 3
Total	$ 29 3

FISH/SHELLFISH STUDY NUMBER 3

Study Title: Coded-Wire Tag Recovery and Analysis

Lead Agency: ADF&G

PROJECT JUSTIFICATION

This is a closeout budget for a damage assessment project based on coded-wire tagging of pink salmon in Prince William Sound The tags applied as part of NRDA and restoration activities since 1989 have been partially recovered and the analyses of these data are needed to estimate reductions in salmon production attributable to injury from the Exxon Valdez oil spill. These data are important to understanding the nature of the spill-related injury as well as designing and assessing the success of important management-related restoration implementation projects. The commercial fishery in Prince William Sound is of major economic importance and also plays a major role in regulating populations of salmon in Prince William Sound. Wild stocks which were injured by the Exxon Valdez oil spill play a major role in the Prince William Sound ecosystem and are frequently intercepted in mixed stock fisheries dominated by hatchery fish. Fisheries cannot be managed to totally exclude the harvest of wild fish without compromising the quality of hatchery fish harvest. However, with prior knowledge of hatchery and wild stock abundance and distributions, fisheries managers may limit interceptions of wild fish. Data from this project will guide the design of future tagging projects Future tagging projects for stock identification will be used to restore salmon populations by selectively reducing harvest of injured stocks while permitting the continued harvest of hatchery surpluses

	BUDGET ($K)
Salaries	$ 103 7
Travel	2 4
Contractual	2 2
Supplies	2 4
Equipment	0 3
Subtotal	$ 111 0
General Administration	15 7
Total	$ 126 7

FISH/SHELLFISH STUDY NUMBER 4A

Study Title: Early Marine Salmon Injury Assessment in Prince William Sound

Lead Agency: ADF&G

Cooperating Agency: NOAA

PROJECT JUSTIFICATION

Recruitment to adult salmon populations appears to be strongly affected by the high mortality during the early marine life stage. During this period, slow-growing individuals sustain a higher mortality, because they are vulnerable to predators for a longer time than fast-growing individuals. In the laboratory, sublethal hydrocarbon exposure has been shown to cause reduced growth of juvenile salmon. Thus, in the wild, sublethal hydrocarbon exposure is expected to cause reduced growth resulting in increased predation.

Oil contamination may also have reduced survival by decreasing prey populations or disrupting migration patterns. Oil can be toxic to littoral and pelagic macroinvertebrates Hydrocarbon exposure can injure olfactory lamellar surfaces and cause an avoidance reaction

During the past decade, five salmon hatcheries have been established within Prince William Sound These facilities, operated by private non-profit corporations, produced approximately 535 million juvenile salmon in 1989. Approximately one million of these fish were marked with a coded-wire tag (CWT) Recoveries of these marked fish in Prince William Sound has played a major role in our assessment of the impact of the oil spill on salmon

This damage assessment project has provided evidence of reduced growth and fry-to-adult survival among juvenile salmon in oiled nearshore habitats. However, additional sample and data analysis is needed to quantify the effect of oil contamination on fry growth and fry-to-adult survival and adequately establish that environmental and oil effects are not confounded This will be accomplished by comparing fry food consumption and food abundance between oiled and non-oiled areas. The data obtained during the three years of field studies will be completely analyzed and conclusions synthesized in a final report.

The final report will synthesize project results and provide data summaries. A fully documented database will be produced for incorporation into the Natural Resource Damage Assessment database being developed by the Alaska Department of Fish and Game.

SCHEDULES AND PLANNING

Date	Activity
1992	
March - August	Conduct otolith, stomach, and zooplankton sample analyses in laboratory
June - December	Data entry, database documentation, and data analysis
1993	
January 15	Complete all data analysis
January 31	Complete ADF&G technical data report
February 28	Complete final report

BUDGET ($K)

Salaries	$ 89 8
Travel	4 0
Contractual	23 0
Supplies	7 0
Equipment	4.2
Subtotal	$128 0
General Administration	17 2
Total	$145 2

FISH/SHELLFISH STUDY NUMBER 4B

Study Title: Impact of Oil Spill on Juvenile Pink and Chum Salmon and Their Prey in Critical Nearshore Habitats

Lead Agency: NOAA

Cooperating Agency: ADF&G

PROJECT JUSTIFICATION

Preliminary results from this study have documented effects of the Exxon Valdez oil spill to juvenile pink salmon, including exposure and hydrocarbon body-burden, mixed-function oxidase (MFO) induction, and reduced growth in oiled areas. The hydrocarbon profiles in contaminated pink salmon indicate that ingestion of oil, either directly or through contaminated prey, was the route of contamination. Density of juveniles, abundance of prey, and temperatures in the areas sampled do not explain the differences in growth observed. Field studies in 1989 and 1990 showed that temperatures and abundance of zooplankton prey were not different between oiled and non-oiled areas sampled, littoral epibenthic prey resources tended to be higher in oiled areas; and abundance of juvenile salmon was higher in non-oiled areas The differences in growth are thus attributed to effects of oil contamination In support of this conclusion, preliminary analysis of laboratory experiments in 1991 showed that ingestion of whole oil in food can adversely affect growth and survival of juvenile pink salmon.

Many of the results and conclusions from this study regarding effects of oil contamination to juvenile salmon are preliminary and tentative at this time because of incomplete sample and data processing. From the 1989/1990 field collections, there are still outstanding hydrocarbon analyses, incomplete transfer of data on hydrocarbon analyses actually done, outstanding contracts on meiofauna analyses from experimentally oiled sediments, epibenthic crustaceans, MFO's, and pink salmon otoliths From the 1991 oil-ingestion experiment, growth measures from RNA/DNA assays and otolith increment analysis are incomplete, and no data are yet available for hydrocarbon tissue measures or MFO induction When these data sets are completed, a final report will be prepared.

	BUDGET ($K)
Salaries	$ 50.0
Travel	4 0
Contracts	37 0
Supplies	12.0
Equipment	6.0
Subtotal	$ 109.0
General Administration	10.4
Total	$ 119 4

FISH/SHELLFISH STUDY NUMBER 5

Study Title: Injury to Dolly Varden Char and Cutthroat Trout in Prince William Sound

Lead Agency: ADF&G

PROJECT JUSTIFICATION

This closeout budget represents the cost for final biometric review and preparation of final report for the data collected in this project through 1991.

	BUDGET ($K)
Salaries	$ 17.4
Travel	1.0
Contractual	0 5
Commodities	0 5
Equipment	0 0
Subtotal	$ 19.4
General Administration	2.8
Total	$ 22 2

FISH/SHELLFISH STUDY NUMBER 11

Study Title: Herring Injury

Lead Agency: ADF&G

PROJECT JUSTIFICATION

Pacific herring, Clupea harengus pallasi, are a major resource in Prince William Sound from both a commercial and ecological perspective. The timing of the Exxon Valdez oil spill overlapped with the annual spring migration of herring spawners to nearshore areas. Over 40% of the herring spawning and egg deposition areas, as well as 90% of the summer rearing and feeding areas, were lightly to heavily oiled prior to the spawning events As a result, herring encountered oil during each of their four life stages in 1989 and, to a lesser extent, in 1990 and 1991. Adult herring traversed areas covered by oil sheens and mousse while traveling northward and eastward in Prince William Sound Eggs were deposited on oiled shorelines and were "dipped" in sheen through tidal action while incubating. Larvae hatched that contained lipophilic petroleum hydrocarbons in their yolk sacs, and larvae encountered sheen near the surface while in their most sensitive stages. Post-larval or juvenile herring swam through and remained near lightly to heavily oiled shorelines, regularly encountering sheen, mousse and dissolved oil particulates and components through the summer while feeding in shallow nearshore bays and passes.

Egg and larval mortality, larval tumors, and other larval injury such as elevated anaphase aberration rates, increased cytogenetic and cytologic anomalies, and morphological abnormalities were much greater in oiled areas than in non-oiled areas in 1989 and 1990 Injuries were more common and more severe in oiled areas than unoiled areas, with injuries declining from 1989 to 1990. The broader ecological implications of the loss of these larvae to the food chain can only be contemplated at this time.

Observed injury to adult herring included stress-related hemorrhaging around the vent and enlarged bright gall bladders in 1989, as well as hydrocarbon metabolites throughout the whole fish and its bile. In addition, preliminary data from histopathological examinations revealed that herring captured near and in oiled areas in 1990 suffered increased hepatic lesions in comparison to herring captured in unoiled areas.

The goal of this project is to estimate the injuries accumulating to populations of herring in Prince William Sound. The level of injury needs to be established to evaluate natural restoration processes and to direct restoration activities. A summary of the lethal and sublethal injury will be completed. In addition, accurate and precise estimates of population abundance, age structure, weight, and length composition data will be completed to measure changes at the population level. Sublethal injury to adults will be evaluated and interpreted in terms of potential impacts on the population and reproduction. An intensive modeling effort will be conducted to look at the overall effects of the Exxon Valdez oil spill on the larval and adult components of herring in Prince William Sound.

OBJECTIVES

1. Estimate the total level of injury of the Exxon Valdez oil spill to the early life stages by.

    a. Summarizing and synthesizing components of the egg mortality, egg incubation, and egg and larval cytogenetic and histologic examinations,

    b. Summarizing the larval herring distribution and abnormality index data from the 1989 larval trawl survey,

    c. Finalizing chemistry data from the hydrocarbon sample database;

    d. Combining components a , b., and c to relate level of oiling with level of injury.

2. Summarize the results from the laboratory and field exposure dose-response studies and to compare effects of known dosing on egg survival, hatching success, percent viable hatch, larval abnormalities (Graded Severity Index), cytogenetics, and mixed function oxidase (MFO) levels to the field data collected in 1989-1991. This data will be used to refine Objective 1.

3. Complete the literature review and compare results from other studies to the findings in Objectives 1. and 2.

4. Estimate the total level of injury to herring at the adult stage by:

    a. Summarizing and synthesizing the histopathological presence and type of injury to tissues and vital organs from herring collected in oiled and non-oiled areas during 1989, 1990, and 1991,

    b. Summarizing the level of egg atrophy in adult female gonads (oocyte-loss) in samples collected during 1989, 1990, and 1991;

    c. Coordinate with National Marine Fisheries Service (NMFS/NOAA) to synthesize the results from the adult dose-response experiment (1991 and 1992), the adult parasite study (comparing herring from oiled and unoiled area during 1989 and 1991), and from other studies reported in the scientific literature.

DELIVERABLES

Reports to be prepared by Department staff are listed below:

Title	Deadline
Temporal and spatial comparisons of fecundity of Pacific herring in Prince William Sound	Feb. 1993
Effects of the *Exxon Valdez* oil spill on Pacific herring eggs and larvae in Prince William Sound	Feb. 1993
Long-term effects of the *Exxon Valdez* oil spill on Pacific herring in Prince William Sound	Feb 1993
Loss of Pacific herring eggs deposited in Prince William Sound	Feb. 1993.

In addition, two reports will be completed this year that will provide background and baseline information for the damage assessment summaries:

Estimates of spawning biomass of Pacific herring in Prince William Sound from spawning deposition surveys(review draft)	Feb 1992
Historical summary of Pacific herring in Prince William Sound (review draft)	Feb. 1992

Reports and work products that will be produced by the contractors are listed below:

Contractor, Product	Deadline
Hose, Final report on 1991 data and re-analysis of 1989 data (data includes cytogenetics, abnormality indices, cytologic, and oocyte loss)	May, 1992
Hose, Synthesis work product for preliminary modeling effort	August, 1992
Hose, Synthesis work product for final modeling effort	January, 1993
Kocan, Final report on 1991 dose-response experiment	March, 1992

Kocan, Literature review and first synthesis product
April, 1992

Kocan, Final report on 1992 dose-response work
August, 1992

Kocan, Synthesis work product for final modeling effort
January, 1992

Hinton, Final work product results on 1989 and 1990 adult histopathology and Dr Hose's 1990 and 1991 larvae
February, 1992

Hinton, Preliminary results of 1991 adult histopathology and first synthesis work product April, 1992

Hinton, Final results of 1991 adult histopathology and larval data from Hose May, 1992

Hinton, Synthesis work product for final report
January, 1993

	BUDGET ($K)[1]
Salaries	$ 161.3
Travel	14.5
Contractual	92 6
Supplies	3 1
Equipment	1 4
Subtotal	$ 272.9
General Administration	30 7
Total	$ 303.6

[1] Budget is for all activities performed from March 1, 1992 to February 28, 1993. A detailed line item budget has been prepared and submitted separately to the Trustee Council.

FISH/SHELLFISH STUDY NUMBER 13

Study Title: Clam Injury

Lead Agency: ADF&G

PROJECT JUSTIFICATION

Part I

This project seeks to determine injuries to bivalves from the Exxon Valdez oil spill and has involved the study of four species. These are: 1) pacific littleneck clam (*Protothaca staminea*), 2) butter clam (*Saxidomus giganteus*); 3) cockle (*Clinocardium nuttali*); and 4) razor clam (*Siligua patula*) These animals are relatively sedentary, occur on beaches throughout the Exxon Valdez oil spill area, and are known to bioaccumulate hydrocarbons The presence of elevated levels of hydrocarbons in bivalves is known to cause an increase in mortality, decrease growth, and other sublethal injuries. This study has focused on documenting the presence of hydrocarbons, decreased growth, and identifying other sublethal injuries.

This project will include the computerized entry of all data collected thus far, the analysis of this data with biometrics support, and a preliminary report outlining the injuries documented thus far.
This report is to be submitted for peer review and a determination made whether additional funding for a full project closeout will be recommended to the Trustee Council

Part II

If a decision is made by the Trustee Council to provide funding for a full project closeout, any additional monies will be allocated to collection of growth and age data from clams collected in 1991, synthesis of hydrocarbon results from studies which shared adjacent study locations, submission of 1991 histopathology samples for analysis, finalization of descriptive mapping products in conjunction with the GIS group, and preparation of a final report

	BUDGET ($K) (Part I)
Salaries	$ 25.9
Travel	1 5
Contractual	3 8
Supplies	0 8
Equipment	4 7
Subtotal	$ 36 7
General Administration	4 1
Total	$ 40.8

	BUDGET ($K) (Part II)
Salaries	$ 40 9
Travel	2 2
Contractual	14.7
Supplies	0 0
Equipment	0.5
Subtotal	$ 58.3
General Administration	7.2
Total	$ 65.5 *

* Pending peer review of Part I and approval of Trustee Council

FISH/SHELLFISH STUDY NUMBER 28

Study Title: Salmon Oil Spill Injury, Life and Run Reconstruction

Lead Agency: ADF&G

PROJECT JUSTIFICATION

This project will quantify the injury to the wild salmon stocks of the Prince William Sound from the Exxon Valdez oil spill Understanding this injury is necessary for continuing fishery management of injured stocks and rational restoration One of the main tools being developed to reach this goal is a run reconstruction model This model will be used to estimate production from each of the Prince William Sound wild stock groups, both before and after the oil spill. The adult tagging study described below will provide information that will improve the already good foundation of this run reconstruction model

Because of extremely large increases in hatchery production, Prince William Sound as a whole is producing salmon at all-time record levels. These hatchery salmon are essentially inputs to the fishing industry. The wild stocks, which are an important component in the natural ecosystem, originate from a multitude of natal stream locations throughout the Prince William Sound The aggregate hatchery component of the total production can be determined with coded-wire tags The estimated percent of the hatchery pink salmon in the Prince William Sound harvest has fluctuated from slightly over 50% in 1987 to in excess of 90% in 1988 and the gap in proportions of wild and hatchery contributions to the run seems to be getting bigger

The stock-specific origins of the wild portion of the harvest are unknown. This information is necessary to understand oil spill injury to manage the fishery, to protect affected wild stocks, and to begin other restoration measures The run reconstruction model is a tool for detecting these stock-specific origins This model is a mathematical description of wild stock return patterns, accounting for removal by harvest in a series of mixed stock fisheries. This accounting of the harvest, by stock, in mixed stock fisheries is the heart of the model

The University of Alaska, Juneau Center for Fisheries and Ocean Sciences, has developed a run reconstruction model for this project for a single fishing district, although work continues on a computer implementation The next level of complexity, the multi-district model, requires spacial and temporal information on the migratory movement of pink salmon in Prince William Sound. Data from previous adult tagging studies could not be used to complete this task. Exhaustive efforts were made to use the historical data. These data have proved unsuitable because they are too incomplete: no record was made of the fraction of the fishery sampled to collect those tags that were recovered. An adult tagging study will take place during the 1992 season to estimate these key missing parameters. The study will use radio or sonic tags on a small number of fish Rather than infer movement patterns from the recovery of a large number of tags, the study will attempt to directly observe the movement of a smaller number of fish.

OBJECTIVES

The objective of the Pink Salmon Adult Tagging Study is to quantify the migratory movement and rates of pink salmon through the Prince William Sound as they proceed to their natal streams. Movement of salmon through the Prince William Sound will be modeled by a probability transition matrix whose elements are the probabilities of salmon moving from one district to another.

Currently, it is assumed that pink salmon enter Prince William Sound through the Southwest District (226) and proceed in a clockwise direction through the Prince William Sound to their natal streams. This study will be used to examine this hypothesis and estimate daily district-to-district migratory rates

Salmon Migration Example

As a hypothetical example, consider 100 salmon entering into the Prince William Sound via District 226 on an arbitrary day Using the clockwise migration hypothesis the model will move the salmon toward Districts 223 and 222. Once in District 222 they are permitted to enter District 221 then into 228. The model will also allow salmon to exchange between Districts 226 and 227. A hypothetical transition matrix that will induce this type of movement is presented below.

$\underline{\Theta} = (\theta_{ij})$

	i	j district	1 221	2 222	3 223-24	4 225-26	5 227	6 228
Northeast	1	221	0.95	0	0	0	0	0.05
Northern	2	222	0.05	0.95	0	0	0	0
Coghill	3	223-24	0	0.01	0.99	0	0	0
Southwestern	4	225-26	0	0.02	0.02	0.95	0.01	0
Montague	5	227	0	0	0	0.01	0.99	0
Southeastern	6	228	0	0	0	0	0.01	0.99

Here each entry is the probability of salmon moving from the row district to the column district. Now, the simulation of movement is created by taking powers of the transposed transition matrix and pre-multiplying with the vector $n^{I} = (0, 0, 0, 100, 0, 0)$ (note the 100 in the fourth position represents 100 fish released into the fourth district, or Districts 225-26). This is denoted mathematically as

$$n(k) = \left(\Theta^{T}\right)^{k} n$$
$$= \Theta^{T} n(k-1)$$

where k is the number of days in the Prince William Sound (see the Data Analysis section for more details).

The table below shows the hypothetical number of salmon in each district after $k = 1, 2, 5, 10, 20$ and 30 days in the Prince William Sound.

Number of days in the Prince William Sound							
district	0	1	2	5	10	20	30
221	0	0	0 1	0 87	3 08	8 15	11 82
222	0	2	3 82	8 33	13 29	17 18	17 03
223-24	0	2	3 88	8 86	15 30	23 11	26 62
225-26	100	95	90 26	77 47	60 21	36 84	23 09
227	0	1	1 94	4 43	7 66	11 70	13 92
228	0	0	0	0 05	0 46	3 02	7 51

The reason for this simplified demonstration is not only to show how the transition matrix induces movement in the simulation model, but also to point out one property of the transition matrix with large powers of the transition matrix the rows converge to constant values. That is, each row becomes identical The example transition matrix converges to (0 0588, 0 0588, 0 1471, 0 0735, 0.3676, 0.2941) as k gets large (about 60 days) The implication is that the transition matrix does impose stock-like restrictions on the salmon: it determines the long run distribution of salmon among the districts at the end of the season The key point to be made here is that one cannot arbitrarily create a transition matrix and use it in the run reconstruction model to estimate stock-specific catch rates without seriously biasing the results.

METHODS

Throughout July of 1992, a small number of adult pink salmon are to be tagged on the southern perimeter of the Prince William Sound each week. The tagged fish will then be move through the Prince William Sound to spawning areas Some will be harvested in subsequent fishing periods. They will be turned in by fishermen Some will escape the fishery and move into freshwater areas.

Tags

Fish will be tagged with a radio or sonic tag. The most appropriate tag has not yet been determined Fish with one of these radio or sonic tags will also be tagged with an external spaghetti tag indicating the district of tagging, and each will bear a unique number and Alaska Department of Fish and Game identification.

Tagging Operations

If possible, fishing vessels will be recruited on a volunteer basis with the use of giveaway hats and tee shirts with a tagging study logo. If necessary boats will be chartered on a daily basis from the Prince William Sound purse seine fishing fleet One project scientist or technician will be aboard to actually conduct the tagging, provide instructions, record data, and control quality Pre-printed, waterproof data sheets will provide for date, location, vessel, set number, personnel, time of day, weather conditions, tag numbers, and the number of injured or unsuitable fish. At the end of each tagging operation, the data will be transferred to a computer spreadsheet which will be backed up onto a diskette.

After the seine is set, the bunt end will be left in the water to form a bag alongside the boat Each sampled salmon will be lifted into a tagging cradle, and the tags inserted Each single set will constitute a tagging operation.

Number to Tag

The number to tag will be determined by the actual cost of the tags.

Tag Recovery

Tags will be detected by means of aircraft overflights if radio tags are used, or line transacts if sonic tags are used Fishermen will be offered souvenir hats and tee shirts to return externally tagged fish that were harvested, if information on date and place of capture is provided.

DELIVERABLES

Data and report submission schedule

During 1992, the data collected by this study will allow the estimation of key parameters of the run reconstruction parameter model, as it exists now. A final report on the run reconstruction model, including the adult tagging operation, will be made by the fall of 1992. During the late fall of 1992, efforts will be redirected to the Salmon Life History Model, with particular attention to joining the run reconstruction with the life history information. After slight fine-tuning from the life history model, the run reconstruction model will be altered for use in other years, and estimates will be generated for several years before and after the oil spill.

Three basic reporting tasks are currently envisioned. First, there is to be a report documenting the run reconstruction model methods. The authors will include the cooperating scientists at the University of Alaska Fairbanks, and the two Alaska Department of Fish and Game investigators. Second, there is to be a document or series of documents covering the adult tagging operation. Third, documentation of the run reconstruction estimates themselves will be provided as an Alaska Department of Fish and Game technical report.

The life history model and injury estimates should follow similar reporting lines: a report documenting methods for the primary scientific literature, and a report of actual estimates The documentation of the life history model will complete Study 28. A single final report covering all of the above will be prepared

SCHEDULES & PLANNING

APPROXIMATE DATE	ITEM
1992	
March 15.	Begin purchasing equipment, tags, etc
March 15.	Begin Life History data organization
May 15.	Hire Fishery Biologist I
Late June	Begin tagging operations in District 226
July 1	Begin overflights or line transacts
Aug. 30.	Begin to assemble database
September	Continue on Life History model development
September	Provide basic data to run reconstruction modelers
November	UAF model fully completed
November	Begin Life History model reports
1993	
February	Final Reports due

BUDGET ($K)

Salaries	$ 91 8
Travel	56.0
Contractual	43 0
Supplies	18 5
Equipment	25.7
Subtotal	$ 235.0
General Administration	16 8
Total	$ 250 6

MARINE MAMMAL STUDY NUMBER 1

Study Title: Effects of the Exxon Valdez Oil Spill on the Distribution and Abundance of Humpback Whales in Prince William Sound, Southeast Alaska, and the Kodiak Archipelago

Lead Agency: NOAA

PROJECT JUSTIFICATION

During 1989 and 1990, photographs of individual humpback whales occurring in Prince William Sound and Southeast Alaska were collected from May to September to assess the impact of the Exxon Valdez oil spill on humpback whale life history and ecology In Prince William Sound, 547 days were spent traversing approximately 20,000 nautical miles in search of whales or while photographing whales. In Southeast Alaska, 230 days were spent conducting field research during the 1989 season to determine if Prince William Sound humpback whales were relocating to other areas

In 1989, photographic analysis of Prince William Sound humpbacks revealed 59 identifiable whales in 119 encounters. In Southeast Alaska, 516 whales were identified in 1989, based on 2,448 encounters. During the 1990 season, photographic analysis of Prince William Sound humpbacks revealed 66 identifiable whales in 201 encounters. The total count represents the largest number of individual humpback whales ever photographed in Prince William Sound. A decline in the number of Prince William Sound humpback whales was not identified.

The distribution of humpback whales in Prince William Sound during the 1989 season was compared to their distribution in 1988. In 1988, more humpback whales used Lower Knight Island Passage area The effect of increased vessel and aircraft traffic may be responsible for the whale distribution pattern observed in 1989 The distribution of whales in Prince William Sound during the 1990 season was compared to previous data No apparent shift in distribution was noted in 1990 No observations were made of humpback whales swimming through oil. Despite considerable effort, Prince William Sound humpback whales were not observed during concurrent photographic studies in Southeast Alaska

Synthesis of these data and the review of available scientific literature will allow the preparation of a final report which provides an interpretation of the results This information may be useful to help manage the recovery of the North Pacific's endangered humpback whale population Accordingly, preparation of a final report is warranted.

	BUDGET ($K)
Salaries	$ 15.0
Travel	0.0
Contracts	0 0
Supplies	0 0
Equipment	0.0
Subtotal	$ 15 0
General Administration	2 3
Total	$ 17 3

MARINE MAMMAL STUDY NUMBER 2

Study Title: Assessment of Injuries to Killer Whales in Prince William Sound and Southeast Alaska

Lead Agency: NOAA

PROJECT JUSTIFICATION

Photographs of individual killer whales occurring in Prince William Sound were collected from May to September in 1989, 1990, and 1991 to assess the potential impacts of the Exxon Valdez oil spill on killer whale life history and ecology. Over 25,000 nautical miles were traversed in search of whales or while photographing whales, reflecting 617 days of field research for the three-year period.

An unusually high number of killer whales were reported missing from one of the resident pods named AB pod. The stability of resident pods of killer whales is such that when an animal is listed as missing for more than one year, that animal is considered dead. Prior to the oil spill, the number of whales in AB pod changed from 35 to 36 (1984-1988). During this time period, 8 whales died and 9 whales were born.

During 1989, 7 whales were missing from the AB pod. During 1990, six additional whales from AB pod were added to the missing list. This represents an average mortality rate of approximately 20%, an order of magnitude greater than that seen in the 20-year study of killer whales in British Columbia and Washington State (1 8%) and more than three times the average mortality rate (6 1%) seen in AB pod during the 1984-88 period. Additionally, in 1989 and 1990, no calves were born in the AB pod In 1991, one whale was reported missing and one calf was born to AB pod

In addition to missing whales in the AB pod, significant changes occurred in the pod's social structure. Although carcasses of missing whales have not be found, there is a correlation between the discovery of unusually high mortality in AB pod and the Exxon Valdez oil spill.

For this closeout project, a complete analysis will be conducted This will allow an evaluation of all aspects of the killer whale data The final report will make available information useful in understanding and managing the killer whales of Prince William Sound.

BUDGET ($K)

Salaries	$ 28.0
Travel	1.0
Contracts	0 0
Supplies	0.0
Equipment	0.0
Subtotal	$ 29 0
General Administration	4 3
Total	$ 33 3

MARINE MAMMAL STUDY NUMBER 6

Study Title: Assessment of Magnitude, Extent, and Duration of Oil Spill Impacts on Sea Otters

Lead Agency: USFWS

PROJECT JUSTIFICATION

The major NRDA studies on sea otters included (a) estimates of distribution and abundance through aerial and boat surveys; (b) estimates of reproductive rates, survival rates and documentation of sea otter movements; (c) recovery of carcasses in the spill zone to determine age and evaluate patterns of mortality; (d) toxicology and pathology work such as histological examination of tissue samples, necropsy of several hundred carcasses, and analysis of blood, fat and milk for hydrocarbon content, (e) standard clinical evaluation of blood samples to determine the health/physiological status; (f) determination of prey species and collection of samples for hydrocarbon analysis, and (g) modeling work to estimate numbers of otters exposed to oil and population recovery.

Injury to sea otters resulting from the oil spill included 1,011 dead sea otters recovered from within the spill zone. A synthesis of loss estimates suggests that between 3,500 and 5,500 sea otters may have died from acute exposure to oil Chronic injury to sea otters may result from either sublethal initial exposure and continued exposure to environmental hydrocarbons Preliminary findings of the Coastal Habitat and Shellfish NRDA studies have identified elevated levels of hydrocarbons in intertidal and subtidal sediments and in several species of benthic marine invertebrates eaten by sea otters Continuing injury is indicated by significantly higher numbers of prime age sea otter carcasses being recovered in comparison to pre-spill in western Prince William Sound and continued declines in sea otter abundance in oiled areas. Post-weaning pup mortality in the winter of 1990-91 was significantly higher in western Prince William Sound than eastern Prince William Sound. Significant differences in blood parameters were detected for adult males between eastern and western Prince William Sound; results suggest systemic hypersensitivity reactions in males sampled in western Prince William Sound

A preliminary report of results has been prepared for this study but comprehensive data synthesis and analysis have not been completed.

The preparation of a final report will be essential for understanding the injuries the spill caused to sea otters If this information is not clearly and completely available to those responsible for restoration, it will not be possible to adequately address the restoration needs of the resource.

BUDGET ($K)

Salaries	$ 127 2
Travel	0 0
Contractual	50 0
Commodities	0 0
Equipment	0 0
Other Non-Contractual	0 0
Subtotal	$ 177 2
General Administration	22 5
Total	$ 199 7

TERRESTRIAL MAMMAL STUDY NUMBER 3

Study Title: Assessment of the Effects of the Exxon Valdez Oil Spill on River Otter and Mink in Prince William Sound

Lead Agency: ADF&G

PROJECT JUSTIFICATION

The river otter and mink damage assessment study was initiated in 1989. Some mortality was documented soon after the oil spill and subsequent long-term sublethal effects have continued to be documented. Impacts have been demonstrated at the population level in this species through continued introduction of toxic oil substances in the habitat resulting in direct exposure and introductions through prey resulting in internal exposure.

Funds provided in 1992 will be used for completion of analysis of substantial amounts of data collected in the three years of this study and preparation of a final report

	BUDGET ($K)
Salaries	$ 32 1
Travel	3.0
Contractual	30 0
Supplies	2 0
Equipment	0 0
Subtotal	$ 67 1
General Administration	6 9
Total	$ 74 0

SUBTIDAL STUDY NUMBER 1A

Study Title: Petroleum Hydrocarbon-Induced Injury to Subtidal Marine Sediment Resources

Lead Agency: NOAA

Cooperating Agency: ADEC

PROJECT JUSTIFICATION

The primary goal of Subtidal Study Number 1 is to determine the spatial and temporal distribution of oil in subtidal sediments in Prince William Sound and the Northeastern Gulf of Alaska As of June 1990, subtidal sediments were contaminated by oil at no fewer than 15 sites within the Prince William Sound. Hydrocarbons had contaminated sediments to a depth of 20 m at least at 8 sites. In or near two heavily contaminated bays, petroleum hydrocarbons were detected in sediments at a depth of 100 m. There is also evidence suggesting a trend for petroleum hydrocarbons to move from the intertidal region to greater depths (3, 6, and 20 m) between May and November 1989 at Sleepy Bay At Northwest Bay and Herring Bay there appeared to be a tendency toward an increase in contamination of the 6 and 20 m depths between July 1989 and June 1990 At least 7 sites along the Kenai and Alaska Peninsulas showed contamination of subtidal sediments by hydrocarbons Petroleum hydrocarbons were detected below a depth of 6 m at three of those sites.

These results are based on a small number of samples because of delays associated with hydrocarbon analysis In early fall of 1991, the results of the hydrocarbon analysis of 894 of the 1820 samples submitted to date were received. These data are currently undergoing the final stages of quality control Analysis of the data from all these samples should provide a reasonably complete picture of contamination by the oil spill of subtidal sediments in Prince William Sound. A less complete summary will be available for the Gulf of Alaska. This proposal supports analysis of the data on these samples and write-up of the results of that analysis.

This study supports other studies requiring documentation of hydrocarbon contamination of subtidal sediments such as those studies of impacts on benthic communities as well as specific fish and invertebrate species Results of the University of Alaska Fairbanks study on the responses of hydrocarbon degrading bacteria in subtidal sediments appear to be consistent with hydrocarbon results indicating contamination to a depth of 100 m at a minimum of two sites in Prince William Sound Both the deep benthos (ST 2B) and the microbiological components of ST 1B are dependent on the results of the sediment hydrocarbon analyses.

	BUDGET ($K)
Salaries	$ 68 6
Travel	3 8
Contracts	13 5
Supplies	2 6
Equipment	3.8
Subtotal	$ 92.3
General Administration	11 2
Total	$ 103.5

SUBTIDAL STUDY NUMBER 1B

Study Title: Hydrocarbon Mineralization Potentials and Microbial Populations in Sediment

Lead Agency: ADEC

Cooperating Agency: NOAA

JUSTIFICATION

All of the field and laboratory work has been completed on this project. Results from 6 cruises from 1989 through 1991 are being analyzed and summarized into a final report

Preliminary results show that microbial numbers and activity in sediments are good indicators of previous exposure to hydrocarbon contamination. In addition, these measurements yield information on the mobilization of oil to deeper sediments over time. Microbial activity, even in 1991, remains high at some sites presumably where relatively fresh oil is still present The information collected in this project will be used in linking other NRDA studies and for prioritizing sediment hydrocarbon samples for analysis.

BUDGET ($K)

Salaries	$ 12 4
Travel	1 9
Contractual	1 1
Commodities	0 6
Equipment	0 0
Subtotal	$ 16 0
General Administration	1 1
Total	$ 17 1

SUBTIDAL STUDY NUMBER 2A

Study Title: Injury to Shallow Benthic Communities

Lead Agency: ADF&G

PROJECT JUSTIFICATION

Benthic organisms associated with subtidal sediments generally represent good monitors for measuring effects of oil fluxing to the bottom. These organisms typically remain close to or at the site of larval settlement and, consequently, represent good monitoring organisms. The composition of the marine benthic fauna has been successfully used at various locations throughout the industrial world as a basis for measuring effects of pollutants on the bottom.

Shallow (<20 m) subtidal studies were initiated in Prince William Sound in the fall of 1989, and continued during the summers of 1990 and 1991. Thus far, the 1989-90 sampling effort has demonstrated the presence of oil (observed as sheens) and/or injury to marine plants, invertebrates, and fishes in sill fjord, eelgrass (Zostera) and Laminaria/Agarum bay habitats (Jewett et al , 1992).

Deep (>20 m) benthos studies were initiated in the Prince William Sound in July 1990. Six of the deep benthos sites sampled in 1990 were adjacent to eelgrass sites sampled by the shallow benthic program. Preliminary results from the deep benthos study indicated significant differences for infauna within oiled embayments in comparison with unoiled embayments.

OBJECTIVES

Determine the temporal and spatial effects of the Exxon Valdez oil spill on the infaunal invertebrate communities within eelgrass embayments. These objectives will also be attempted on communities within Laminaria bays, on a "time available basis only" at no additional cost.

METHODS

The final phase of this project will concentrate on processing samples, analyses, and reporting on the shallow subtidal communities that were sampled in the Prince William Sound eelgrass (Zostera) habitat in 1991. This habitat, as well as Laminaria bays, was chosen because of relative ecological importance, history of prior injury, and on proportion of total habitat in the oiled Prince William Sound area. Six of the sites within the eelgrass habitat are also the deep benthos sites All studies were conducted at oiled sites (selected at random when possible) and control sites that are matched to the oiled sites with regard to geomorphology, degree of freshwater input, substrate type, and general circulation and wave exposure regimes

Other areas (Kenai and Kodiak regions) were excluded because it is anticipated that effects were greatest within Prince William Sound and because of logistics of sampling in those other regions.

BUDGET ($K)

Salaries	$ 7.1
Travel	0.0
Contractual	95.0
Commodities	0.0
Equipment	0.0
Subtotal	$ 102.1
General Administration	7.7
Total	$ 109.8

SUBTIDAL STUDY NUMBER 2B

Study Title: Deep Water Benthos

Lead Agency: ADF&G

PROJECT JUSTIFICATION

Part I

A peer review of the Status Report for this project suggests that the biological data be reanalyzed to sort out sedimentological effects and to relate biotic parameters to petroleum contaminants in sediments. The objective of this work is to complete sediment analyses for all stations examined and to analyze the data to relate the biological results to sediment parameters as suggested by the peer review.

OBJECTIVES

1. To reanalyze the deep benthic data to assess the relationship - or lack of relationship - of benthic faunal distributions to sedimentological parameters between the oiled and unoiled sites.

2. To assess the deep benthic data in relationship to petroleum contaminants in the sediments at the study sites, contingent upon receipt of hydrocarbon data from NOAA

It is anticipated that at least six to seven weeks will be needed to obtain sediment data for the 1990 samples This work entails sediment analysis of 14 stations x 3 depths = 42 sediment samples. A short report assessing the results of the expanded analyses will be submitted no later than June 30

Part II

Assuming that reanalysis of the deep benthic biological data relative to sediment parameters at the study sites reinforces the conclusions in Feder (1991), the deep benthic study will be continued until all samples have been examined and a Final Report can be written. The fourteen study sites chosen on the NOAA ship in July 1990 were selected at random with 7 oiled and 7 unoiled sites chosen.

It is the intent of this damage assessment final report to compare all of the 1990 and 1991 deep benthic biological and associated sediment data from oiled and unoiled bays in Prince William Sound. The composition of the marine benthic fauna has been successfully used at various locations throughout the industrial world as a basis for measuring effects of pollutants on the bottom, inclusive of oil that has settled after oil spills Assessment of the benthic fauna within Prince William Sound should prove useful for assessing biological effects of the Exxon Valdez oil spill in the Sound. Preliminary examination of benthic biological data from the 14 sites, three depths at a site, suggests that oil on the bottom in bays subjected to impact from the Exxon Valdez oil spill may have affected the faunal composition Verification of this suggestion is contingent upon analysis of sediment differences between sites and petroleum hydrocarbon composition on the bottom at the sites. The former analysis is to be completed no later than May 30, 1992.

OBJECTIVES

1. Completion of the taxonomic determinations of benthic samples from stations at 100 m and >100 m collected in July 1991.

2. Sediment analysis, inclusive of organic carbon and nitrogen determinations as well as carbon isotopic determinations, for the sediment samples collected in July 1991

3. Completion of statistical and other analyses of the 1990-91 biological data.

4. Completion of all multivariate analyses involving sediment and hydrocarbon parameters (if the latter data are available).

5. Completion of a Final Damage Assessment Report no later than November 30, 1992. This report will represent a compilation of 1990 and 1991 deep benthic data and will examine the data for possible effects resulting from the Exxon Valdez oil spill

	BUDGET ($K) (Part I)
Salaries	$ 0 0
Travel	0.0
Contractual	10.0
Supplies	0 0
Equipment	0 0
Indirect Costs	0 0
Subtotal	$ 10 0
General Administration	0.7
Total	$ 10 7

	BUDGET ($K) (Part II)
Salaries	$ 1 8
Travel	0 0
Contractual	70 0
Supplies	0 0
Equipment	0 0
Indirect Cost	0 0
Subtotal	$ 71 8
General Administration	5 1
Total	$ 76 9

SUBTIDAL STUDY NUMBER 3A

Study Title: Bioavailability and Transport of Hydrocarbons

Lead Agency: NOAA

Cooperating Agency: ADEC

PROJECT JUSTIFICATION

The goal of the NOAA component of project Subtidal Study #3 is to document petroleum hydrocarbon loading in near shore waters impacted by the Exxon Valdez oil spill In 1989, hydrocarbon loading was monitored by direct sampling of seawater in Prince William Sound and in 1989, 1990, and 1991 by deployment of hydrocarbon-free mussels along the oil spill trajectory for exposure periods of 1 to several months.

In 1989, chemical analysis of the seawater samples showed the presence of aromatic hydrocarbons of petroleum origin Total aromatic hydrocarbon concentrations ranged up to about 8 $\mu g/l$ (ppb) at the most heavily contaminated sites 8 days after the spill, but after 6 weeks declined to below detection limits Although higher than concentrations reported by Exxon, these concentrations were still lower than those known to cause detectable adverse effects on biological marine resources following relatively short-term exposures.

Caged mussels are sensitive indicators of oil in seawater, because they effectively contact large volumes of seawater, and selectively filter and ingest organic particulates. In 1989, both aromatic and aliphatic hydrocarbons of petroleum origin were detected in tissue of caged mussels at concentrations ranging up to 100 $\mu g/g$ wet tissue (ppm), and were detected at all stations and depths inside Prince William Sound along the spill trajectory Outside Prince William Sound, hydrocarbon concentrations were generally low and highly variable among replicates However, mussels exposed at Tonsina Bay and Chignik showed moderate levels of contamination. Oil contamination levels in the caged mussels declined after May 1989 and approached control levels by Fall 1989 In 1990, oil contamination levels that were significantly above control levels were low and sporadic.

These results from the caged mussels indicate that biologically available hydrocarbons from the Exxon Valdez oil spill were generally pervasive in the upper water column along the spill trajectory inside Prince William Sound during the summer of 1989 This biological availability may result from association of petroleum hydrocarbons with particulate organic material in the water column that can be ingested by larval herring and juvenile salmon, thus providing a mechanism for the adverse effects observed in these fish (see Fish/Shellfish studies)

The Alaska Department of Environmental Conservation component of project Subtidal Study #3 involved the deployment of sediment traps at selected locations within Prince William Sound. Results indicate that petroleum hydrocarbons associated with near-shore sediments or organic particulates can migrate to greater depths. In 1991, caged mussels were deployed with the sediment traps to determine the biological availability of trapped hydrocarbons These results will help to evaluate additional injury to biological resources caused by these migrating hydrocarbons

The analysis and interpretation of these results will be completed and a final report produced in 1992.

	BUDGET ($K)
Salaries	$ 32.1
Travel	2.2
Contracts	0.0
Supplies	0 0
Equipment	0.0
Subtotal	$ 34.3
General Administration	4 8
Total	$ 39 1

SUBTIDAL STUDY NUMBER 3B

Study Title: Bioavailability and Transport of Hydrocarbons in the Nearshore Water Column

Lead Agency: ADEC

Cooperating Agency: NOAA

JUSTIFICATION

The Alaska Department of Environmental Conservation (ADEC) has deployed sediment traps in Prince William Sound since November 1989 to monitor nearshore sedimentation in the wake of the Exxon Valdez oil spill. These sediment traps capture particulates settling out of the water column, which are then analyzed for hydrocarbon chemistry, organic carbon/nitrogen and mineralogy The objectives of the ADEC portion of Subtidal Study #3 are, 1) to determine the presence or absence of petroleum hydrocarbons in the water column, and 2) to collect data on the mobility of petroleum hydrocarbons in the near shore. The study will show whether hydrocarbons are present in the particulate matter utilized by filter-feeding organisms in the water column (mussels) and whether there is a continuing input of petroleum hydrocarbons to the subtidal from these settling particulates. Sediment grain size data will provide information relating particle size to hydrocarbon chemistry These size data are important because many filter feeders show a preference for certain particle size ranges, and because hydrocarbon adsorption and particle settling rates are also dependent on size. Data from sediment cores in the vicinity of the traps will add knowledge of petroleum hydrocarbon contamination of benthic sediments due to mixing and bioturbation Besides providing a connection between oiled particulates and uptake into the food chain, the sediment traps present an opportunity to investigate the continued mobility and transport of petroleum hydrocarbons into subtidal areas from shorelines where surface or subsurface oiling remains.

The analysis and interpretation of the data collected from 1989 through 1992 from this study should be completed and published because: 1) this study represents the longest monitoring of settling particulates after a major oil spill, 2) the study provides a potential connection between shoreline and subtidal oiling and uptake by marine organisms, and, 3) because the results may shed light on questions regarding the efficacy and environmental benefit of shoreline treatment and the possible continuing inputs of oil from remaining shoreline contamination Results to date found significant quantities (>200 ppm) of oil in settling particulates two years after the oil spill at several of the study sites where there is a continued presence of subsurface shoreline oiling.

	BUDGET ($K)
Salaries	$ 16 5
Travel	4 4
Contractual	25 1
Commodities	0.7
Equipment	0 0
Subtotal	$ 46.7
General Administration	4.2
Total	$50 9

SUBTIDAL STUDY NUMBER 4

Study Title: Fate and Toxicity of Spilled Oil From the Exxon Valdez Oil Spill

Lead Agency: NOAA

PROJECT JUSTIFICATION

This study, originally called Air/Water Project Number 6, was designed and undertaken by NOAA in 1990 The study was designed to: a) determine the toxicity of oiled environmental samples, using standard toxicity tests, b) examine the extent to which any observed toxicity may be attributed to oxygenated, polar products in weathered oil (versus the parent hydrocarbons found in fresh crude); and c) promote the synthesis of data and information (generated largely by other projects) on the geographic distribution, weathering, and potential effects of petroleum on living marine resources.

Toxicity testing has been conducted on sediment samples taken both inside and outside of Prince William Sound in 1989, 1990 and 1991. Petroleum hydrocarbon concentrations were estimated by ultraviolet fluorescence spectroscopy on the sediment samples collected in 1989 and 1990 Between 1989 and 1991, oil concentrations declined in intertidal sediments sampled at most oiled locations, while the concentrations in shallow subtidal sediments (3-20 meters) remained about the same, or in some cases, rose slightly Patterns of sediment toxicity to test organisms (marine amphipods and larval bivalve molluscs) reflected similar patterns In 1990, significant toxicity was associated only with intertidal sediment samples from heavily oiled sites, but in 1991, toxicity was associated primarily with sediment samples from the shallow subtidal zone The toxicity of sediments from oiled sites was generally greater than that from unoiled reference sites in both 1990 and 1991 Final interpretation of sediment toxicity will require data on hydrocarbon chemistry and grain size of the sediments (expected from Technical Services Study Number 1) These analytical data are now available for 1989 and 1990, but have not yet been analyzed in detail; data for 1991 are not yet available.

The study determined the extent to which any toxicity present in oiled sediments and interstitial waters may be attributed to polar oxidation products (as opposed to parent hydrocarbons) in petroleum. Intertidal sediments and interstitial waters from oiled and reference sites in Prince William Sound were extracted and separated into polar and nonpolar fractions, and the fractions were tested for relative toxicity Polar fractions from most heavily oiled sites exhibited toxicity similar to that associated with the nonpolar fractions, but this toxicity was detectable only at very high concentrations. A draft final report on these tests is expected in March 1992. Extracts of mussel tissues from oiled and unoiled sites were chemically fractionated into nonpolar and polar constituents and analyzed by ultraviolet fluorescence spectroscopy. Polar constituents occurred in mussel tissues from oiled sites at levels that were proportional to, or less than proportional to, the amounts present in the original parent oil simultaneously accumulated in the tissues. These analyses have verified that toxicity associated with oiled sediments may arise in part from polar constituents and/or metabolites, however the toxicity levels associated with polar and nonpolar constituents were generally similar for all of the endpoints tested

Relevant literature and data have been identified and assembled for the petroleum budget (objective c above), and a synthesis workshop still is recommended as an important step in completing this synthesis task.

No new field work is proposed under this project, and a final report will be prepared at the end of the year on all aspects of the projects. The synthesis and integration of data and information of the fate of the spilled oil through time will provide essential context for the interpretation of initial injury to, and subsequent recovery from the spill

	BUDGET ($K)
Salaries	$ 29.0
Travel	15 0
Contracts	4 0
Supplies	0 0
Equipment	0 0
Subtotal	$ 48.0
General Administration	4.6
Total	$ 52.6

SUBTIDAL STUDY NUMBER 6

Study Title: Injury to Rockfish

Lead Agency: ADF&G

PROJECT JUSTIFICATION

This closeout budget represents the cost for preparation of a final report for the data collected in this project through 1991 Work will not begin on this activity until receipt of sample analyses results in June.

	BUDGET ($K)
Salaries	$ 13 5
Travel	0.0
Contractual	1 0
Supplies	0 0
Equipment	0 0
Subtotal	$ 14 5
General Administration	2 1
Total	$ 16 6

SUBTIDAL STUDY NUMBER 7

Study Title:	Assessment of Oil Spill Impacts on Fishery Resources: Measurement of Hydrocarbons and Their Metabolites, and Their Effects
Lead Agency:	NOAA

PROJECT JUSTIFICATION

Beginning in late spring of 1989, Subtidal 7 (earlier designated as Fish/Shellfish 24), has systematically evaluated the exposure of several fish species to petroleum hydrocarbons both in Prince William Sound and at numerous sites along the path of the Exxon Valdez oil spill, to Kodiak Island and beyond. Both shoreline and demersal species have been studied In addition to assessing exposure, reproductive parameters have been measured in Dolly Varden char and yellowfin sole, and histopathological structure has been examined in most species. To date, petroleum exposure has been assessed in over 1,400 fish, and indicators of reproductive function have been evaluated in about 400 adult female fish

The analyses of fish sampled in 1989 showed that Dolly Varden, Pacific halibut, salmon and three species of flounder (yellowfin sole, rock sole, and flathead sole) had been exposed to petroleum-derived compounds. The degree of exposure was found to have decreased in 1990 in some species (Dolly Varden), but to have remained constant in three benthic species Preliminary evidence of histopathological alteration of gill epithelium in rock sole was observed. By 1991, exposure to petroleum-derived compounds had generally decreased in all fish species, but the results suggested that some fish continued to be exposed at sites inside Prince William Sound The data obtained in 1991 do not indicate a substantial impact on reproductive processes in the species examined.

Results of the Subtidal 7 studies indicate that spilled oil from the Exxon Valdez oil spill moved to the benthic environment and benthic fish species showed signs of exposure to oil during the first three years after the oil spill A detailed examination of all the data collected will provide valuable information concerning the potential impact of the oil spill on demersal fishes

These studies have generated a large quantity of data showing that substantial portions of the populations of flatfish in areas in or near the path of the Exxon Valdez oil spill have been, and apparently continue to be, exposed to petroleum products. Moreover, some shoreline species, such as Dolly Varden char, were substantially exposed during the first months following the spill, but exposure had declined markedly by 15 months after the spill The funding proposed for 1992 is specifically aimed at putting all of these data into a context of how this exposure has been changing with time, and what the implications of such exposure might be For example, some indications of reproductive changes and histopathological alterations have been noted in the studies funded under Subtidal 7. An examination in detail of all data collected, together with review of available scientific data from 1) other NRDA studies and 2) previously published studies of the effects of oil exposure in fish, will allow for a balanced interpretation concerning the potential impact of the oil spill on demersal fishes.

BUDGET ($K)

Salary	$ 48.5
Travel	2.5
Contracts	2.0
Supplies	0 0
Equipment	0 0
Subtotal	$ 53 0
General Administration	7.4
Total	$ 60 4

1C. DAMAGE ASSESSMENT CONTINUATION

Six projects begun under damage assessment will continue in 1992 Several of these projects provide service or supporting data for other projects and are needed for accurate analysis and final reporting of those projects. Service and support projects include hydrocarbon analysis, Technical Services Study Number 1 (TS1), geographic information system (GIS) mapping and analysis (TS3), mussel tissue and sediment hydrocarbon data synthesis, Subtidal Study Number 8 (ST8), and database management, Fish/Shellfish Study Number 30 (FS30). Other projects are continuing because the population level impacts of injuries to early life history stages of some species will not become apparent for several years. These include injury to shrimp (ST5) and sockeye salmon (FS27).

The sockeye overescapement project (FS27) may not have a clear estimation of injury until fish from eggs laid in 1989 return as adults in 1993 and beyond. Commercial fishing for sockeye in Cook Inlet and the Kodiak area was closed in 1989 when fish could not be harvested without contaminating them by means of oiled gear Consequently so many fish escaped to some freshwater systems that the juveniles produced by these fish could not be supported by the production of these systems Few smolts were observed leaving the systems in 1991. Unless the food base in these systems recovers, injury to other year classes may also occur This study will continue to observe these systems and document continuing injury or recovery.

Fish/Shellfish Study 30 provides a data storage and retrieval mechanism by which investigators can gain access to data produced by other investigators (though they do not have the ability to change those data) even though they may be in different locations in the state. Investigators will, as with TS1, TS2, and ST8, be able to synthesize their results and make meaningful comparisons among studies.

The shrimp study (ST5) requires investigators to sample shrimp in late fall, several months after field work for other projects has ended. Because shrimp injury analysis lags behind that of other species, peer review of 1991 results has not yet occurred If their review indicates that further investigation is necessary, additional sampling will take place in the fall of 1992.

In order to document the presence of oil at specific locations, investigators for many of the damage assessment studies collected mussel and sediment samples from each of the sites at which they were conducting their studies. Therefore, investigators studying birds, mammals, fish and shellfish all collected mussel and sediment samples to determine presence or absence of oil Some also took tissue samples from the project animals to determine exposure of individuals to oil

Analytical chemical results are often confusing to investigators who may lack the ability to interpret the hydrocarbon data from TS1. The investigators from ST8 provide this service to them Because ST8 analyzes data from many projects, the investigators will be able to synthesize these results and provide a broad picture of where oiling occurred and to what degree. These ST8 investigators will also provide some quality assurance for the results of TS1 and identify contaminated samples

TS1 has been responsible for processing these samples, but since so many were collected, a backlog developed Completing the reports for many of the damage assessment studies requires this information so that the injuries observed can be compared to the degree of oiling.

Data from TS1 and ST8 are entered into the oil spill GIS of TS3 to produce maps of the movement and fate of oil These maps support and are incorporated into the final reports for other damage assessment projects.

FISH/SHELLFISH STUDY NUMBER 27

Study Title: Sockeye Salmon Overescapement

Lead Agency: ADF&G

PROJECT JUSTIFICATION

This study is a continuation of the oil spill damage assessment program initiated in 1990. Recent findings have suggested major economic damage to commercial, subsistence, and sport fisheries may result from overescapement The continuing program is essentially identical to the previous study plans with minor modifications These modifications are highlighted in the following revised plan

Commercial fishing for sockeye salmon in 1989 was curtailed in Upper Cook Inlet, the outer Chignik districts, and the Kodiak areas due to presence of oil and subsequent contamination of catches in the fishing areas from the Exxon Valdez oil spill. As a result, the number of sockeye salmon entering four important sockeye producing systems (Kenai/Skilak, Chignik/Black, Red, and Frazer Lakes) and two less important lake systems (Akalura and Afognak or Litnik lakes) greatly exceeded levels thought to be optimal. Sockeye salmon spawn in lake-associated river systems Adult salmon serve an extremely important role in the ecosystem, providing food for marine mammals, terrestrial mammals, and birds Additionally, carcass decomposition serves to charge freshwater lake systems with important nutrients Juvenile salmon which rear in lakes for one or two years serve as a food source for a variety of fish and mammals. Sockeye salmon are also an important subsistence, sport, and commercial species. The ex-vessel value of the commercial catch of sockeye from these lake systems has averaged about $42 million per year since 1979, with the 1988 catch worth $115 million. Sockeye salmon returns to the Kenai River system support some of the largest recreational fisheries in the State.

Overly large spawning escapements may result in poor returns by producing more rearing juvenile sockeye than can be supported by the nursery lake's productivity (Kyle et al 1988). In general, when rearing fish abundance greatly exceeds the lake's carrying capacity, prey resources are altered by changes in species and size composition (Mills and Schiavone 1982, Koenings and Burkett 1987, Kyle et al. 1988) with concomitant effects on all trophic levels (Carpenter et al. 1985) Because of such changes, growth of juvenile sockeye is reduced, mortality increases, larger percentages holdover for another year of rearing, and the poor quality of smolts increases marine mortality. Where escapements are two to three times normal levels, the resulting high juvenile densities crop the prey resources to the extent that more than one year is required to return to normal productivity Rearing juveniles from subsequent brood-years suffer from both the poor quality of forage and from the increased competition for food by holdover juveniles (Townsend 1989). This is the brood year interaction underlying cyclic variation in the year class strength of anadromous fish.

This project will examine the effects of large 1989 spawning escapements on the resulting progeny for a select subset of the above mentioned sockeye nursery lakes. Three impacted lake systems where the 1989 escapements were more than twice the desired levels (Kenai/Skilak in Upper Cook Inlet, Red and Akalura lakes on Kodiak Island) were selected. Tustumena Lake in Upper Cook Inlet and Upper Station Lake on Kodiak did not receive a large escapement and will be examined as controls.

This study is necessary to obtain a more timely assessment of impact as adult sockeye, produced from the 1989 escapement, will not return until the 1994/1995 season. Further, total return data are not available for individual Kodiak sockeye systems due to the complex mixed-stock nature of the commercial fisheries and the inability to estimate stock-specific catches

In addition to continuing previously identified activities, several new activities are proposed to ensure study results are valid The Red River system is being evaluated based on fry and smolt production of Red Lake. Estimation of spawner distribution outside of Red Lake will be completed by establishing an adult weir on Red River immediately below the lake In addition, the very low numbers of outmigrating smolt estimated by the current mark-recapture method has raised some doubt about violating assumptions of the technique. Approximately 60% of the river flow is intercepted by the traps but recapture efficiency remains below 10%. This indicates avoidance by the marked fish, violating the assumption that all fish have the same probability of being captured. If avoidance rate is great then significant biases may occur. A full smolt weir is proposed to enumerate smolt and verify the current smolt mark-recapture method

On the Kenai River system additional smolt samples will be collected from the Russian River to verify the aging techniques. The current method is suspect because age classes known to be produced from the Russian River do not appear in the smolt traps further downstream. Smolt trapping will also be continued into July to insure current projections of smolt production failure from the Kenai River lake systems are not an artifact of some unknown sampling bias.

Finally, a late fall fry sampling period will be conducted on the major Kenai Peninsula lakes Approximately 50% of the weight gain from fry to smolt on the Kenai River system occurs outside of the current sampling regime. If poor survival occurs because of limitations in rearing habitat quality during this period, these data are crucial for determining the validity of density of fry causing decreased over-wintering survival.

OBJECTIVES

A. Estimate the number, age, and size of sockeye salmon juveniles rearing in selected freshwater systems

B. Estimate the number, age, and size of sockeye salmon smolts migrating from selected freshwater systems.

C. Determine effects of large escapements resulting from fishery closures caused by the Exxon Valdez oil spill on the rearing capacity of selected nursery lakes through:

a. Analysis of age and growth of juveniles and smolts;
b. Examination of nursery area nutrient budgets and plankton populations.

METHODS

Numbers of adult sockeye salmon that entered selected spawning systems outside Prince William Sound prior to and during 1989 have been estimated at weir stations or by sonar This information was collected during projects routinely conducted by the ADF&G as part of their resource management program Optimal escapement levels, which on the average should produce maximum sustained yield, have been based on either past relationships between spawners and returning progeny or the extent of available spawning and rearing habitat. The baseline program will continue at each site including, but not limited to, estimates of adult sockeye escapement and collection of scales for age analysis.

For each of the 4 lake systems identified, the response (abundance, growth, and freshwater age) of rearing juveniles from the 1989 escapement will be studied through its likely period of freshwater residence, early summer 1990 to spring 1992

The total number of juvenile sockeye in each lake will be estimated through hydroacoustic surveys conducted during the summer (late June) and fall (September-October) of 1990, 1991, and 1992. Age and size information as well as diet items will be obtained from samples of juvenile sockeye collected from concurrent mid-water trawl netting surveys. Survey transect designs for hydroacoustic sampling and tow-netting have been established for Kenai and Skilak lakes (Tarbox and King 1989), and will be developed for each additional lake in the study The basic survey design will be a stratified random sample where each lake is subdivided into areas and survey transects randomly selected in each area Such programs, funded through other studies, are already in place for Tustumena and Afognak lakes Depending on densities of rearing juvenile sockeye, estimates of fish densities will be made for each transect either by echo integration or by echo counting. Total fish population estimates will be computed, by summing transect populations, along with 95% confidence intervals (Kyle 1989)

Freshwater growth and age of sockeye salmon rearing juveniles from all study systems will be determined from scale and otolith measurements made either by direct visual analysis of scales or on an Optical Pattern Recognition system In cases where data are available (e g., Kenai and Skilak Lakes), growth of progeny from the 1989 spawning escapements will be compared with growth (size) of progeny produced from spawning within these systems during prior years

Scale analysis used to age Kenai River smolt has been questioned because the numbers of two year old smolt from the Russian River system is far below expectation. Therefore, smolt samples will be taken during the summer of 1992 from the Russian River to verify that these smolt appear in the Kenai River smolt traps and that the current aging techniques are accurate.

The total number of smolt migrating from each system will be estimated with a mark-recapture study during 1990, 1991 and 1992 using inclined plane traps after Kyle (1983), and Tarbox and King (1989). Smolt will be captured in traps, sampled for age and size information, marked with Bismark Brown Y (a biological dye), and transported upstream of the traps and released for subsequent recapture (Rawson 1984). Periodic retesting will determine the capture efficiency of the traps under changing river conditions during the spring. Total population estimates (with 95% confidence intervals) will be made using catch efficiencies, and weekly number weighted smolt size and age information will be calculated using a computer spreadsheet developed by Rawson (personnel communication, 1985). Size and ages of sockeye smolts from the 1989 spawning escapements will be compared with smolt information from spawning within these systems during prior years Finally, smolt programs consistent to those for the study lakes are planned, under separate funding, for Tustumena and Afognak Lakes

In addition, a full weir will be established on the Red River to get a total enumeration of outmigrant smolts. This will be manned 24 hours a day and will be used in comparison with the traps established the previous year for smolt estimation

Limnological studies will monitor the response of the lakes to the high juvenile rearing densities and to estimate the carrying capacity parameters of euphotic volume, nutrient budgets (carcass enrichment), and zooplankton biomass, body-sizes, and population shifts. Approximately six limnology surveys will be conducted at two stations, during 1992 to determine zooplankton species abundance and body sizes, nutrient chemistry, and phytoplankton abundance for Kenai/Skilak, Red, Akalura, and Upper Station lakes Carrying-capacity parameters exist for Afognak and Tustumena lakes based on ongoing studies by FRED and Commercial Fish Divisions.

In cases where seasonal data are available (e.g., Akalura, Kenai, and Skilak lakes), limnological parameters taken during residence of the juveniles from the 1989 spawning escapements will be compared to parameters within these systems during prior years

The holistic approach proposed here involves several evaluation procedures to assess the effects of sockeye salmon overescapement

First, freshwater production from the 1989 escapements will be assessed in Kenai/Skilak, Red, Akalura, and Upper Station lakes. This will be accomplished through analysis of growth, freshwater survival (in particular over-winter survival), and freshwater age of sockeye smolt populations Any anomalies will be determined by analysis of freshwater growth recorded on archived scales, historical freshwater age composition, and modeled freshwater survivals; and from results of previous studies as well as the 1991 smolt characteristics from each of the study systems Also, planktonic food sources will be assessed through estimation of abundance of zooplankton prey biomass and numbers of species.

Second, future sockeye salmon production from the 1989 parent year and subsequent parent years will be estimated based on spawner/recruit relationships incorporating a brood-year interaction term. Losses of adult sockeye production from subsequent parent years may result from negative effects of progeny of the 1989 escapement on the lake's carrying capacity. The spawner/recruit relationships will be estimated from historical stock specific return data (where available), and generalized spawner/recruit data scaled to the carrying capacity parameters (i.e , euphotic volume and zooplankton biomass) of the nursery lakes where stock specific return data are not available (Geiger and Koenings 1991) If it is determined that in any of the affected systems, the density dependent effects are occurring outside of the traditional models, the effects will be isolated by examining a broader time window of the rearing life history of these species

Third, experimental and empirical sockeye life history/production models (Koenings and Burkett 1987, Koenings et al 1989) will be used to compare salmon production by life-stage at escapement levels consistent with management goals to the 1989 escapements

Additionally, in the case of the Kenai system, effects of the 1989 escapement will be viewed independently of the effects on previous brood years with high escapement

DATA ANALYSIS

Analysis of the data will follow the techniques outlined in the references cited in the methods section Where new analysis and problems are identified upon review of data obtained, appropriate standard techniques will be utilized.

DELIVERABLES

A report will be submitted by November 27, 1992 Format and content will follow the two previous reports Damage assessment final report will be submitted at deadlines and in the format to be decided by the Trustees. Data collection on injury may continue up until recovery has been observed in the populations of sockeye salmon under investigation

SCHEDULE AND PLANNING

This study is a continuation of ongoing investigations Continued processing of field samples collected during the previous summer is occurring presently. Upon breakup, field sampling schedules will resume following sampling schedules as reported in the NRDA Annual Report for 1990 under FS #27 Enhanced sampling activities will require collection of samples later in the fall and early winter of 1992-93. Other activities will parallel those as reported previously and as described in previous detailed study plans

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	BUDGET ($K)
Salaries	$329.9
Travel	12 0
Contractual	124 8
Supplies	52.1
Equipment	6 0
Subtotal	$524 8
General Administration	58 2
Total	$583 0

FISH/SHELLFISH STUDY NUMBER 30

Study Title: Database Management

Lead Agency: ADF&G

PROJECT JUSTIFICATION

FS-30 addresses the need to catalogue and maintain the principal electronic copies of raw data collected by the ADF&G Natural Resource Damage Assessment & Restoration (NRDA) Fish/Shellfish and Subtidal projects.

Assessment of injuries, successful restoration, and ongoing monitoring efforts ultimately are grounded in the data sets generated by NRDA studies.

Because of the fundamental role these data play in determining the effectiveness of any restoration program, it is important that care be taken to adequately document, archive, and maintain these principal electronic data sets.

In addition, the ADF&G personnel associated with FS-30 are directly responsible for the maintenance of critical historical fisheries databases referenced by many NRDA projects. This connection provides several added benefits to the NRDA effort, including direct access to historical data, technical expertise, and the use of the ADF&G Commercial Fisheries Wide Area Network (WAN) for electronic correspondence and transfer of data

Principal Copy of
Electronic Data Sets

- NRDA:
  FS-1, 2, 3, 4A, 11, 13, 27, 28,
  ST-5, (FS-5, ST-2AB, ST-6).

- Historical Data·
  Commercial fisheries harvest
  Fisheries escapement data

- Restoration Projects:
  R-53, 58, 59, 60ABC, 105, and
  113, (R-90, 106)

Documentation (DOCS) Database Management System (DBMS)

FS-30 supports 17 NRDA and restoration projects, with ancillary support to an additional 6 projects. Including historical data sets, the current amount of raw electronic data involved is estimated to be between 1,500,000,000 and 1,800,000,000 bytes. Tracking this volume of information requires significant time and effort; leaving it to Principal Investigators (PIs) would severely limit their ability to focus on project work Ignoring data management entirely would ultimately lead to the loss of millions of dollars in data collection effort as projects complete or personnel transition to other projects. In brief, this project·

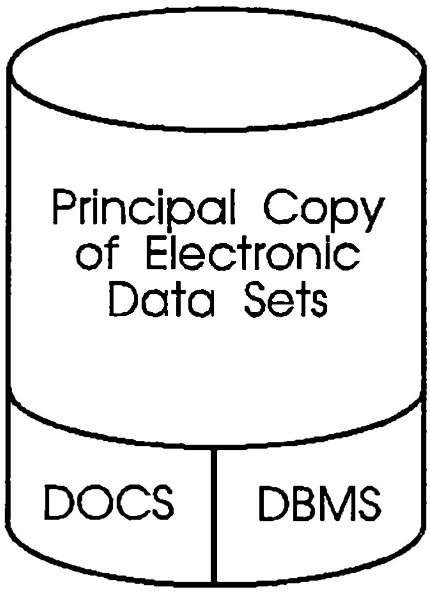
- Catalogues, archives, and maintains the principal copy of raw electronic data sets for FS-1, 2, 3, 4A, 11, 13, 27, 28, ST-5, (FS-5, ST-2AB, ST-6)

- Facilitates direct access by PIs to historical fisheries data sets essential to NRDA studies. Historical data includes commercial fisheries catch and escapement figures

- Provides data processing and technical support for PIs and NRDA functions, including the use of ADF&G Commercial Fisheries WAN

- Proposes to unify the data catalogues and maintenance of principal data sets for continuing ADF&G fisheries assessment, restoration, monitoring projects. This should facilitate sharing raw data between agencies and the ability to provide this information to the public.

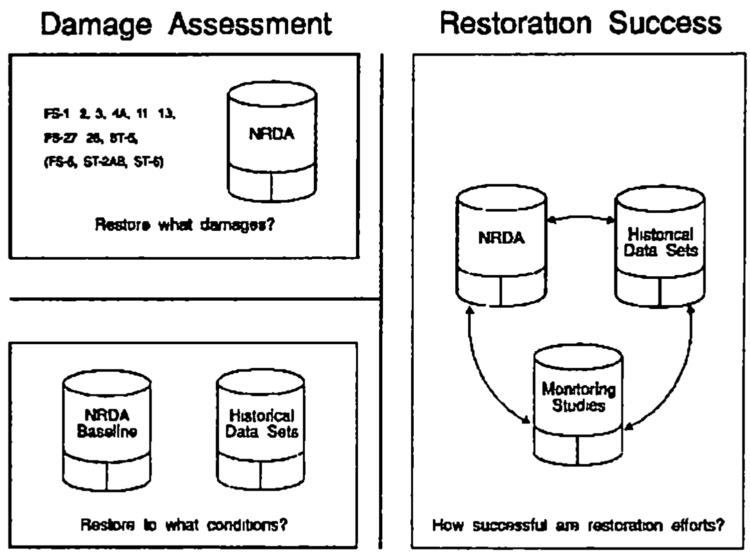
- Proposes to catalogue, archive, and maintain the principal electronic data sets for R-53, 58, 59, 60ABC, 105, 113, (R-90 and 106).



Demonstration of the success of restoration effort depends directly on measurable results. Any restoration assertion is ultimately linked to principal assessment, restoration, and historical data sets.

For this reason, it is important that principal data sets of NRDA studies be documented, archived, and maintained

OBJECTIVES AND PRINCIPAL COMPONENTS



Synthesis

Most of the original NRDA projects are targeted at the species level. Restoration projects which are targeted at the ecosystem level require synthesis of broadly disparate electronic data sets.

In addition, future restoration studies at the species level will depend heavily on access to established assessment and historical data.

FS-30 documents the content of existing NRDA and relevant historical data sets, making the sharing of data between projects possible (This documentation covers all types of data relevant to a given study, and is not limited to chemical or GIS information.)

Data Management

It is important that a principal copy of raw data be identified and archived. When data is shared between projects, multiple copies often diverge; any resulting conflicts must be resolvable through reference to a recognized true copy of the data

FS-30 is responsible for storing true copies of raw data, and documenting changes made through ongoing quality control Inherent in this responsibility is need to limit access to authorized parties. FS-30 also implements regular back-ups of electronic data sets.

Requests for Information

When NRDA data are released by the Trustees, the public demand for this information may overwhelm PIs and support staff, thereby limiting their ability to focus on restoration work By providing a central catalogue of raw data, and a recognized true copy of data sets, the extra work resulting from information requests should be reduced

Confidentiality

The dissemination of certain data integral to NRDA projects is limited by Alaska statute. Personnel associated with FS-30 are charged with tracking this information, and ensuring that state law is not violated.

Technical Support

FS-30 is staffed by data processing and computer professionals. By its nature, this project has close contact with PIs and is aware of their technical needs FS-30 assists PIs and their affiliates with technical issues, and thereby allows these individuals to focus on restoration work

The ADF&G section charged with FS-30 also supports a statewide computer network (separately funded and maintained by ADF&G), which greatly facilitates sharing of information between PIs, Managers, and the Trustee Council Current and future proposals, their support, and on-going requests for additional information rely heavily on this network

General

FS-30 is responsible for constructing a cost effective database management system (DBMS) to readily retrieve and order selected data from original data in electronic form according to user specified criteria of time, space, and other variables The DBMS should be constructed to meet the following criteria, in order of priority:

1. Completeness of contents

2. Speed of retrieval

3. Ease of use in assembling primary data into datasets for further analysis by other software

Specific Objectives

1. Continue maintenance of the secure repository for identified FS and ST studies NRDA and Restoration Project Data

   The data generated from studies relating to the Exxon Valdez oil spill are an important resource for the State of Alaska, the Federal Government, and the scientific community Besides providing information for improved management of natural resources, these data will play a vital role in determining the success of ongoing restoration and enhancement projects.

The data will also serve an important role in subsequent legal actions related to the Exxon Valdez oil spill. Due to the data's potential role in the settlement of legal disputes, it is important that the conclusions derived from raw data be reproducible. When dealing with large raw data sets, reproducibility can only be ensured if a single repository of the data is acknowledged. Without a recognized (single) repository, proliferation of updates and changes in the data across multiple copies may lead to contradictory conclusions

2. Protect project data from accidental loss

   The datasets from NRDA and Restoration Projects should be adequately protected from inadvertent loss Placing a study's principal copy of electronic data on a database server with regularly scheduled backup procedures should reduce the responsibility of the principal investigators in this important task.

3. Provide easy access to designated individuals and agencies

   It is essential that principal investigators have ready access to raw data Research efforts should not be limited by access to data.

4. Limit unauthorized access

   The data storage facility must provide mechanisms for adequate security. Only designated individuals should have access to the data obtained from NRDA and Restoration projects.

5. Establish procedures for sharing data between studies and agencies.

   It is recognized that the collective data of the NRDA studies may lead to conclusions which were not anticipated on a study by study basis. The data should be stored in such a fashion that it is possible to test hypotheses which span multiple studies. To this end, the data from the individual studies must be catalogued and stored in a way that facilitates sharing between studies and agencies.

6. Catalogue NRDA data and future Restoration Project data

   A complete catalogue of Assessment and Restoration Project data should include both general and detailed descriptions of the data. General descriptions should allow an independent party to determine the content and potential relevance of a dataset; detailed descriptions are essential for incorporating data into further studies

7. **Expedite information requests.**

   It is anticipated that future legal action on the Exxon Valdez oil spill may place heavy demands on PIs and staff, both in the form of standard requests for information, as well as through the deposition process. While only the PIs and individuals associated with a specific study are qualified to evaluate and conduct analyses of data, a properly constructed repository of data and clearly defined procedures for accessing raw data should ease the burden of information requests and the demands on individuals involved in deposition.

8. Establish procedures for maintaining the repository data.

   Clearly identified procedures will be implemented for maintaining information in the data repository Such procedures should address the means for adding, deleting, and modifying data in the datasets, and should provide suitable documentation of relevant maintenance activities.

9. Describe the WAN database, and its implications

   A central repository of the data is envisioned. This repository should contain the current principal copy of electronic data for any given study. For performance reasons, it may be necessary to distribute portions of this database to local offices; procedures must be elaborated for synchronizing distributed copies of the datasets

10. Provide both text and Graphical User Interface (GUI) access to historical data bases catch, escapement etc.

    Develop direct access to important historical databases, including the capability for customized record selection, summary, and formatting. PIs can, from personal computers attached to the ADF&G Commercial Fisheries WAN, select data subsets using their own criteria, custom summarize data to 10 levels, then electronically transfer their new dataset to their location for use in their study environment (R BASE, SAS, etc) Records on a detailed level will be available, selected and sorted to the user's specifications

STUDY METHODOLOGY

Access to historic databases in support of NRDA studies will be provided through an interface capable of providing summary and detail records sorted in a variety of output formats according to user specifications. The system will be accessible by authorized IBM-compatible personal computers on the ADF&G Commercial Fisheries WAN. It will be made available through a linked system of Local

Area Networks (LANs) covering offices in Kodiak, Anchorage, Cordova and Juneau. The interface allowing non-programmer access to the database will be developed for text and GUI platforms

The NRDA study databases will be cataloged and stored in a central secure repository. Access to these data will be available to authorized staff. Documentation will include descriptions of each data set, covering aspects of physical layout, fields contained, purpose of data set, and author. This documentation should facilitate sharing data between PIs and agencies. Also, subsequent requests by the public will be facilitated by this documentation

The original scope of data for FS-30 was commercial species from Prince William Sound, Kodiak, Cook Inlet, and Chignik areas After discussions with assessment and restoration researchers we have changed the priority and type of observations to be incorporated. They are, in order of priority:

1. NRDA project data of global interest

2. Commercial fisheries catch and effort data by area, species, and gear type.

3. Salmon escapement data, including aerial survey counts, stream counts, weir counts, and sonar counts.

4. Pre-emergent and egg density counts.

5. Biological data including age composition, size, sex, growth, and stock composition

6. Groundfish and shellfish survey data

This project will make use of an ADF&G statewide database network infrastructure being separately developed with State of Alaska general funds. Exxon Valdez oil spill settlement monies are not used to develop this network

NRDA Project Data Sets

1. A secure database/file server system has been installed. (Objectives 1, 2, 3, 4)

   A database server has been installed in the Region II ADFG office. Separate areas for each of the NRDA studies have been established. Procedures are being developed for establishing accounts, granting access, and ensuring appropriate backup of the datasets

2. The documentation of NRDA (FS,ST) datasets is proceeding in two phases. (Objectives 5, 6, 7)

In the first phase, a general description of the datasets for a given NRDA study are completed Included for each study are a qualitative description of the dataset, an estimate of the size of the dataset, the working format of the dataset, the individual responsible for the content of the data, the primary fields represented, and an estimate of the dataset's completeness and an estimate of the extent to which the data has been verified. In addition, primary investigators and their associates are identified as part of this general documentation process.

In the second phase, detailed descriptions of the data are elaborated. In addition to a textual description for each data field, the following data are defined at the field level: type, size, key status (must exist, must be unique), data validation rules, lookup tables (foreign keys), null values, value justification in the field, and leading fill characters Synonyms for the fields are included where appropriate and known. Record definitions are defined as aggregates of the field definitions

3. Procedures for data maintenance are under development. (Objectives 1, 8, 9)

   Procedures are being developed for maintaining data in the repository. The repository holds the current principal copy of raw data for any given study. Procedures for reporting suspect data, modifying and updating datasets, and logging versions are under development Performance of the WAN must be monitored before the procedures for data maintenance can be finalized

Commercial Fisheries Historical Data

1. Programs have been written to analyze historic harvest data for errors. To date over 3.5 million records from spill affected areas have been searched

2. Original documents have been obtained for incorrect records and corrections applied to the database

3. Documentation has been written and assembled for changes made to the historic database (samples attached)

4. The technical card documenting codes has been revised and will be printed and distributed soon

5. The detailed project plan for developing the historic commercial catch database has been substantially revised, now with an emphasis on NRDA direct access to detailed and summary data, and output formats in ASCII, spreadsheet, and R:BASE formats. (See attachments)

6. Purchase and development of a batch processor (separately funded) is under way and the interim detail data made available to NRDA researchers could be replaced by late spring.

7. The lead programmer is working closely with Commercial Fisheries networking staff to ensure that access to the wide area network is available and compatible with Oil Spill division administration and NRDA projects

8. The Anchorage office is now connected to the department's wide area network Cordova is scheduled to be connected by the end of November The NRDA PIs, their affiliates, and Oil Spill Division staff now communicate and exchange documents via electronic mail.

DELIVERABLES

The primary deliverables for FS-30 include

- Documentation of principal electronic data sets for selected NRDA FS/ST studies and future restoration projects This documentation includes general description of data set content, import/export mechanisms facilitating data sharing between projects and agencies, and detailed data element definitions.

- Archives of principal electronic data sets, and modification logs to principal data

- Support documentation (in electronic form) for selected NRDA FS/ST studies and future restoration projects

- Software systems providing direct access to selected historical fisheries data sets by designated PIs and their affiliates.

SCHEDULE AND TIMELINES

The work of FS-30 is tied directly to the progress of NRDA FS, ST, and Restoration projects Data collected by studies that FS-30 supports is keyed and subjected to quality control measures by the principal investigators of the specific FS, ST, or Restoration Project. After QC is completed, a principal copy is made available to FS-30 for inclusion in the data repository. Concurrent with QC efforts are data documentation procedures which support the principal data sets.

Historical fisheries catch data is currently available to PIs through the Commercial Fisheries Fish Ticket System New user interfaces will be in place for direct access to this data by the end of the state's fiscal year. Additional work on the Fish Ticket system will be completed May 1, 1992. (This additional work, which develops the existing system according to user requests, is separately funded through ADF&G's Commercial Fisheries budget).

FS-30 Database Management:

Catalogues, archives, and maintains the principal copy of raw electronic data sets for FS-1, 2, 3, 4A, 11, 13, 27, 28, ST-5, (FS-5, ST-2AB, ST-6).

Facilitates direct access by PIs to historical fisheries data sets essential to NRDA studies Historical data includes fisheries catch and escapement figures

Proposes to unify the data catalogues and maintenance of principal data sets for continuing ADF&G fisheries assessment / restoration / monitoring projects This should facilitate sharing raw data between agencies and providing this information to the public

Proposes to catalogue, archive, and maintain principal electronic data sets for R-53, 58, 59, 60ABC, 105, and 113, (R-90, and 106).

Provides data processing and technical support for PIs and NRDA functions, including the use of ADF&G Commercial Fisheries WAN (wide area computer network)

ACRONYMS AND ABBREVIATIONS

DBMS - Database Management System
EVOS - Exxon Valdez Oil Spill
FS - Finfish / Shellfish (also, some Subtidal Studies)
FT - Fish Tickets
GUI - Graphic User Interface
NRDA - Natural Resource Damage Assessment
PI - Principal Investigator
WAN - Wide Area Network

SCENARIOS

FS-30 is unique among NRDA projects, in that it participates in the responsibility for maintaining principal copies of raw electronic data from other NRDA studies The unique roll FS-30 plays in NRDA efforts is exemplified by the following possible scenarios.

1.) Different copies of a particular data set are used leading to different conclusions The validity of the data is questioned, and the entire data set is deemed unusable.

FS-30 defines and archives the principal copy of data, and ensures that any changes made to this data are appropriately catalogued

2) A given data set is inadequately documented, and units are omitted. For example, is a given value in fathoms, meters, feet, or yards?

FS-30 directly addresses and eliminates this problem through the data catalogue it maintains

3.) A PI retires or moves on to other work. A recognized copy of raw data may not exist. The value of any existing primary raw data is questionable without adequate support documentation.

FS-30 archives and documents existing data sets, thereby facilitating transition of personnel

4.) The raw data from a given study proves vital to a number of external public agencies and/or private concerns The PI is overwhelmed with requests for information, leading to a compromise of effort on current restoration activity

FS-30 can provide a first point of inquiry regarding raw data, including both general and detailed descriptions of principal data sets. Most initial information should be obtainable without direct interaction with the PI.

5) Because a federal or state agency is not familiar with the details of data from an existing NRDA study, effort is expended to re-obtain information Alternatively, a project is never proposed, because the prospective PI is unaware of existing data obtained through the efforts of other studies

FS-30's catalogue of data sets should provide a general description of what is currently available, and what the possibilities are for future restoration.

	BUDGET ($K)
Salaries	$154 0
Travel	6.9
Contractual	10.4
Supplies	4 6
Equipment	2.8
Subtotal	$178 7
General Administration	23 8
Total	$202 5

SUBTIDAL STUDY NUMBER 5

Study Title: Injury to Shrimp

Lead Agency: ADF&G

PROJECT JUSTIFICATION

PART I

This project is aimed at assessing possible injury to spot shrimp, (Pandalus platyceros), due to oil spilled from the T/V Exxon Valdez, and is a continuation of Fish/Shellfish Study 15 conducted during 1989 and 1990 and Subtidal Study 5 conducted in 1991

Spot shrimp is a representative species of the deepwater nearshore benthic ecosystem, serving as a food source for a variety of fish and shellfish. Spot shrimp share aspects of their distribution and food habits with other economically important fish and shellfish species (Butler 1980). Spot shrimp themselves support important commercial, subsistence and recreational fisheries in Prince William Sound. This species favors steep, rocky habitat which is found in patches throughout Prince William Sound Much of this habitat is contained within the traditional harvest area of the spot shrimp commercial pot fishery, which includes the area west of a line from Montague Point to Bidarka Point A large portion of this harvest area was in the direct path of the 1989 Exxon Valdez oil spill.

Adult spot shrimp, along with other pandalid shrimp, are known to be sensitive (lethal and sublethal effects) to oil contamination (Anderson et al. 1981, Rice et al 1979, Sanborn and Malins 1980, Stickle et al. 1987, Vanderhorst 1976) Larval and juvenile shrimp are known to be more sensitive than adults lower concentrations of oil will kill half the study group in less time (Brodersen et al 1977, Brodersen 1987, Mecklenburg et al 1977, Rice et al 1984) Also, larval and juvenile shrimp may be exposed to higher concentrations of oil contamination toxins than adults since larvae occur in surface waters and juveniles tend to inhabit shallow subtidal areas while adults live well below the surface (Barr 1971, Barr 1973, Butler 1964, Butler 1980).

Sample collection for spot shrimp takes place in the fall, leaving no time for sample analysis prior to the reporting period at the end of November each year Consequently, peer reviewers have not had an opportunity to adequately review 1991 results The Trustee Council has approved a sufficient budget to analyze and report 1991 results which will be forwarded to peer reviewers Based upon their recommendations, the project will go forward with additional sampling in the fall of 1992 or be terminated Two budgets appear at the end of this detailed plan The first is the budget authorized through the end of 1991 sample analysis and reporting (Part I). The second is the budget which may be authorized by the Trustee Council if peer reviewers recommend continued sampling (Part II).

OBJECTIVES

1. Determine the relative abundance by weight, number and sex of spot shrimp, as well as the relative abundance by weight of incidentally caught pink (Pandalus borealis) and coonstripe (Pandalus hypsinotus) shrimp, in oiled and non-oiled areas, and compare these values to those obtained from surveys conducted in 1989, 1990, and 1991.

2. Use historic catch data from the commercial spot shrimp fishery to estimate fishing mortality and effort to

   a). Evaluate the feasibility of incorporating fishing mortality into relative abundance estimations, to improve accuracy of stock assessment estimates.

   b). Compare fishing effort in oiled and unoiled areas between pre- and post-oil spill years

3. Compare size and age frequencies of spot shrimp (by sex) among sites using various methods of length frequency analysis (mixture modal analysis).

4. Compare fecundity, egg mortality, and other sublethal effects between oiled and non-oiled areas over time, and determine whether these effects caused decreased reproductive viability

5. Document injury to spot shrimp tissue samples and compare differences between oiled and non-oiled sites and among years

6. Synthesize information on spot shrimp stock status, hydrocarbon exposure and injuries to determine whether a restoration plan to manage the spot shrimp resource is needed

PART II

The following field work will proceed only if peer reviewers recommend additional sampling after review of 1991 results.

Methodology developed in previous studies (Kimker and Donaldson 1987, Donaldson 1989, Donaldson and Trowbridge 1989, and Kruse and Murphy 1989) will be used again this year.

Data obtained in this study when combined with 1991 study results, will indicate whether spot shrimp juveniles and larvae were exposed to lethal levels of oil contamination (though little knowledge will be gained on whether sublethal exposure occurred). Given the sampling gear used and the growth rate of spot shrimp, 1991 would have been the first year in which recruitment from the 1988 and 1989 year classes would have been observed In the 1992 season, all of the 1988 and most of the 1989 year classes should have recruited in to the sampled population

To determine what effects hydrocarbons from the spill had on spot shrimp, samples will be collected from the same three oiled and three non-oiled sites in western Prince William Sound surveyed in 1989 and 1990. An additional oiled site (Snug Harbor), first sampled in 1991, and an unoiled site (Whale Bay) to be sampled for the first time this year, will be added to the study to give a more balanced design and to use an unoiled area in the southwest Prince William Sound.

METHODS/DATA ANALYSIS

Samples will be collected during November 1992 using the ADF&G research vessel Montague This time frame, while a departure from the 1990 study plan, follows the 1991 study plan in which samples were taken following the fall molt and when egg extrusion was completed. Specific data to be collected are described below.

Study Sites

Spot shrimp habitat within Prince William Sound was divided into oiled and unoiled strata. Localized spot shrimp distribution in these areas was determined from commercial fishermen interviews and results of previous ADF&G studies. Unoiled areas are generally located in the northwestern portion of Prince William Sound Unakwik Inlet, a site used for previous ADF&G studies on abundance and growth of spot shrimp (Kimker 1984, 1985, Kimker and Donaldson 1986, 1987); Port Wells (Golden), Culross Passage, Whale Bay Oiled areas are located in central and southwestern Prince William Sound: Green Island, an ADF&G test fishing site in 1981, Chenega Island (northeast corner), Herring Bay, Snug Harbor.

Sample Design

Each of the eight sites will be sampled at depths between 35 and 130 m This approach differs from the sampling design used in 1989, 1990 and 1991 in which depths greater than 130 m were also sampled Data collected during the last three survey years has shown that spot shrimp were not abundant below 130 m at all sample sites. Thus to lower necessary effort and to make a more balanced statistical design, only one depth stratum will be used this year Also, 1992 sampling will be directed at younger individuals which tend to occur at shallow depths. Reduction in sampling effort at each site will allow two additional sites to be sampled in 1992.

Eleven commercial pots of a standard size, spaced 18 5 m apart, will be fished on a long line. Each string of pots, spanning a distance of 185 m, constitutes a sampling station A minimum of three stations will be fished at each site. Thus, a total of 264 pots (33 pots at each of the 8 sites) will be deployed over the course of the survey. If necessary, pots will be reset and deployed an additional day at each site to obtain adequate sample sizes for length frequency analysis Spot shrimp caught in these extra sets will not be included in relative abundance estimates, since extra sets will be made at depths where large concentrations of shrimp were caught during previous sets

Data Collection

Station information including location (latitude and longitude), depth (fathoms) and time (hours) pots were fished will be recorded by the vessel skipper on a standard form

Environmental Samples

Water temperature, salinity, and dissolved oxygen concentration at each site will be recorded using a Sea Bird Electronics Conductivity, Temperature and Depth (CTD) meter Data will be transferred from the CTD to a micro-computer and stored on diskette. CTD casts will be taken within 1 km of each site The CTD will be lowered at a rate of 60 meters per minute, to provide environmental data at half meter intervals. Due to the configuration of the CTD, only readings from the downcast will be used

Biological Samples:

Total weight of catch, subsample weight, and total weight of each species in a subsample will be recorded at the time each pot is retrieved on a standard form. Total weight of shrimp per pot will be determined by weighing the contents of each pot on an electronic scale. The average number of shrimp per kilogram will also be determined. If less than 500 spot shrimp are estimated caught at a station all of them will be sampled If more than 500 spot shrimp are estimated caught at a station a constant proportion by weight will be subsampled from each pot to obtain approximately 500 spot shrimp.

All spot shrimp in samples and subsamples will have their carapace length measured to the nearest 0.1 millimeter using a digital caliper, and their sex determined according to the methods (Standard Operating Procedure) described by Trowbridge and Coyer (1989: Appendix C). For female spot shrimp the following information will be noted: egg color and stage of development (eyed or uneyed); relative clutch size, presence of breeding dress, occurrence of egg and external parasites Each female retained for fecundity analysis will be identified with a code number to allow cross-referencing of fecundity and other data. All data collected will be recorded on a standard data form

Histopathology Samples:

Specimens to be used for histopathology analysis will be removed from pots before catches are weighed and processed. This will ensure that only freshly killed samples are analyzed. Twenty shrimp from a single station will be selected randomly for each histopathology sample Each histopathology sample will be weighed and recorded on a standard form Histopathology samples will be labeled with the date, station number, latitude and longitude, sample number, project leader's name, species, and agency. Samples will be prepared according to methods specified by Dr. Donald Lightner, associate professor, University of Arizona.

Fecundity Samples:

Fifteen egg-bearing females will be randomly selected from each station to estimate fecundity and egg mortality This will yield a total of 360 females. Specimens from each station will be individually labeled with a fecundity number, their carapace length measured, and placed together in a plastic bag Each sample bag will be labeled with the project leader's name, species name, "eggs", date, station, and agency. Data taken at the time of subsampling will be recorded on a standard form and later entered into an R.base computer file.

Fecundity will be determined by removing all eggs from the pleopods, drying each egg mass to a constant weight, weighing a subsample containing a known number of eggs, and multiplying the weight of the entire clutch by the number of eggs per unit weight in the subsample.

Total number of spot shrimp examined for fecundity estimation will be determined by time and budget constraints If all 15 shrimp from each of the station samples cannot be processed, subsamples will be processed from each station. A minimum of ten shrimp from each station will be sampled to provide an adequate sample size for detecting differences in fecundity among oil impact areas.

Fish Tickets and Log Books

Voluntary log books from commercial spot shrimp fishermen will be collected and copied in Cordova. Fish ticket information will be accessed through the ADF&G records in Juneau. The fish ticket records will be sent on computer diskettes via the United States Postal Service.

Data analysis

Objective number 1 (estimation of relative abundance) will be addressed by calculating average species catch per pot by weight, number, and sex. Analysis of variance (ANOVA) will be used to test for significant differences (p-value < 05) in each of these categories among sites and between oiled and non-oiled areas, using the following model:

$$CPUE_{ijk}=\mu+\alpha_i+\gamma_{j(i)}+\epsilon_{ijk}$$

where μ is the grand mean, α_i is the oiling effect, $\gamma_{j(i)}$ is the site effect nested within oiling strata and ϵ_{ijk} as the error term.

Changes in average catch per pot over time among different sites and between oiled and non-oiled areas will be analyzed using the above ANOVA model with a time term, β_l, added

To meet objective number 2 (examination of fishery trends), information from commercial fishing log books and fish tickets collected both before and after the Exxon Valdez oil spill, will be used to estimate effort and catch in areas frequently fished A weighted fishing intensity term, θ_m, may be added to the above ANOVA model to determine whether differences occurred among sites and between oiled and unoiled areas A weighted fishing intensity term will be used since information may be incomplete and biased and differences in effort occurred throughout Prince William Sound

A size frequency distribution of spot shrimp will be made by sex to address objective number 3 (determination of differences in size and age composition). The hypothesis that no significant difference exists among oil impact areas in size frequency distribution of spot shrimp catches will by tested using quantile-quantile plots, Chi-square (χ^2) tests or other appropriate methods A t- or Mann-Whitney test will be used to test for similarity between means. Changes in size frequency distribution over time will be examined using either a t- or Mann-Whitney test for comparing means and an appropriate method for comparing frequency distributions.

To meet objective number 4 (examination of sublethal effects), the relationship between spot shrimp size and fecundity will be examined. For each station the following will be determined: percentage of female spot shrimp bearing eggs, stage of egg development; percentage of egg fouling and mortality, fecundity by size; relative clutch size χ^2 tests will be used to test for site differences and treatment levels since data will be expressed as percentages. Differences in fecundity and relative clutch size among sites, and between oil and unoiled areas will be tested using ANOVA procedures.

To address objective number 5 (documentation of injury), the percentage of shrimp with abnormal tissues in oiled and non-oiled areas will be determined. A χ^2 test will be used to determine whether differences in the percentage of shrimp with abnormal tissues among sites, and between oiled and unoiled areas

To meet objective number 6 (development of restoration plans), it will be necessary to examine changes in catch per unit effort, age class strength, and reproductive viability to determine whether management actions implemented to restore injured stocks are having the desired effect. Further regulation of human use, including time and area closures may be necessary to reduce fishing mortality on oil-injured stocks and allow them to recover Additionally, the need for continued stock monitoring to evaluate effectiveness of recovery methods will be assessed.

All catch, size, and station data will be entered into R.BASE computer files using portable micro computers Statistical tests will be conducted using commercially available software such as SAS, Minitab, Lotus and SYSTAT software

SCHEDULES AND REPORTS

Date(s)	Activity
November 1992	Field program will last approximately 10 days (Approximately Nov , 1992), Sampling will occur daily while in the field One of the eight sites will be sampled each day, day one will be used for travel to the area and setting the initial 3 strings of pots. The remaining time will be used for resetting pots at sites for which 500 spot shrimp were not obtained
December-February 1993	Data entry & analysis
February-March 1993	Preliminary report on impacts of oil on shrimp
December 1993	Final report on damage assessment on spot shrimp

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Table 1. ADF&G SPOT SHRIMP SAMPLING PLAN

I. SITES

A. Non-oiled
1. Unakwik Inlet
2. Port Wells (Golden)
3. Culross Pass
4. Whale Bay

B. Oiled
1. Herring Bay
2. Chenega Island
3. Green Island
4. Snug Harbor

II. STATIONS

A. Exact station locations at each site were chosen with the help of fishermen experienced at spot shrimp fishing in those areas

B. Each station will consist of one string of eleven pots fished on a long line Pots will be spaced 18 5 m (approximately 10 fathoms) apart for a total length of 185 m for each string of pots.

III FISHING PLAN

A Weekly Schedule

1. Day 1 Sail to Unakwik Inlet set stations 1, 2 and 3.
Day 2 Pick Stations 1, 2 and 3. Sail to Port Wells and set stations 4, 5 and 6
Day 3 Pick stations 4, 5 and 6 Sail to Culross Passage and set stations 7, 8 and 9
Day 4 Pick stations 7, 8 and 9 Sail to Herring Bay and set stations 10, 11 and 12
Day 5 Pick stations 10, 11 and 12 Sail to Chenega Island and set stations 13, 14 and 15
Day 6 Pick stations 13, 14 and 15 Sail to Whale Bay and set stations 16, 17 and 18
Day 7 Pick stations 16, 17 and 18 Sail to Snug Harbor and set stations 19, 20 and 21
Day 8 Pick up Stations 19, 20, 21 Sail to Green Island and set stations 22, 23 and 24
Day 9 Pick stations 22, 23 and 24 Return to Cordova, end of trip

Additional days will be allocated at a given site if the sample size objective of 500 shrimp per site is not achieved

B. Daily Schedule

1. Gear will fish a standardized overnight period of 16 to 18 hours.
2. Pots will be pulled in the morning and subsequently set such that the desired soak time will be achieved If the desired soak time cannot be achieved, pots will be fished to minimize variance from this desired fishing time.

BUDGET ($K)
(Part I - 1991 Analysis and Report only)

Salaries	$17 3
Travel	0.8
Contracts	0.9
Supplies	0 8
Equipment	0.2
Subtotal	$20.0
General Administration	2 7
Total	$22 7

BUDGET ($K)
(Part II - Full Study Pending Peer Reviewer Recommendations)

Salaries	$43 0
Travel	1 8
Contracts	12 3
Supplies	2 4
Equipment	1.9
Subtotal	$61 4
General Administration	6 5
Total	$67 9

SUBTIDAL STUDY NUMBER 8

Study Title: Mussel Tissue and Sediment Hydrocarbon Data Synthesis

Lead Agency: NOAA

INTRODUCTION

The goals of project Subtidal Study #8 are (1) to evaluate the internal consistency of sediment and mussel tissue hydrocarbon data, and (2) to objectively identify the presence of Exxon Valdez petroleum hydrocarbons in these samples The first goal is necessary to minimize the effects of errors in sample collection, documentation, and analysis that are inevitable with a large number of samples collected for several different projects, and that are chemically analyzed using a complex procedure The more of these errors that can be objectively identified, the greater will be the power of subsequent statistical tests The second goal is necessary to provide an objective evaluation of the persistence and geographic extent of petroleum hydrocarbon contamination of these samples. This evaluation will provide a common reference for the participating projects, will minimize duplication of expensive analytical effort, and will provide the most comprehensive view of contamination possible with these data

Inconsistent hydrocarbon data are identified using computer-based statistical methods to identify groups of samples that are clearly biased systematically, or that have been clearly exposed to extraneous contamination unrelated to the oil spill Computer-based methods are necessary because thousands of sediment and mussel tissue samples have been analyzed for 63 independent analytes each. However, these methods are also very powerful just because of the large number of samples involved Once identified, these samples may be excluded from subsequent statistical tests, which may greatly enhance the power of these tests

The presence of Exxon Valdez petroleum hydrocarbons in analyzed samples is objectively determined using a computer-based pattern recognition method called principal component analysis (PCA). This method provides an objective and consistent way of determining the presence and relative amount of oil in samples, and works particularly well with NRDA oil spill samples because the oil spill is by far the major source of hydrocarbons found in Prince William Sound after March 1989

Once Exxon Valdez petroleum hydrocarbons have been objectively and reliably identified in samples, the results can be mapped to yield a picture of the overall extent of contamination By including results from all the projects that collected sediment or mussel tissue samples, the most complete and detailed maps of oil contamination will be prepared, providing a common reference for the participating projects. This, in turn, will provide scientific investigators and the general public with the most accurate indication of the persistence and geographic extent of oil-contaminated sediments and mussels.

OBJECTIVES

A. Develop appropriate criteria for the final acceptance of hydrocarbon data prior to further analysis.

B. Calculate a hydrocarbon summary index that expresses quantitative amount and qualitative character of all hydrocarbons detected in sediment and mussel tissue samples

C. Provide PIs with evaluated sediment and mussel tissue hydrocarbon summaries in the form of tables, charts, graphs and maps.

D. Prepare a comprehensive interpretation of sediment and mussel tissue hydrocarbon data identifying patterns of contamination across all the NRDA projects that generated these samples.

METHODS

A. Sampling methods: No samples will be collected by this project.

B. Standard operating procedure requirements See Data Analysis, below.

C. Quality assurance and control plans See Data Analysis, below.

D. Information required from other investigators Hydrocarbon analysis data and associated sampling data from the Technical Services #1 database

E. Safety requirements: N/A

F. Animal health and welfare N/A

DATA ANALYSIS

Evaluation of Hydrocarbon Data Consistency

Hydrocarbon analytical data will be examined for conformance with two expectations. First, hydrocarbon concentrations in replicate samples are expected to be more or less similar Second, samples collected from a priori control sites are not expected to contain hydrocarbons characteristic of crude oil

A. Replicate Sample Similarity

The procedure described below includes two basic parts; identification of "deviant" samples, followed by an examination of the way these deviant samples are distributed among batches of samples analyzed. Samples may be deviant for many very legitimate reasons. However the samples identified as deviant should not be contained within a very few batches of samples analyzed. If they are, then the batches comprising these deviant samples merit close examination.

Great dissimilarity in hydrocarbon concentrations among samples that are replicates may result from patchiness in the way hydrocarbons are distributed in the matrix sampled, or from systematic bias introduced during sampling, sample storage, or sample analysis. Dissimilarity arising from the way hydrocarbons are distributed in the matrix should be preserved, because one object of sampling is to describe this distribution, so attempts to eliminate such dissimilarity will introduce bias into the data. However, dissimilarity arising from systematic bias should be minimized, to realize the power of subsequent statistical tests.

The samples that contain deviant hydrocarbon concentrations, when compared with their respective replicate samples, should be nearly randomly distributed among all collected samples, if the deviance arises from the way hydrocarbons are distributed in the matrix sampled. Consequently, a very non-random distribution of such dissimilar samples may be taken as an indication of systematic bias For example, if all the deviant samples identified were analyzed on the same day at the same laboratory, then introduction of systematic bias would be suspected. We will therefore determine the probability that such deviant samples have the distribution observed among sample batches, or catalogues, using the procedure following, and assuming a random distribution among catalogues Highly unlikely associations of such samples will be removed from consideration until the distribution of the remaining deviant samples is plausible. In this way, systematic bias will be identified and reduced, without compromising the integrity of the remaining data

1. Identification of Deviant Samples

To determine the probability of an observed distribution of deviant samples among catalogues on the assumption of an underlying random distribution, the deviant samples must first be identified After these deviant samples are identified, the distribution of them among sample analysis catalogues can be compared with random distributions of the same number of deviant samples

Each sample is analyzed for 63 different hydrocarbons A sample will be considered deviant if the concentrations of more than 9 of these are simultaneously very different, when compared with respective concentrations in the remaining replicate samples The justification for this criterion, together with a quantitative definition of what is meant by "very different", is contained in the following procedure that will be used to identify deviant samples.

For each hydrocarbon, the logarithm of the squared range of the hydrocarbon for each set of replicate samples is plotted against the logarithm of the median for that set (Sets of replicates that have zero range for the hydrocarbon considered are not included) The log-log plot accounts for the expected increase in the variance of each hydrocarbon at higher concentration A linear regression line is calculated for this plot, and the replicate sets associated with the highest 5% of positive deviations from this regression line are identified. (Only positively deviant replicates on the plot are identified because these have the largest ranges, the negatively deviant replicates are those that agree most closely for the hydrocarbon under consideration.) Within each set of replicates in the highest 5%, the sample with the deviant hydrocarbon concentration is identified, and that sample is given a score of 1 A tally is then made of the number of hydrocarbons having a score of 1 in each sample of each set of replicates Thus, each replicated sample will contain some number, n, of hydrocarbon concentrations that are identified as deviant using the above procedure.

If the distribution of these deviant hydrocarbon concentrations were random within and among samples, then each hydrocarbon has a 5% probability of being deviant in each sample The probability, P, that a sample will contain n deviant hydrocarbons simultaneously under these assumptions is:

$$1 \qquad P = \binom{k}{n}(0.05)^{n}(0.95)^{k-n}$$

where k = 63 is the number of hydrocarbons analyzed in the sample According to equation 1, the probability that more than 9 hydrocarbons are simultaneously deviant within a sample is less than 0.2% (k=63, n=10). This means that the above procedure will misidentify less than 0.2% of the samples as deviant, if instances of deviation really are randomly distributed within and among samples If deviant samples are identified, they are flagged, and the above process is reiterated using a log-log plot that does not include replicates of the flagged samples. The process is reiterated because exclusion of the flagged samples and their replicates changes the regression line of the log-log plot for each hydrocarbon, which may then reveal new deviant samples Reiterations of the process continue until no additional deviant samples are revealed. Thus, the above provides an objective way of identifying deviant samples.

2. Identification of Suspect Catalogues

Samples may be deviant due to the way hydrocarbons are distributed in the matrix sampled, or due to systematic bias To evaluate these alternatives, we examine the way deviant samples are distributed among sample catalogues, based on an approach that is analogous with eq. 1. Given j samples identified as deviant among a total of J samples initially considered, the probability P that a catalogue containing L samples of which m are deviant is

$$2 \qquad P = \binom{L}{m}\left(\frac{j}{J}\right)^{m}\left(1-\frac{j}{J}\right)^{L-m}$$

assuming the underlying distribution of deviant samples among catalogues is random. These probabilities are calculated for each catalogue, and the plausibility of the observed probabilities is evaluated using a chi-square test An estimate of chi-square is calculated as:

$$3 \qquad \chi^2 = \sum_{i=1}^{h} \frac{((j/J)L_i - m_i)^2}{(j/J)L_i}$$

where h is the number of catalogues considered If this estimate is higher than the critical value of chi-square at $\alpha = 0.05$ and h-2 degrees of freedom, then all the deviant samples associated in the least probable catalogue are flagged as systematically deviant. A new estimate of chi-square is calculated for the remaining catalogues, where both j and J are reduced by the m and L, respectively, of the excluded catalogue The new estimate of chi-square is compared with the critical value, and the process is reiterated until the chi-square estimate is less than the critical value. The catalogues that contain samples flagged as systematically deviant are listed as type I suspect catalogues

B. Evaluation of Hydrocarbons in Control Site Samples

A second list is obtained by reviewing the results of the hydrocarbon analysis for the control site samples These samples were collected from locations picked a priori by the PI for each project, and are not expected to contain hydrocarbons characteristic of crude oil, on the basis of independent evidence (such as other chemical analyses, absence of hydrocarbon degrading bacteria, etc.). The PIs will be polled to identify the sample numbers of such control site samples, and then the number of these catalogue will be determined. Catalogues containing at least 5% of these control site samples will be identified, and the control site samples in these catalogues will be examined for evidence of extraneous hydrocarbon contamination. Extraneous hydrocarbon contamination will be considered present if more than 5 hydrocarbon analytes in the following hydrocarbon classes are present at greater than 5 times their respective method detection limits (MDL): fluorenes, dibenzothiophenes, phenanthrenes, chrysenes, and phytane. Catalogues containing at least 5% control site samples, of which one or more control site samples contain extraneous hydrocarbon contamination, are listed as type II suspect catalogues.

C. Final Data Evaluation

The final acceptability of samples in these catalogues will depend on which of six categories the catalogues belong First, consider catalogues that contain more than 5% control site samples, there are four possibilities. If a catalogue is neither type I nor type II suspect, then all of the samples in that catalogue will be accepted. Alternatively, if a catalogue is both type I and type II suspect, then none of the samples in that catalogue will be accepted. If a catalogue is type I but not type II suspect, then all the identified deviant samples, together with all other samples in the catalogue that do not have replicates, will not be accepted. If a catalogue is type II but not type I suspect, then none of the samples in that catalogue will be accepted.

Second, consider catalogues that contain less than 5% control site samples; there are two possibilities - they may or may not be type I suspect. At a minimum, all the identified dissimilar samples, together with all other samples in the catalogue that do not have replicates, will not be accepted in these type I suspect catalogues.

Samples that are accepted after evaluation using the processes described above will be used for the further statistical tests below.

Hydrocarbon Data Interpretation

There are three main phases to be completed in order to satisfy the objectives of this project after all spurious data have been removed. Each of these phases must be completed for both the sediment and mussel tissue hydrocarbon data Initially, the hydrocarbon analyses will be resolved into a simple index that describes the amount of oil observed at each site. The second phase provides each PI with a summary of their samples and associated amounts of oil. In addition, patterns in the data will be highlighted and statistically interpreted. Finally, the indices will be used in conjunction with a GEO/SQL database to explore the data across projects, and perform the indicated analyses

A. Development of Hydrocarbon Index

An index reflecting the amount of oil in a sample will be developed for accepted samples. This index will be the first component score from a principal component analysis (PCA) for the whole data set. Previous work with a small subset of this data has shown the first component score to be highly correlated with hydrocarbons characteristic of crude oil PCA is an ordination technique where final component scores are derived from the data matrix alone, and no extrinsic values are required PCA resolves the data set into a space described by **k** axes (components) so that each axis accounts for progressively smaller amounts of variance Ideally, the first few components account for the majority of the variance, and the system can be discussed in terms of the reduced space (For a complete description see Gauch 1982). Scores will be obtained by submitting the data set to a PCA routine in the Statistical Analysis System (SAS) computer system After the PCA is completed each PI will receive a report listing the samples retained in the data set, the concentration of each of the hydrocarbons, and the component 1 score.

B. Pattern Recognition and Interpretation

After PCA scores are obtained the scores will be mapped using a GEO/SQL mapping system. Map symbols will be developed that reflect various hydrocarbon quantities and the overall component 1 score. Additional symbols will be developed for each project The symbols will be mapped onto their geographic locations permitting identification of patterns in oil distribution and response variables PIs will be provided with summaries of each analysis, test results, associated maps and rationale

C. Identification of Patterns Across Projects

Once the PIs have been provided with summaries of hydrocarbon analysis for their projects we will begin to explore patterns in oil distribution and response across all projects Response and oiling symbols will be mapped using a GEO/SQL computer system While each project provides insight into the effects of the Exxon Valdez oil spill, the most complete picture will emerge by combining the results of all contributing projects

DELIVERABLES

A. Data - Lists of evaluated samples and associated hydrocarbon indexes will be provided to the PIs who collected the samples.

B. Maps - Maps of hydrocarbon indexes and summary contamination levels will be produced for each project that collected samples, and for all projects together, for 1989 and 1990 samples.

C. Reports - A final report will be prepared describing in detail the final procedures and criteria used, the results, and conclusions supported by the results.

SCHEDULES AND PLANNING

Data and Report Submission Schedule

MILESTONE	EXPECTED COMPLETION DATE
Identification of suspect catalogues	Mar 16 1992
Development of hydrocarbon index	Mar 31 1992
Pattern recognition and interpretation	Aug 30 1992
Pattern recognition across projects	Dec. 1 1993
Final Report	Feb 28 1993

Sample and Data Archival

Data will be archived in the Technical Services #1 database, where additional fields will be added to identify samples associated with suspect catalogues, types of suspect catalogues, and final petroleum hydrocarbon indexes arising from the principal component analysis. Maps will be archived with Technical Services #3

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	BUDGET ($K)
Salaries	$ 118.6
Travel	1.8
Contracts	40.0
Supplies	9.6
Equipment	15.0
Subtotal	$ 185.0
General Administration	20.6
Total	$ 205.6

TECHNICAL SERVICES STUDY NUMBER 1

Study Title: Hydrocarbon Analytical Support Services and Analysis of Distribution and Weathering of Spilled Oil

Lead Agency: NOAA, USFWS

INTRODUCTION

To document the exposure of natural resources to oil spilled by the T/V Exxon Valdez, NRDA projects collected samples of these resources to be analyzed for petroleum hydrocarbons The data from the analysis of these samples define the exposure of that resource to spilled oil, indicate the possible effects of the oil on the resource, and provide information on the subsurface transportation and residence time of the oil These uses require that the analytical data be accurate, precise and comparable across projects and throughout the time of the NRDA process

Technical Services #1, a cooperative project between NOAA and FWS coordinates the chemical analysis of all samples collected by the NRDA studies to develop a single set of analytical data from the Exxon Valdez NRDA effort. This dataset is made up of data and information from all the NRDA projects, supports all the NRDA projects and allows the synthesis of the individual project data and information to form general interpretations and system-wide conclusions.

The NOAA manages those samples from federal or state studies involving water, sediment, fish, shellfish and marine mammals - with the exception of sea otters. The NOAA-managed samples represent 90% of the samples in the sample inventory. The FWS manages those samples from studies involving birds, sea otters and terrestrial mammals. The majority of these samples are being analyzed through a FWS contract with Texas A&M University, the remainder by NOAA/NMFS laboratories The NOAA bears main responsibility for implementing the Quality Assurance programs and updating and maintaining the sample inventory and analytical databases

OBJECTIVES

1. Develop a single, integrated, coordinated set of analytical data from the Exxon Valdez NRDA effort This dataset will consist of analytical data and information from all the NRDA projects, support all the NRDA projects and allow the synthesis of the individual project data to form general interpretations and system-wide conclusions

2 Develop and manage a Quality Assurance program to assure and demonstrate the accuracy, precision and comparability of all chemical analytical data developed by the NRDA.

METHODS

This project will coordinate the analysis of samples for petroleum hydrocarbons and the metabolites of petroleum hydrocarbons. In cooperation with the Project Leader, samples for analysis will be selected based on the quality and relevance of the sample Samples will be selected for analysis in an iterative manner to provide the strongest description of injury for the minimum of cost The project will arrange for analysis and track the samples through this process; provide analytical data to the Project Leader in a timely and useful fashion, and, if requested, assist in the interpretation of these data

The project will:

- Develop and implement Quality Assurance programs for the measurement of petroleum hydrocarbons and their metabolites.
- Select analytical laboratories based on their performance.
- Review and maintain analytical SOPs.
- Develop and provide quality control materials for the metabolite assay
- Monitor the data from the analysis of all quality control materials, i.e. field and analytical blanks and calibration, reference and control materials, to ensure compliance with data acceptance criteria
- Plan and conduct intercomparison exercises to demonstrate the accuracy and comparability of the analytical data.
- Conduct audits of sample and data handling processes
- Develop and implement electronic systems for a) sample inventory and tracking and b) the archival, manipulation and retrieval of the analytical data.
- Define samples in terms of the material collected or subsampled and document it to an exact field collection location and time
- Assign a unique identification code to every sample and subsample to assist in sample and data archival and tracking.
- Archive all analytical data, bulk parameters and supporting QC data as hard copy, electronic copy and supporting documentation, e g. chromatograms
- Examine all data for reasonableness
- Develop a preliminary interpretation of the data and return the results to the Project Leaders

BUDGET ($K)

	NOAA	USFWS	Totals
Salaries	$ 100.5	$ 42 2	$ 142.7
Travel	1.5	1 5	3 0
Contracts	707.5	118 1	825 6
Supplies	0 5	0 2	0 7
Equipment	0 0	0 0	0 0
Subtotal	$ 810.0	$ 162 0	$ 972 0
General Administration	41 7	14 6	56 3
Total	$ 851 7	$ 176 6	$1028 3

TECHNICAL SERVICES STUDY NUMBER 3

Study Title: Geographic Information System (GIS) Technical Support

Lead Agency: USFWS, DNR

PROJECT DESCRIPTION

During 1989 and 1990 this study focused on the acquisition, development and distribution of the centralized NRDA database This information was incorporated into two basic categories primary which includes shoreline oiling, shoreline treatment, coastal morphology, bathymetry, hydrography, wildlife habitat, land status, and land cover, and thematic which includes hydrocarbon information, and wildlife distribution and abundance data In 1991, the study focus shifted toward analytical services through the integration of primary and thematic layers. Examples of products for NRDA data synthesis include distribution of results in a comprehensive manner, relating various themes simultaneously, calculating proximity of one or more themes, and predictive and interpretive modeling of unsampled areas

This project will support NRDA studies that have outstanding GIS components to their data analysis. This information will provide necessary data analysis for the preparation of final reports The preparation of final reports will be essential for understanding the spill injuries. If this information is not clearly and completely available to those responsible for restoration, it will not be possible to adequately address the restoration needs of the resource.

BUDGET

The budget for each agency and the total budget will be developed following Trustee Council approval of projects to be included in the 1992 Work Plan. A placeholder of $375 2K has been identified for this project.

2. RESTORATION

2A. RESTORATION INTRODUCTION

The ultimate aim is to see the Exxon Valdez oil spill area restored to its pre-spill condition. Although natural recovery is effective for some resources, for others restoration will significantly augment the rate of recovery If the rate of natural recovery is determined to be insufficient, certain actions can be taken to assist recovery These actions may vary from management actions that affect use of the natural resources in the region, to actively effecting changes through enhancement or manipulation measures, to acquiring and protecting habitat The following subsections describe restoration projects that have been approved by the Trustee Council for public review

2B. RESTORATION TECHNICAL SUPPORT

The computer technology offered by the Geographic Information System (GIS) group provides graphical and analytical support to the field of natural resource management. GIS provides four levels of information management services that include input; data management (storage and retrieval), manipulation and analysis, and output (maps and tables) It provides an information synthesis and analysis tool for restoration activities Use of GIS for traditional map making will continue to be important to the process, along with data analysis capabilities in a geographic context

RESTORATION PROJECT NUMBER 92

Study Title: Geographic Information System Technical Support

Lead Agencies: USFWS, ADNR

Cooperating Agency: USFS

INTRODUCTION

The Geographic Information System (GIS) technical group was created following the Exxon Valdez oil spill to acquire, develop, and distribute a centralized Natural Resource Damage Assessment (NRDA) database. The information was divided into two basic categories: primary and thematic. Primary data layers include general inventory information such as shoreline oiling, surface oiling, shoreline treatment, coastal morphology, bathymetry, hydrography, wildlife habitat, land status, land cover, and land use Thematic layers are specific to individual NRDA studies and include hydrocarbon information, wildlife distribution and abundance data, and survey transect designs The GIS workload was distributed between the Alaska Department of Natural Resources (ADNR) and the U S. Fish and Wildlife Service (USFWS) to better utilize computer resources and staff expertise The USFWS focused mainly on development of thematic data layers for wildlife resources and provision of analytical services to NRDA studies

The GIS will provide a reservoir of geographic data and assure the consistency and quality of these data It also will provide managers, investigators, and peer reviewers with tools for spatial analysis as a means to better understand complex data. The overlay analysis and data integration capabilities of GIS provide an opportunity to create summaries useful for further statistical analysis by investigators

The USFWS will use GIS primarily as a synthesis and analysis tool for restoration activities. Examples of specific applications include: (a) relating marbled murrelet nest and activity data with land cover and timber information to help describe habitat requirements; and (b) using results from synthesis efforts to identify land protection measures needed to enhance recovery

OBJECTIVES

The GIS technical support group will develop information as needed by project leaders to evaluate or implement specific restoration objectives identified in their detailed study plans

Objectives are:

1. to provide a reservoir of geographic data in support of the restoration process,

2. to assure the consistency and quality of these data;

3. to provide managers, investigators, and peer reviewers with the tools for spatial analysis as a means to better understand complex data, and

4 to produce and disseminate maps and analytical products for participants in the restoration process.

METHODS

ARC/INFO, GIS software will be used to automate, manipulate, analyze, and display NRDA and restoration geographic data in digital form. The ARC/INFO data model (ESRI 1989) organizes geographic data using a relational and topological model to efficiently handle locational features (points, lines or areas) and the attribute data that describe the characteristics of those features Examples of features include points - Technical Services #1 (TS-1) hydrocarbon sample database, lines - Environmental Sensitivity Index (ESI) shoretype data, areas - bathymetric depth zones from NOAA source data These data and all NRDA and restoration data layers are described in the NRDA study plan and report (GIS Technical Group 1989, 1991).

The following list of GIS data layers are available for the restoration process:

Oil on the Water
* ADEC - June 20, 1989 cumulative oiling map
* NOAA - Hazmat trajectory model output data, Oiling is depicted in point, line and polygon (areas) formats

Shoreline Surface Oiling
* ADEC - Summer 1989 shoreline assessment data (cumulative oiling)
* ADEC - Fall 1989 shoreline assessment data
* Multi-agency spring 1990 survey (SSAT)
* Multi-agency spring 1991 survey (MAYSAP)

Shoreline Type
* ESI coastal morphology

Land Ownership
* Comprehensive for spill zone at survey section level of resolution

Hydrography, Anadromous Streams
* Comprehensive for Prince William Sound and Cook Inlet/Kenai, only hydrography for Kodiak/Alaska Peninsula

Bathymetry
* Depth zones, comprehensive for Prince William Sound, Cook Inlet/Kenai and Kodiak/Alaska Peninsula

Topography
* USGS 1:250,000 scale digital elevation model for Cordova, Seward, Seldovia and Kenai quadrangles

USFWS Surveys and Studies
* Designs and results from NRDA boat and aerial surveys for birds and sea otters
* Bald eagle nest database
* Seabird colony locations
* Sea otter radiotelemetry study data
* Marbled murrelet study data for Naked Island, Prince William Sound
* Black oystercatcher nest locations in Prince William Sound study

Hydrocarbon Database (TS-1)
* Point data for samples at various stages of completion

The functional areas of GIS data manipulation are 1) input, 2) analysis; 3) data management; and, 4) display and conversion. All restoration projects to be supported will require effort in one or more functional areas. Based on review of draft restoration study plans, most projects will require some level of data input to include digitizing, editing, or reformatting data into a usable form. Input may be required for data collected by other cooperating agencies. For example, some data from U.S Forest Service (USFS) such as timber type maps may need to be digitized for certain study areas.

Information Required from Other Investigators

* Landcover, forest or timber data (USFS)
* Landcover, forest or timber data (ADNR)

DATA ANALYSIS

It is assumed that all data acquired from cooperators or other investigators in a digital form have been checked and edited for transcription and automation errors It is also assumed that all source and integrated data will be at a comparable input scale.

This project will utilize the analytical capabilities of GIS, taking advantage of the ability to synthesize a variety of data layers and output results for more rigorous statistical analyses by the various PIs. Overlay analysis will be performed with the ARC/INFO data model (ESRI 1989). The overlay process will allow us to combine physical and biological data layers, and output results that depict spatial relationships among the data

For example, analyzing patterns of marbled murrelet activity in relationship to the physical environment, such data as landcover or timber type from USFS will help locate, describe and quantify important components of their habitat Analysis of marine bird boat survey data with overlays of bathymetry and ESI shoreline information will provide descriptions of important use areas.

DELIVERABLES

GIS products will include new data layers for the restoration database, results from spatial analysis of newly integrated data, and appropriate displays of data for reports, briefings or distribution.

All requests for deliverables will be channeled through the GIS project approval process for Technical Service Number 3 (TS-3), adopted by the Restoration Team (RT)

SCHEDULES & PLANNING

Data and Report Submission Schedule

Following the guidelines of the operating procedures for TS-3, adopted by the RT, all GIS services will be channeled through a screening committee for approval After the first quarterly screening committee meeting, a GIS activity timeline will be developed for those projects receiving committee approval The GIS project schedule will be amended, if necessary, following screening committee recommendations

Data Archival

Data will be stored and managed by GIS project staff System security measures will be implemented and backup copies of digital data will be maintained All appropriate restoration data will be exchanged with ADNR GIS group to provide additional data backup

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BUDGET ($K)

The current budget estimate is $125,500. The actual breakout of costs between ADNR and USFWS will be determined during a GIS synthesis meeting in the spring of 1992

2C. RESTORATION RECOVERY MONITORING

Estimates of the rate and adequacy of natural recovery are fundamental to selecting restoration measures. In some cases, it may be appropriate to allow natural recovery to proceed without human intervention. Determining when, and if, natural recovery restores injured resources or services to their pre-spill baseline conditions is essential to understanding how the oil-affected environment is responding to the healing effects of time. This will be an important concept in considering the effectiveness of no-action/natural recovery as a restoration alternative

To maximize the benefits of restoration expenditures, it will be necessary to consider whether natural recovery has occurred or is occurring before investing restoration funds As restoration options are implemented, recovery monitoring will also be important to evaluate the effectiveness of restoration and to identify where additional restoration actions may be necessary In a scientific sense, full ecological recovery will have been achieved when the full contingent of pre-spill flora and fauna are again present and productive, and affected environments have achieved normal age distributions indicating a healthy system

The duration of recovery monitoring will depend upon the time necessary to establish recovery or a trend for recovery This, in turn, will depend upon the severity of the acute effects of the spill and implications of the chronic effects of the spill at the population level.

RESTORATION PROJECT NUMBER 11

Study Title: Murre Restoration Project

Lead Agency. USFWS

INTRODUCTION

The 1989 oil spill in Prince William Sound prompted surveys of seabird colonies in Prince William Sound and other areas westward along the spill trajectory. Most of these colonies have had censuses at least two and up to six different years out of the 18 years prior to the oil spill Murres and kittiwakes on one nearby colony site, Middleton Island, have been censused 14 of the last 18 years. Cliff-nesting species such as the black-legged kittiwake and common murre were the primary emphasis of the 1989-90 censuses Timing of egg laying and productivity (numbers of fledging chicks) were also noted for these species. In 1990, and continuing in 1991, the major effort was placed on replicate counts of murres in those areas that showed the most drastic changes relative to historical data. Semidi Islands and Middleton Island monitoring continued as the main control sites for murres (Nysewander, 1990, Nysewander and Dippel, 1990, Nysewander and Dippel 1991 - NRDA studies).

Approximately 320 seabird colonies, not including the Semidi Islands, occur within the area affected by the oil spill These colonies contain about 1 million breeding seabirds of which about 300,000 are breeding murres (U S Fish and Wildlife, Catalog of Alaskan Seabird Colonies--Computer Archives 1986) Diving seabirds like murres are known to be easily impacted by oil spills (King and Sanger, 1979). In addition, these species are long-lived with low reproductive rates, thus making any mortality of adults a critical factor in these species' ability to recover Direct mortality immediately following the spill was estimated at about 300,000 murres, including wintering and non-breeding birds

This project will monitor the recovery of breeding common and thick-billed murres in the Barren Islands and Puale Bay colonies on the Alaska Peninsula. The reductions in numbers of breeding adults at these colonies, the delayed reproductive chronology, the lack of synchrony of egg laying, and the low or zero reproductive success seen the last three years at these colonies in the oil spill area are the major injuries that will be monitored by this study The murre population in the oil spill area began to show some slight signs of recovery in 1991. However, the population may have essentially produced no young for three years, which could greatly extend the time needed for full recovery The next several years of monitoring data for murres will give us important insight on how a murre colony recovers from such injury and how recovery might be facilitated if desirable. The extent and persistence of injury will determine the level of restoration necessary

OBJECTIVES

1. Document rate of recovery of murres breeding in the Barren Islands and at Puale Bay by determining the number of breeding adults and their reproductive success and chronology

2. Use time lapse video camera equipment to improve methods of censusing murre colonies for reproductive data where boat-based censusing has historically been the only option

METHODS

A and B. Sampling Methods and SOP Requirements

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

1. Population counts will be a combination of total island or subcolony counts and plot counts These counts will be accomplished by a combination of land-based and boat-based counts, depending on the historical and feasible options for each site In all cases, the population counts will be replicated over 5-7 separate days when conditions are optimal during the period in the reproductive cycle when most birds are incubating eggs Large format photo documentation will also be used on the plots and colonies. Photos taken simultaneously while a count is being done have the potential for establishing correction factors of photo interpretation. Standard methodologies for counts will be followed (Byrd 1989; Hatch and Hatch 1988 and 1989, Irons et al. 1987, Nishimoto and Rice 1987) The specific procedures of boat-based counting are the following.

a) Anchor the boat or hold it in one position by motoring

b) Use the largest boat available or feasible, ideally boats no smaller than 25 feet Conduct boat censuses when seas are less than three feet and there is little or no rain

c) Murres are counted individually in small colonies or cliff sections and in blocks of ten for larger concentrations

d) Three to five people count a plot or section of a plot at least two times each without revealing their counts to each other

e) The counts are then compared to see if they fall within 5-10% of each other, thus catching any obvious lapses or double counts (quality control)

f) More counts are made if there is much difference in the counts.

g) The mean of the majority of counts (at least four to five) that clump together are used for the count in reporting for that particular plot

h) This process is repeated on five or more days during the incubation phase of murre reproduction.

In the past (NRDA bird study number 3), population counts have been done at the major murre colonies near Puale Bay, Cape Aklek and Cape Unalishagvak, using the M/V Surfbird as the counting platform Funding for these counts is no longer available, since these counts are not possible without the use of a larger support vessel For the Barren Islands, several one-week trips will be planned to cover the extended breeding season.

2. Chronology and productivity will be studied using land-based plots. At the Barren Islands, traditional land-based monitoring of productivity has not been possible due to geographic and logistical concerns. However, past efforts will be expanded by putting some blinds on sites like E. Amatuli Light The use of time lapse video cameras will also be expanded For Puale Bay, nesting phenology and reproductive performance on land-based plots will be determined by viewing nests at regular intervals of approximately three days Nest sites will be numbered on plot photographs and drawings and then checked throughout the field season Attendance of adults, nest starts, and the presence or absence of eggs or chicks will be recorded for kittiwakes and fulmars, while the presence of an egg or chick is the prime observation on murres. For murres, it is frequently not possible to see the contents of a nest site because the birds remain motionless for long periods of time Distinctive behavior (e.g. wings held over the back so that tips do not cross, tail down, back slightly humped) is used to indicate that a murre is incubating an egg. However, because it is possible to misinterpret such posture, a bird must be observed in "incubating posture" on at least three consecutive checks to consider the site as having an egg. Observations of wing positioning will be used to indicate that a murre has a chick However, only one sighting of wing mantling is necessary to consider a murre to have a chick or to be in a "brooding posture". The conventions of murre monitoring (Mendenhall 1991) as used by the Alaska Maritime National Wildlife Refuge are and will be used to resolve any questions of interpretation.

C Quality Assurance and Control Plans

To ensure that standard censusing procedures are followed, all personnel will participate in trial surveys prior to initial censusing. This training, along with previously mentioned methods, will ensure the integrity of the data collected

D. Information Required from Other Investigators

Information required from other investigators should be minimal. Improved oil drift maps with shorter time intervals will be helpful in answering some questions (provided by the GIS technical support group).

E. Safety Requirements

All personnel are required to participate in the Alaska Maritime National Wildlife Refuge safety program before going into the field. Included in this training are small boat operation, immersion suit use, cold water survival, shore survival, bear encounter training, and CPR and first aid training The safety plan is on file at the Refuge headquarters

F Animal Health and Welfare

Animal health and welfare is not a concern with this study since trapping or capturing of murres is not planned

DATA ANALYSIS

The standard procedures and assumptions used by the U S. Fish and Wildlife Service for censusing colonies in the Alaska Maritime National Wildlife Refuge are described by Garton 1988 and Byrd 1989. Key assumptions include 1)Plots, by necessity, are not random and selection is based on accessibility, hence this study assumes that plot counts are representative of the entire colony 2)Plot counts and counts of entire colonies are considered indices, and this study assumes that changes in these indices represent the changes occurring in the colony 3)Plot counts are unlikely to be normally distributed and are more likely to be skewed and clumped This type of data requires either very large sample sizes, the use of a non-parametric test, or logarithmic transformation prior to testing by the appropriate parametric test. Logarithmic transformation normalizes the data and is required for valid application of statistical tests when sample sizes are small (Fowler and Cohen 1986; D. Robson pers. comm) Under standard USFWS procedures trends among years are compared using replicate counts where all plots are censuses each count day and these counts are replicated on successive days. Within-year replication is useful to test for annual variation, but annual variation is anticipated even without the influence of a factor such as an oil spill The important question is therefore whether the post-oil colony numbers are outside the annual variation in colony numbers that would be expected from past historical data without oiling effects.

DELIVERABLES

A final report will be generated in January, 1993

SCHEDULES & PLANNING

A. Data and Report Submission Schedule

Puale Bay field camp deployment· 15 June 1992
Begin Barren Island colony census: 6 July 1992
Complete Barren Island colony census. 3 September 1992
Puale Bay field camp closed 30 September 1992
Complete final report. 25 January 1993

B. Data Archival

Data from this study will be archived in the U S Fish and Wildlife Service Seabird Colony Catalog. All data forms and log books will be kept at the Alaska Maritime National Wildlife Refuge office in Homer, Alaska. Copies of these data will be sent to the FWS oil spill files in the Anchorage Regional Office

C Management Plan

This study will be managed by a principal investigator, who will be responsible for either coordinating the collection of, or generating field data, and for the timely reporting of the data in draft and final reports. The interim principal investigator will be Dave Nysewander.

D. Logistics

To complete the proposed study will require the use of the M/V Sandlance (25ft Boston Whaler) and support from a larger vessel able to accommodate up to six field personnel A field camp is required at Puale Bay. See appendix for map of areas covered by this study.

PERSONNEL QUALIFICATIONS

Principal Investigator - David Nysewander Dave Nysewander received his B.S. from the University of Michigan and Principia College in 1965 and his M.S. in wildlife biology from the University of Washington in 1977. From 1973 to 1975 he worked in Washington State on colony censuses and reproductive biology of marine and shorebirds. He joined the U.S. Fish and Wildlife Service in Alaska in 1975. Between 1975 and 1989 he has held several positions with the Service: 1) from 1975 to 1980 he served as biologist and camp leader on pelagic and colony studies, specializing on Gulf of Alaska sites associated with the Offshore Continental Shelf Evaluation and Assessment Project in the Service's Office of Biological Services/Coastal Ecosystems, 2) from 1980 to 1986 he served with the Marine Bird Management Project in Alaska as wildlife biologist and later as acting project leader, specializing in distribution, colony census, and productivity of marine birds and mammals in Prince William Sound, southeastern Alaska, Kodiak Island, Cook Inlet, and eastern Aleutian Islands, 3) from 1986 to the present he served with the Alaska Maritime National Wildlife Refuge primarily as a supervisory wildlife biologist, whose work has dealt with colony censuses and monitoring, reproductive biology, and distribution of marine birds along with management concerns like eradication of introduced predators and reintroduction of endangered species, 4) from 1989 to present he has been the principal investigator for the Exxon Valdez oil spill natural resource damage assessment - bird study #3 which, in essence, this study will continue. In 1991 he served as a peer reviewer for the Apex Houston oil spill which occurred along the California coast

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	BUDGET ($K)
Salaries	$ 121 2
Travel	5.8
Contractual	93 5
Commodities	29 0
Equipment	42 5
Other Non-Contractual	0 0
Subtotal	$ 292.0
General Administration	24 7
Total	$ 316 7

RESTORATION PROJECT NUMBER 60C

Study Title: Injury To Salmon Eggs and Pre-emergent Fry In Prince William Sound

Lead Agency: ADF&G

INTRODUCTION

Pink salmon (<u>Oncorhynchus gorbuscha</u>) is a key species in the Prince William Sound 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 areas in the North Pacific to nearshore waters and upstream areas of Prince William Sound

Wild pink salmon production in Prince William Sound 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 Prince William Sound Oil from the March 24, 1989, <u>Exxon Valdez</u> oil spill 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 western Prince William Sound 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 physical and genetic abnormalities in alevins and fry. Emergent salmon fry and smolt from throughout Prince William Sound migrated through and developed in areas contaminated by oil These fry had diminished growth and lowered survival. This suite of injuries has led to an apparent decline in the size and overall well-being of wild pink salmon which may persist for several years

The Alaska Department of Fish and Game (ADF&G) has sampled pink and chum salmon pre-emergent fry since the 1960's in order to predict the magnitude of future salmon returns The oil spill had the potential to cause mortality to the critical egg and fry life stages, and thus an increased and more comprehensive fry sampling program was necessary An expanded NRDA study of eggs and fry along with NRDA F/S Studies 1, 3, and 4 supported a comprehensive and integrated determination of injury to Prince William Sound salmon stocks. Results included documentation of oil in intertidal salmon spawning habitat, pre-spill and post-spill estimates of total adult returns of wild and hatchery stocks, wild stock spawning success, wild stock egg to fry survival, and early marine survival of wild and hatchery stocks. Information on the extent and persistence of oil in the intertidal zone has been supplemented by Coastal Habitat Study 1A.

The goal of continuing the egg and pre-emergent fry damage assessment project as a restoration project is to monitor recovery of Prince William Sound wild pink salmon stocks injured by the Exxon Valdez oil spill. Injury to pink salmon eggs, alevins and juveniles from the oil spill may be persistent since oil remaining in streams may continue to cause reduced survival, and genetic damage from oil contamination may persist for several generations Efforts to restore injured pink salmon populations depend upon the ability to identify sources of reduced survival and to monitor their disappearance or persistence

OBJECTIVES

1 Estimate the density, by tide zone, of pre-emergent fry in 48 streams and eggs in 31 streams using numbers of live and dead eggs and fry.

2. Estimate egg mortality and overwinter survival of pink and chum salmon eggs in both oiled and unoiled (control) streams.

3. Document hydrocarbon contamination in pre-emergent fry using tissue hydrocarbon analysis and for eggs and pre-emergent fry using mixed-function oxidase (MFO) analysis

4. Investigate probable causes of continued high mortality of eggs in oiled streams in 1991. Investigations may include but will not be limited to cytogenetic studies designed to document genetic damage to germ cells in populations exposed to oil as eggs or fry in 1989 and 1990 Pending a peer review meeting with other project scientists, detailed methods cannot be described for achieving this objective.

5. Assess any loss in adult production from changes in overwinter survival using the results of NRDA F/S Studies 1, 2, 3, and 4

METHODS

There are approximately 900 anadromous fish streams in Prince William Sound. Pre-emergent fry sampling from some of these streams has historically provided a pink salmon abundance index which was used to forecast future returns In recent years, 25 index systems considered representative of pink and chum salmon producing streams have been sampled Sampling had been performed on as many as 45 streams prior to 1985 This study is designed to compare rates of mortality and abundance among areas with various levels of oil impacts.

Sampling will consist of egg deposition surveys performed from late September to mid-October and pre-emergent fry sampling conducted from mid-March to mid-April. Spring fry sampling in 1992 will be conducted on 48 streams These will include the 25 streams in the ongoing ADF&G pre-emergent index program plus 23 additional streams. The additional streams are located in Central and Southwest Prince William Sound where most of the oiling occurred. New study streams were selected using the following criteria·

1. Adult salmon returns were expected to be large enough to indicate a high probability of success in egg and fry sampling.

2. Egg and fry sampling had been done in past years.

3 Streams with low to no oil impact, i e., controls, were selected in the immediate vicinity of high oil impact streams to help account for possible variability in egg and fry survival due to different environmental conditions

Most of the streams with suspected or obvious oil impact were not sampled prior to the <u>Exxon</u> <u>Valdez</u> oil spill The 30 streams in low impact areas include 27 with a history of sampling, six suspected of having received some impact including four with a history of sampling; and 12 streams with oil visibly present in the intertidal zone, including five with a history of sampling

Egg sampling will be conducted in the fall on 31 of the 48 streams sampled for pre-emergent fry. Streams included in the fry sampling program but not in the egg program are traditional fry sampling streams located on the eastern and northern shore of Prince William Sound. These streams are outside the area studied for oil impact effects. The 13 streams in low impact areas left in the egg sampling program include four with a history of sampling Streams suspected of having some oil impact and streams which had visibly obvious impact are included in both the egg and fry sampling programs.

Sampling methods are identical for the pre-emergent fry and egg sampling and are modeled after procedures described by Pirtle and McCurdy (1977) On each study stream, four zones, three intertidal and one above most tidal influence, will be identified and marked during pre-emergent fry sampling The zones are 1 8-2 4 m, 2 4-3 0 m, 3.0-3.7 m above mean low water, and upstream of mean high tide (3.7 m). Separate linear transects 30 5 m in length will be established for egg and pre-emergent fry samples in each zone (one transect for each type of dig in each zone) The transects will run diagonally across the river with the downstream end located against one bank and the upstream end against the opposite bank Overlapping of transects will be minimized to control the influence of fall egg sampling on perceived abundance of fry during spring sampling. Fourteen 0.3 m^2, circular digs (56 per stream) will be systematically made along each transect using a high pressure hose to flush eggs and fry from the gravel. Eggs and fry will be caught in a specially designed net.

The following data will be collected for each tide zone transect during both egg and fry sampling:

1. The sample date.
2. The sample tide zone.
3. The start and stop time for each tide zone transect
4. Numbers and condition (live or dead) of fry and eggs by species for each dig.
5. A subjective estimate of the overall percent yolk sac absorption for fry in each dig sample

Data will be entered from "Rite in the Rain" books into a Lotus spreadsheet for editing and summarization

Pink salmon eggs will be separated from chum and coho (*O kisutch*) salmon eggs by their smaller size Chum salmon eggs will be separated from coho salmon eggs by their greater development and different coloration. An egg will be considered dead if it is opaque or discolored with concentrations of lipids Pink salmon fry will be differentiated from chum salmon fry by their smaller size and lack of parr marks Sampling will often kill fry (especially newly hatched fry), so fry will only be considered dead if decomposition is evident.

Pre-emergent pink salmon fry will be collected for tissue samples from the intertidal channels of streams Tissue samples will be analyzed for the presence of hydrocarbons characteristic of those found in oil from the T/V Exxon Valdez

Fry sampled for hydrocarbon analysis will be collected from the intertidal stream bed at a level approximately 2 5 m above mean low water. Samples will be collected when the tide is below that level to avoid contamination from any surface oil film A clam rake will be used to dislodge the fry from the gravel. A stainless steel strainer, pre-rinsed in dimethylchloride and dried, will be used to catch fry as they are swept downstream Captured fry will be placed in jars with teflon lined lids and frozen Replicate samples of fry will be collected whenever possible.

Eggs and fry from each tide zone will also be collected for mixed-function oxidase (MFO) analysis Live eggs and fry will be separated from dead eggs and fry for all digs in a transect and then randomly selected from the total Whenever possible, two samples of at least 50 live eggs and fry and one sample of at least 50 dead eggs and fry will be collected and placed in glass jars containing phosphate buffered formalin solution.

DATA ANALYSIS

Numbers of live and dead pre-emergent fry and eggs will be summarized by date, stream, level of hydrocarbon impact, and stream zone. Densities of live eggs for stream i, zone j in m^2 (E_{ij}) will be estimated by:

$$\hat{E}_{ij} = \frac{\Sigma LE_{ijk}}{0.3n_{ij}} \quad , \tag{6}$$

where LE_{ijk} is the number of live eggs found in the k^{th} dig, in stream i, zone j, and n_{ij} is the number of digs from stream i, zone j. Densities of dead eggs as well as dead and live fry will be calculated using the same estimator with appropriate substitutions

Pink salmon egg mortality will be estimated for each stream using the following relationship:

$$\hat{M}_{ij} = \frac{\Sigma(DE_{eijk} + DF_{eijk})}{\Sigma(LE_{eijk} + DE_{eijk} + LF_{eijk} + DF_{eijk})} \quad , \tag{7}$$

where DE_{eijk}, DF_{eijk}, LE_{eijk}, and LF_{eijk} are the number of dead eggs, dead fry, live eggs, and live fry for the k^{th} dig from stream i, zone j, collected during egg dig e, respectively

The Arcsin square root transformation will be examined as well as the Logit transform of egg mortality [ln (odds)]

$$\mathrm{Logit}_{ij} = \ln\left[\frac{\Sigma(DE_{eijk} + DF_{eijk})}{\Sigma(LE_{eijk} + LF_{eijk})}\right] \tag{8}$$

Pink salmon egg to pre-emergent fry survival will be estimated as

$$\hat{S}_{ij} = \frac{(\Sigma LF_{fijk}) / n_f}{\Sigma(LE_{eijk} + DE_{eijk} + LF_{eijk} + DF_{eijk}) / n_e} \quad , \tag{9}$$

where LF_{fijk} is the number of live fry for the k^{th} dig from stream i, zone j, collected during fry dig f, and n_e and n_f are the number of digs for stream i, zone j for egg dig e and fry dig f

Differences in egg mortality and survival will be examined using a mixed effects two-factor experiment with repeated measures on one factor (Neter, Wasserman, and Kutner, 1985)

$$Y_{ijk} = \mu + O_i + Z_j + (OZ)_{ij} + S_{k(i)} + e_{(ijk)} \qquad (10)$$

The two treatments will be extent of oiling, (O_i, 2 levels, oiled and unoiled), and height in the intertidal zone (Z_j, 4 levels, 2 1, 2.7, and 3.4 m above mean low water, and upstream) both fixed effects. The data will be blocked by stream ($S_{k(i)}$), a random effect nested within extent of oiling. The interaction of extent of oiling and height in the intertidal zone will also be examined. Equality of variances will be tested using the F_{max}-test (Sokal and Rohlf, 1969), while normality will be visually assessed using normal quantile-quantile and box plots (Chambers et al 1983) If the data appear to be non-normal, data transformations will be examined If a significant difference due to oiling is detected (α = 0 05), four contrasts (oil vs. unoiled for the four stream zones) and corresponding Bonferroni family confidence intervals (α = 0.10 overall) will be estimated.

Extent of oiling for analysis will be based on visual observations of streams (NRDA F/S Study 1 and 2) and the hydrocarbon results from mussel samples (NRDA F/S Study 1) Different groupings of oiled and unoiled streams will be analyzed if evidence of oiling is not consistent.

Power of the test was estimated for the analysis of variance using data from the 1976 and 1977 egg and pre-emergent fry samples in Prince William Sound These data indicated the ability to detect an increase of 15% in egg to fry mortality (e.g 10% mortality to 25% mortality) at α = 0 05, 95% of the time.

DELIVERABLES

The main product from this project will be a report which summarizes the results of the current-year egg and pre-emergent fry data The most significant information on injuries demonstrated in 1989 through 1991 will be written up as a close out report for the NRDA Study.

SCHEDULES AND PLANNING

Field Work, Data Analysis and Report Submission Schedule

Dates	Activity
March 16-April 10, 1992	Pre-emergent fry sampling on 48 streams.
May 1-September 1, 1992	Analysis and preliminary summarization of 1992 pre-emergent data
September 15-October 15, 1992	Egg deposition sampling.
October 30-December 15, 1992	Analysis of egg data and final report for egg and fry data

A final report will be completed by February 28, 1993

Sample and Data Recording, Processing and Archival

Numbers of live and dead eggs and fry by stream, tide zone, transect, dig location and species are recorded in pre-printed "Rite in the Rain" books which are archived in local storage in the Cordova ADF&G office. Data from notebooks will be entered into an R:BASE data base which will be added to an existing historic egg and fry sampling data base dating back to 1960. There is a row in the data base for each 0 3m^2 sample which is identified by stream number (ADF&G Stream Catalogue), stream name, elevation above mean low tide, a standardized transect location code, and a sequential sample site number within each transect. Each row also contains the number of live and dead eggs and fry by species in each 0 3m^2 sample, a sample condition code which describes stream conditions affecting sampling (ie stream dry or iced over), and a code for other species or parasites present (i e flat worms, copepods, etc.).

R.BASE is used for basic data summarization and additional detailed statistical analyses are done in LOTUS, SYSTAT, SPSS, and other micro-computer based statistical packages All raw and summarized data and reports are stored as hard copy and electronically on diskettes and on magnetic tape in two separate ADF&G offices in Cordova.

Biological samples for hydrocarbon, MFO, histopathology, and genetics analyses are clearly labeled both on the inside and outside of the container. Labels are in indelible ink on write in the rain paper and include an ADF&G stream catalogue number, stream name, stream-mouth latitude and longitude, sample transect height above mean low tide, sample date and time, sample collectors, preservative used, species, and tissue type Standard chain of custody forms are filled out for all samples and samples are stored in locked storage in the ADF&G warehouse prior to shipment for analyses.

MANAGEMENT PLAN

Overall supervision of this project will rest with the ADF&G Fisheries Biologist III, principal investigator The Fisheries Biologist III will supervise a Fisheries Biologist assistant and the daily activities of a data entry technician or research analyst. Field work will be reviewed periodically by the principal investigator but daily supervision will be the responsibility of the Fisheries Biologist I project assistant The project assistant will supervise a field crew of three or at times four Fish and Wildlife Technicians. All payroll and administrative tasks for this project will be completed by ADF&G Oil Spill Impact Assessment Division and ADF&G Division of Administration personnel The consulting Biometrician II will review all operational plans, project reports, and be responsible for all statistical products and statistical reporting

LOGISTICS

Sampling crews will be transported between sampling locations by the ADF&G R/V Montague which will be used for the purpose Crews will be housed and fed aboard the R/V Montague and will be transported to shore at each stream in a project skiff piloted by a vessel crew member. Sample sites for pre-emergent fry and egg deposition are shown in Figures 1 and 2

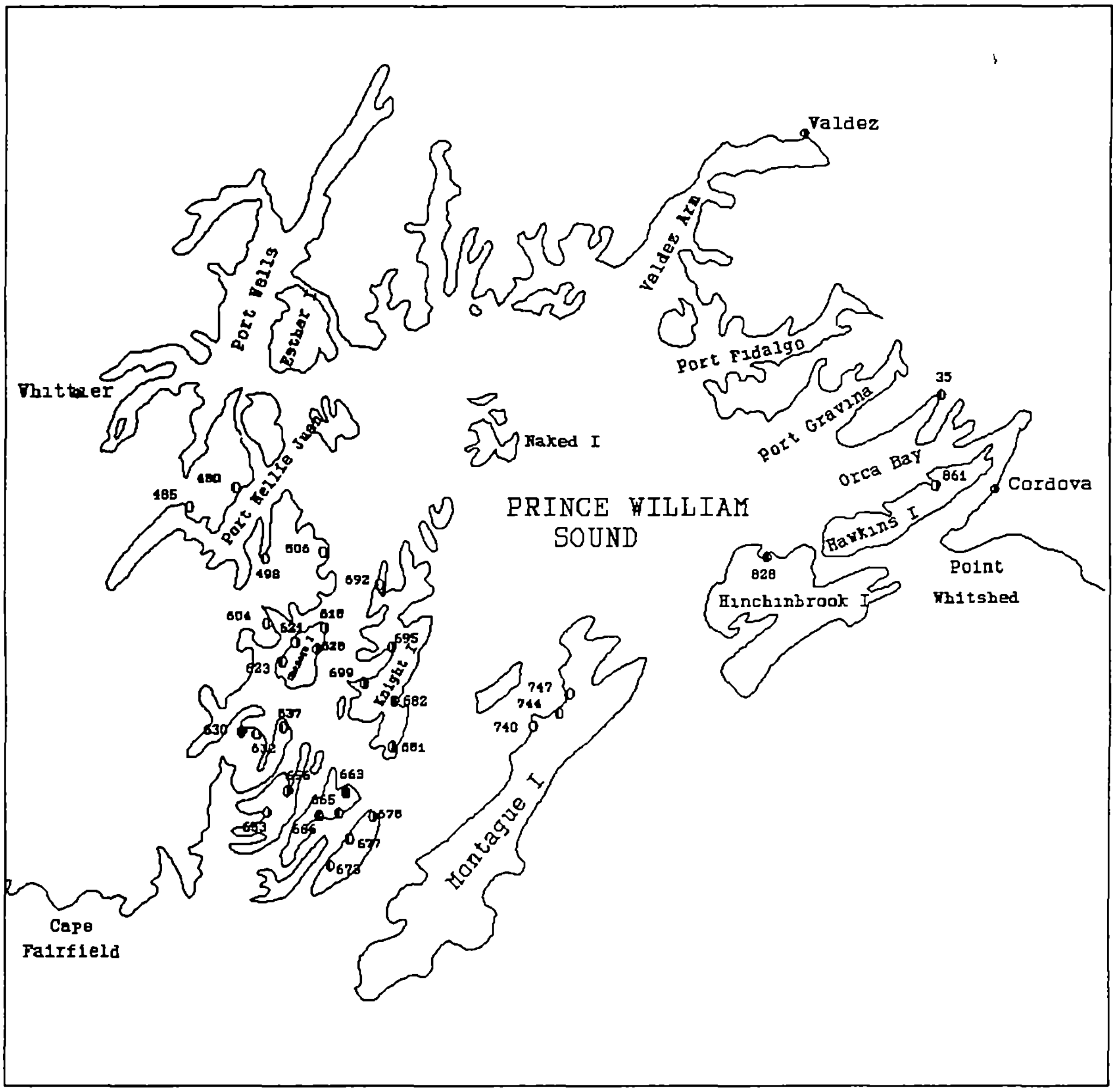

Figure 1 Location of streams to be sampled for egg deposition

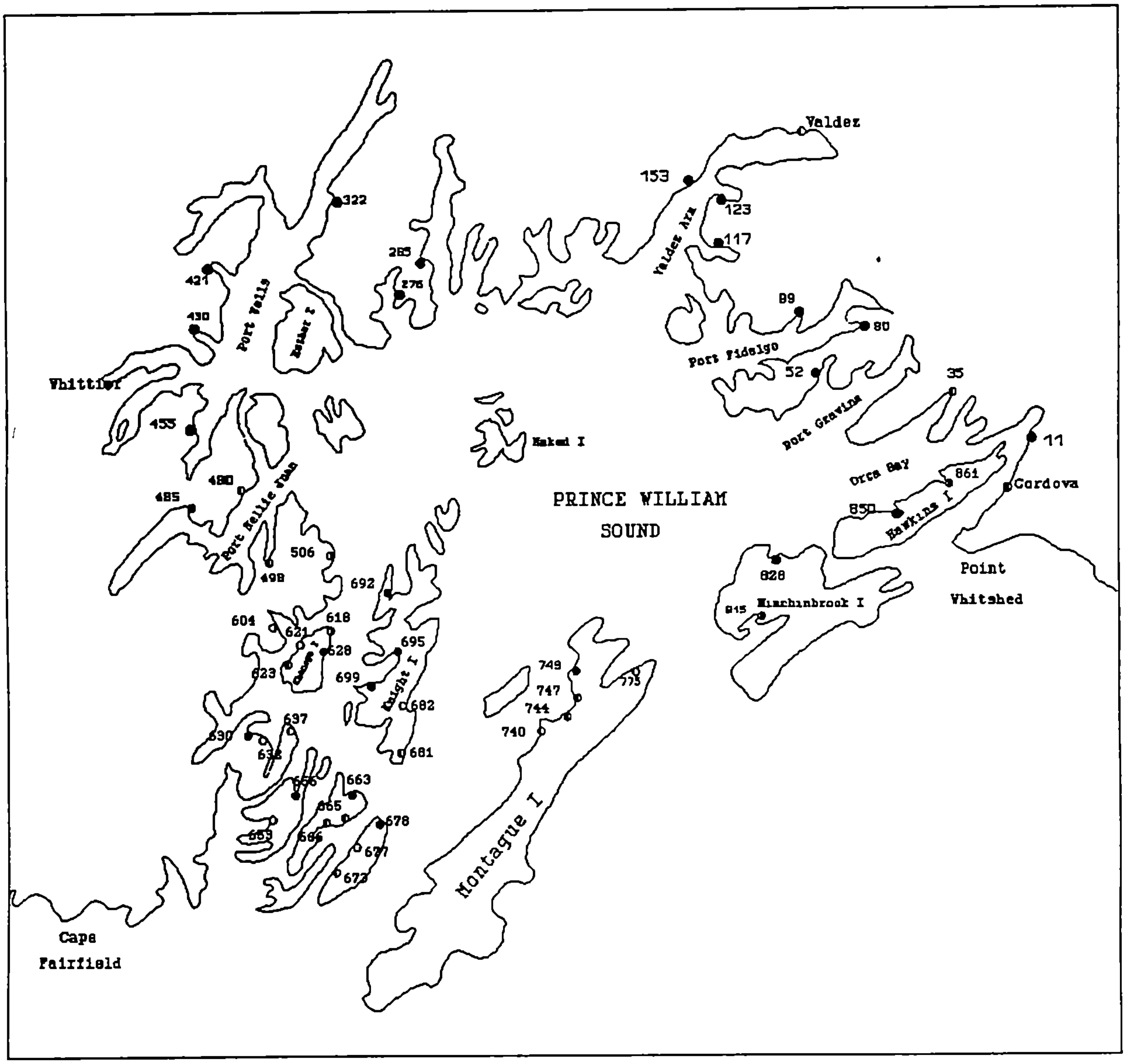

Figure 2. Locations of streams to be sampled for pre-emergent fry.

PROJECT PERSONNEL

Fisheries Biologist III Principal Investigator - Samuel Sharr

Mr. Sharr received a Bachelor of Science degree in Biology from the University of Washington in 1968 He has been a research biologist for ADF&G since 1979 and has worked on Prince William Sound salmon and herring since 1981. He assumed his present position as the ADF&G, Division of Commercial Fisheries, Biologist III, Prince William Sound Area Finfish Research Project Leader in 1986 In this capacity, Mr. Sharr oversees all the salmon and herring research conducted by the Division of Commercial Fisheries in Prince William Sound. His involvement with the Prince William Sound salmon escapement aerial survey program dates from the early 1980's. Mr Sharr has supervised a total re-edit of the historic aerial and ground survey data and designed a new R BASE data base for inseason escapement analyses. Mr. Sharr wrote the original operational plans for NRDA F/S Studies 1,2 and, 3 and has been the Principal Investigator for those projects since their inception

Fisheries Biologist I Project Assistant - Andrew Craig

Mr Craig has a Bachelor of Science in Fisheries from Cornell University. He has been employed by ADF&G since spring of 1991 He has experience supervising adult salmon weirs and has a field season of experience in the NRDA egg deposition study (F/S Study #2).

Biometrician II - Brian G Bue

Brian Bue has a Bachelor of Science in Biology and a Bachelor of Science in Fisheries from the University of Alaska, Fairbanks He also possesses a Masters degree in Fisheries with an emphasis on quantitative studies from the University of Alaska, Fairbanks Brian has worked with the Alaska Department of Fish and Game from 1974 through present in many capacities He has worked as a consulting biometrician on oil spill damage projects since the first days of the Exxon Valdez spill

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BUDGET ($K)

Salaries	$ 200 3
Travel	14 8
Contracts	53 6
Supplies	30 5
Equipment	56 7
Subtotal	$ 355 9
General Administration	33 9
Total	$ 389 8

RESTORATION PROJECT NUMBER 90

Study Title: Injury to Dolly Varden Char and Cutthroat Trout Monitoring

Lead Agency: ADF&G

PROJECT JUSTIFICATION

This closeout budget represents the cost for removal of weir material and camp equipment from all field locations, and for the production of a final report.

BUDGET ($K)

Salaries	$ 45.6
Travel	2 0
Contractual	31 7
Supplies	3 0
Equipment	0 0
Subtotal	$ 82 3
General Administration	9 2
Total	$ 91 5

RESTORATION PROJECT NUMBER 102

Study Title: Coastal Habitat Restoration

Lead Agency: ADF&G

PROJECT JUSTIFICATION

This project description will be developed after a synthesis meeting in the spring of 1992

BUDGET ($K)

Salaries	$	5 1
Travel		0 0
Contracts		458 0
Supplies		0 0
Equipment		0 0
Subtotal	$	463 1
General Administration		22 5
Total	$	485 6

2D. RESTORATION IMPLEMENTATION PLANNING

In some cases the feasibility of a restoration option is well established, but the Trustees lack site-specific information needed to determine which methods are appropriate given the physical and biological characteristics of the specific sites Without this site-specific information, it may not be possible to identify all the actions needed, nor to estimate the costs

Thus, implementation planning projects are intended to provide the information needed to evaluate and execute restoration projects in the field. In 1992, the Trustee Council proposes carrying out one implementation planning project, "Survey and Evaluation of Instream Habitat and Stock Restoration Techniques for Anadromous Fish "

RESTORATION PROJECT NUMBER 105

Study Title: Survey and Evaluation of Instream Habitat and Stock Restoration Techniques for Anadromous Fish

Lead Agency: ADF&G

Cooperating Agency: USFS

PROJECT JUSTIFICATION

The Exxon Valdez oil spill injured wild pink and chum salmon in Prince William Sound. Various amounts of oil were deposited in intertidal habitats where up to 75% of the spawning occurs Salmon eggs deposited in 1989 and all subsequent years have been contaminated and direct egg mortality has been documented. A higher incidence of somatic, cellular, and genetic abnormalities were also found among alevins and fry in oiled creeks Wild salmon fry were further injured when they entered the nearshore marine environment and consumed oil-contaminated prey This caused reduced growth and fry-to-adult survival, because predators targeted the smaller, slower growing fish. Migration patterns indicated that nearly all the salmon fry exiting Prince William Sound passed through heavily oiled habitats in the southwestern Prince William Sound Diminished growth and survival during the early marine period may have reduced the wild and hatchery reared salmon return to Prince William Sound in 1990 by 15 to 25 million fish Recently detected genetic injuries may further reduce the productivity and fitness of wild salmon populations in Prince William Sound for many years to come

This project has focused on identifying the most appropriate restoration techniques for injured anadromous fish spawning habitats and specific stocks of anadromous fish The project was initiated in 1991, by the Alaska Department of Fish and Game (ADF&G). The study area includes Prince William Sound, lower Cook Inlet, and Kodiak Island. In 1992, the project will be conducted cooperatively by the ADF&G and the U.S Forest Service (USFS). The USFS will provide expertise in habitat restoration in Prince William Sound, and the ADF&G will focus on stock and habitat restoration in the Exxon Valdez oil spill impact area The USFS will conduct hydrological surveys at sites in the National Forest, further evaluate fish pass sites identified in 1991, and determine appropriate restoration techniques for anadromous fish (salmon and trout) stocks and habitats in the most heavily oiled streams in Prince William Sound The ADF&G will estimate the area of salmon spawning habitat injured by the oil spill in Prince William Sound, determine the most appropriate techniques for replacing this habitat within the oil spill impact area, and coordinate with the USFS on evaluation of fish stock restoration techniques

Results from ongoing genetic studies will be used to determine the most appropriate restoration techniques for stocks in oiled areas. If genetically discrete stocks are identified within the oiled area, restoration efforts will concentrate on restoring or replacing injured habitat or stocks If genetically discrete stocks are not identified within the oiled area, injured habitat and stocks will be restored throughout the Exxon Valdez oil spill impact area using the most cost-effective methods.

Specific study sites were identified in 1991 from previous reports, aerial photographs, aerial surveys, and ground surveys Identification of study sites will continue in 1992 More intensive investigations of sites identified in 1991 will also be conducted. Appropriate restoration or enhancement techniques may include spawning channels and improvement of fish passage through fish ladders, or step-pool structures to overcome physical or hydrological barriers. These measures will provide oil-free spawning habitat to replace oil-impacted spawning areas. Additional wild salmon stock rehabilitation measures may include stream-side incubation boxes, remote egg-takes and incubation at existing hatcheries for fry stocking in oil-impacted streams, and fry rearing

OBJECTIVES

1. Review existing literature and databases, determine preliminary restoration techniques for specific sites, and identify sites where field studies are needed.

2. Conduct field studies at specific sites to collect additional data needed to evaluate restoration techniques

3. Compile available data and select the most appropriate fish restoration projects.

4. Collect additional field data if necessary to develop project design and cost estimates, and write proposals for specific projects.

5. Estimate the total area of anadromous fish spawning habitat that was oiled in Prince William Sound

METHODS

Objective 1:

Although many potential instream habitat and fish stock restoration sites were identified in 1991, review of existing literature and databases will continue in 1992 to ensure that all potential sites have been evaluated.

Additional data will be included in a benefit-cost analysis initiated in 1991. This analysis will determine the most cost effective wildstock restoration techniques in general A summary of previous project costs will be developed after a literature review. When no data are available for a given technique, preliminary project budgets will be developed. Pink and chum salmon survival rates in natural streams, in the ocean, and resulting from various enhancement techniques will be summarized The information gathered from this review will be used to evaluate the cost effectiveness of various enhancement techniques for wild salmon populations in general. The results from this analysis will be used to focus restoration survey efforts on the most effective and beneficial techniques.

Spawning channel sites described in the literature will be evaluated on the seasonal stability of groundwater height, groundwater temperature, groundwater gradient, groundwater chemistry, flooding risk, availability of substrate, and availability of broodstock (Sanner 1982b) Streams identified as potential spawning channel sites from the literature review will be further evaluated using aerial photographs and topographic maps. Data from topographic maps will be used to estimate surface gradient and stream length. These variables are likely correlated with groundwater gradient and stability.

The feasibility of fry rearing at various streams will be evaluated using aerial photographs, historical spawning escapement and pre-emergent fry index data collected by the ADF&G, and shoreline oil-contamination maps constructed by the Alaska Department of Natural Resources (ADNR) and the Alaska Department of Environmental Conservation (ADEC). Criteria used to evaluate potential fry rearing sites will include the degree of oil contamination in intertidal spawning habitats, probable magnitude of fry outmigrations, availability of mooring sites for net pens, feasibility of operating fry weirs, and proximity of weir sites to net pen sites

Salmon stocks that might be best restored by remote eggtakes will be identified using historical salmon spawning escapement data, anadromous stream catalogs, and shoreline oil-contamination maps Criteria used to evaluate remote eggtakes at these sites will include degree of oil contamination, probable spawner abundance, and availability of mooring sites for net pens

Objective 2:

Two potential fish pass sites were identified in Prince William Sound and six sites in the Kodiak area in 1991 More detailed investigations will be conducted at these sites in 1992 Other potential fish pass sites will continue to be evaluated from aerial and ground surveys. The abundance of spawning salmon, barrier falls height, stream width, stream depth, stream gradient, and substrate type will be estimated from aerial surveys. The information gained from these surveys will be used to eliminate some streams from further consideration. More extensive ground surveys will be conducted at sites that appear suitable from aerial surveys. The following physical measurements will be made during ground surveys. Barrier falls height will be estimated with a clinometer and measuring tape. The USFS stream habitat foot survey methods will be used to estimate available spawning habitat above the barrier (Olsen and Wenger 1991).

Fifteen potential spawning channel sites were identified in Prince William Sound and one site in lower Cook Inlet in 1991. Additional aerial and ground surveys will be conducted at these and other sites as needed. Aerial surveys will be conducted to identify specific sites that appear suitable for spawning channels within river valleys. The apparent size composition of the substrate, groundwater level, flooding risk, and ease of access will be criteria used to identify specific sites Ground surveys will be conducted at sites that appear suitable from aerial surveys. A preliminary ground survey will be conducted to determine flooding risk, the approximate depth of groundwater, and the size composition of the substrate. If the area appears to be unaffected by floods, the groundwater is shallower than 2 meters, and the substrate is composed largely of gravel or cobbles, additional survey work will be conducted.

Standpipes will be installed at the fifteen potential spawning channel sites identified in 1991 Ground surface gradients and drainage basin lengths at these sites range from 0 3% to 2 5% and 0.5 to 19.0 miles, respectively Standpipes will be installed at each of these sites to a depth at least 2 m below the groundwater level, parallel to the surface gradient, along the most likely location of the spawning channel Standpipes will be constructed from 1.5 m sections of 5 cm diameter galvanized well pipe, with a sandpoint, and galvanized couplers Electronic water level recording devices will be installed on selected standpipes to monitor changes in groundwater height Data obtained from the recorders will be used to evaluate groundwater stability and the rate of intragravel flow at each site. At two potential spawning channel sites, two standpipes with water level recorders will be installed 50 m and 150 m from the mainstem stream channel to evaluate the relationship between groundwater stability and distance from the mainstem channel. Each standpipe will be covered with insulation at the surface and marked with a pole and flag.

Six potential fry rearing sites were identified in Prince William Sound and one site in lower Cook Inlet in 1991 Additional field surveys will be conducted to identify other potential fry rearing sites in the <u>Exxon Valdez</u> oil spill impact area Fry rearing study sites will be aerially surveyed when the tide is at about the six foot level. A video camera will be used during the aerial survey of each stream for later review. A ground survey will be conducted to measure the distance across the stream channel, mean stream depth, and mid-channel current speed at the intended location of the fry weir. The estuarine area near the potential weir site will be surveyed to locate a suitable area to moor net pens. The distance between net pen mooring sites and fry weir sites will be measured with a rangefinder. If possible, potential fry weir sites will be visited at high tide immediately after a storm.

No ground surveys were required to determine the feasibility of eggtakes at remote sites. Suitable sites for net pen mooring will be identified from aerial photographs and aerial surveys Spawner abundance will also affect the feasibility of remote eggtakes Aerial surveys conducted immediately before eggtakes will be required to estimate spawner abundance.

All restoration survey efforts will be coordinated with local landowners and governments.

Objective 4:

Full proposals will be developed for projects that receive a high ranking in the decision matrix. Additional field work may be required to collect engineering data needed for development of detailed project designs. USFS and ADF&G engineers will work on these projects as needed to collect engineering data and design structures.

Objective 5:

The total area of anadromous fish spawning habitat that was oiled will be estimated from aerial photographs This information will be used to help determine the area of fish spawning habitat that needs to be replaced within the Exxon Valdez oil spill impact area by construction of fish passes or spawning channels The ADF&G Habitat Spill Response Group (HSRG) has compiled a list of oiled anadromous streams in Prince William Sound. Aerial photographs will be taken of these streams at low tide A planimeter will be used to estimate the area of intertidal fish spawning habitat on each photograph The total area of intertidal fish spawning habitat in these streams will be estimated by summing the area estimates for the individual streams. Data collected by the HSRG and the ADF&G Commercial Fisheries Division will be used to estimate the average proportion of intertidal spawning habitat that was oiled in streams for which data is available. The total area of anadromous fish spawning habitat that was oiled will be estimated by applying this proportion to the estimated total area of intertidal spawning habitat in the streams on the HSRG list

DATA ANALYSIS

Objective 2:

Data obtained from electronic water level recording devices will be analyzed to evaluate groundwater stability and the probable rate of intragravel flow at potential spawning channel sites. The rate of intragravel flow is an important variable affecting egg-to-fry survival in salmon spawning beds (McNeil 1966) The power spectrum will be estimated for each groundwater height time series (Jenkins and Watts 1968). The information contained in the power spectrum will be used to evaluate the variance of groundwater height and the principal frequencies of variability These characteristics of the groundwater variability will be related to distance from the mainstem channel, substrate type, and drainage basin area and gradient. This analysis will provide insight into factors affecting groundwater flow and stability that will be useful for identifying other suitable spawning channel sites in the Exxon Valdez oil spill impact area.

Objective 3:

After all necessary data has been collected, a weighted decision matrix will be used to establish priority among potential projects. Detailed proposals will be developed for projects that receive a high ranking The following criteria (unweighted) will be used in the decision matrix.

1. Oil-spill injuries to spawning habitats and salmon stocks;

2. The estimated increase in fish production resulting from the proposed project;

3. The importance of the estimated increase in fish production to subsistence, sport, and commercial user groups,

4. The estimated benefit/cost ratio of the proposed project,

5. The potential for the proposed project to maintain the genetic characteristics of the affected salmon population,

6. Level of genetic damage within the stock;

7. Demonstrated effectiveness of the restoration technique;

8. Requirement for future project maintenance,

9. Ability of the resource to recover naturally,

10. Ability to document the success of the project;

11. Compatibility of the proposed project with established land uses in the area, and

12. Compatibility of the proposed project with regional salmon enhancement plans.

DELIVERABLES

The results from 1992 investigations will be summarized in a report prepared by the USFS and ADF&G.

SCHEDULES AND PLANNING

Date — Activity

June - October

Conduct stream habitat surveys at selected sites in cooperation with the USFS,

Conduct aerial photographic surveys of oiled anadromous streams in Prince William Sound and estimate area of fish spawning habitat in each stream,

Survey potential spawning channel sites and install standpipes.

September - February

Re-visit potential spawning channel sites and collect data from water-level recorders

Compile and evaluate data, select sites for development of detailed project proposals, and collect additional engineering data if necessary

October - February

Prepare engineering designs and detailed project proposals

PERSONNEL QUALIFICATIONS

Mark Willette:

Master of Science, Fisheries Oceanography, 1985, Bachelor of Science, Fisheries Science, 1983, Area Biologist, ADF&G, Fisheries Rehabilitation and Enhancement Division (FRED) Cordova, March 1991-present Conduct various fisheries enhancement projects in Prince William Sound including limnological investigations of sockeye salmon producing lakes, and quality control of coded-wire tagging at private hatcheries. Principal Investigator on NRDA studies on juvenile salmon in Prince William Sound Instructor/ Assistant Research Professor, University of Alaska Fairbanks, 1986-1991 Conduct various fisheries research projects Design and implement a program of education, research, and public service in north-west Alaska.

Nick Dudiak:
Bachelor of Science, Zoology, 1968, Area Biologist, lower Cook Inlet, ADF&G FRED Division, 1977-present, Project Leader Paint River fishway feasibility study, Chenik Lake sockeye salmon rehabilitation program, Leisure Lake sockeye salmon stocking and fertilization program, Tutka Hatchery pink and chum salmon evaluation program.

Lorne White:
Bachelor of Science, Biology, 1973, Area Biologist, Kodiak, ADF&G FRED Division, 1987-present, Project Leader· Rehabilitation of sockeye salmon at Karluk Lake, Asst Project Leader Scallop mariculture feasibility study, Research Experience evaluation of 15 proposed fish passes on Kodiak Island, fertilization, instream habitat studies related to hydroelectric development.

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BUDGET ($K)

	ADF&G	USFS	TOTAL
Salaries	$91 7	$40 0	$131 7
Travel	3.9	6 3	10 2
Contractual	91.5	26 0	117 5
Supplies	17.8	1 4	19 2
Equipment	37.8	3 2	41 0
Subtotal	$242 7	$76 9	$319.6
General Administration	20 5	8 0	28 5
Total	$263 2	$84 9	$348.1

2E. RESTORATION MANIPULATION/ENHANCEMENT

Manipulation/enhancement projects are active intervention measures which actively promote recovery of injured resources or provide an alternate service to those who use the resources A fish ladder would be an example of an activity which promotes recovery of the resource by expanding the area of a stream accessible to spawning fish. Stocking fish in a location other than that of the injured resource could provide a service to those people who had used that resource. With the exception of one project, the Trustee Council chose not to implement manipulation and or enhancement activities until full public participation in the project selection process was possible. The one project described below has severe time constraints necessitating an early start Most of the work for that project will not be carried out until after public review.

Red Lake sockeye salmon restoration, Restoration Project Number 113 (R113), seeks to restore sockeye salmon in Red Lake (Kodiak Island) by incubating sockeye eggs and short-term rearing the fry in Pillar Creek Hatchery, returning fingerlings to Red Lake and fertilizing the lake. The egg incubation and fry rearing is based upon predictions of poor adult returns in 1993, most activities will not begin until then. The level of funding provided by the Trustee Council allows advance purchase of hatchery equipment needed in 1993. Poor juvenile and smolt survival due to the oil spill will not be reflected in poor adult returns until 1993 and major manipulation/enhancement activities will not be needed at Red Lake until then. Therefore, despite 1992 funding for equipment purchases, full funding for this project in 1993, like other projects in this category, will be subject to full public scrutiny

RESTORATION PROJECT NUMBER 113

Study Title: Red Lake Sockeye Salmon Restoration

Lead Agency: ADF&G

PROJECT JUSTIFICATION

Red Lake, located on the southwest side of Kodiak Island, has historically been one of the most consistent producers of sockeye salmon for the Kodiak commercial salmon fishery The Department of Fish and Game's annual escapement goal for this system ranges from 200 to 300 thousand sockeye (Malloy 1988) The mean harvest of Red Lake sockeye has been 450,000 since 1980 and ranged from 25,000 to 1.5 million. The mean annual value of this harvest is $2.2 million to the fisherman.

In 1989, as a result of the Exxon Valdez oil spill, some commercially harvested fish were oiled, which resulted in closures over most of Kodiak Island waters This resulted in an escapement of 786,000 sockeye into Red Lake, which equated to a 2 5 fold increase over the maximum desired escapement. Careful management of the number of spawning fish is required to maintain this fishery If too many adult sockeye spawn in the lake system, an overabundance of juvenile sockeye will deplete their plankton food source, resulting in decreased freshwater growth and high mortality This will then result in fewer smolt migrating to the ocean and a significant decrease in the return of adult sockeye

Data gathered from Fish/Shellfish Number 27 (sockeye overescapement) showed low survival of juvenile sockeye from the 1989 escapement year (Schmidt 1991). Hydroacoustic and tow net surveys showed low levels of juveniles in the lake in the fall of 1990, and smolt enumeration in the spring of 1990 and 1991 showed reduced levels of migrant smolts. This information indicates that a significantly reduced number of sockeye will return as four, five and six year old fish in 1993, 1994 and 1995 According to this data the return may fall below the desired escapement of 150,000 fish. If this occurs, the productivity of the lake would be underutilized and the fishery and local economy would be seriously impacted. Immediate action would be required to avoid this impact. Therefore, supplemental production would be implemented immediately to restore the sockeye run, through the collection of 6 million Red Lake sockeye eggs and the resultant stocking of 4 9 million fry in to the lake. This stocking would produce approximately 146,000 adult sockeye. This restoration project would cost approximately $70,000 annually after FY93 until returns are restored to pre-spill levels.

DISCUSSION

The Red Lake restoration project will improve the rate of recovery of Red Lake sockeye if the projected injury, due to overescapement, occurs. Fry plants are a proven method used by FRED Division of ADF&G to rehabilitate and enhance sockeye stocks. FRED Division has pioneered the culture of sockeye salmon in Alaska with great success. Survival from egg deposition to fry lake entry ranges from 4 - 10% (Drucker, 1970) in wild stocks When incubating eggs in artificial conditions in a hatchery, survival from egg to fry is usually greater than 80% This increased survival total will subsequently increase the number of ocean migrating smolt and returning adults.

The restoration of Red Lake sockeye, through fry planting, will be monitored through various mechanisms to assure that no other factors hinder recovery. Such mechanisms include smolt survival monitoring, escapement counts, water quality monitoring, zooplankton abundance, and hydroacoustic surveys These mechanisms will occur directly through this project and indirectly through the linkage to Fish/Shellfish Number 27.

It should also be noted that other species are directly affected by the Red Lake sockeye runs, such as mammals that feed on sockeye (bears, otters, birds, etc) and also would benefit from this project. It is important to be prepared to supplement the sockeye production at Red Lake if the sockeye overescapement does result in a depressed return of adults in 1993. These preparations will need to begin in this year to assure readiness to collect eggs, receive eggs, and incubate and rear eggs and fry, if the escapement levels are below 150,000 by August 1 in 1993

OBJECTIVES

1. Increasing the incubation and rearing capacity of Pillar Creek Hatchery to support additional Red Lake eggs and fry

2. Collecting 6 million early run Red Lake sockeye eggs, beginning in 1993 and continuing through 1995, contingent upon Red Lake escapement falling below the minimum escapement goal of 150,000 by August 1.

3. Incubation of 6 million Red Lake sockeye eggs at Pillar Creek Hatchery with 90% survival from green to eyed eggs

4. Rearing of approximately 5 4 million Red Lake sockeye fry at Pillar Creek Hatchery to the size of .25 grams with 90% survival.

5. Evaluating freshwater survival and the success of hatchery fry plants, by thermally marking otoliths of fry prior to stocking into Red Lake.

6. Stocking of approximately 4 9 million fed fry (25 gm) into Red Lake with timing parallel to the period of wild stock recruitment.

7. Producing approximately 146,000 adult red salmon from annual fry plants (3% fry to adult survival).

METHODS

Pillar Creek Hatchery will be modified where required under ADF&G-FRED Division guidelines to assure isolation of Red Lake sockeye eggs from other stocks present in the facility This will require an incubation module used solely for Red Lake eggs. An additional 24 Kitoi box incubators will be acquired and plumbed into this module and 8 aluminum raceways will be brought on line for rearing requirements.

Net pens, net pen frames, beach seines, weatherports, safety gear and egg take supplies for a remote egg take of 6 million Red Lake eggs will be staged in Kodiak in July each year until the run is restored. Red Lake sockeye escapements will be monitored each year through counts from the ADF&G Commercial Fish Division adult enumeration weir. If escapement levels are below 150,000 by August 1 of each year, the egg take would proceed Operational monies will be held as a contingency pending escapement counts in each of these years. The appropriate federal permits will be obtained from the U.S. Fish and Wildlife Service prior to conducting any work on Kodiak National Wildlife Refuge lands in which the Red Lake system is included.

Aerial and foot surveys will be conducted to determine when sufficient sockeye are holding near the mouth of major spawning tributaries. Brood will be seined and sorted by sex and held in net pens in Red Lake until females have ripened Remote egg collection will follow procedures outlined in FRED Division sockeye egg take Standard Operating Procedures After fertilization, disinfection and water hardening, eggs will be chilled to delay development in preparation for transport to the city of Kodiak. Eggs will be placed in coolers with ice Disease screening will be conducted to determine titer levels of IHN virus in ovarian fluid Eggs will be transported by float plane to the city of Kodiak and then transported to Pillar Creek Hatchery Eggs will be seeded into Kitoi box incubators after being water temperature acclimated if necessary. Egg density in each incubator will be 250,000 with flows set at 10 gpm. A fertility check will be conducted each day eggs are seeded into the incubators as a quality control measure to assure high green to eyed egg survival

During the incubation period, temperature units (TU) will be monitored daily to track egg development. Eggs will be treated with formalin as required to control fungus Other general maintenance will be conducted according to FRED Division fish culture standard operating procedures (Fish Culture Manual, 1983) After reaching the eyed stage of development, eggs will be shocked and dead and live eggs will be enumerated to calculate green to eyed egg survival. Artificial substrate will be added to each incubator with the live eggs after all the dead eggs have been removed. Incubators will be maintained throughout the rest of the incubation period following FRED standard operating procedures as previously mentioned.

During incubation, between the eyed and hatched stages, eggs will be marked by thermally induced otolith banding The mark will be induced by using a rapid temperature change of 2 - 3° C

Sockeye fry will voluntarily migrate from incubators to raceways. Red Lake fry will be segregated from other hatchery stocks in raceways according to FRED Division compartmentalization policy Fry will be enumerated as they enter the raceways using an electronic counter. Fry will be fed, beginning with Oregon Moist Pellet (OMP) semi-moist starter mash After reaching 0 3 gm in size, fry will be fed OMP semi-moist pelletized feed. Fry will be reared according go FRED Division Standard Operating Procedures and sampled weekly to estimate feed conversion and growth

After fry reach 0.25 gm and/or when Red Lake surface water temperatures reach 6° C, fry will be stocked into Red Lake. Fry will be removed from raceways and transported in an oxygenated tank from Pillar Creek Hatchery to float plane staging area There they will be transferred to a transport tank in a float plane where they will be monitored by a fish culturist while in transit to Red Lake Fry will released into Red Lake after being acclimated to the lake water temperature.

As part of Fish/Shellfish Number 27 (sockeye overescapement), Commercial Fish Division enumerates Red Lake smolt as they migrate from the lake to the ocean. A smolt sample will be collected and preserved in alcohol. Otoliths from these smolt will be analyzed to determine hatchery and wild fry-to-smolt survival.

Commercial Fish Division monitors Red Lake sockeye returns at an adult weir site. Escapement counts will be important to monitor this restoration project

Since this project is closely linked to Fish/Shellfish Number 27, data will be shared between the two projects Specifically, smolt enumeration and sampling data, and juvenile fry population estimate data will be provided by the Project Leader for NRDA study # 27. In addition, Commercial Fish Division will provide weir escapement counts to the Project Leader of this study on a daily basis

DELIVERABLES

A project report will be completed at the end of 1992

TENTATIVE SCHEDULE AND PLANNING

(FY93)

Event		Begin	End
1	Purchasing incubators, raceways, pipeline, and plumbing	7/92	1/93
2	Purchasing egg take supplies	1/93	2/93
3.	Project Status Report	11/92	12/92
	(FY94)		
4.	Preparation of Pillar Creek Hatchery for receiving of eggs, incubator, raceways, and pipeline installation, egg take camp set up and supply ordering	3/93	6/93
5.	Egg take site preparation	7/93	8/93
6	Red Lake sockeye egg take and site breakdown	8/93	9/93
7.	Project Status Report	11/93	12/93
8.	Red Lake sockeye incubation and rearing	8/93	2/94
	(FY95)		
9.	Continue Red Lake sockeye incubation and rearing	3/94	6/94
10.	Thermal otolith marking	4/94	5/94
11.	Stocking fry into Red Lake	6/94	6/94
12.	Red Lake sockeye egg take and site breakdown	8/94	9/94
13	Project Status Report	11/94	12/94
14.	Red Lake sockeye incubation and rearing	8/94	2/95

Project Management: Responsibilities

Project Leader: Lorne White- overall project management and report writing.

Lead Fish Culturist. Chris Clevenger- hatchery operations, remote egg take, incubation and rearing.

Assisting Personnel: Steve Honnold- assisting project Leader with project management and report writing.

Field Fish Culturist: Steve Schrof- remote egg take

Logistical requirements for this project include 1) transport of all remote egg take and field camp gear by float plane from Kodiak to Red Lake; 2) transport of all field personnel from Kodiak to egg take site; 3) during the remote egg take, supplies will also be flown in along with ice to chill the eggs on a daily basis; 4) chilled eggs will be flown out of Red Lake to Kodiak, and then to Pillar Creek Hatchery after each day's egg take, 5) egg take site and field camp will be dismantled and all material returned to Kodiak by float plane; 6) personnel will be returned to Kodiak as required by egg take work schedule; 7) fry stocking in Red Lake will require transport by float plane from Kodiak

PERSONNEL QUALIFICATIONS

Lorne White: Area Biologist, FRED Division, ADF&G for 6 years; Fishery Biologist, FRED Division, for 13 years

Chris Clevenger: Hatchery Manager, Pillar Creek Hatchery, for 2 years, Assistant Hatchery Manager, Big Lake Hatchery, for 5 years

Steve Honnold: Assist Area Biologist, FRED Division, ADF&G for 3 years, Fish Culturist, Big Lake Hatchery, for 3 seasons.

Steve Schrof: Fish Culturist, Pillar Creek Hatchery, for 1 season, Fisheries Technician, Snettisham Hatchery, for 4 years

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BUDGET ($K)

Salaries	$9.2
Travel	0.9
Contractual	4 8
Supplies	6 6
Equipment	32.7
Subtotal	$54.2
General Administration	1 7
Total	$55 9

2F. RESTORATION HABITAT PROTECTION PLANNING

Adequate habitat is essential to resources and the services they provide, and one means of encouraging the recovery of resources and services injured by the Exxon Valdez oil spill is to afford additional protection to important habitat There are various means by which protection measures can be implemented, and these range from purchase of land, purchase of "conservation easements", to landowner agreements, or changes in future land management actions. (Conservation easements involve the purchase of certain rights to use land, e.g standing timber, without the purchase of the land itself.)

The Volume I: Restoration Framework lays out a five-step process for identifying and protecting strategic habitats and recreation sites

Before protection measures are pursued, it is necessary to determine which areas are the most important to fish and wildlife Several of the proposed projects do this for biological resources For example, the Harlequin Duck Restoration Project (R71) and the Marbled Murrelet Restoration Project (R15) will determine, among other things, the nesting habitat requirements of those species, both of which were injured by the spill Another project, Stream Habitat Assessment (R47), will focus on assessing the habitat value of streams and adjacent habitat on lands that are scheduled for land use alteration in the near future. This project will evaluate habitats for several injured species, including pink salmon, Dolly Varden, cutthroat trout, harlequin ducks, and bald eagles

Habitat protection will be considered through the development and implementation of a comprehensive Restoration Plan

RESTORATION PROJECT NUMBER 15

Study Title: Marbled Murrelet Restoration Study

Lead Agency: USFWS

Cooperating Agency: USFS

INTRODUCTION

The marbled murrelet (Brachyramphus marmoratus) is a small seabird which largely depends on old-growth forests for nesting (Binford et al. 1975, Marshall 1988, Manley and Kelson 1991, 1992, Quinlan and Hughes 1990, Singer et al 1991, 1992, Nelson et al. 1992) The species currently is being considered for threatened or endangered status throughout most of its range, excluding Alaska Prince William Sound is one of three major population centers of the marbled murrelet in Alaska (Mendenhall 1988) This population suffered substantial direct mortality from the Exxon Valdez oil spill. Based on an eight percent chance of carcass recovery (Ford et al. 1991), an estimated 9,570 murrelets were directly killed. In Prince William Sound, marbled murrelets were 12% of retrieved carcasses, which is proportionally more of the seabird population than the numbers at risk at the time of the spill (Piatt et al 1990). Additionally, petroleum hydrocarbon contamination has been found in the livers of unoiled murrelets collected in 1989 in oiled areas of the Prince William Sound (Kuletz 1992a) Murrelets collected in unoiled areas of Prince William Sound after the spill were uncontaminated.

The Prince William Sound marbled murrelet population has declined significantly, from approximately 300,000 in 1972 to 100,000 in 1989-1991 (Laing 1991), thus it is difficult to determine the contribution of the Exxon Valdez oil spill to this decline There was no significant difference in murrelet counts between oiled and unoiled shoreline in the Prince William Sound boat surveys or the Naked Island area surveys. Since only about 25% of the murrelets occupy waters within 200 m from shore (Laing, unpubl data), and murrelets are highly mobile in foraging, it is unlikely that an oiling effect could be detected using the current methods of analysis.

The limited data available on murrelet breeding biology suggests that their reproductive success is quite low (Hamer and Cummins 1991, Kuletz 1992b, Nelson et al. 1992, Singer et al 1991, 1992) Murrelets face additional impacts from loss of nesting habitat due to logging, which could threaten natural recovery Protection of forested nesting habitat through acquisition is one potential approach for aiding recovery of murrelets in the oil spill area

Integral to this approach is the ability to identify appropriate habitat for protection. However, because so little is known about the murrelet's habitat requirements or its breeding distribution, further efforts are needed to achieve this goal. Two primary components are intimately linked in identification of appropriate sites - what are the characteristics of murrelet nesting habitat and which potentially suitable areas in the oil spill area are being used by the species? Documenting areas used by nesting murrelets is elusive because nests are generally difficult to find. This study will attempt to answer these questions

An attempt will be made to locate a relatively large number of murrelet nests in an area in which ground search techniques have proven to be an effective means for finding nests (Kuletz 1992b) At these sites critical elements of nesting habitat will be quantified and behaviors, vocalizations and activity patterns associated with nesting will be defined These results will be used to establish criteria for inferring use of an area by nesting murrelets, for refining nest search techniques and for determining nesting habitat requirements (Objective 1) Censuses will also be conducted at various locations in Prince William Sound to locate high use areas. The results from known nest sites will then be used to interpret the significance of murrelet activity (Objective 2).

Marbled murrelets typically forage in shallow nearshore waters during the breeding season. This area is particularly vulnerable to oil pollution and human disturbance Consequently, proper management of the adjacent marine environment is also important in protecting murrelet habitat. Thus, delineation of nearshore murrelet distribution relative to nesting areas has been included in Objectives 1 and 2. The results of this study will be integrated with other sources of data on murrelets in the Exxon Valdez oil spill area (Objective 3) These data will be analyzed, synthesized and used to corroborate nesting requirements and appropriate protection measures.

Completion of this phase of the study in 1992 will result in knowledge of murrelet nesting habitat requirements and identification of uplands with the most potential for murrelet nesting. This study will also provide guidelines for identifying nesting habitat throughout the oil spill area.

OBJECTIVES

1. Determine marbled murrelet nesting habitat requirements and develop criteria for documenting occupied nesting habitat within forested portions of the Exxon Valdez oil spill area

2. Survey uplands throughout portions of the oil spill area to investigate murrelet use of those habitats

3. Compile, analyze and synthesize all murrelet data relevant to the oil spill area.

METHODS

Sampling Methods

Field training will be conducted prior to field work according to the training procedure. This session will be held on the south side of Kachemak Bay or on Naked Island (Appendix A) immediately following establishment of the field camp. Participants will be trained to identify marbled murrelets, to distinguish between marbled and Kittlitz's murrelets and to conduct dawn watch surveys The dawn watch survey is the fundamental method used for recording murrelet activity at dawn, the peak period when murrelets fly between their marine foraging sites and inland nesting areas.

Objective 1 Determine marbled murrelet nesting habitat requirements and develop criteria for documenting occupied nesting habitat within forested portions of the Exxon Valdez oil spill area

Nest Searches

To determine nest habitat requirements and develop criteria for documenting occupied nesting habitat, as many nests within the Naked Island Archipelago will be located as possible Nest searches will be conducted in areas previously established as nesting or suspected nesting habitat, based on results of the 1991 Restoration Project and the 1990 pilot study (Kuletz 1991, 1992b). Initial efforts will focus on Naked Island (e g near nest sites in South Cabin Bay, McPherson Bay, and suspected nest sites in Northwest Naked and Bass Harbor), then Storey and Peak islands Nest searches will begin mid-May to include the prospecting and incubation stages of nesting During these stages, murrelets are most visible or predictable around nests, and nests are most likely to be found then (Naslund, N, FWS, unpubl. data) Focusing efforts during these stages is critical to maximizing the sample size of nests. Forty-five dawn nest search surveys will be implemented to identify potential nest sites, or find nests when possible. This search technique will be supplemented with pre-dawn observations at possible nest trees using a night viewing device Areas identified as promising through dawn nest search surveys will be thoroughly checked from the ground using binoculars and spotting scopes If no murrelets are readily visible from the ground, an intensive nest search will be undertaken When behavior at dawn indicates nesting but view of the suspected nest is obscured by vegetation, a tree adjacent to the suspected nesting tree will be climbed. The climber will then visually search for signs of nesting from this elevated vantage point. Additionally, the ground below potential nest trees will be searched for eggshell fragments, as has successfully been done in Washington (Becking 1991, Reed and Wood 1991, Hamer and Cummins 1990, 1991).

Identifying Occupied Nesting Habitat

Use of potentially suitable nesting habitat can be determined through two means: 1) finding nests and 2) inferring use by certain observable behaviors. Four sources of information from nests found in 1992 will be used to identify and define flight behaviors and vocalizations indicative of nesting and to refine nest search techniques. In turn, these data will be used to define occupied and unoccupied forest stands and to determine the best method for assessing occupied and unoccupied status of forest stands. These results will be used to interpret murrelet activity observed throughout Prince William Sound (under Objective 2) These results will also be used to assess potentially occupied murrelet nesting habitat at specific sites within the Exxon Valdez oil spill area in the future The four methods are as follows

1. Dawn watch surveys Dawn watch surveys will be carried out four times each during the incubation phase and nestling phase at three nests. These data will be analyzed and compared with murrelet activity recorded at non-nesting sites.

2. Dawn nest search surveys Behaviors observed during nest search efforts will be used to supplement findings from dawn watch surveys when establishing criteria for occupied status.

3 24-hour nest monitoring 24-hour video recordings will be implemented bi-weekly at 2 nests A spotting scope and a night viewing device will alternately be attached to the video camera to enhance observations Activity patterns will be analyzed to determine the appropriate time of day to conduct intensive nest searches in future nest search efforts.

4. Inside/outside stand comparisons Twenty paired dawn watch surveys, with one observer stationed inside and one stationed outside a stand, will be done in known nesting habitat to determine the best census method for documenting flight behaviors and vocalizations needed to assess occupied and unoccupied status of forest stands

Nesting Habitat Requirements

To assess nesting habitat requirements and the potential recovery of murrelets through habitat acquisition, the following methods will be used. An attempt will be made to find all nests within selected stands for density estimates. Each documented nest will be checked at least once to determine nesting outcome. The 1991 nest trees will be checked bi-weekly for signs of reuse Murrelet nest, tree, and stand characteristics will be quantified upon the completion of nesting efforts. The information gained will assist management in determining the appropriate amount of acreage for habitat protection and to predict subsequent recovery rates.

Three survey types will be used to gather data on the marine distribution of murrelets which will be integrated with data on terrestrial habitats. Results can be used to guide appropriate management of the nearshore environment adjacent to proposed habitat acquisitions. The survey types include.

1. Bi-monthly shoreline censuses of Cabin and Outside bays on Naked Island will be done following the dawn watch surveys at the three upland monitoring sites, described under 'Seasonal Variation' below. The shoreline censuses will be conducted by two observers using an inflatable boat, all murrelets within 200 m of shore will be counted. Results of these surveys will be analyzed to determine how well the morning nearshore distribution corresponds to inland habitat use

2. A complete shoreline census will be conducted around Naked, Peak and Storey islands in June to determine murrelet nearshore distribution during the incubation period

3. Murrelet distribution within 5 km of Naked, Peak and Storey islands will be censured once each in the early, mid and late nesting season, following the methods implemented in the 1991 pilot study.

Predator Counts

Evidence indicates that nesting murrelets are quite vulnerable to predation (Singer et al 1991, Kuletz 1992b, Nelson et al 1992) Therefore, predation risk is an important component of murrelet nesting habitat. Potential avian predators associated with nesting habitat will be investigated using the fixed-point count survey method near each nest and from analysis of the 24-hour video recordings at nests discussed above.

Seasonal Variation

Bi-monthly dawn watch surveys will be conducted at three upland monitoring sites established in 1990 and 1991 (e g sites #1, #2 and #5, see Kuletz 1991, 1992b). These data will be used to monitor seasonal and annual variation, for comparisons with documented nesting phenology and dawn watch surveys at nest sites, for comparisons with activity recorded elsewhere in Prince William Sound (Objective 2), and for murrelet marine-terrestrial habitat associations.

Objective 2: Survey uplands throughout portions of the _Exxon Valdez_ oil spill area to investigate upland murrelet use of these habitats.

General Procedures

This objective of the study will be to identify areas of high murrelet upland activity, indicative of nesting habitat Building on results from the Naked Island portion of this project, surveys in high-use areas may be required in later years to identify 'documented use' stands In 1992, upland activity by murrelets will be assessed in various locations in Prince William Sound from a boat anchored near shore The basic sampling method will be the 'dawn watch' survey, as described in the Pacific Seabird Group protocol (Paton et al. 1990), with some modifications for Alaskan conditions. One dawn watch will be conducted at each site. This project is not designed to define sites as unoccupied by murrelets, since that would require a minimum of four visits to each site for verification (Nelson 1991) Results from these surveys will be integrated with USFS habitat data and analyzed for significant murrelet - habitat associations.

This survey will be conducted by three USFWS and three USFS field personnel operating from a chartered 58-foot vessel. Half of the dawn watches will be conducted from the deck of the large vessel by one of the USFWS observers This method was tested in Prince William Sound in 1991 and proved useful (Kuletz 1992). A second crew of two observers, also based on the larger vessel, will travel to adjacent sites in an inflatable boat and conduct dawn watches at shoreline or further inland at some locations The latter effort is designed to make a paired comparison between murrelet detection levels observed from the anchored boat and those detected further inland.

Sample Size

The survey period for marbled murrelets in Alaska is from early May to early August (Kuletz 1991) Surveys will begin approximately 5 May and continue until 8 August A minimum of 60 shoreline sites and 20 adjacent inland sites is the survey goal for 1992 A 58-foot vessel will be chartered for 55 days, to allow for weather days and logistical delays. Thus, there will be 40 days available for dawn watch surveys, or 40 'anchor sites' At 20 anchor sites, a remote crew of two people will move to an adjacent inland site to conduct a dawn watch for comparison with the watch done from the anchored vessel. At the other 20 sites, a remote crew will travel via inflatable raft to a nearby cove or bay to conduct a separate dawn watch from shore. Thus, there will be a minimum total of 60 sites surveyed from shoreline, with 20 of those having a paired inland site, for a total of 80 dawn watch surveys

Site Selection

Currently, a comprehensive habitat data base for Prince William Sound upland habitat is unavailable, thus, sample sites for this portion of the study will not be pre-selected based on habitat criteria. In 1992, sampling effort will be concentrated in the western half of Prince William Sound where USFWS surveys indicate murrelet concentrations are generally high in the summer (Irons, unpubl. data; Laing, unpubl data) Dawn watch sites will be selected to include both private and public lands. Selected sites will be divided between areas with high and low at-sea murrelet densities, using the transect data from USFWS boat surveys Sites will be clustered to facilitate the sampling efforts of the USFS habitat crew. Logistical constraints will be a factor in site selection and seasonal distribution of sampling effort

Habitat Classification

Once at the anchor site, habitat within view will be defined and photographically recorded. Four basic habitat categories will be included in the sampling effort densely forested, mixed forested/unforested, muskeg/meadow and alpine Detailed habitat data for the areas surrounding the anchor sites will also be gathered by USFS botanists. The USFS habitat plots will be central to one or several USFWS dawn watch sites The USFS data will contribute to the database for the ecological mapping units, to allow access through their GIS system Use of the GIS will allow more precise analysis of murrelet habitat data

Marine Habitat Use

This study will include a limited effort to study murrelet use of the nearshore environment for two reasons. First, future upland surveys will benefit if it is shown that at-sea counts are indicative of upland nesting nearby If this is true, at-sea surveys can be used to focus upland surveys to find nesting habitat. Second, a correlation between at-sea counts and upland flights would suggest that proximity to forage habitat is an important component of murrelet nesting habitat, and these nearshore foraging areas should be managed to reduce human disturbance during the breeding season. The null hypothesis of independence between at-sea counts and adjacent upland activity will be tested with three data sets:

a. Selected sites will be divided between those in association with transects of high and low at-sea murrelet density, based on USFWS boat survey data The dawn activity levels will be compared between the areas associated with high and low at-sea counts.

b. Fixed-point counts. Following the dawn watch from the anchored vessel, the observer will count all murrelets within

200 m of the boat. The area within view will be outlined on a marine chart for later calculation of area and conversion of murrelet counts to densities

c. Shoreline surveys: Since all of the Prince William Sound shoreline has been delineated into transects for standard shoreline boat surveys of marine birds and mammals (Irons et al. 1987, Klosiewski and Hotchkiss 1990), each anchor site used for a dawn watch survey will be associated with a USFWS transect. At every anchor site (including the shoreline site surveyed by the remote crew), a shoreline survey will be done along the associated shoreline transect. Two observers will cruise in an inflatable boat 100 m offshore and count birds out to 200 m from shore, using binoculars

Objective 3. Compile, analyze and synthesize all murrelet data relevant to the Exxon Valdez oil spill area.

Data in a variety of formats are available for marbled murrelets in the oil spill area. This information will be valuable in determining future restoration efforts, interpretation of on-going projects and as a baseline for documenting recovery. These data have not been easily accessible because of the range of data types, different degrees of compilation and analysis, and the variety of agencies involved in data collection

This objective of the study will locate and synthesize information which will aid restoration efforts for the marbled murrelet Some of the data sets which will be accessed include, but will not be limited to:

1. Outer Continental Shelf Environmental Assessment Program (OCSEAP) from the 1970's,

2. Surveys of the Kodiak Archipelago by the Kodiak National Wildlife Refuge;

3. Surveys of the Lower Cook Inlet and Kenai Peninsula by the Alaska Maritime National Wildlife Refuge and Kenai Fjords National Park,

4. Surveys of Prince William Sound by USFWS in 1972-1973, 1984-1985 and 1989-1991;

5. Unanalyzed data from marbled murrelet damage assessment studies in 1989-1990 with emphasis on effects of human disturbance and daily and seasonal variation in at-sea distribution;

6. Bathymetric features and shoreline habitats of Prince William Sound, to be integrated via GIS with at-sea data and results of the 1992 upland surveys,

7. Published and unpublished reports of _Brachyramphus_ nests and juveniles found by various people throughout the _Exxon Valdez_ oil spill area;

8. Information on prey species used throughout the oil spill area from USFWS food studies, including unpublished results, and,

9. Gillnet mortality records for Prince William Sound from the NOAA Marine Advisory Program

Standard Operating Procedures

These standard operating procedures will be used to meet Objective 1 and are fully described in "Other Information" below

1. Training procedure
2. Dawn nest search survey
3. Intensive nest search
4. Dawn watch survey
5. Nest site sampling
6. At-sea transects

Quality Assurance and Control Plans

Quality control will be provided for the dawn watch, the basic sampling method, by training all field personnel in Anchorage and on-site, following the Standing Operating Procedure Data taken on hand-held recorders during the dawn watch will be transcribed by the observer as soon as possible, using the data sheet developed for this study. The data sheet will be field-checked by the field supervisor, entered at the USFWS Anchorage office, checked against the raw data, and corrected

Habitat classification will be checked by USFS personnel on site, to assure standardization of habitat types during the Prince William Sound surveys At nest sites, habitat classification and plant identification will be conducted by or checked by USFS personnel. Vegetation samples taken from nests will be kept in paper bags, catalogued and identified by USFS personnel Eggshell samples will be catalogued and the majority of samples archived at the University of Alaska, Fairbanks museum

All at-sea murrelet counts will follow SOPs Standardization of distance judgements will be assured by practice and occasional observer calibration with use of a buoy on a 100 m line trailed from the censusing vessel. Data will be transcribed directly onto a waterproof data sheet and field checked

The principal investigator will be responsible for study design and analysis of data, which will be submitted for peer review

Information Required from Other Investigators

This study is a cooperative project with the USFS It will also require cooperation with GIS support services of both USFS and USFWS oil spill offices Prince William Sound boat survey data will be provided by NRDA Bird Study 2

Safety Requirements

All field personnel will attend standard USFWS safety training, which will include CPR, first aid, marine safety and survival, bear and gun safety. In addition, they will attend a four-day tree-climbing workshop given by Chuck McDonald (USFS, Quinalt Ranger District, Washington). Field personnel will also attend a map reading and orienteering class in preparation for upland surveys Float plans will be submitted prior to every marine trip Emergency procedures and standard safety operations followed in 1991 will be reviewed and maintained

DATA ANALYSIS

All data will be entered into a Paradox Relational Database (Release 3.0, Borland International) and will be transferred to SAS (Release 6.04, SAS institute, Inc) for analysis Steve Klosiewski, Biometrician for Migratory Bird Management, USFWS, will be consulted for assistance in analysis and interpretation of statistical results. Mapping and integration of GIS data will be done with the assistance of Tom Jennings and Barbara Boyle, USFWS.

The three dawn watch sites in Cabin Bay at Naked Island to be used as monitoring sites will be censured on the same day and all detections combined for examining trends in detection levels Morning detection trends will be graphed in five minute intervals before and after sunrise. Seasonal trends will be examined by graphing the total detections for each bi-monthly monitoring survey between May and August Seasonal changes in certain behavioral observations will be examined by graphing the frequency distribution of each behavior over time, and testing for significant differences in presence/absence of the behavior using a contingency table and Chi-square statistic. A similar test will be done between those sites known to be near a murrelet nest and those with no known nest.

For comparison between dawn surveys done inside and outside a forest stand, paired t-tests will be done on the total number of detections, number of visual detections and numbers of specific types of behaviors per watch

For both the Naked Island dawn surveys and those done throughout Prince William Sound, the rank correlation between number of upland detections and the at-sea counts conducted the same mornings will be tested using the Kendall's Tau-b statistic, to compensate for 'outlier' data points. Among the Prince William Sound survey sites, the mean number of detections between areas chosen for their high at-sea counts vs. those chosen for their low at-sea counts will be tested for a significant difference with a t-test

For the Prince William Sound surveys, the number of murrelet detections recorded during dawn watch surveys will be graphed to determine if there is a definitive separation between 'high-use' and 'low-use' sites. If so, these categories will be used to test (by T-test for continuous variables, Chi-square test for categorical variables) for significant differences in habitat features between sites with high vs. low murrelet activity Otherwise, a multivariate analysis will be done using habitat variables against the dependent variable of number of murrelet detections.

DELIVERABLES

This project will provide three reports·

1. A field season status report one month after completion of the field season;
2. A preliminary report for peer review, and,
3. A final report, in three sections, to address the three prime objectives Three sets of maps will be provided using the GIS:

    a) the Prince William Sound upland survey sites and their relative murrelet upland activity levels,

    b) the Naked Island survey sites, and the location of any murrelet nests, in conjunction with the ecological mapping units defined by the USFS, and,

    c) the at-sea distribution of murrelets, based on the randomly chosen transects around the Naked Island complex, once each for May, June and July

The Naked Island nesting habitat component will also provide a detailed description of nesting habitat and nest trees, plus definitions of behavioral cues indicative of nesting This component of the project will result in a refined training program and manual for conducting dawn watch surveys in Alaska, including audio tapes (and possibly video).

SCHEDULES & PLANNING

A. Data and Report Submission Schedule

1992 March	Secure charter vessel Hire personnel Order selected equipment
April	Preparation for field season (procurement and personnel, safety training, contracting)
1 - 10 May	Dawn-watch survey training
10 May - 20 Aug	Field season for Naked Island component
10 May - 8 Aug	Field season for Prince William Sound survey component
31 Aug	Status report on 1992 field season
10 Aug - Sept	Data entry and compilation
Oct - Dec	Data analysis and report writing
Dec	Preliminary report
1993 March	Final report

Sample and Data Archival

All nest samples and data will be archived at the Oil Spill Office, U.S Fish and Wildlife Service, Anchorage, Alaska

Management Plan

The Principal Investigator, Kathy Kuletz, will coordinate activities and data exchange with the U S Forest Service The USFS will have a botanist and two biological technicians gathering habitat data in the field. The Principal Investigator will be responsible for study design, coordination, data analysis and completion of final products. Two USFWS wildlife biologists (one for the Prince William Sound surveys and one for the Naked Island nesting habitat study) will be responsible for field operations and field checking of data. They will also assist in data entry, synthesis and analysis. In addition to the field supervisors, five USFWS biological technicians will assist in gathering data and data entry.

Logistics

Objective 1, the nesting habitat portion of this project, will be based on Naked Island, Prince William Sound The four permanent personnel based at this site will maintain a 25-foot Boston Whaler on site for at-sea transects, transport among islands, resupply trips to Whittier and as an emergency backup transport. They will also have a 12-foot inflatable boat for local transport The camp supplies and gas barrels will be delivered by barge in early May, and picked up in mid-August. Personnel will be equipped for overnight backpacking trips for surveying or locating nests distant from base camp.

Objective 2, the Prince William Sound survey of upland habitat use, will rely on a chartered 58-foot vessel equipped with at least one inflatable boat. The vessel, Auklet, under USFS contract, will be scheduled for use on this project with the cooperation of the vessel's owners and USFS. The Auklet sleeps six plus crew, and will provide for all food and fuel for the Prince William Sound surveys. Personnel will also be equipped for overnight backpacking and camping for surveying sites away from the anchor sites.

Objective 3, may require some travel by the PI or an assistant to review or retrieve data from the agency of origin Travel and per diem expenses are included in the budget

PERSONNEL QUALIFICATIONS

Principal Investigator: Kathy Kuletz received her M.S. from the University of California, Irvine, in 1983. Her thesis, based on research done at Naked Island, Prince William Sound, was on foraging and reproductive success of pigeon guillemots. Ms Kuletz has worked in Alaska since 1976 for the USFWS, Dames and Moore Consulting and LGL Alaska Research In 1988, she conducted an independent study on at-sea censusing of murrelets for the Alaska Maritime National Wildlife Refuge Since 1989, Ms Kuletz has been P.I. for the marbled murrelet damage assessment study and the restoration feasibility study for marbled murrelets

Naked Island field supervisor. Nancy Naslund did her M S. thesis research on the breeding biology of marbled murrelets in central coastal California. This work led to the discovery of two murrelet tree nests and represents the only in depth study yet conducted on murrelet breeding behavior Part of this study also resulted in the development of a ground search technique for locating murrelet tree nests. In addition, Ms Naslund has conducted field work since 1980 on a variety of terrestrial and marine bird species including the California least tern, peregrine falcon and California condor Ms Naslund was part of the 1991 team for the marbled murrelet restoration feasibility study

Prince William Sound Survey field supervisor: Dennis Marks completed his M.S. at the University of Oregon Institute of Marine Biology where he studied the feeding ecology of several species of bottom fish. In 1990 he participated in the marbled murrelet and pigeon guillemot damage assessment studies. In 1991 he was part of the Marbled Murrelet Restoration study Previous to these studies, Mr. Marks spent several years coordinating field projects on the west coast and abroad.

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OTHER INFORMATION

STANDARD OPERATING PROCEDURE REQUIREMENTS

A. Training procedure. All new field personnel will undergo training and verification prior to conducting dawn watch surveys. The training program will consist of three phases Trainees will first attend an introductory lecture explaining survey procedures and initial instruction on murrelet identification using videos of flying murrelets and audio recordings of murrelet calls and calls of other species that may be encountered. The next phase will include three days during which trainees are instructed in the field on the identification of flying murrelets and their calls, behavior classifications, and proper completion of data forms Finally, trainees will be tested in the field. Successful completion of the course will occur when a trainee adequately records 80% of the murrelet detections recorded by the instructor during a dawn watch survey.

B. Dawn watch surveys (for forest and alpine habitats) Dawn surveys of murrelet activity will be conducted using established protocol for "Intensive Inventory Surveys" (Paton et al. 1990). The following revisions will be made, based on prior studies at Naked Island and elsewhere

1. Dawn watch surveys will begin 1 hour prior to official sunrise (instead of 45 minutes) to compensate for the increased pre-dawn light levels associated with northern latitudes, relative to more southern latitudes where murrelet survey protocols were initially developed,

2. Additional data on flight behaviors and vocalizations, potentially important for interpreting murrelet activity, will be recorded (Nelson 1989, 1991; Naslund et al 1990b, Singer et al. 1991, Kuletz, unpubl. data, Naslund, unpubl data), and

3. The presence of other avian species will be recorded to determine the presence of potential avian predators.

C. Nest search protocols A ground search technique developed in California (Naslund et al 1990b) with appropriate revisions based on results of efforts on Naked Island in 1991 (Kuletz and Naslund, unpubl. data) will be used to search for nests This technique has two primary components and is summarized as follows:

1. Dawn nest search surveys. Searches begin 1 hour prior to and last 1 hour after official sunrise or

15 minutes after the last detection, whichever is later. Two or three observers are stationed at vantage points affording good visibility of the tree crown or stand canopy of interest Observers are located at opposing sides of the tree or stand so that visual and auditory detections of murrelets can be triangulated to determine specific areas of use. Observers focus on flight patterns that may indicate nearby nesting including 'fly-bys', 'flying in tandem', 'stall-outs', and landings and departures as well as vocalizations associated with incubation exchanges During the nestling phase, surveys will continue an additional half hour since murrelets are known to fly in to feed chicks throughout the day (Hamer and Cummins 1991, Naslund et al. 1990a); and

2. Intensive nest search An observation spot is established at least 25 m from the suspected nest tree with good visibility of the potential nest branch. Observations are made through a spotting scope and data recorded on a microcassette recorder. The objective is to observe the murrelet turning its egg, the time when an otherwise camouflaged murrelet becomes most visible Observation periods last for at least 2 uninterrupted hours during the morning to maximize the chance of observing a turning bout (based on activity patterns in California, Naslund et al. 1990a)

D. Nest site sampling Established protocol for collecting data on nests, nest trees and nest tree stands (Varoujean and Carter 1989) will be used, with one exception The dimensions of stand composition plots will be measured on the ground surface instead of a horizontal plane, to enable quantitative comparisons between plots (Mueller-Dombois and Ellenburg 1974).

E At-sea transects At-sea transects will repeat the pilot effort conducted in 1991, which tested the applicability of stratified random sampling in a relatively small area of marine habitat. A 1 km grid was overlaid on a nautical chart, with three strata being used

1. shoreline to 200 m from shore, using a complete shoreline census;

2. 200 m to 2 km from shore, creating a "buffer zone" surrounding Naked, Storey and Peak islands and,

3. 2 km to 5 km from shoreline, thirty blocks were randomly chosen in each of the last two strata, and within selected

blocks, the actual transect line was chosen among five possibilities, in increments of two degrees

These sixty 200 m-wide, 1 km-long transects will be censused once each in May, June and July to monitor seasonal changes in at-sea distribution. To minimize day-to-day effects, the complete census should be done over three consecutive days To minimize effects of diel activity patterns, the transects will only be censused between 0600 and 1200 hours. Seas should be calm (< 5 m) and visibility good. The driver and observers will use binoculars for positive identification and scan in a forward direction. Boat speed will be approximately 8 knots All birds and marine mammals will be counted, but priority will be given to murrelet counts and identification where aggregations of birds are encountered. Murrelets that cannot be positively identified to species will be categorized as *Brachyramphus* murrelet. Data will be recorded directly onto a waterproof data sheet (Appendix D) by one of the observers.

BUDGET ($K)

	USFWS	USFS	TOTAL
Personnel	$ 185.5	$ 38 9	$ 224.4
Travel	15.0	4 5	19.5
Contractual	61 8	23 0	84 8
Commodities	12.0	0.9	12 9
Equipment	36.7	1.5	38 2
Subtotal	$ 311.0	$ 68.8	$ 379.8
General Administration	32 1	7 4	39.5
Total	$ 343 1	$ 76 2	$ 419 3

RESTORATION PROJECT NUMBER 47

Study Title: Stream Habitat Assessment

Lead Agency: ADF&G

INTRODUCTION

Coastal stream systems and associated riparian areas are important habitat for a number of species that were injured by the Exxon Valdez oil spill. Stream surveys by ADF&G intend to focus on habitats that are of potential importance to pink salmon, Dolly Varden char, cutthroat trout, harlequin ducks, and bald eagles. These species are documented to have sustained injuries as a result of the oil spill, and all are associated to some extent with stream environments. Pink salmon, Dolly Varden char and cutthroat trout are anadromous species of fish that utilize freshwater environments for important life functions such as spawning, rearing and overwintering. Harlequin ducks use freshwater streams for nesting and feeding activities. Bald eagles frequently nest in the vicinity of freshwater streams where feeding opportunities are abundant.

Pink salmon exhibited higher than normal egg mortality rates in oiled areas (70 percent in 1989, 50 percent in 1990), and fry showed evidence of gross physical abnormalities Dolly Varden char and cutthroat trout sustained higher than normal annual mortalities (up to 32 percent) compared to unoiled areas; cutthroat trout had reduced growth rates in oiled areas In excess of 200 harlequin ducks died from direct exposure to oil in 1989, and studies indicate that ducks may have suffered a nearly complete reproductive failure in the Prince William Sound oil spill area during 1990 and 1991. At least 144 bald eagles died as a result of direct exposure to oil or by eating oiled carrion, and bald eagles have experienced higher rates of nest failure in oiled areas

Certain development activities, particularly clearcut logging of mature forests, represent a potential threat to fish and wildlife resources that rely on these habitats for critical life functions. This threat is expressed as an incremental loss of habitat that may impede the recovery of injured species populations or may inflict additional injury. The proposed surveys are intended to focus on private lands that are scheduled for logging or other types of major habitat alteration Unless these surveys are conducted in 1992, opportunities may be lost to identify and protect key habitats that sustain fish and wildlife populations. The surveys will cover the entire spill area

Survey data will be designed and presented to provide the basic habitat information needed to identify and prioritize the most important habitat areas for protection and enhancement decisions.

Another benefit is that previously unidentified streams will be added to the ADF&G Catalog and Atlas of Anadromous Waters and consequently protected under the provisions of the state's Anadromous Fish Act and Forest Practices Act

Stream habitat surveys will be coordinated with ADF&G Sport Fish and Wildlife Conservation division efforts to restore other injured species habitats. 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, particularly in areas outside of Prince William Sound. 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.

OBJECTIVES

The overall goal of this project is to facilitate the recovery of injured species and prevent additional injury by protecting important stream habitats and riparian zones in the oil spill area from logging and other potentially detrimental activities This goal will be met by accomplishing the following objectives and tasks:

Objective 1:

Using the Trustee Council process for identifying and evaluating lands and habitats necessary and appropriate for protection, identify and prioritize private lands where an imminent and significant habitat alteration threat exists

Task:

A. Evaluate private lands by employing aerial photographs and the ADF&G Anadromous Waters Catalog to select potential areas for expanding fish distribution or identifying new streams

B. Determine development schedules. Obtain approvals for access to private lands for purposes of conducting stream habitat surveys.

C. Review permit application and approvals.

Objective 2:

Initiate surveys on private lands to document anadromous fish distribution and stream habitat characteristics

Task:

A. Locate sites and record habitat characteristics using a Global Positioning System (GPS) Record the upstream distribution of fish using a backpack electroshocker

Objective 3:

Provide decision-makers with products that can be used in implementing protective measures or developing acquisition strategies.

Task:

A. Conduct post-processing of GPS locational data and integrate with the survey results into a Geographic Information System (GIS) database Develop maps delineating fish distribution and habitat parameters Compile an project report detailing results of stream surveys. Provide digital data upon request to supplement related restoration projects.

METHODS

A. Sampling Methods

In order to be responsive to the needs of the restoration program, study site selection will be influenced by the following factors. 1) a prioritized list of private lands in the oil spill area that are scheduled for development within the next five years; 2) policy decisions by the Trustees that focus on certain lands for potential acquisition or some other protection strategy, 3) the approval of land owners to access lands for purposes of conducting surveys, 4) existing Anadromous Waters Catalog information that depicts a potential for expanding anadromous fish resources in candidate areas; and 5) integration with other upland habitat assessment studies

Once potential sites are selected, one or two reconnaissance visits will be conducted in each area to assess general hydrologic, topographic and vegetative features This information will be used to determine the overall approach to conducting a more detailed survey of the area Considerations to be addressed during initial site reconnaissance are access, vegetative cover, helicopter logistics, obvious barriers to upstream fish migration, and estimated time to complete the survey

Surveys will employ standard, established techniques for recording information and documenting fish distribution Streams will be surveyed after spawning has begun during the months of July, August and September. A field crew will walk stream channels and record site locations and habitat characteristics using a Global Positioning System (GPS) Streams will be segmented into homogeneous reaches in order to accurately describe physical features Habitat characteristics that will be recorded include substrate, gradient, stream width, bank incision, riparian vegetation, and instream debris. In addition, a backpack electroshocker will be used to sample for fish presence. All wildlife observations will be recorded.

The information generated during a stream survey will be downloaded to a laptop computer from handheld GPS receivers and post-processed to provide accurate locational and attribute data. It is intended that this digital data will then be imported to a geographic information system (GIS) for further analysis and mapping The database structure that is to be used in cataloging various habitat parameters is included in Section XI (Other Information)

Field crews will be based on-site at logging camps, or will utilize other facilities such as recreational cabins for base camps.

B. Standard Operating Procedures

Not applicable.

C. Quality Assurance and Control plans

All habitat parameters and species counts will be integrated with location data to form a GIS database. Geographic coordinates will be logged at regular intervals using a Trimble GPS Pathfinder receiver, and attributes such as species counts and habitat parameters will be entered into the data logger through bar codes. During post processing, the coordinates will be verified and adjusted through a differential correction process, utilizing base station control positions. Upon arrival at a survey site, aerial photographs will be taken of the stream to obtain as large a coverage as possible to allow for further verification of location data

The stream habitat portion of the data will be transferred to a laptop computer after each survey. Downloaded data and forms containing species counts and general stream information will be reviewed prior to submittal for data processing, and after data entry.

D. Safety Requirements

Prior to onset of the field season all personnel who will go on any survey will be trained or updated as necessary to be current on the following: Red Cross First Aid and CPR, bear training and wilderness survival training. According to current FAA procedures, the survey crew is briefed on specific helicopter safety procedures by the pilot before each takeoff.

F. Animal Health and Welfare

Not applicable.

DATA REDUCTION AND ANALYSIS

A. Methods

The intent of this study is to document the presence of anadromous fish species and the upper limits of their distribution, and to map habitat parameters within these limits. As such, statistical analyses are not warranted and data reduction will be limited to GIS processes and production of tables. Upon data entry and QA/QC, the data will be loaded into R:BASE, and integrated into GIS through Geo/SQL for final output in Autocad It is intended that this process will occur in real time. R:BASE will serve as the basis for data storage, table generation and data transfer.

DELIVERABLES

Data output will consist of color coded maps and overlays depicting stream sections and their associated habitat parameters, annotated incidental species catches, and documented upper limits of anadromous species. Tables of this information with additional references to wildlife observations, sampling conditions and location information will be generated, accompanied by a summary report. Digital data and Autocad transfer files will be available upon request. An accompanying report will describe survey methodology and results in narrative form.

SCHEDULES AND PLANNING

A Data Report and Submission Schedule

April 1, 1992
Work with Restoration Team to fit project into land and habitat identification draft process.

May 15, 1992
Land identification process completed. Access approvals obtained.

June 1, 1992
Training for field personnel. Equipment purchases. Specific survey planning.

July 1, 1992
Stream surveys begin. At biweekly intervals, data will be submitted to the Anchorage regional office and processed. Surveys will continue on a 10 day on, 4 day off schedule throughout the next ninety days.

September 30, 1992
End of data collection

October 30, 1992
Data QA/QC has been completed for all streams surveyed during the season. Generation of final maps and data tables begins.

November 30, 1992
Maps and tables undergo final review Report production begins.

December 15, 1992
Report and data submission deadline.

Field staff will be deactivated on November 30. The principal investigator and data management coordinator will continue through the remainder of the fiscal year. Ongoing responsibilities include 1) coordination with the Restoration Team (RT) on land acquisition and protection strategies; 2) coordination with private land owners on land development planning; 3) coordination with NRDA and restoration scientists on survey results; 4) administrative and logistical planning.

B. Sample and Data Archival

Data forms, field logs, diskettes and rolls of photos will be transferred to the Anchorage office. Upon transfer, copies of the above will be submitted to RT for archiving. The originals will be archived at Habitat, ADF&G in Anchorage. For each stream surveyed, a stream file will be set up that will contain all updates and documentation pertaining to this stream. Data files will be backed up after each modification, along with a digital file listing in detail each modification.

C. Management Plan

Coordination and overall project supervision will occur in Anchorage. The principal investigator will attend all necessary meetings, participate in the land identification process, conduct site reconnaissance surveys and participate in stream habitat surveys. In addition, the principal investigator will be responsible for all administrative duties including budgeting, logistics, and training. The data management coordinator will oversee all data-related functions, including GPS post-processing, database development, GIS mapping and report generation The data management coordinator will also serve as the primary field supervisor. The remainder of the field crew, including one crew leader and two technicians, will be responsible for acquiring stream habitat data.

D. Logistics

Logistics are contingent upon the region in which the study is located. For surveys in Kachemak Bay and the outer Kenai Coast, field personnel will reside in Homer and fly daily by helicopter from Homer to the survey streams For surveys in Prince William Sound and on Afognak Island, the field crews will be accommodated in logging camps or Forest Service cabins. A helicopter and pilot will be stationed with the crew at each camp in order to minimize the number of lost days due to poor weather between the flight service and the crew's location. Fuel will be cached near the base camps by boat prior to the field season Estimates of helicopter charter costs are based upon previous ADF&G experience conducting stream habitat surveys on Montague Island in Prince William Sound Actual helicopter needs will vary with specific site conditions

PERSONNEL QUALIFICATIONS

Principal Investigator

Mark N. Kuwada. Habitat Biologist with the Alaska Department of Fish and Game for 12 years. Extensive experience in mitigating major project impacts and restoring injured habitats· Susitna Hydroelectric Project, Bradley Lake Hydroelectric Project; Diamond Chuitna Coal Project Response Coordinator, Exxon Valdez oil spill, for ADF&G.

Project Assistant:

Kathrin Sundet Habitat Biologist and Fisheries Biologist with the Alaska Department of Fish and Game for 7 years Data management for Kinnetic Labs, America North Inc., and environmental consulting companies in California for 4 years Experience in management of biological databases, GIS, fish habitat evaluations and various fisheries related field projects: Susitna Hydroelectric Project and Exxon Valdez oil spill.

	BUDGET ($K)
Salaries	$211 0
Travel	7 8
Contractual	85.4
Supplies	31 0
Equipment	25 0
Subtotal	$360 2
General Administration	39 4
Total	$399 6

RESTORATION PROJECT NUMBER 71

Study Title: Harlequin Duck Restoration and Monitoring

Lead Agency: ADF&G

PROJECT JUSTIFICATION

Component I

The Exxon Valdez oil spill of March 24, 1989, heavily impacted the harlequin duck (Histrionicus histrionicus) population in western Prince William Sound The Sea Duck Study in Bird Number 1 reported sublethal symptoms of petroleum hydrocarbon contamination, including an apparent reproductive failure in harlequin ducks (Patten 1991).

Harlequin ducks breed along mountain streams in coastal old growth forests in Prince William Sound Harlequin ducks have a relatively low reproductive rate because of small brood size (3 4 ducklings/brood in Prince William Sound), second year sexual maturity and low breeding frequency (<50%) of hens (Dzinbal 1980, Crowley 1991). Harlequin ducks have high fidelity to breeding and wintering areas (Bengtson 1972) Kuchel (1977) stated that several consecutive years of very low production or injury to winter and breeding habitat could completely eliminate a local harlequin duck population.

The Harlequin Duck Restoration Project (Crowley 1991) documented successful harlequin duck reproduction in 1991 in unoiled northern, eastern, and southern (referred to collectively as "eastern" unless specified) Prince William Sound This area was not impacted by the oil spill. However, large tracts of harlequin duck breeding habitat in old growth forest of prime commercial value are currently scheduled for logging in Prince William Sound

The impaired status of harlequin duck populations in the Exxon Valdez oil spill area of western Prince William Sound may necessitate protection and management of populations in the non-impacted areas of Prince William Sound. A large population of harlequin ducks in eastern Prince William Sound could provide a pool of immigrants to western Prince William Sound Recolonization of the oil spill area by reproducing harlequin ducks should eventually occur provided that petroleum hydrocarbons are at sufficiently low levels in the intertidal zone Management of harlequin duck populations could be accomplished through protection and possible enhancement of undisturbed riparian corridors within timber sale areas. Required width for protection of harlequin ducks using riparian corridors has not been determined conclusively Nest locations in 1991 indicated that current buffer strips required for protection of anadromous fish streams may not protect all harlequin duck breeding habitat.

Harlequin ducks are among the least understood waterfowl species in North America. Prior to the 1990 feasibility study, which reported characteristics of streams on which harlequin duck broods were observed, little was known about habitat requirements of harlequin ducks breeding in Prince William Sound The harlequin duck restoration crew began locating and recording harlequin duck nesting habitat in 1991.

The harlequin duck restoration project in 1992 will continue to document nesting and brood-rearing habitat requirements of breeding harlequin ducks by capturing and radio-tagging hens Study of nest site habitat, including nest bowl (down-lined depression containing eggs) cover, may provide information for habitat enhancement By documenting breeding stream habitat within the structure of a hierarchical stream profile, a model predicting potential breeding habitat will be developed for use in the oil spill area and other coastal areas. A catalog of harlequin duck breeding streams in eastern Prince William Sound will be completed. Duckling survival and productivity will be determined by monitoring radio-tagged hens throughout the brood-rearing period. Molting habitat and population status will be determined using standardized boat survey methods developed in 1991

OBJECTIVES

1. Locate, identify and describe harlequin duck nesting streams in Prince William Sound.

2. Identify habitats used by nesting and brood-rearing harlequin ducks by documenting topographic, hydrologic and vegetative characteristics at nest sites and brood-rearing areas.

3. Identify other harlequin duck breeding habitat parameters such as distance from nest to coast, distance from nest to stream and physical features of nest sites.

4. Construct a model that predicts potential harlequin duck nesting streams and high quality habitat along those streams using the characteristics identified in objectives 2 and 3

5. Measure harlequin duck breeding productivity by identifying clutch size, hatching success, and duckling survival to fledgling.

6. Document sightings of harlequin duck breeding behavior including pair-bonding, nest prospecting, nesting, and brood-rearing in eastern Prince William Sound to provide a study control for

the harlequin duck monitoring study in the Exxon Valdez oil spill area.

7. Determine width of forested buffer strips required to protect harlequin duck breeding sites from the effects of timber harvest in Prince William Sound

8. Determine feasibility of stream habitat enhancement by erecting artificial nesting cavities (nest boxes) along known breeding streams and testing for use by harlequin ducks

METHODS

The Prince William Sound Harlequin Duck Restoration Project is now in its second year; the methods described below have been used and modified as necessary.

If present, breeding harlequin ducks of both sexes and nonbreeding hens can be readily captured during twilight hours as they fly to and from estuaries from breeding stream habitat in spring and early summer. Harlequin duck trapping efforts will begin in late May 1992 on streams used by breeding harlequin ducks in 1991 Harlequin ducks will be caught during their nest prospecting, egg-laying and incubation periods by suspending mist nets over breeding streams

All captured harlequin ducks will be weighed, measured and banded with a USFWS leg band A blood sample will be drawn from each harlequin duck to help determine if harlequin ducks from eastern Prince William Sound may winter in the Exxon Valdez oil spill area. Blood samples will also be used to compare physiological condition of harlequin ducks between study areas Captured harlequin hens, regardless of breeding status, will be tagged with a small (4 5 g) radio transmitter and released Transmitters are glued to the bases of center tail feathers and will be shed in early September The transmitter did not noticeably affect diving, preening or breeding of harlequin ducks in 1991

When harlequin duck nests are located, eggs will be counted, weighed, measured and candled to determine approximate stage of incubation (Weller 1956). Project staff will return to nests located in 1992 and to those located in 1991 again during the 1992 field season to count membranes and addled eggs to determine hatching success. The Mayfield method (Klett and Johnson 1982) will be used to determine nesting success Terrestrial and aquatic habitat of breeding and non-breeding streams will be recorded and statistically compared using a principal components analysis This test will determine habitat characteristics important for nesting and brood-rearing harlequin ducks

The use of wooden nest boxes by harlequin ducks will be tested by placing 20-25 boxes along known breeding streams, near known nest sites in spring 1992. A box design has been developed based on specifications of nesting boxes used by aviculturalists to breed harlequin ducks in captivity. If harlequin ducks follow behavioral patterns described for other sea ducks, limited use of nest boxes would be expected during the first year and increased use in subsequent years, especially by first-time breeders. Should the results indicate that harlequin hens readily select artificial cavities for nesting, and if nest cover is a limiting factor on streams in Prince William Sound, this technique could potentially increase stream nesting density of harlequin ducks. Such an increase would accelerate restoration of harlequin ducks in western Prince William Sound, provided that petroleum hydrocarbons are no longer present in the intertidal food chain

During the last two weeks of May, approximately 350 miles of unoiled coastline and estuaries from Cordova to Valdez will be surveyed for harlequin duck flocks and breeding pairs Surveys will be repeated in late June through early July in both study areas to locate and document important molting habitat, and repeated again in August for brood documentation

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Component II

The Division of Wildlife Conservation, Alaska Department of Fish and Game, will conduct a 1992 monitoring study of a population of harlequin ducks that suffered reproductive failure in western Prince William Sound as a result of the Exxon Valdez oil spill of March 24, 1989.

Harlequin ducks are a resident waterfowl species breeding in Prince William Sound during the spring and summer (Isleib and Kessel, 1973; Hogan, 1980). Harlequin ducks, because of their resident, breeding status and intertidal foraging habits, have been considered substantially at risk from effects of the Exxon Valdez oil spill (King and Sanger, 1979).

Harlequin ducks feed in the intertidal zone and consume a wide variety of intertidal clams, snails, small blue mussels, and limpets (Koehle, Rothe and Dirksen, 1982, Dzinbal and Jarvis, 1982, Vermeer and Bourne, 1982). Bivalves, particularly blue mussels (*Mytilus*), and small clams (*Macoma*), are well-known for their ability to concentrate pollutants at high levels (Shaw et al, 1976). The crude oil spilled from the T/V Exxon Valdez injured marine invertebrates that support sea ducks throughout the year (Stekoll, Clement, and Shaw, 1980) Bioaccumulation in the food chain may result in uptake of petroleum hydrocarbons by sea ducks over a long period (Dzinbal and Jarvis, 1982, Sanger and Jones, 1982).

Other studies in the seabird literature have indicated that low doses of petroleum exposure through ingestion have resulted in failure to reproduce (Fry et al, 1986) Birds fed single doses of petroleum oils exhibited altered yolk structure and reduced hatchability of eggs (Grau et al, 1977) These results are in accordance with theoretical predictions of effects of petroleum exposure through the food chain to higher trophic level invertebrate predators such as seaducks. The duration of this reproductive failure is unknown.

Consumption of oiled invertebrate prey items is the probable mechanism of sublethal petroleum hydrocarbon exposure. The degree of exposure is in turn most likely related to the foraging areas of the respective species. The zone of maximum oil impact is demonstrably the intertidal area Harlequin ducks, because of their intertidal foraging habitats, appear most exposed of six seaduck species examined.

Buried oil occurs in Prince William Sound and relatively unweathered crude oil remains in mussel beds where harlequin ducks and other seaducks feed. As long as substantial oil remains in Prince William Sound, particularly in the intertidal, harlequin ducks may fail to breed, and monitoring is required Since harlequin ducks are sensitive to disturbance, the lessening of the massive disturbance associated with clean-up activities in Prince William Sound also provides the setting for a natural monitoring experiment to test the effects on harlequin duck reproduction.

Post-oil spill reproduction, recolonization, and survival of harlequin ducks in the oil spill area of Prince William Sound are to be addressed in this study Harlequin ducks may serve as an indicator of the health of the recovering ecosystem, but their recovery will be impeded as long as their food chain remains contaminated with petrochemicals.

OBJECTIVES

1. Monitor scope, magnitude, and duration of harlequin duck reproductive failure in western Prince William Sound; determine the extent of this phenomenon in northern and southern Prince William Sound. In other words, where does normal harlequin duck reproduction begin? Extend monitoring of harlequin duck reproductive failure within Prince William Sound; conduct surveys to establish areas of use; survey numbers of harlequin ducks using oiled vs. non-oiled streams.

2. From the concluding Damage Assessment Study, relate pending petroleum toxicology analysis of blue mussels (Mytilus) and other invertebrates from seaduck proventriculus samples collected in '89 -'90 to histopathological analyses and to continued reproductive failure of Prince William Sound harlequin ducks in monitoring study

3. Relate the reproductive status of harlequin ducks in the Monitoring Study to the presence of Exxon Valdez oil in established blue mussel (Mytilus) beds in Prince William Sound

4. Compare habitat, food items, and other characteristics associated with streams on which successful reproduction is occurring in eastern Prince William Sound with "similar" streams having no reproduction in western Prince William Sound

5. Determine effect of reduction of disturbance associated with cessation of clean-up activities on reproductive performance of harlequin ducks in Prince William Sound

6. Continue review of issue of sport and subsistence harvests of harlequin ducks, especially in reference to Kenai Peninsula and Kodiak Island. Hunting in Prince William Sound was closed to take of harlequin ducks for the month September 1991 in order

to protect remaining resident individuals from additional mortality.

METHODS

This project uses established methodology derived during three previous years of harlequin duck damage assessment studies and two previous years of harlequin duck restoration work

ADF&G will perform an analysis of the reproductive failure of harlequin ducks observed in the oil spill area of western Prince William Sound in 1990-91. This activity will answer physiological and behavioral questions such as. what is the nesting status of harlequin females along streams in western Prince William Sound? Were all females exhibiting fidelity to nest sites removed from the western Prince William Sound population by the oil spill and thus no nesting? If nesting is occurring, are eggs viable? Are hatching and fledging success depressed? If ducklings fledge in the oil spill area in 1992, brood size (a productivity measurement) will be compared to unoiled areas of Prince William Sound

The ADF&G will conduct extensive surveys of anadromous streams and molting sites used by harlequin ducks in Prince William Sound Harlequin duck breeding pairs and young females normally prospect for nest sites during twilight hours in spring along mountain drainages flowing into Prince William Sound Incubating females fly from nest sites to feed in intertidal estuaries Mist nets were placed by ADF&G personnel across the mouths of twelve of the larger anadromous fish streams in western Prince William Sound in spring and summer 1991. If harlequin ducks attempt reproduction in the oil spill area in spring 1992, incubating females will be mist-netted and radio-tagged at stream mouths These harlequin ducks will be radio-tracked along streams to nesting sites Nesting females are secretive and nests otherwise difficult to locate. If breeding is verified, ADF&G will determine harlequin duck productivity by following radio-tagged hens and offspring through the nesting and brood-rearing cycle Clutch size, hatching success, and brood size (a productivity index) will be obtained from sample nest sites in oiled areas Limnological work on nesting and non-nesting streams will be expanded using standard techniques. Results will be compared to the harlequin duck restoration study in unoiled eastern Prince William Sound, which acts as an unexposed (control) case.

File searches at the Oil Spill Public Information Center and US Coast Guard _Exxon Valdez_ oil spill libraries will also be conducted to obtain existing documentation of presence of oiled mussel beds in Prince William Sound and will cooperate fully with the proposed 1992 NOAA mussel bed restoration study

Toxicological and histopathological tissue sample results will be obtained from the concluding Seaduck Damage Assessment Study. These results will be related to the physiological and reproductive data in the monitoring study

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BUDGET ($K)

Salaries	$191 3
Travel	50.0
Contractual	74 3
Supplies	35.0
Equipment	40 0
Subtotal	$390 6
General Administration	33 9
Total	$424 5

2G. RESTORATION MANAGEMENT ACTIONS

The Trustee agencies were responsible for managing the resources affected by the Exxon Valdez oil spill prior to its occurrence Management actions control human access to and harvest of a resource in order to ensure its continued abundance in the future. At one extreme no harvest of a resource would be allowed, or perhaps access to nesting sites would be restricted. Some birds often fall into this category At the other extreme, commercial fishing for a particular species is often allowed up to the maximum sustainable yield (that maximum level of harvest which does not cause a decline in recruitment to future populations). The Exxon Valdez oil spill increased the effort and expense of management actions needed to provide the same level of resource protection as prior to the spill. Therefore the Trustee Council decided that expenditure of settlement monies was appropriate for projects that make management actions possible which would promote recovery of injured species. Five projects in this category were funded to go forward and two received sufficient funds to close out the projects.

Kenai River Sockeye Salmon Restoration, Restoration Project Number 53 (R53), and Assessment of Genetic Stock Structure of Salmonids (R59) combine efforts to identify stocks of sockeye from different Cook Inlet drainages. Techniques perfected in 1992 will be used in 1993 (the first year of expected poor adult returns) to identify stocks of salmon as they enter Cook Inlet. Fishing for stocks bound for the Kenai system will be restricted or closed while fishing for non-impacted stocks will be allowed Because of this, sufficient adults may avoid the fisheries and return to the Kenai River to spawn and restore these stocks while commercial fishermen are still able to harvest some fish bound for non-Kenai systems

Pink Salmon Stock Identification (R60AB) will recover and read coded wire tags placed in Prince William Sound pink salmon in 1991. Outmigrating fry were tagged with codes unique to each stream. The tags are removed from the heads of returning adults and read with a microscope. This knowledge helps managers re-direct the fisheries away from impacted wild stocks Many people are required to recover these tags from fisheries, canneries and streams, but this effort in 1991 helped many wild streams make escapement goals

In 1989, most oiled mussel beds were subjected to aggressive treatment. In 1990 and 1991, oiled mussel beds were purposefully spared from these types of treatment because it was believed that more harm than good would result from application of these techniques. Because of the nature of mussel beds, oil was trapped between mussels and the rocks to which they were attached and has remained unweathered to the present Mussel communities are important in the diets of several oil-impacted birds and mammals. Destruction of the oiled beds would remove a food source for these animals whereas leaving the beds continues to expose the animals to toxic mussels and oil. The Oiled Mussel Bed Project, Restoration Project Number 103 (R103), will determine the effects of oiled beds on these other animals and devise amelioration options

In the cleanup process following the Exxon Valdez oil spill, many archeological sites were discovered or became more widely known Vandalism of some of these sites occurred and because of the increased awareness of their existence, vandalism may increase in the future. Some sites are sacred to Alaska's Native peoples and other sites will provide information about native heritage if they are excavated using scientific archaeological techniques Vandalism desecrates some sites and forever destroys the opportunity to learn from others. Protecting these sites is not an easy task and is a skill requiring instruction Site Stewardship (R104A) recruits, educates and involves local people from throughout the spill zone in the process of protecting archeological resources.

The two projects being brought to a close by the Trustee Council, the Harbor Seal Restoration Study (R73) and Technical Support for the Restoration of Dolly Varden and Cutthroat Trout, Restoration Project Number 106 (R106), have some costs associated with completing the field work and preparing final reports The information in these reports will be used by resource managers to reduce human use of these species until they can recover

RESTORATION PROJECT NUMBER 53

Study Title: Kenai River Sockeye Salmon Restoration

Lead Agency: ADF&G

PROJECT JUSTIFICATION

Sockeye salmon (Oncorhynchus nerka) which spawn in the Kenai River system (Figure 1) were injured by the Exxon Valdez oil spill. Greatly reduced fishing time in the Upper Cook Inlet area due to the oil spill caused sockeye salmon spawning escapement levels in the Kenai River system to exceed the desired amount by three times The biological impact of the oil spill on Kenai River sockeye salmon stocks is expected to be serious Data collected by NRDA Fish/Shellfish Study 27, Sockeye Salmon Overescapement, indicated greatly reduced survival of juvenile sockeye salmon during the winter-spring rearing period. The extremely high escapement may have initially produced more rearing juvenile sockeye salmon than could be supported by nursery lake productivity. In general, when rearing salmon abundance greatly exceeds lake carrying capacity, the species and size composition of prey resources are altered, which affects all trophic levels Because of such changes, juvenile sockeye growth is reduced, freshwater mortality is increased, greater proportions of fry remain in the lake for another year of rearing, and smolt condition is reduced and marine mortality is increased 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 low that a severe reduction, or complete elimination, of human use of this species may be necessary starting in 1993 to ensure minimum escapements

The goal of this project is to restore Kenai River sockeye salmon stocks injured by the Exxon Valdez oil spill This will be accomplished through improved stock assessment capabilities, more accurate regulation of spawning levels, and modification of human use. Restoration of Kenai River sockeye salmon stocks will be achieved when average fry, smolt, and adult production can be maintained. Prey resources of rearing lakes must also be restored to normal levels (This will be monitored under another restoration study, which will be based on information obtained from NRDA Fish/Shellfish Study 27).

OBJECTIVES

The objectives of this study are to

1. Improve stock identification capabilities by combining parasite and genetic stock identification information with available scale growth data in algorithms to provide estimates of Kenai River stocks in the mixed stock fishery of Upper Cook Inlet (UCI),

2. Increase the accuracy and precision of escapement monitoring by replacing obsolete hydroacoustic equipment, and,

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

METHODS

Stock identification

Stock identification studies used to regulate human use of UCI sockeye salmon have in past years relied on scale growth patterns. The accuracy and precision of this technique has varied considerably from year to year (Waltemyer, D , personal communication, ADF&G). Kenai stocks typically dominate the total return, and their scale patterns are generally distinct enough to provide some separation from other stocks. However, when runs to other systems are more abundant (as may occur in 1993 and 1994) separation of Kenai stocks will be much more difficult To be able to identify the contribution of Kenai River sockeye salmon to the total run accurately in this situation 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. The combination of scale patterns, parasites and genetic stock identification techniques (Restoration Science Study Number 59) should greatly increase the accuracy of UCI stock assessment estimates

Sockeye salmon escapements into major drainages of Upper Cook Inlet (Table 1) will be sampled for genetic, parasite, scale and otolith characteristics. During the first year, 25 baseline populations will be sampled for genetic characteristics In addition, mixed stock samples will be collected from four mainstem sites and from two drift net fishing periods Sample sizes for allozyme baseline collections have been set at 100 to maximize the precision around allele frequency estimates (Allendorf and Phelps 1980, Waples 1990). Mixed stock sample sizes have been set at 200 (Pella and Milner 1987) and will be adjusted in 1993 based on the results of simulation studies conducted with 1992 baseline data (Restoration Science Project R59).

Muscle, liver, eye, and heart will be dissected from recently killed sockeye salmon. Tissues will be placed in labeled cryovials stored in liquid nitrogen until transferred to -80°C storage freezers in Soldotna or Anchorage. Soldotna samples will be shipped to the Anchorage laboratory on dry ice or liquid nitrogen and again placed in -80°C storage until processed.

The body cavity of each sockeye salmon will be examined for the presence of the nematode _Philonema oncorhynchi_ (Tarbox et al. 1991). Scales will be taken from the left side of each sockeye salmon sampled. These scales will be removed from a location approximately two rows above the lateral line on the diagonal row that extends down from the posterior insertion of the dorsal fin (Koo 1955). Sacculus otoliths will be taken using procedures of Williams and Bedford (1973).

Escapement Monitoring

Bendix Corporation side scan hydroacoustic equipment has been 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 Corp Not only has it been difficult to obtain parts for these units, but advances in hydroacoustic technology have made this equipment obsolete. New units are able to track individual fish, obtain target strength measurements, and document calibration Court actions associated with the _Glacier Bay_ oil spill in UCI placed the hydroacoustic escapement monitoring program under intense scrutiny Although Ehrenberg (1992) concluded that the Bendix counters produced reliable escapement counts under conditions found in UCI systems, it is imperative that replacement alternatives be pursued Lack of Bendix replacement parts and the inability to purchase new Bendix counters may compromise the future ability to provide escapement estimates. Accuracy of estimates would certainly be enhanced through use of newer, more technically advanced equipment.

Two hydroacoustic equipment manufacturers will be selected to perform "in situ" tests of their equipment during the 1992 field season. Criteria for selection of hydroacoustic contractors will include: 1) historical performance (counting precision and accuracy) in similar environments; 2) specifications on manufactured systems including frequency, transducers; pulse repetition rates, multiplexing ability, beam characteristics, repair record, total cost (including maintenance), remote site use, and fish passage rate limitations, 3) data processing requirements, including software and hardware, 4) real time ability to track individual fish, calculated hourly passage rate, estimate target strength, determine direction of fish travel, and provide permanent data; and 5) personnel training required to operate system, including specialized areas of expertise

"In situ" field tests will be conducted on the Kenai River A minimum of 48 hours of data will be collected during a 72 hour period on each river bank (a total of 96 hours of data collection) This data will be compared with data from the existing Bendix counters. Operation of the equipment will be the responsibility of the manufacturer's representatives Individual target and site information will also be required These data will include transducer aiming and bottom characteristics, counting range, threshold used, pings/target, target strength, direction of fish travel, fish tracking parameters used, calibration records for each hydroacoustic unit used, beam pattern factors, and standard "in situ" target measurements

Evaluation of 1992 tests will result in selection of the most appropriate replacement system During the 1993 and 1994 field season the manufacturers, under the direction of ADF&G, may conduct continuous operations on both river banks during a three week period (to encompass the peak of the sockeye salmon run) During this period the Bendix counters will also be operated so that redundant counting systems will be in place and additional comparison data can be generated

Offshore Test Fish Program

The sockeye salmon total run to UCI has been estimated early during the season by test fishing between Anchor River and Red River delta (Tarbox, 1992) Sockeye salmon returning to UCI are captured with a drift gill net at a series of stations Salmon are identified to species and sex and length measurements made. Estimates of total sockeye salmon return are made several times during the 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 run size more accurately, additional sampling effort will be added to the existing program. Starting in 1992 hydroacoustic equipment and techniques will be developed through a contractor experienced in marine salmon investigations This technique 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

During the 1992 field season a feasibility study will be conducted in the area of the existing test fish program Replicate transects, each covering 6 km, will be made. Preliminary estimates indicate that a minimum of four transects per day can be completed However, the actual number of replicates obtained will depend on weather and other factors The contractor will be responsible for all aspects of the project including field data collection and data analysis. Anticipated results include 1) operating parameters of the hydroacoustic system used, 2) real time estimates of fish density, 3) fish distribution across the transects, and 4) definition of run timing models and total return estimates

Quality Assurance and Control Plans

Written instructions for the collection and analysis of all data will be prepared and made available to each project participant. In addition, a team, composed of Al Menin (designer of the Bendix sonar counters), representatives of the Chief Fisheries Scientist office, and local staff will be formed to thoroughly review all aspects of the hydroacoustic studies Written findings of the review team will be maintained as part of the project records.

Information required from other investigators

Analysis of genetic samples will be conducted under Restoration Science Study 59. Incorporation of genetic data into UCI stock identification models will remain part of this investigation.

Safety requirements

Personnel will be trained in standard safety procedures required for ADF&G work. Special instruction in handling liquid nitrogen for storage of genetic samples will be provided under Restoration Science Study 59.

Animal Health and Welfare

Sockeye salmon will be killed to obtain genetic samples.

DATA ANALYSIS

Stock Identification

Stock composition of mixed stock fishery samples can be estimated using scale pattern analysis (Bethe et al 1980, Cross et al 1981, 1982, 1983, 1986), parasite data (Tarbox et al 1991), genetic data (Pella and Milner 1987), or a combination of all three (Fournier at al. 1984, Wood et al. 1987, 1989).

Stock resolution will be enhanced by using several kinds of biological marker data simultaneously. Typically a maximum-likelihood estimation procedure for a mixture problem with learning samples has been used to combine these data (Millar 1987, Wood et al. 1987). Scale, parasite, and genetic data have been combined for sockeye salmon returning to British Columbia, Canada, and Southeast Alaska (Wood et al. 1989), while parasite data has been used in conjunction with scale data in Southeast Alaska (personal communication Kathleen Jensen, ADF&G, Douglas, Alaska)
This methodology assumes there are a total of K stocks which could occur in the mixture. For each stock j, an independent random sample of fish is taken and for each fish r, a vector of character-

istics $\mathbf{X}_{jr}$ (scales, parasites, genetics) is observed It is assumed that for each stock the vector of observed characteristics for a fish from that stock is a random vector with a probability mass function $f_j(\mathbf{X};\mathbf{A}_j)$ which depends on the unknown parameters $\mathbf{A}_j$. In addition, there is also a random sample of fish indexed by s which is taken from the mixture, and $\mathbf{Y}_s$ is the vector of characteristics of the sth fish taken from the mixture

Let p_j, $j = 1, \ldots, K$, be the proportion of the mixture which is composed of the jth stock The maximum-likelihood estimates for the A_j and p_j are found by maximizing the likelihood function, i e finding the solution to the problem

$$\max_{p_j A_j} \left[\sum_j \sum_r \log_e(f_j(X_{jr}, A_j)) + \sum_s \log_e \left(\sum_j p_j f_j(Y_s, A_j) \right) \right] \tag{1}$$

subject to the constraints

$$p_j \geq 0 \quad and \quad \sum_j p_j = 1$$

Rather than dealing with the somewhat difficult maximization problem (1), Fournier et al (1984) first found the values $\hat{A}_j$ which solve the problem

$$\max_{A_j} \left[\sum_j \sum_r \log_e(f_j(X_{jr}, A_j)) \right] \tag{2}$$

These are the maximum-likelihood estimates for the $\mathbf{A}_j$ given the learning samples alone They then estimate the p_j by finding $\hat{p}_j$ which solve the problem

$$\max_{pj} \left[\sum_s \log_e \left(\sum_j p_j f_j(Y_s, \hat{A}_j) \right) \right] \tag{3}$$

Escapement monitoring

Regression analysis will be used to compare tested sonar units to the Bendix units Residuals of the regression will be visually examined and appropriate data transformations used, if necessary, to insure that assumptions are met A formal statistical test will be used to determine if a correlation exists (H_0 $b_1 = 0$; Neter et al. 1990). If a relationship is detected, a second test will be preformed to determine whether the slope is different from 1 0 (H_0 $b_1 = 1.0$). A slope of 1.0 indicates no detectable difference in counting performance between the counters All statistical tests will be performed at $\alpha = 0\ 05$.

DELIVERABLES

A report detailing the 1992-1993 sample acquisition and sample analysis will be completed by February, 1993

Periodic progress reports at the completion of significant phases of the project (e.g selection of hydroacoustic equipment for purchase) will be completed prior to starting the next phase.

SCHEDULES AND PLANNING

Data and Report Submission Schedule

Date	Activity
1992 March - April	Purchase hardware and supplies for genetic samples
	Develop hydroacoustic criteria for selecting contractors, prepare contract for 1992 field season
May - June	Award bid for hydroacoustic contracts
July - September	Collect genetic samples
	Test hydroacoustic equipment in Kenai River
	Conduct offshore test fishing feasibility study
October - December	Prepare reports on field activities
1993 January - February	Submit final report
	Purchase hydroacoustic equipment

Sample and Data Archival

Both hard and electronic copies of data will be archived Original data will be maintained in the Soldotna office of ADF&G

Management Plan

Principal investigators will manage activities in close coordination with Lisa Seeb, Anchorage office (Principal Investigator of project 59).

Management Team:

Person	Responsibilities
Kenneth E. Tarbox	Supervise staff, data collection, analysis and report writing, budget responsibility
Linda Brannian	Data base management, data handling and transfer, biometrics support, budget responsibility
Fish Bio II	Supervise permanent/seasonal staff, field data collection, prepare data summaries, preliminary analysis, report preparation
Biometrician	Stock identification model building, statistical design and review of data analysis procedures
Other staff	Field crew leaders, primary data collectors

Logistics

Support requirements for this project are extensive Genetic sampling covers 25 systems in UCI, most of which are remote Therefore, field crews will be required to live in remote field camps for part of the study. Escapement monitoring logistics will require the duplication of counting operations during the peak of the sockeye return. This will require coordination to ensure system compatibility and support The offshore test fish project will require the contractor to hire a vessel and coordinate with existing ADF&G test fish vessels

PERSONAL QUALIFICATIONS

Principal Investigator

Kenneth E. Tarbox has been the Research Project Leader for the Commercial Fisheries Division, UCI, ADF&G since 1980. Prior work experience includes 8 years with Woodward Clyde Consultants, Anchorage. He has authored numerous reports and presently he is a co-principal investigator for NRDA study 27

Linda Brannian is the Regional Biometrician for the Commercial Fisheries Division, Anchorage, ADF&G. She has participated in numerous research projects since joining ADF&G in 1983

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Table 1. Locations of sockeye salmon stocks to be sampled for genetic, parasite, scale, and otolith characteristics.

River/Drainage/ Fishery	Location	Production Potential[a]	Timing[b]	Sample Size
Susitna River:				
Mainstem	Composite[c]		JUL3	400
Upper	Stephan Lake	63700	SEP1	100
Talkeetna	Larson	45100	AUG4	100
Lower	Redshirt Lake	69500	AUG3	100
Yentna	Composite		JUL3	400
	Chelatna Lake	389200	AUG3	100
	Hewitt/Whiskey	83000	SEP1	100
West Fork	Unnamed Slough		AUG4	100
Skwentna	Shell Lake	103800	SEP1	100
Talachulitna	Judd Lake	59500	SEP2	100
	Trinity/Movie	19300	AUG3	100
Subtotal				1700
Knik Arm:	Fish Creek	192352	SEP1	100
Kasilof River:				
Mainstem	Composite		JUL2	400
	Nikolai Creek	36000	AUG2	100
	Bear Creek	127532	AUG2	100
	Glacier Flat	121400	AUG3	100
	Moose Creek	21200	AUG3	100
Subtotal				800
Kenai River:				
Russian	early		JUN2	100
Russian	late	112000	JUL3	100
Mainstem	Composite		JUL2	400
	Hidden Creek	70000	JUL3	100
	between lakes		AUG3	100
	outlet Skilak Lake		AUG3	100
	Quartz Creek	73345	AUG3	100
Subtotal				1000

Table 1. (Con't.)

River/Drainage/ Fishery	Location	Production Potential[a]	Timing[b]	Sample Size
Bishop Creek:	Daniels Lake	7800	SEP2	100
Westside:				
Big River	Wolverine Creek	32980	JUL4	100
Beluga	West Fork Coal	12000	AUG3	100
Chakachatna	Chilligan	38576	SEP2	100
Subtotal				300
Crescent River:				
Mainstem	Composite	120219	JUL3	200
Subtotal				200
Kalgin Island:	Packers Creek	50026	JUL2	100
Subtotal				100
Total Escapement				4300
Commercial Fishery				
Drift	Composite (2 fishing periods)		JUL	400
Grand Total				4700

[a] Production potential represents a maximum survey count or escapement estimate.

[b] Timing represents the time period for sampling and is coded; for example, JUL3 represents the third week of July.

[c] Composite represents a mixture sample of subpopulations that will be taken from existing project sampling sites

	BUDGET ($K)
Salaries	$156.9
Travel	12.0
Contractual	232.3
Supplies	29.1
Equipment	204.1
Subtotal	$634.4
General Administration	39.8
Total	$674.2

RESTORATION PROJECT NUMBER 59

Study Title: Assessment of Genetic Stock Structure of Salmonids

Lead Agency: ADF&G

PROJECT JUSTIFICATION

The overescapement that occurred after the <u>Exxon Valdez</u> oil spill is expected to cause a severe decline in adult returns in 1993 and 1994. Total closure or severe reduction of the commercial and sport sockeye fisheries may be necessary in those years to enable recovery of this species Genetic stock identification (GSI) techniques will be implemented to manage the harvest of these spill-injured stocks in Cook Inlet mixed harvest areas GSI has only recently been applied as an in-season management tool, and it has proven to be extremely effective for allocating and adjusting the harvest of stocks intercepted in stock mixtures such as those that occur in Cook Inlet (e g , White and Shaklee 1991)

Starting in 1992, baseline genetic data will be collected from 28 subpopulations from the Kenai, Kasilof, and Susitna Rivers Samples from the Cook Inlet commercial harvest will be analyzed and reduced to stock components using these data and GSI techniques in subsequent years Area managers will use this information to modify fishing areas and openings in order to facilitate harvest of the surplus Kasilof River and Susitna River stocks while protecting the oil spill-injured Kenai River stocks

Fishing time in the Upper Cook Inlet area was greatly reduced in 1989 due to the presence of oil from <u>Exxon Valdez</u> oil spill As a direct result, sockeye salmon spawning in the Kenai River system exceeded optimal escapement goals by three times This extremely high escapement may have 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 Controlling 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

Attempts to use stock identification to manage harvest of Cook Inlet sockeye salmon relied on scale growth patterns in the past Alaska Department of Fish and Game (ADF&G) evaluated both scale pattern analysis and GSI during the mid-1970's, and at that time, with only three genetic markers and limited baseline data available (e.g , see Grant et al 1980), decided to pursue the use of data from scales. However, the accuracy and precision of the scale technique alone has not been great, and it is insufficient to permit the in-season protection of the injured Kenai River stocks

Fortunately, GSI analyses have proven extremely effective for stock management in recent years (Seeb et al 1986, 1990, Shaklee and Phelps 1990, White and Shaklee 1991), and many additional genetic markers have been found which discriminate stocks of sockeye salmon (e.g., Wilmot and Burger 1985, Tony Gharrett and Paul Aebersold, NMFS, personal communication). Seeb and Wishard (1977) found five marker loci which resolved mixed-stock samples of sockeye salmon from the Lake Washington drainage; Grant et al (1980) showed a high degree of success using the three markers to classify samples from the Kasilof and Susitna drainages, but incomplete baseline data confounded the Kenai River classifications Strong supporting evidence (described above and including sockeye salmon data from Bob Davis, ADF&G, unpublished; and Richard Wilmot, USFWS, unpublished) indicate that GSI analyses including many marker loci and complete baseline data will provide accurate estimates of stock composition for in-season protection of the Kenai River stocks.

Additionally, ADF&G and NMFS personnel recently discovered that parasite data may provide stock discriminating power for Cook Inlet stocks (Tarbox et al. 1991) The ADF&G plans to evaluate the use of all possible techniques to maximize the accuracy and precision of stock identification analyses (cf , Wood et al. 1989, R-53) and will incorporate parasite data into the GSI models

OBJECTIVES

The objectives of this study are to:

1. Obtain baseline genetic data (during 1992-1995) from all significant spawning stocks contributing to mixed-stock harvests of sockeye salmon in Cook Inlet

2. Obtain genetic data each week from samplings of the various mixed-stock harvests occurring in 1993 and 1994.

3. Use GSI algorithms (e.g., Pella and Milner 1987) to provide weekly estimates of the presence of Kenai River stocks in the different mixed-stock areas so that managers may modify area and time of harvest in order to protect these injured stocks while targeting surplus Kasilof River and Susitna River stocks.

METHODS

Sampling Methods

Baseline and mixed stock samples will be collected by personnel conducting R53 - Kenai River Sockeye Salmon Restoration During the first year 28 baseline populations will be collected (Appendix A). In addition, mixed stock samples will be collected from three mainstem sites and from cannery samplings of four driftnet fisheries. Sample sizes for allozyme baseline collections will be 100 to maximize the precision around the allele frequency estimates (Allendorf and Phelps 1980, Waples 1990) Mixed stock sample sizes will be set at 200 (Pella and Milner 1987) and will be adjusted in 1993 based on the results of simulation studies conducted using the 1992 baseline data

Muscle, liver, eye, and heart will be dissected from freshly killed individuals. Tissues will be placed in labeled cryovials and transferred into liquid nitrogen Tissues will be stored on liquid nitrogen until transferred to -80°C storage in Soldotna or Anchorage. Soldotna samples will be transferred to the Anchorage laboratory on dry ice or liquid nitrogen and again placed in 80°C storage where they will remain until laboratory analysis

A comprehensive examination for discriminating gene markers will be done. It will focus on the use of allozyme data because of its successful application in similar studies and the promising pilot work completed in Cook Inlet Mitochondrial DNA markers have shown promise in some situations (e g., see Lansman 1981, Bermingham 1990), and a subset of samples will be so screened to evaluate any potential additional resolving power

Allozyme electrophoretic data (Utter et al 1987, Seeb et al 1987) will be collected for the loci identified in sockeye salmon (Grant et al. 1980, Wilmot and Burger 1985, Appendix B) Allozyme techniques will follow those of Harris and Hopkinson (1976), May et al. (1979), and Aebersold et al. (1987), nomenclature rules will follow the American Fisheries Society standard (Shaklee et al 1990). A photographic record of each polymorphic gel will be made

The DNA will be extracted from liver and heart tissue (Chapman and Brown 1990, Bermingham et al 1991) using phenol/chloroform extractions and ethanol precipitation (Sambrook et al 1989) from a subsample of the baseline individuals After extraction, the DNA will be amplified using the polymerase chain reaction (PCR) (Kocher et al. 1989, Chapman and Brown 1990, Carr and Marshall 1991). Primer selection for PCR will include both universal (Kocher et al. 1989) and other unpublished primers (Kessing et al 1989) and include those from the D-Loop, cytochrome *b*, and ORF5/6 regions of mtDNA. Amplified DNA will be cut with up to 20 restriction enzymes and separated on agarose gels Fragments will be visualized under UV light, and a photographic record will be made of each gel.

Quality Assurance and Control Plans

All tissues will be placed in individually labeled cryotubes Individual sample numbers will be assigned to uniquely identify all genetic tissues and the associated collection and parasite information. As a minimum, labels will include the following information: 1) species, 2) collection site and/or code, 3) collection date, 4) individual number, and 5) tissue type Samples will be stored at -80° C until analysis. A telephone alarm will be connected to the freezers to notify laboratory personnel in the event of a power outage.

A collection of mobility standards for all scored alleles will be constructed and used to verify alleles. Similar procedures will be followed with unique mtDNA haplotypes After analysis, the remaining tissue samples will be retained until the results of the study have been finalized.

Information Required From Other Investigators

Again, genetics samples will be collected by Soldotna field staff conducting R-53. Parasite data collected by Soldotna field staff will be incorporated into GSI models The principal investigators of the two studies will work in close collaboration throughout the duration of the studies and coordinate all aspects including sample collection, laboratory, and data analyses

Safety Requirements

Personnel will be trained in the safe handling of liquid nitrogen Additionally, instructions for the use of liquid nitrogen are included as part of the sampling instructions Laboratory safety procedures and training will follow guidelines outlined in the Genetics Laboratory Hazard Communications Program This program is currently being developed with the assistance of the Alaska Department of Occupational Safety and Health.

Animal Health and Welfare

Not applicable to this study--only frozen tissues will be analyzed

DATA ANALYSIS

Tests

The allozyme data will be analyzed using the genetic analysis program, BIOSYS-1 (Swofford and Selander 1981). Genotypic and allelic frequency estimates will be calculated for each baseline and mixed-stock sample at every locus. Genetic distance measures (Nei 1978), which summarize multi-locus data into a single number, will also be calculated between all pairs of spawning locations These values will be used to construct branching diagrams using numerical taxonomic techniques (UPGMA, Sneath and Sokal 1973) which provide a representation of overall phenetic similarity The stability of the resulting dendrogram will be evaluated using the jackknifing procedures of Lanyon (1985). Chi-square goodness-of-fit to Hardy-Weinberg equilibrium will be performed to test for random mating within each population.

Homogeneity of allelic frequencies among the various collections will be tested using a log-likelihood ratio analysis (G-statistic) (Smouse and Ward 1978) (α=0.01) (Cooper 1968). Rejection of the null hypothesis of homogeneity is indicative of discrete spawning populations. The total gene frequency dispersion at each locus will be subdivided into within-and among-river system components in a hierarchical fashion. Hierarchical levels will be organized to test for homogeneity of 1) within drainages of the systems, 2) among drainages within river systems, and 3) among river systems with Cook Inlet. The likelihood analysis will use the computational formula of Sokal and Rohlf (1981) This statistic is distributed approximately as the chi-square statistic with (no of alleles - 1) X (no. of region - 1) = (degrees of freedom) The likelihood values (G) can be summed over all loci to obtain a total value at each level of analysis

The mtDNA data will be analyzed using the REAP analysis program (McElroy et al. 1991) Evolutionary divergence (*d*) will be estimated between mtDNA haplotypes (Nei and Li 1979, Nei 1987) Pairwise *d* values will be used to construct a UPGMA clustering diagram (Sneath and Sokal 1973) The extent of geographic heterogeneity in population frequency distributions will be analyzed using the Monte Carlo simulation techniques of Roff and Bentzen (1989)

Stock contribution to mixed fishery samples will be estimated using a conditional maximum likelihood program (GIRLSEM) developed by National Marine Fisheries Service (NMFS) (Pella and Milner 1987, Masuda et al. 1991). Both allozyme and parasite data will be used, parasite presence/absence will be treated as a discrete character in combination with a multi-locus genotype (Masuda et al 1991) The precision of the stock composition estimates will be determined by bootstrap resampling (Efron and Tibshirani 1986) In bootstrapping, individuals of the stock and mixture samples are randomly resampled with replacement to obtain new samples equal in size to the original samples. Standard errors of stock composition estimates due to sampling errors in the stock and mixture samples can be estimated from the standard errors of composition estimates over resamplings of the bootstrap Approximately 100 bootstrap resamplings should provide sufficiently accurate estimates of standard error (Masuda et al 1991) Accuracy graphs will be obtained by constructing simulated samples of mixtures with specific stock proportions and then by bootstrap resampling the baseline to obtain estimates of stock proportions This same type of simulation will be used to evaluate the effect of mixture sample size on the accuracy and precision of the stock composition estimates and will be used to adjust mixture sample size in succeeding years.

Simulation studies will be performed to test the additional resolution that could be provided by mtDNA data The mtDNA data will be treated as a single character with multiple alleles corresponding to haplotypes and will be used in conjunction with parasite and allozyme data.

DELIVERABLES

A project report detailing the 1992-1993 sample acquisition and sample analysis will be prepared February 1993.

SCHEDULES AND PLANNING

Data and Report Submission Schedule

Date	Activity
March-April 1992	Hardware and supplies acquisition, -80°C freezer set-up in Soldotna and Anchorage
April-June	Collect test-lots of smolts for primary genetic screening; optimize allozyme and DNA protocols for resolution of genetic variation
July-August	Mixture collections/coordination with project R53
August-December	Baseline sample collection of adults/ coordination with project R53
July-December	Laboratory analyses of mixture populations
January-April 1993	Laboratory analysis of baseline populations
February	Final report preparation
April-May	Laboratory analyses of mixtures, numerical analyses of stock structure
May-June	Post-season analyses of mixed-stock composition; modelling for 1993 mixture analyses

Sample and Data Archival

Tissue storage will be in -80° C freezers strategically located in Soldotna and Anchorage Each freezer will be equipped with an alarm-activated telephone monitoring system to notify personnel in case of power outages Multiple subsamples of tissues expressing variant alleles will be archived at -80°C to provide mobility standards for future allelic comparisons

Both hard and electronic copies of data will be archived Original lab notebooks will be maintained in the ADF&G genetics laboratory in Anchorage. All raw and processed data will also be electronically stored on databases in Anchorage, archived on the local area network, and archived through FS30 database management These Wordperfect and R.BASE files will be readily retrievable

MANAGEMENT PLAN

The co-principal investigators will manage activities in close coordination with Ken Tarbox, Soldotna area office, and Linda Branian, Anchorage office (Principal Investigators of project R53) Soldotna staff will handle field logistics and collect the specimens. Anchorage genetics staff will conduct all laboratory analyses, perform GSI analyses and modelling, and provide training for field crews on handling of liquid nitrogen, sample dissection and storage, etc Laboratory staff will be cross-trained in both allozyme and DNA methods of analysis

Genetics Team

Person	Responsibilities
Lisa W. Seeb, co-PI	Supervise lab staff during DNA analyses, supervise biometrician and GSI analyses, report writing
James E. Seeb, co-PI	Supervise lab staff during allozyme analyses, coordinator with Soldotna, budget manager, report writing
Project Biometrician	Data-base management, data handling and transfer, GSI analyses, simulation and modeling
Laboratory Staff	
Fish Bio II	Lab logistics, allozyme and DNA team leader

Fish Tech III	allozymes and DNA
Fish Tech III	allozymes and DNA

Logistics

Logistics will be limited to the routine acquisition of supplies for lab analyses, normal equipment maintenance and repair, and sample shipping and storage. Field crews will return either to Anchorage or Soldotna with samples (depending upon point of departure and location of collection site). Samples stored in the -80^0 C freezer in Soldotna will be allowed to accumulate until their number warrants a pick-up by the Anchorage-based genovan (special ADF&G truck equipped with dry ice coolers)

PERSONNEL QUALIFICATIONS

James E. Seeb, Principal Geneticist
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EDUCATION: B.S., Biology, 1974, University of Puget Sound
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Ph.D., Fisheries, 1987, University of Washington

PROFESSIONAL EXPERIENCE

1990-	Principal Geneticist, FRED Division, ADF&G
1988-1990	Assistant Professor, Southern Illinois University
1987-1988	Research Assistant Professor, University of Idaho
1982-1986	Graduate Research Assistant, University of Washington
1980-1982	Fish Biologist, Pacific Fisheries Research, Olympia, WA
1978-1980	Fish Biologist, Washington Department of Fisheries

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EDUCATION:

A.B. Zoology, 1973, University of California, Berkeley
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PROFESSIONAL EXPERIENCE:

1991-	Statewide Geneticist, ADF&G, Anchorage
1988-1990	Assistant Professor, Southern Illinois University
1984-1988	Research Assist. Prof., University of Idaho

1978-1981 Fish Geneticist, Pacific Fisheries Research, Olympia WA
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APPENDIX A

Proposed sampling locations for Cook Inlet sockeye salmon GSI study.

River/Drainage	Location or Timing	N
SUSITNA RIVER		
Mainstem	Mixed stock	200
- Talkeetna	Larson	100
	Stephan Lake	100
- Lower	Redshirt Lake	100
- Yentna	Mixed stock	200
	Chelatna Lake	100
	Hewitt/Whiskey	100
- West Fork	Unnamed slough	100
- Skwentna	Shell Lake	100
- Talachulitna	Judd Lake	100
	Trinity/Movie	100
KASILOF RIVER		
Mainstem	Mixed stock	200
	Nikolai Creek	100
	Glacier Flat	100
	Moose Creek	100
	Bear Creek	100
KENAI RIVER		
Mainstem	Mixed stock	200
	Outlet Skilak	100
	Between lakes	100
	Hidden Creek	100
	Quartz Creek	100
Russian	Early	100
	Late	100

River/Drainage	Location or Timing	N
WESTSIDE		
- Beluga	West Fork Coal	100
- Chakachatna	Chilligan	100
- Big River	Wolverine Creek	100
CRESCENT RIVER		
- Mainstem		100
KALGIN ISLAND	Packers Creek	100
DRIFT FISHERY	Mixed stock	800

APPENDIX B

Enzymes or proteins to be screened in Cook Inlet sockeye salmon Enzyme nomenclature follows Shaklee et al (1990), and locus abbreviations are given. Variable loci are those observed by Grant et al. (1980), Wilmot and Burger (1985), and personal communications (P. Aebersold, NMFS, Seattle; A. J Gharrett, NMFS, Auke Bay)

Enzyme or Protein	Enzyme Number	Locus	Known to be Variable
Aspartate aminotransferase	2.6 1 1	*sAAT-1,2*	yes
		sAAT-3	yes
		sAAT-3	no
		mAAT-1	yes
		MAAT-2	no
Acid phosphatase	3 1 3 2	*ACP*	no
Adenosine deaminase	3 5 4 4	*ADA-1*	yes
		ADA-2	no
Alcohol dehydrogenase	1 1 1 1	*ADH*	yes
Aconitate hydratase	4 2.1.3	*mAH-1,2*	yes
		MAH-3	yes
		sAH	yes
Adenylate kinase	2 7 4 3	*AK*	no
Alanine aminotransferase	2 6 1 2	*ALAT*	yes
Creatine kinase	2 7 3 2	*CKA-1*	no
		CKA-2	no
		CKC-1	no
		CKC-2	no
Esterase-D	3 1 1 -	*ESTD*	yes
Fructose-biphosphate aldolase	4 1 2 13	*FBALD-1*	no
		FBALD-2	no
		FBALD-3	no

Enzyme or Protein	Enzyme Number	Locus	Known to be Variable
		FBALD-4	yes
Fumarate hydratase	4.2.1.2	*FH*	yes
beta-N-Acetylgalactosaminidase	3 2.53	*bGALA*	yes
Glyceraldehyde-3-phosphate dehydrogenase	1.2.1.12	*GAPDH-1*	no
		GAPDH-2	no
		GAPDH-3	no
		GAPDH-4	yes
		GAPDH-5	no
Guanine deaminase	3 5 4 3	*GDA-1*	yes
		GDA-2	yes
N-Acetyl-beta-glucosaminidase	3 2 1 53	*bGLUA*	no
Glycerol-3-phosphate dehydrogenase	1 1 1 8	*G3PDH-1*	yes
		G3PDH-2	yes
		G3PDH-3	no
		G3PDH-4	no
Glucose-6-phosphate isomerase	5.3.19	*GPIB-1*	yes
		GPIB-2	yes
		GPIA	yes
		GPIR	yes
Glutathione reductase	1 6.4.2	*GR*	yes
beta-Glucuronidase	3.2 1 31	*GUS*	no
Hydroxyacylglutathione hydrolase	3 1 2.6	*HAGH*	yes
Hexokinase	2 7 1 1	*HK*	no
L-Iditol dehydrogenase	1 1 1 14	*IDDH-1*	no

Enzyme or Protein	Enzyme Number	Locus	Known to be Variable
		IDDH-2	no
Isocitrate dehydrogenase (NADP+)	1 1.1 42	*mIDHP-1*	yes
		mIDHP-2	yes
		sIDHP-1	yes
		SIDHP-2	yes
L-Lactate dehydrogenase	1 1 1 27	*LDHA-1*	no
		LDHA-2	no
		LDHB-1	yes
		LDHB-2	yes
		LDHC	yes
Lactoylglutathione lyase	4 4 1 5	*LGL*	no
alpha Mannosidase	3.2 1 24	*aMAN*	yes
Malate dehydrogenase	1 1 1 37	*sMDHA1,2*	yes
		sMDHB1,2	yes
		mMDH-1	yes
		mMDH-2	no
Malic enzyme (NADP+)	1.1 1 40	*sMEP1*	yes
		sMEP2	no
Mannose-6-phosphate isomerase	5 3 1 8	*MPI*	yes
Dipeptidase	3.4 - -	*PEPA*	no
Tripeptide aminopeptidase	3 4 - -	*PEPB-1*	no
Proline dipeptiase	3.4 13 9	*PEPD-1*	no
		PEPD-2	no
Peptidase-LT	3 4 - -	*PEPLT*	yes
Phosphogluconate dehydrogenase	1 1 1 44	*PGDH*	yes
Phosphoglucomutase	5 4 2 2	*PGM-1*	yes

Enzyme or Protein	Enzyme Number	Locus	Known to be Variable
		PGM-2	yes
		PGM-3	no
		PGM-4	no
Phosphoglycerate kinase	2 7.2 3	*PGK-1*	yes
		PGK-2	no
Pyruvate kinase	2 7 1 40	*PK-1*	no
Pyruvate kinase		*PK-2*	yes
Purine-nucleoside phosphorylase	2.4 2 1	*PNP-1*	no
		PNP-2	no
Superoxide dismutase	1.15 1 1	*sSOD-1*	yes
		mSOD	no
Triose-phosphate isomerase	5.3 1 1	*TPI-1*	yes
		TPI-2	no
		TPI-3	yes
		TPI-4	yes
Xanthine oxidase		*XO*	

BUDGET ($K)

Salaries	$ 202 3
Travel	5 5
Contractual	8 0
Supplies	34 5
Equipment	39 7
Subtotal	$ 290 0
General Administration	30 9
Total	$ 320 9

RESTORATION PROJECT NUMBER 60AB

Study Title: Prince William Sound Salmon Stock Identification and Monitoring Studies

Lead Agency: ADF&G

INTRODUCTION

This project has evolved from former Natural Resources Damage Assessment Fish/Shell Fish Studies #1 and #3 but now includes only the tag recovery aspects of each of those projects The goal of combined studies 60A and 60B is to provide inseason time and area specific estimates of the catches of injured wild stocks and inseason assessments of escapement performance for injured stocks Fisheries managers will use this information to reduce exploitation rates on injured stocks which need protection. To assess the effectiveness of this restoration tool and monitor the recovery of the injured wild stocks, the project will also provide post-season estimates of the total returns of tagged stocks

Functionally, wild stock returns include both catch and escapement components. To estimate the total return by stock, the catch must be enumerated, the component from the tagged population must be estimated, and the adult escapements for each tagged stock must be totally enumerated In addition, adult escapements of tagged stocks must also be scanned for coded-wire tags to account for changes in the untagged to tagged ratios between fry and returning adults due to tag loss and differential mortality Finally, based on evidence for straying of hatchery and wild fish from NRDA F/S Study 1 in 1991, some effort must also be expended to account for the portion of tagged returns which stray to non-natal streams and are not accounted for in either the catch or the natal stream escapement components.

The proposed study 60A is for recovery of coded-wire tags in the catches in Prince William Sound Study 60B enumerates escapements for the six tagged wild stocks, recovers tags in the escapements to verify tagged to untagged ratios used in catch contribution estimates, and includes limited examination of neighboring streams to assess the degree of straying to non-natal streams While studies 60A and 60B are both tag recovery projects the objectives and methodology for recoveries in catches and escapements are quite distinct and for sake of clarity have been retained as separate sections in a unified operational plan Processing of heads for tag extraction is identical for both catch and escapement samples but for the sake of simplicity has been included in the budget for Study 60A which accounts for the majority of heads and tags recovered.

INTRODUCTION - 60A

Wild stock production of pink salmon in Prince William Sound has ranged from 10 to 15 million fish in recent years. Much of the spawning for pink salmon (up to 75% in some years) occurs in intertidal areas. Intertidal spawning areas are susceptible to marine contaminants and there is strong evidence the Exxon Valdez oil spill adversely affected spawning success and early marine survival in Prince William Sound (Sharr et al 1991) Salmon stocks impacted by the oil spill are also heavily exploited in commercial, sport, and subsistence fisheries. These stocks can most effectively be restored through stock-specific management practices designed to reduce exploitation on impacted stocks. The stocks from areas heavily impacted by the oil spill are present in fisheries dominated by hatchery and wild stocks from unaffected areas of the Prince William Sound. The management of this mixed stock fishery has historically been based on maintaining good temporal and spatial distribution of spawning escapement for groups of stocks in eight major fishing districts. The success of this management strategy relies upon the manager's ability to control stock-specific exploitation rates. Restoration premised on stock-specific management of the commercial fishery for reduced exploitation of impacted stocks will require even more accurate inseason catch stock composition estimates if different harvest rates are to be achieved for injured wild stocks versus unimpacted wild stocks or hatchery stocks.

This project is designed to provide accurate, real time, catch contribution estimates for the pink salmon stocks of Prince William Sound. Accurate escapement estimates from another proposed restoration program will enable managers to identify stocks which are experiencing escapement shortfalls Accurate and timely catch contribution estimates from this coded-wire tag recovery project will enable managers to identify times and areas where exploitation of these depleted wild stocks can be minimized and still permit the harvest of surplus hatchery returns Post-season analyses of the catch contribution estimates together with results from the proposed salmon escapement enumeration project will provide stock specific estimates of total return and survival and enable managers to assess the effectiveness of stock specific management strategies.

In the absence of improved stock specific management capabilities afforded by this project, salmon stocks in western Prince William Sound which have already been stressed and depleted by the oil impacts will potentially be over-exploited in the commercial, sport and subsistence fisheries Population levels of stocks may be reduced below those needed for rapid recovery and in some instances may result in virtual elimination of impacted stocks If adequate stock monitoring programs are not in place, changes in fishing effort to areas of less oil impact could also result in over-exploitation of otherwise healthy, unimpacted stocks

The foundations for this project were established in feasibility studies which were conducted beginning in 1986 and extending through 1988. During the damage assessment process in Natural Resources Damage Assessment (NRDA) Fish/Shellfish (F/S) Study #3 large scale tagging and recovery projects (Attachment 1) were instituted and perfected Some of the tags applied using NRDA or Restoration funds have been recovered but others have not. If recovery efforts proposed here are not instituted in 1992 important restoration and population monitoring data will be irretrievably lost. Tags applied to wild pink fry from six streams (three oiled and three unoiled) in 1991 are among those which must still be recovered. Although privately funded, tagging also continued for all hatchery releases of pink salmon in 1991 and those tags could be recovered concurrently.

Results of this study will provide estimates of hatchery and wild stock contributions to commercial harvests, hatchery cost recovery harvests, hatchery brood stocks and wild stock escapements. Stock specific catch contributions will be by date and fishing district and will be used inseason by fisheries managers to reduce effort on injured stocks and target effort on healthy hatchery returns Post-season analyses of current year as well as historic tag recovery data will be coupled with escapement data for wild stocks to make estimates of wild stock total returns and survival These data are important as a tool for assessing the effectiveness of various management strategies Post-season analyses of tagging data will also identify trends in the time and distribution of stocks in the fisheries These data are important to fisheries managers who must anticipate the effects of fishing strategies in future years if depleted stocks are to be protected Stock-specific management strategies for fish returning to oiled streams as well as other populations affected by altered fisheries management will be developed using tagging and escapement data Similar data from coded-wire tagging projects funded by the NRDA process have been used to justify time and area fishery closures and effectively reduce exploitation on oiled stocks in portions of southwestern Prince William Sound in 1990 and 1991. Serious escapement shortfalls were avoided despite intense fishing pressure on surplus hatchery fish in adjacent areas

OBJECTIVES - 60A

A. Recovery of coded-wire tags and otoliths from catches of pink salmon to:

   1. Estimate temporal and spatial contributions of tagged wild stocks to Prince William Sound commercial and hatchery harvests. (Since coded-wire tagging of hatchery fry is expected to continue independently of the restoration process, these tags will also be recovered from harvests

These data will also be used to enhance restoration efforts directed at wild stocks.),

2. 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;

3. 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.)

B. Recovery of coded-wire tags and pink salmon otoliths from spawning populations to

1. Estimate tag loss and mortality of tagged pink salmon,

2. Determine total return and overall survival of tagged pink salmon stocks, including sub-populations within the same stream tagged in intertidal and upstream zones (To be accomplished, this objective will require tag recovery data from catches.);

3. 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,

4. Examine effects of egg and fry densities, fry migration timing, nearshore zooplankton abundance, and juvenile growth and survival upon adult survival,

5. Collect samples for documentation of pervasive somatic, cytologic, and genetic abnormalities in adults returning to oiled streams.

6. Estimate straying rates of hatchery and wild stocks of pink salmon. Straying of hatchery fish into streams which were impacted by the spill may alter the genetic composition and reduce the fitness of injured wild populations

METHODS - 60A

Personnel policy, purchasing practices, field camp operations, safety procedures, and project administration will be in compliance with the ADF&G Division of Commercial Fisheries Manual of Standard Operating Procedures. Data collection procedures are similar to those used in NRDA F/S Study #3 These procedures have been thoroughly reviewed by the NRDA peer review process and approved by the Management Team.

Tag Recovery

Commercial Catches

The Alaska Department of Fish and Game will oversee the recovery of coded-wire tagged fish in commercial salmon harvests in Prince William Sound. The recovered samples will be from a stratified random sample (Cochran 1977). Fisheries will be stratified by district and discrete time segments. The recovery will be further stratified by processor as described in Peltz and Geiger (1988) For each time and area specific stratum, 15% of the pink salmon catch will be scanned for fish with a missing adipose fin. Catch sampling will be done in four fish processing facilities in Cordova, one facility in Seward, and three facilities in Valdez When feasible, sampling will occur at facilities in Kodiak, Kenai, Anchorage, and Whittier and on large floating processors All deliveries by fish tenders to these facilities will be monitored by radio and by daily contact with processing plant dispatchers to ensure that the catch deliveries being sampled are district specific.

Scanning commercial pink salmon catches for coded-wire tags involves visually selecting adipose clipped fish from a mixture of unclipped and clipped fish on a conveyor belt Samplers will select fish on the basis of whether they have a good view of the adipose fin region; negative sampling bias may occur by consistent exclusion of tagged fish. This possible sampling bias will be periodically tested for by comparing the tag recovery rates of sampled fish to recovery rates in a censuses of sampled loads of fish. In addition to catch sampling at the processing facilities, approximately 15% of the fish in the hatchery terminal harvest areas will be scanned for fish missing adipose fins

Hatchery Brood Stocks and Wild Escapements

Brood stock and escapement sampling are critical to estimating hatchery and wild contributions Due to differential mortality between tagged and untagged fish as well as differential tag loss between release groups, the tag expansion factor at release for hatchery fish may no longer accurately reflect the tag expansion factor in the adult population Theoretically, brood stock and spawning escapements are composed of 100% fish which originated from the hatchery or stream where sampling occurs and are representative of returns from each fry or smolt release group Based on this assumption, tag recovery rates from brood stock and escapements can be used to adjust the initial tag expansions for each tagged hatchery release group or each wild stream out-migration.

There will be a brood stock tag recovery effort at each of the three hatchery facilities where tags were initially applied. Technicians will be stationed at each of the 5 Prince William Sound hatcheries to scan the brood stock during egg take for all five species of salmon. After the salmon are manually spawned, technicians will use visual and tactile methods to scan approximately 95% of the fish. Total number of fish scanned and total number of fin-clipped fish found will be recorded on a daily basis.

There will be an intensive survey of adult pink salmon returning to natural systems. Weirs will be operated for sampling adult sockeye salmon on those systems where sockeye salmon were tagged. Carcasses will be scanned for coded-wire tags in adult pink salmon returning to the six tagged wild stock streams Loomis, Cathead, Herring, Totemoff, O'Brien, and Hayden Creeks. Only carcasses with a visible adipose region will be counted Heads will be removed from the adipose clipped carcasses, soaked in a brine solution, and put into plastic bags. Total number of carcasses and total number of adipose clipped fish will be recorded on a daily basis for each stream surveyed. Heads and their corresponding data sheets will be picked up on a regular basis and returned to Cordova for editing and shipping to the Juneau tag lab.

Untagged Wild Escapements

Based on tag recovery results from NRDA F/S Study #3 in 1991 it appears portions of spawning escapement and hatchery brood stocks may consist of fish which stray and do not return to their hatchery or parent stream. Significant straying could bias tag recovery results if it is not accounted for. To quantify the extent of straying, approximately 8 to 10 additional streams near weired streams will be sampled for coded-wire tags Recovery methods will be identical to those already described for wild pink salmon systems where tags were applied.

DATA ANALYSIS - 60A

Estimates of Valid Tags

Following the application of tags at hatcheries and at wild stock streams, the total number of fry with valid tags was estimated as·

$$T_{vt} = (T_t - M_{ot})(1 - L_{ot})\ C \quad ,$$

where

T_t = total number of fish tagged from group t,
M_{ot} = overnight mortality of tagged group t fish,
L_{ot} = overnight tag loss rate of group t fish,
C = good clip rate

At least one hatchery facility includes a term for short term mortality of tagged fish from treatment group t during saltwater rearing (S_t). The number of tagged fish released for that facility becomes:

$$T_{vt} = (T_t - M_{ot} - S_t)(1 - L_{ot}) C.$$

Contribution Estimates

The first step in the coded-wire tag analysis will be to estimate the harvest of salmon from each tag lot, in units of adult salmon. Adult salmon from these tagged lots will be recovered in the common property fishery, the hatchery cost recovery fishery, and the adult brood stock. For the hatchery stock, a modification of the methods described in the ADF&G technical report by Clark and Bernard (1987) will be used. The specific methods are described in ADF&G technical reports on two previous studies of pink salmon in Prince William Sound: Peltz and Geiger (1988), and Geiger and Sharr (1989). Additional references on methods of tagging pink salmon in Prince William Sound can be found in Peltz and Miller (1988). In the case of the wild stocks, the methods and estimators and necessary assumptions are described by Geiger (1988)

The basic principle behind the estimates can be described as follows. The contribution of a particular tag lot, to a particular fishery stratum, is estimated by multiplying the number of tags recovered in the structured recovery survey, by the inverse of the proportion of the catch sampled (the inverse sampling rate), and by the inverse of the proportion of the tag lot that was actually tagged (the inverse tag rate) The escapement (brood stock) of each tag lot will be estimated using methods unique to the particular situation. After the contribution to each fishery is estimated for the tag lot, the survival is calculated by summing the estimated harvest of the tag lot in each fishery, and the estimated escapement (brood stock), and dividing by the estimated number of fish represented by the tag code

Total catches stratified by week, district, and processor will be obtained from summaries of fish sales receipts (fish tickets) issued to each fisherman The total hatchery contribution to the commercial and hatchery cost recovery harvest is the sum of the estimates of contributions in all week, district, and processor strata.

$$\hat{C}_t = \Sigma_i X_{ti} (N_i / S_i) p_t^{-1}$$

where:

$\hat{C}_t$ = catch of group *t* fish,
X_{ti} = number of group *t* tags recovered in ith strata,
N_i = number of fish caught in ith strata,
S_i = number of fish sampled in ith strata,
p_t = proportion of group *t* tagged

For sampled strata, we used a variance approximation which ignores covariance between release groups (Geiger 1988):

$$\hat{V}\ (\hat{C}_t) \quad = \quad \Sigma_i X_{ti} (N_i/S_i p_t)^2 [1 - (N_i/S_i p_t)^{-1}].$$

The assumptions necessary to estimate C and the associated variances and confidence intervals are as follows

1. The numbers of tagged fish and untagged fish are known exactly;

2. The tagged sample of the original hatchery tag group is a simple random sample,

3. The tags do not affect the fish with respect to the items under study (survival, timing, homing, etc),

4. None of the tags or marks are lost,

5. The number of fish in the fishery and the number of fish in the fishery sample are known exactly,

6. The sample of the fishery is a simple random sample (i.e , every fish in the collection of fish under consideration has an equal probability of selection independent of every other fish in the sample); and

7. All marks are observed and all tags are decoded.

The average tag recovery rate for all processors in a week and district will be used to estimate hatchery contribution in catches delivered to processors not sampled for that district and week.

DELIVERABLES - 60A

Catch contributions will be reported bi-weekly to the Fishery Manager from mid-July through August A report, which summarizes the results of the current-year study, will be completed in February, 1993.

SCHEDULES AND PLANNING - 60A

Date(s)	Activity
March 15-June 15, 1992	Pink salmon wild stock tagging
October 1, 1992	Tag application report

June 9-September 10, 1992	Tag recovery in commercial, cost recovery, and adult spawning populations of pink salmon
May 15-September 30, 1992	Tag recovery in commercial and cost recovery harvests, and adult spawning populations of chum, sockeye, coho and chinook salmon
December 30, 1992	Draft Report
February 15, 1993	Final Report

SAMPLE AND DATA RECORDING, PROCESSING AND ARCHIVAL - 60A

In the catch, terminal harvest, brood stock, and natural system surveys, the total number of fish scanned and the number of scanned fish with missing adipose fins will be recorded The heads will be removed from fish with missing adipose fins Each head will be tagged with uniquely numbered strap tags. Recovered heads will be assembled and pre-processed in the Cordova area office Heads will then be sent to the FRED Division Coded-Wire Tag Laboratory in Juneau for decoding and data posting

A statewide coded-wire tag lab is located in Juneau and operated by FRED Division of ADF&G Coded-wire tag sampling forms will be checked for accuracy and completeness. Sampling and biological data will first be entered onto the laboratory's database Next, the heads will be processed. This involves removing and decoding the tags, and entering the tag code and the code assigned in the recovery survey into the database Samples will be processed within five working days of receipt Sampling information and tag codes entered into the database will be available for analysis the following morning. Data will be automatically transferred from Juneau to Cordova. Eventually, online access from Cordova will provide in-season information to fisheries managers in Cordova to allow assessment of oil spill impacts and implementation of any required in-season management actions Catch and sampling information will be integrated with tag codes to automatically calculate in-season and post-season hatchery contribution estimates. A historic database of coded-wire tag information from Prince William Sound tagging and tag recovery programs will be maintained and will be easily accessible by managers and researchers

MANAGEMENT PLAN

The Principal Investigator (PI) for the project is a Fisheries Biologist III with the Alaska Department of Fish and Game The PI will be responsible for writing project operational plans, administering project budgets, quality control of data collection, supervising data analyses, and co-authoring final reports The PI will be assisted by a Fisheries Biologist II Project Leader (PL) who will hire project personnel, supervise day to day project operations, maintain data quality, assist in data analyses, and coauthor final reports. The PL will be assisted by two Fisheries Biologist I's. One of these assistants will be in charge of supervising day to day sampling activities in Cordova, Seward, and at remote camps. The other will supervise sampling activities in Valdez, Anchorage, Whittier, and Kodiak Crews at each port city will have Fisheries Technician III crew leaders. The remainder of each crew will be Fisheries Technician I's and II's Each day, two persons on each crew will scan pink salmon at each processing plant and, where needed, an additional person per facility will scan other species. Under the supervision of the project Fisheries Biologist I's, two Fisheries Technician III's in Cordova will conduct the daily data logging, editing, and archiving activities The consulting Biometrician I will review all operational plans, project reports, and be responsible for all statistical products and statistical reporting

PROJECT LOGISTICS - 60A

Tag Recovery in Commercial and Cost Recovery Harvests

Sampling materials, data forms, and sampling equipment will be purchased or shipped to Cordova from the ADF&G, FRED Division Tag Lab no latter than May 1, 1992. Fisheries Biologists for this project are already employed as part of the NRDA close out for F/S Study #3 and will assume their restoration duties in mid-May when recovery activities for sockeye salmon begin Some Fish and Wildlife Technicians employed for sampling chum, sockeye and chinook salmon will be hired in May 1992. The remainder of the sampling crews will be hired in June. Crews sampling in Anchorage, Whittier, Seward, Kenai, and Kodiak will be hired locally and will provide their own room and board. Project biologists will visit each port a minimum of once every two weeks to answer questions, and provide quality control supervision.

Crews employed by the proposed adult salmon escapement enumeration project will conduct tag recovery activities on wild stock spawning grounds. Biologists for the Coded-wire Tag project will coordinate with biologists from the escapement enumeration project and provide quality control supervision for tag recovery operations at remote sites.

PERSONNEL QUALIFICATIONS - 60A

Fisheries Biologist III Principal Investigator - Samuel Sharr

Mr. Sharr received a Bachelor of Science degree in biology from the University of Washington in 1968 He has been a research biologist for ADF&G since 1979 and has worked on Prince William Sound salmon and herring since 1981. He assumed his present position as the ADF&G, Division of Commercial Fisheries, Biologist III, Prince William Sound Area Finfish Research Project Leader in 1986. In this capacity, Mr. Sharr oversees all the salmon and herring research conducted by the Division of Commercial Fisheries in Prince William Sound. His involvement with the Prince William Sound salmon escapement aerial survey program dates from the early 1980's. Mr. Sharr has supervised a total re-edit of the historic aerial and ground survey data and designed a new R BASE database for inseason escapement analyses Mr Sharr wrote the original operational plans for NRDA F/S Studies 1, 2, and 3 and has been the Principal Investigator for those projects since their inception

Fisheries Biologist II Project Leader - Carol Peckham

Ms. Peckham has a Bachelor of Science in Wildlife Biology from the University of Alaska and has completed all course work requirements for a Masters degree in statistics She has been employed by ADF&G since 1984. As a college intern for the ADF&G Stock Biology Group Ms. Peckham gained valuable experience in a wide variety of biological sampling and stock identification techniques in Cook Inlet and Prince William Sound Ms Peckham has been involved in coded-wire tag recovery activities in Prince William Sound since their inception and since 1987 she has been the Fisheries Biologist in charge of coded-wire tag recovery operations for Prince William Sound salmon. She has excelled in that capacity Her experience includes supervision of sampling activities spread throughout south-central Alaska. She has co-authored several reports in the ADF&G Technical Data Report series and she was a coauthor of the 1991 NRDA F/S Study #3 interim status report

Fisheries Biologist I Assistant Project Leader - Jodi Smith

Ms. Smith has a Bachelor of Science in Marine Biology from the University of Alaska. Prior to working for ADF&G, Ms Smith worked for four years in aquaculture related activities including hatchery work in Prince William Sound Ms Smith has worked for ADF&G Division of Commercial Fisheries since 1989 when she became a Fisheries Biologist I for NRDA F/S Study #3 In 1990 Ms Smith supervised tag recovery activities in Valdez and in 1991 in Cordova. She also supervised quality control for tagging activities at Prince William Sound hatcheries in 1990 and 1991. Ms. Smith is presently assisting in close out activities for NRDA F/S Study #3.

Biometrician I - David G. Evans

David Evans received a Bachelor of Science in Soil Science from the University of Nottingham (Great Britain) in 1981. He went on to obtain his Masters and Ph.D. in Soil Science from the University of Guelph (Canada) in 1984 and 1988 He obtained a Masters in Statistics from Oregon State University in 1991. Dr Evans began working with coded-wire tags in mid-December 1991

LITERATURE CITED - 60A

Clark, J.E., D.R. Bernard. 1987. A compound multivariate binomial hypergeometric distribution describing coded microwire tag recovery from commercial salmon catches in southeastern Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 261

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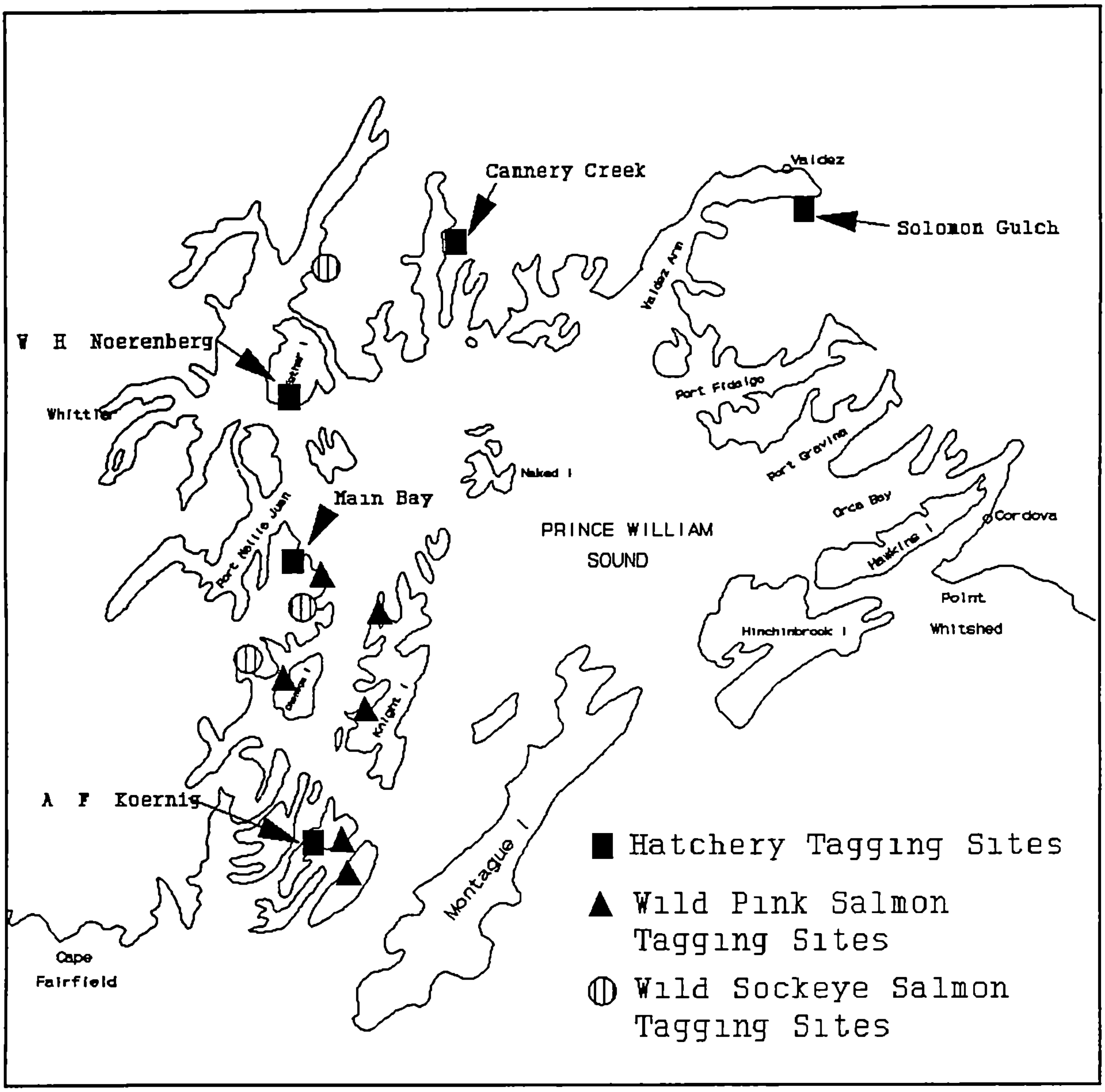
Sharr, S., Bue, B. and S Moffitt 1991 Injury to salmon eggs and pre-emergent fry in Prince William Sound. Alaska Department of Fish and Game, Division of Commercial Fisheries. In press



Attachment 1. Map showing the location of tagging sites for Hatchery and wild stocks of salmon which will contribute to adult returns in 1992.

INTRODUCTION - 60B

Wild stock production of pink salmon, Oncorhynchus gorbuscha, in Prince William Sound has ranged from 10 to 15 million fish in recent years. Most pink salmon (up to 75% in some years) spawn in intertidal areas which are susceptible to contamination from marine pollution. There is strong evidence the Exxon Valdez oil spill adversely affected spawning success and early marine survival of Prince William Sound pink salmon (Sharr et al. 1991, Raymond et al 1991). Exxon Valdez oil spill impacted stocks are harvested in commercial, sport, and subsistence fisheries. Commercial fisheries, which account for most of the pink salmon caught in Prince William Sound, harvest a mix of wild stocks from both affected and unaffected areas as well as hatchery stocks. Management of this mixed stock fishery has been based on achieving good temporal and spatial distributions of spawners for groups of stocks in eight fishing districts. Success of this management strategy has depended upon aerial surveys to estimate escapement during the season. Restoration of stocks injured by the Exxon Valdez oil spill can only be effected through stock-specific management designed to reduce commercial exploitation on impacted stocks. To accomplish this, more accurate inseason escapement estimates are needed both for impacted and unimpacted wild stocks.

This project is designed to provide accurate, real time, escapement estimates for Prince William Sound pink salmon wild stocks. Such estimates will enable fishery managers to closely monitor the numbers of spawners in impacted streams so that harvest rates can be regulated to achieve desired escapement levels This will allow managers to protect impacted stocks while directing fishing effort to harvest surplus fish. Post-season analysis of escapement enumeration data together with data from the proposed stock assessment restoration project (R60A) will provide stock-specific estimates of total return and enable managers to assess the effectiveness of stock-specific management strategies.

In the absence of improved escapement estimation capabilities afforded by this project, pink salmon stocks in western Prince William Sound which have already been injured by the Exxon Valdez oil spill may be over-exploited by commercial, sport, and subsistence fisheries. This could drive these stocks below levels needed for rapid recovery, and in some instances, below levels needed for continued survival. Without an improved escapement monitoring program, the risk of either over- or under-exploiting stocks not impacted by the Exxon Valdez oil spill is also greatly increased

Escapement enumeration procedures to be used for this project were developed and perfected during Natural Resources Damage Assessment Fish/Shellfish Study 1 (NRDA F/S 1) This study was conducted on pink salmon spawning in 138 streams, a subset of the 218 streams included within the department's aerial survey program. Total area of intertidal spawning habitat was estimated for all 138 streams and total area of upstream spawning habitat was estimated for 100 of the 138 streams. In 1989 and 1990 ground surveys to count pink salmon spawners were made for all 138 streams Total pink salmon spawning escapement was counted at weirs for 4 streams in 1990 and 7 streams in 1991. Stream residence time (stream life) of spawners was also estimated for 22 streams in 1990 and 40 streams in 1991. The damage assessment program in 1991 was supplemented by Restoration Study 9 (RS 9), a project similar to the one proposed in this detailed study plan. RS 9 included escapement enumeration at weirs on 3 additional streams as well as stream life estimates in 8 additional streams.

To determine whether oil from the Exxon Valdez oil spill was present in intertidal spawning areas, visual surveys of the habitat were made and mussel (*Mytilus* sp) samples for hydrocarbon analysis were collected at the mouths of all 138 streams in the ground survey program in 1989 and 1990 Additionally, tissue samples for hydrocarbon analysis were collected from spawning pink salmon in 12 oiled and 10 unoiled streams during 1990 and 1991 ground surveys.

This project is focused on restoration of specific stocks of pink salmon Work will emphasize more detailed and intensive data collection on fewer streams than were included in NRDA F/S 1 Streams in the oil impacted areas of western Prince William Sound, as well as streams representative of unimpacted areas in eastern Prince William Sound, will be included in this study. Weirs will be placed on the same streams studied in 1991 as part of NRDA F/S 1 and RS 9. Six of these are streams where pink salmon fry were counted and tagged in 1990 and 1991 as part of NRDA F/S 3. Ground surveys, stream life, and tag recovery studies will be continued at all streams with weirs as well as approximately 8 additional streams. Visual surveys for oil as well as collection of tissue samples from adult pink salmon will be done at all surveyed streams for the duration of the project.

Results of the proposed restoration study will furnish estimates of average stream life for pink salmon in Prince William Sound, provide bias adjustment factors to increase the accuracy of aerial survey spawner counts, and use this information to develop accurate escapement estimates for all 218 streams included in the department's aerial survey program for the current as well as prior years All available aerial survey data will be used to construct run timing curves and set escapement goals for individual pink salmon stocks. This information will be used to direct management actions to regulate human use of Exxon Valdez oil spill injured pink salmon stocks, as well as to ensure that other stocks are not under- or over-exploited. Data from RS 9 were used to set time and area fishery closures which effectively reduced exploitation on Exxon Valdez oil spill injured pink salmon stocks in southwestern Prince William Sound. This allowed adequate escapements to be obtained for those stocks despite intense fishing pressure on surplus hatchery fish in adjacent areas.

This study will also document recovery of pink salmon stocks from oil injury and provide important information to develop and implement future efforts which may be needed to restore injured stocks (e.g. stream rehabilitation). The study will provide estimates of post-oil spill spawning distribution within streams and among streams; total available intertidal and upstream spawning habitat for each stream; marine survival of 6 wild pink salmon stocks using coded wire tagging and recovery. Finally, proposed work will document any continued presence of oil in intertidal spawning habitat and provide an atlas of aerial photographs and detailed maps of important spawning sites.

OBJECTIVES - 60B

A. Weir and Ground Survey Enumeration of Prince William Sound Pink Salmon Escapements

1. Enumerate total intertidal and upstream spawning escapement of pink salmon through weirs installed on 10 representative streams in the aerial and ground escapement survey programs

2. Estimate the number of spawning salmon within standardized intertidal and upstream zones in weired streams using systematic daily ground survey counts of live and dead fish.

3. Estimate average stream life of pink salmon in weired streams using a variety of techniques

4. Enumerate spawning escapements and assist in spawning ground recovery of coded wire tags in streams where wild pink salmon were tagged in 1991.

5. Document pink salmon straying by assisting in recovery of coded wire tags in streams where pink salmon were not tagged. This information will help define stock structure and rebuilding

6. Document the persistence of oil in intertidal spawning habitats through visual observations

7. Collect tissue samples from spawning pink salmon to determine the persistence of sublethal morphological, cytogenetic or histopathological injuries in oil impacted stocks. These samples will also be used to identify the genetic structure of salmon stocks in oil impacted areas.

B. Aerial Estimation of Prince William Sound Pink Salmon Escapements

1. Increase the accuracy, precision, and timeliness of aerial escapement estimates for the 218 streams routinely monitored

by the department. This will permit fishery managers to regulate human use and protect injured stocks while harvesting other wild and hatchery stocks

2. Correct bias and error in total escapement estimates based on aerial observations by using paired comparisons of weir or ground survey data with concurrent aerial survey data obtained from the same streams

3. Provide corrected estimates of total pink salmon escapements to the 218 aerial index streams from 1961 through the current year based on aerial survey average observed error and stream life data from 1990-1992

4. Develop spawning goals and run timing curves for all pink salmon stocks in the department's aerial survey program to improve inseason stock specific management and allow rebuilding of injured stocks

METHODS - 60B

Personnel policy, purchasing practices, field camp operations, safety procedures, and project administration will be in compliance with State Standard Operating Procedures (SOP) Data collection procedures will be similar to those used in NRDA F/S 1 and RS 9 These procedures have been thoroughly evaluated in the NRDA peer review process and approved by the restoration team

The technology and methodology for escapement enumeration using systematic aerial and ground surveys, as well as weirs, have been well established and have a long history of success in Alaska. The historic aerial and ground survey database for Prince William Sound is one of the most extensive in the world. These data provide the basis for inseason management decisions and will be critical components of stock specific restoration efforts NRDA F/S 1 and RS 9 greatly enlarged the scope of pre-spill escapement enumeration projects. The proposed pink salmon escapement enumeration project is needed to improve the accuracy and resolution of fisheries management actions in order to ensure restoration of injured stocks. The methods proposed are a logical extension of existing management programs and the NRDA process

Aerial Surveys

Aerial survey estimates of pink salmon in 209 index streams will be flown by experienced personnel from ADF&G Division of Commercial fisheries (Figure 1). The historic survey program includes approximately 90 streams in the oil impacted area of Prince William Sound Nine additional streams in oiled areas were incorporated into the program in 1989, and approximately 40 additional streams were added in 1991 Surveys have historically been flown weekly

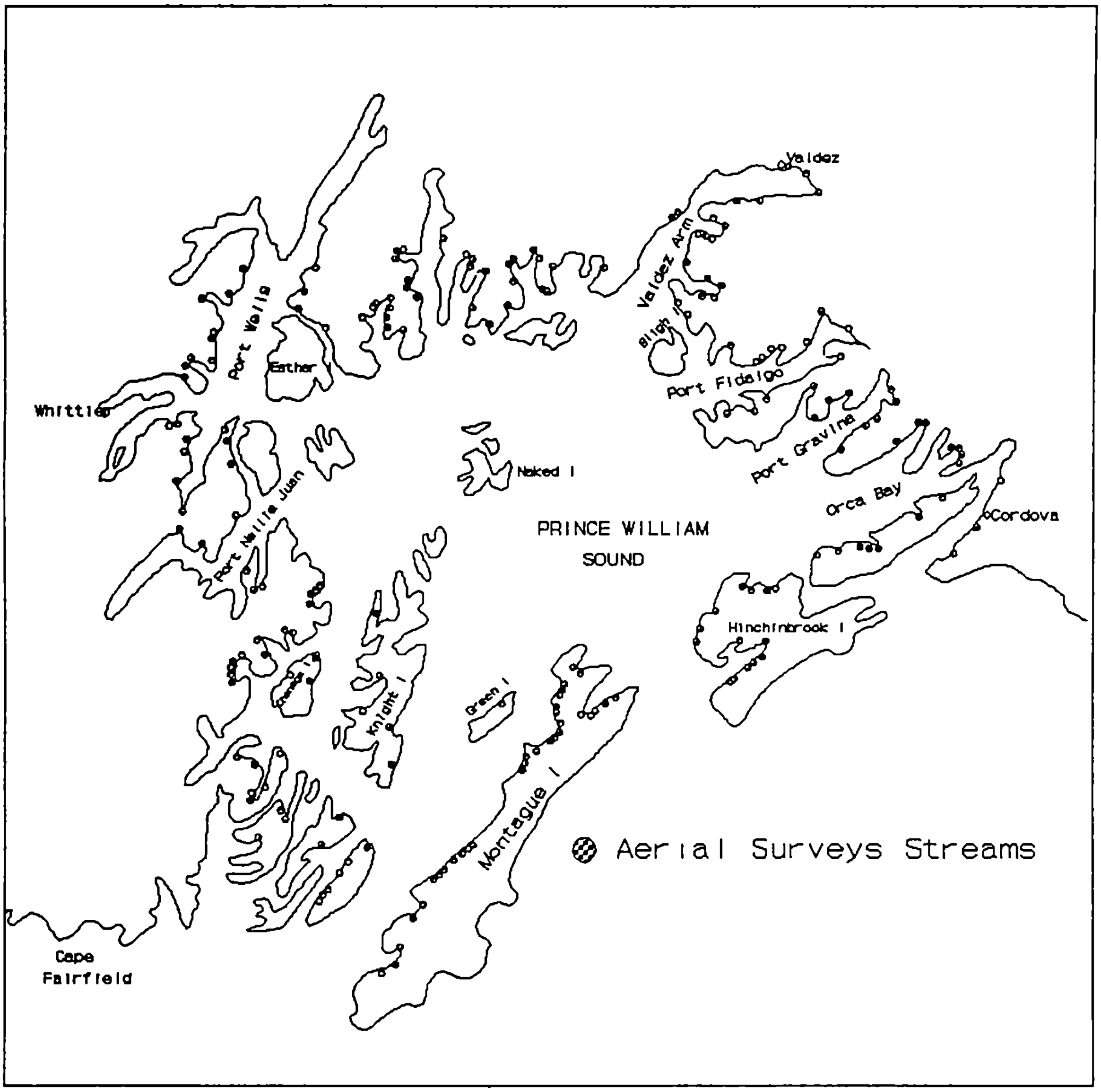


FIGURE 1. Streams included in the aerial survey programs for estimating pink and chum salmon escapement to Prince William Sound

from mid-June to mid-September each year since 1961. In 1992, the survey frequency will be increased to twice weekly Counts of live salmon by species are recorded for the bay at the terminus of each stream, the mouth of each stream, and within the stream (Pirtle, 1977). Counts for 18 streams included in the weir and foot survey program will be further stratified into intertidal and upstream counts. The mean high tide mark (3.7 m) at each of these streams will be marked with a large orange float which will be clearly visible from the air.

Paired aerial and weir data will be used to calibrate aerial estimates and examine observer bias Aerial data from randomly selected streams which have not been historically surveyed will be used to estimate escapement into unsurveyed streams

Total Enumeration Studies

Weirs for total escapement enumeration will be installed on 10 streams in 1992 (Figure 2) These same streams had weirs in 1991 and include those with weirs in 1990 as part of NRDA F/S 1 as well as the 6 streams in which wild pink salmon fry were marked with coded-wire tags for NRDA F/S 3 Two stream weirs are in eastern Prince William Sound. Both these streams have extensive upstream spawning areas typical of many streams in this area The remaining weirs include oiled and unoiled streams in western Prince William Sound. These streams have moderate to no upstream spawning areas All weirs will be installed near the 1 8 meter tide level or the lower range of intertidal spawning Field crews will record daily passage through each weir.

Ground Surveys of Escapements

The 10 Prince William Sound streams (Figure 2) to be weired and surveyed were selected based on the following criteria

1. each stream must be included in the department's aerial survey program;
2. the set of streams must represent the variety of sizes and types where pink salmon spawning has been documented,
3. the set of streams must receive spawning escapements which represent the full range of run timing and abundance documented,
4. the set of streams must include both oiled and unoiled areas;
5. each stream was included in 1989-1991 stream life studies;
6. each stream was included in prior spawning ground foot survey programs,
7. each stream was included in NRDA F/S 3 (tagging wild fry),
8. where possible streams from NRDA F/S 2 (documenting injury to eggs and fry) and in RS 60C (monitoring recovery of injury to eggs and fry) were included

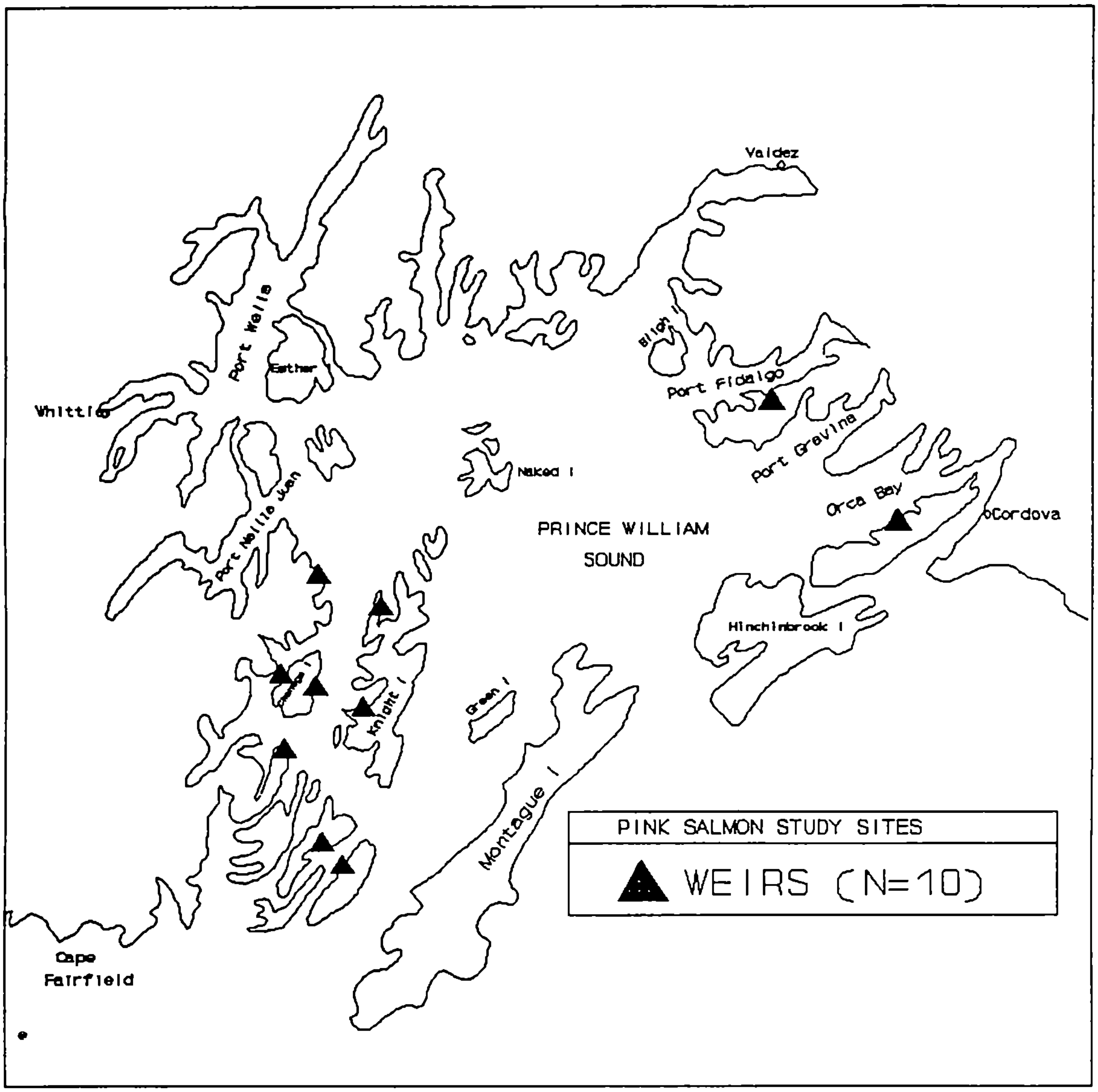


FIGURE 2. Streams proposed for weir, ground survey, and stream life studies in 1992

Tide zones will be marked in June, prior to the return of spawning pink salmon. The location of tide levels 1 8, 2 4, 3 0, and 3.7 m above mean low water will be measured from sea level using a surveyor's level and stadia rod Sea level at each site will be referenced to mean low water with site specific, computer generated tide tables which predict tide heights at five minute intervals Tide zone boundaries will be delineated with color-coded steel stakes; the 3.7 m boundary will be delineated with a large orange float which will be visible to aerial surveyors Field camp crews will conduct daily ground surveys of intertidal and upstream portions of streams with weirs (Figure 2) Live and dead pink salmon will be counted in standard intertidal and upstream zones in each stream. During each survey the following data will be recorded:

1. anadromous stream number and name (if available),
2. latitude and longitude of stream mouth,
3. date and time (24 hour military time),
4. tide stage;
5. observer names;
6. counts of live and dead salmon by species and tide zone (0 0-1.8m, 1.8-2.4 m, 2.4-3.0 m, and 3 0-3 7 m above mean low water and upstream);
7. weather, visibility, lighting, and other survey conditions

All data will be recorded on standard forms Maps will be improved and modified during surveys to show spawner distribution within each zone and the upstream limit of spawning Counts of live and dead salmon will be made for the five tide zones (the intertidal zones < 1.8 m, 1.8-2.4 m, 2 4-3 0 m, 3 0-3 7 m above mean low water and the upstream zone) from the 1 8 m tide level to the limit of upstream spawning on all 10 streams during daily surveys Tide stage will be monitored continuously and survey times and direction will be adjusted accordingly If the tide stage at the time of the walk is at or below the 1 8 m level, the stream walk will begin at the stream mouth and progress upstream

The mouth or downstream limit of the stream has been defined as the point where a clearly recognizable stream channel disappears or is submerged by salt water Salmon seen below the downstream limit will be included in stream mouth estimates and noted as a comment on the data form. If the intertidal portions of the stream above the 1.8 m level are submerged at the time the walk begins, the crew will go to the upstream limit of the walk, proceed downstream, and end the survey at the time predicted for the tide to be at or below the 1.8 m level. The upstream limit of a walk will be determined by the presence of natural barriers to salmon passage (i.e., waterfalls), by the end of the stream, or by the upstream limit of spawning. The upstream limit of spawning will be marked on U S Geological Survey color aerial photos of each stream following each survey.

For counts of live and dead salmon on moderate size streams with a single channel, crew members will walk together but independently count live salmon in each intertidal zone. Crew members will individually enter their counts on mechanical hand tallies. A maximum of three replicate counts may be made in each zone at the request of either observer. Upstream counts in a single channel will be similarly conducted at convenient stopping points (i.e. log jams or other clear markers) For large braided or branched streams, each crew member will count separate channels or upstream forks. To avoid confusion with counts of live salmon, counts of dead salmon will be recorded on the return leg of the stream walk Only salmon that have died since the previous count will be counted as dead in daily surveys. To prevent duplicate counts between surveys, tails and tags of all dead pink salmon observed will be removed. To avoid perpetuating counting biases within a counting crew, personnel will be rotated between crews daily. Whenever possible, crew members will not be assigned the same streams on succeeding days.

Stream-life Studies

All 10 streams in the ground survey program are included in a stream life study (Figure 2). Average stream life of pink salmon in these streams will be estimated using data from daily ground surveys. On the 10 streams with weirs a second, independent estimate of stream life will be made using tagging methods similar to those described in McCurdy (1984) and Helle et al (1964). A third independent estimate of stream life will be made at these 10 streams using daily weir data and carcass counts from daily ground surveys.

For the tagging study, pink salmon will be captured with beach seines at stream mouths and tagged with Peterson disks Tags will be uniquely colored to represent day of tagging and uniquely numbered to identify individual salmon. Each week 120 pink salmon will be tagged from each of 8 streams. At the other 2 streams, which are largest streams in the study, 200 tags will be applied weekly. If fewer than the desired number of pink salmon are available, all captured pink salmon will be tagged. Numbers of tagged live and dead pink salmon observed by ground survey crews each day will be recorded by color and tide zone on standard forms Whenever possible, individual tag numbers will be recorded for tagged live pink salmon and tags will be recovered from carcasses

DATA ANALYSIS - 60B

Data analysis procedures are similar or identical to those used in NRDA F/S 1. These procedures have been thoroughly evaluated through the NRDA peer review process and approved by the Management Team. Report format will follow that established by the Management Team. Reporting style and conventions will otherwise be in accordance with the department's Division of Commercial Fisheries style manual.

Total Escapement Enumeration Data

Total escapement at weir sites will be the sum of daily counts of pink salmon which pass through the weir The number of live pink salmon present in the stream on any date i (L_i) will be the difference between the cumulative count of live pink salmon on that date and the cumulative count of carcasses on that date

$$L_i = \sum_{t=1}^{i} W_t - \sum_{t=1}^{i} D_t \quad , \tag{15}$$

where i = serial day of weir operation;
t = day of weir operation,
W_t = live pink salmon passed through the weir on day t,
D_t = count of dead pink salmon in the stream on day t.

These estimates will be used to validate corresponding counts from aerial and ground surveys.

Adjustment of Aerial and Ground Counts

Stream types will be defined from characteristics of study streams with weirs. Classification will be based on stream size, extent of upstream and intertidal spawning habitat, and other characteristics including water clarity and extent of forest canopy These characteristics will be used to classify all other streams in the aerial and ground survey programs. Daily aerial and ground counts on streams with weirs will be adjusted for bias using the regression of aerial survey counts to live pink salmon in the stream on day i. Adjustment factors for streams with weirs will be applied to aerial and ground counts from streams without weirs having similar stream characteristics.

Stream-life Data

Tagging data will be used to calculate stream life values for individual pink salmon as

$$S = J_r - J_t \quad , \tag{16}$$

where J_t = julian date when the live tagged pink salmon was first observed entering the stream channel from the milling area at the mouth,

J_r = julian date of tag recovery from the dead pink salmon

Stream life estimates for each stream and weekly strata will be the average for individual pink salmon in the strata The stream life estimate for the season will be the average of strata estimates Stream life estimates within weekly time strata will be averaged across all streams to examine time trends in stream life

Another mean stream life estimate for each stream will be calculated as the difference between the mean date of abundance of new arrivals of live pink salmon in the stream and the mean date of abundance of daily dead counts as follows.

$$S = \frac{\sum D_i J_i}{\sum D_i} - \frac{\sum [((L_i - L_{(i-1)}) + D_i) J_i]}{\sum [(L_i - L_{(i-1)}) + D_i]} , \qquad (17)$$

where i = survey number,

L_i = number of live pink salmon observed on survey i,

D_i = number of dead pink salmon observed on survey i;

J_i = Julian date of survey i

For streams with weirs, a third estimate of mean stream life based on daily counts of live pink salmon passed the weir and daily dead counts in the stream will be as follows

$$S = \frac{\sum [(J_i - J_{(i-1)}) \sum (W_i - D_i)]}{\sum W_i} , \qquad (18)$$

where i = serial day of weir operation,

J_i = Julian date,

W_i = live pink salmon passed through the weir on day i;

D_i = count of dead pink salmon in the stream on day i,

S = stream life (in days)

If observations for day i are missing, total live pink salmon in the stream on day i ($\Sigma(W_i - D_i)$) will be linearly interpolated

If significant differences occur in stream life estimates between streams or time strata, stream and week specific stream life estimates will be applied to similarly stratified aerial and ground observations when estimating escapements using the geometric method (see below).

Escapement Estimates Based on Aerial Survey Data

Annual spawning escapement estimates (E) for pink salmon within each surveyed stream will be made using a geometric approach similar to that described by Johnson and Barrett (1986)

$$E = \frac{\sum \left[(J_i - J_{(i-1)}) L_i - \frac{(J_i - J_{(i-1)}) (L_i - L_{(i-1)})}{2} \right]}{S} , \tag{19}$$

where i = survey number,
j = stream category,
J_i = julian date;
L_{ji} = survey estimate of live pink salmon in the stream adjusted for stream category j survey bias on survey i,
S = stream life (in days)

If the maximum daily survey of live pink salmon in the stream exceeds the total escapement estimate based on the geometric method, the maximum daily survey count will be treated as the total escapement.

Escapement estimates for streams not included as historic index streams (U) will be calculated as follows

$$U = \sum R_k P \quad , \tag{20}$$

where k = stream number,
R_k = escapement estimate for randomly selected and typically unsurveyed stream k for which escapement is calculated by applying the geometric method (equation 5) to aerial survey data,
P = proportion of total spawning streams represented by the group of randomly selected unsurveyed streams

Escapement Estimates Based on Ground Survey Data

Ground survey counts will be summarized by species, stream, survey date, zone, and observer for all 10 streams in the study Spawning escapement to streams surveyed from the ground will be estimated using the geometric method described for aerial survey data

Frequently, survey counts (L_1) will be replicated as paired observations from two observers walking in tandem The escapement estimate for a section walked in tandem will be the mean of the observations. The variance will be estimated using all replicates for the section. A one-way analysis of variance will be used to test for differences between replicate observations from separate observers. In instances where the maximum daily sum of live and dead pink salmon in a stream exceeds the total escapement estimate for the stream based on the geometric method, the maximum daily sum of live and dead pink salmon will be the total escapement estimate

DELIVERABLES - 60B

Semi-weekly escapement estimates from aerial surveys and daily counts from weirs and foot surveys will be summarized for the ADF&G salmon management biologists Stream life and surveyor bias estimates will be incorporated into algorithms used to estimate current and historic escapements from aerial results Revised historic escapement estimates and migratory timing curves for streams in the aerial survey index program will be compared with current year data to assess escapement performance and the success of management strategies

A report will be completed in February, 1993

SCHEDULES AND PLANNING - 60B

The field work portion of this project is tentatively scheduled for completion in 1993 The schedule outlined below is for the 1992 field season and subsequent reports.

Data Collection, Analysis and, Reporting Schedule

Planning, outfitting, data collection, analyses and reporting of results for the 1992 field season will proceed as follows

March 1-30 June 1992
: Planning, hiring, purchasing supplies and equipment for field season

July 1-September 15, 1992
: Weir installation and operation, ground surveys, and stream life studies Inseason data entry of weir, ground survey, and aerial survey data Analysis of inseason data and consultation with ADF&G Division of Commercial Fisheries management personnel concerning management decisions regarding oil impacted stocks

September 15-November 30, 1992

Completion of post-season computer data entry and editing.

September 15-December 30, 1992
Completion of preliminary post-season data analysis and progress report.

December 15-February 29, 1993
Finalize post-season data analyses and completion report for 1992 season

Sample and Data Archival

All project operational plans, data logs, field notebooks, as well as original copies of draft and final reports will be kept in locked file storage in the Commercial Fisheries Division and Oil Spill offices in Cordova.

Weir data, ground survey, tagging, and tag recovery forms will be labeled with a three part alpha-numeric code unique to each data type, stream, and date. At the end of each day, forms will be carefully edited and the code for each will be recorded in a data collection log maintained by each field crew As forms are logged they will be initialed by the crew member doing the log-in procedures for that day. Any biological samples collected will similarly be coded as to sample type, sampling site, and date All data and samples collected will be remitted to the Cordova ADF&G office on a weekly schedule according to standard chain of custody procedures. Data collection log numbers, date sent and the initials of the person sending, will be recorded in a the field data camp data transmission log Data received in Cordova will recorded in a data and sample transmission log which will show the codes assigned to each form and sample at each field camp as well as the date received and the initials of the receiver

Original data forms for each data type and stream will be stored in separate, labeled three ring binders in the Oil Spill Impact, Assessment, and Recovery (OSIAR) office Backup photocopies of the data will be stored in corresponding binders in the ADF&G Commercial Fisheries Division office in Cordova All samples will be placed in locked storage and sent to the appropriate processing laboratories or centralized storage facilities when appropriate Standard chain of custody procedures will be followed when any data or samples are remitted from the custody of project personnel in Cordova.

All data will be edited for errors immediately upon receipt in Cordova and then entered into a microcomputer database in R·BASE format. The R:BASE database will be accompanied by full documentation including a description of all columns, tables, and applications. Backup copies of the database will be updated after every data edit or update and placed in locked, fireproof storage in the

OSIAR and Commercial Fisheries Division offices. A complete log of data entries, edits, and archives will be maintained by project personnel which will reflect the alpha numeric data form codes, the date of entry or editing, and the initials of the person performing these functions.

MANAGEMENT PLAN - 60B

The Principal Investigator (PI) for the project is a Fisheries Biologist III with the Alaska Department of Fish and Game The PI will be responsible for writing project operational plans, administering project budgets, quality control of data collection, supervising data analyses, and writing final reports The PI will be assisted by a Fisheries Biologist II Project Leader (PL) who will hire project personnel, supervise day to day project operations, maintain data quality, assist in data analyses, and coauthor final reports. The PL will be assisted by two Fisheries Biologist I's. One of these assistants will be in charge of installing weirs and camps, weir operations, and remote camp logistics. The other assistant will supervise data collection activities in the ground survey and stream life studies. Each weir camp will be manned by two people, one of whom will be partially funded by NRDA Study F/S #3 for recovery of adult salmon bearing coded-wire tags. Each crew will have one Fisheries Technician III as crew leader The remainder of each crew will be Fisheries Technician II's. Each day, two persons on each crew will tend the weir and conduct the ground survey, stream life, and tag recovery activities on the stream with a weir. The other two crew members will conduct ground survey, stream life, and tag recovery activities on streams without weirs. The consulting Biometrician II will review all operational plans, project reports, and be responsible for all statistical products and statistical reporting

Project Logistics

Most weir and camp materials were purchased in the Spring of 1991 with funds from NRDA F/S 1. Any additional required materials will be purchased in the Spring of 1992 with restoration funds. The ADF&G R/V Montague will transport materials to the weir sites in June of 1992. Weirs and camps will be installed at ten sites (Figure 2) in the last week of June Weir operations, ground surveys and, stream life studies will begin on July 1.

Weirs will be supplied semi-weekly by the R/V Montague or as needed by fixed wing aircraft. The PL and the assistant project leaders will visit each camp on a weekly schedule to oversee weir and camp operations, collect completed data forms and heads from tagged fish, answer questions from field crews, and monitor the data quality of data collected. The project leader or the assistant project leaders will maintain twice daily radio schedules with weir camps. During radio schedules, weir crew will transmit weir counts and stream walk counts to the Cordova office and transmit any other information or requests essential to camp operations. Data collected each week will be edited and entered into an R:BASE database in Cordova by a Fisheries Technician III The PI and the PL, in consultation with the OSIAR Biometrician, will update escapement estimates based on aerial and ground survey data and weir counts. These analyses will be completed daily and the results will be passed on to the ADF&G Division of Commercial Fisheries Prince William Sound Area Management Biologist In consultation with the PI, the PL, and other ADF&G fisheries management and research staff, the Area Management Biologist will use these results to make inseason fisheries management decisions.

PERSONNEL QUALIFICATIONS - 60B

Fisheries Biologist III Principal Investigator - Samuel Sharr

Mr. Sharr received a Bachelor of Science degree in biology from the University of Washington in 1968. He has been a research biologist for ADF&G since 1979 and has worked on Prince William Sound salmon and herring since 1981 He assumed his present position as the ADF&G, Division of Commercial Fisheries, Biologist III, Prince William Sound Area Fin Research Project Leader in 1986. In this capacity, Mr. Sharr has in the past been in charge of all salmon and herring research conducted by the Division of Commercial Fisheries in Prince William Sound His involvement with the Prince William Sound salmon escapement aerial survey program dates from the early 1980's. Mr. Sharr has supervised a total evaluation of historic aerial and ground survey data and has designed an R:BASE database for inseason escapement analyses Mr Sharr wrote the original operational plans for NRDA F/S 1,2 and, 3 and has been the Principal Investigator for those projects since their inception

Fisheries Biologist II Project Leader - Dan Sharp

Mr. Sharp has a Bachelor of Science in Fisheries from the University of Idaho and has been employed by ADF&G since 1982 As a biologist for the ADF&G Susitna Hydroelectric Project Mr. Sharp gained valuable experience in a wide variety of techniques to enumerate salmon escapements and estimate migratory timing His experience includes operation of weirs, sonar counters and wheels, as well as tagging studies of juvenile and adult salmon. Mr Sharp has been the Fisheries Biologist II Project Leader for the tagging portion of NRDA F/S 3 since its inception in 1989. In 1991 Mr Sharp also assumed responsibility for adult escapement enumeration and stream life studies (NRDA F/S 1 and RS 9)

Fisheries Biologist I Assistant Project Leader - Roger Dunbar

Mr. Dunbar has a Bachelor of Science in Wildlife Management from the University of Alaska and worked for ADF&G Division of Commercial Fisheries in Bristol Bay for 10 field seasons. He was a Fisheries Biologist I for NRDA F/S 1 in 1991. In that position he helped supervise the installation and operation of 10 adult pink salmon weirs in Prince William Sound and assisted in daily supervision of ground survey and stream life study crews

Biometrician II - Brian G. Bue

Brian Bue has a Bachelor of Science in Biology and a Bachelor of Science in Fisheries from the University of Alaska, Fairbanks. He also possess a Masters degree in Fisheries with an emphasis on quantitative studies from the University of Alaska, Fairbanks Brian has worked with the Alaska Department of Fish and Game from 1974 through present in many capacities He has worked as a consulting biometrician on oil spill damage projects since the first days of the Exxon Valdez spill

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Sharr, S., S. Moffitt, B. Bue 1990 Injury to salmon eggs and preemergent fry in Prince William Sound State/Federal Natural Resources Damage Assessment Draft preliminary Status Report Cordova.

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BUDGET - ($K)

	60A	60B	60AB
Salaries	$812 5	249 4	1,061 9
Travel	15 0	17.2	27 2
Contractual	38 1	54 6	92 7
Supplies	20 5	30 9	51 4
Equipment	18 2	57 5	75 7
Subtotal	$904.3	409 6	1,313.9
General Administration	124 6	41 2	165 8
Total	$1,023.9	$450 8	1,479 7

RESTORATION PROJECT NUMBER 73

Study Title: Harbor Seal Restoration Study

Lead Agency: ADF&G

PROJECT JUSTIFICATION

The harbor seal restoration project will be funded during 1992 to cover project closeout costs. Closeout funds will be used to complete spring 1992 field work and to prepare a final report of harbor seal restoration study activities.

Scheduled field work will entail attaching satellite transmitters to approximately ten harbor seals in Prince William Sound. They will be used to monitor their movements and hauling out and diving behavior until they cease to function and/or fall off during the annual molt in August. As indicated in all previous proposals and budgets for this project, satellite transmitters and data acquisition time for spring 1992 field work have already been procured with 1991 funds. This was necessitated by the three-month lead time required for transmitter manufacture and the requirement that satellite time be committed in January-February.

The final report will present and analyze data from harbor seals that were satellite-tagged in 1991 and 1992 as part of this restoration study. This will include analyses of movements and diving and hauling out patterns, an evaluation of changes in harbor seal distribution and abundance following the Exxon Valdez oil spill in light of these results, the potential application of diving and movements data to design and interpretation of aerial monitoring surveys; and recommendations for further study. In order to allow ample time for analysis of 1992 data, the final report will be completed by December 31, 1992.

BUDGET ($K)

Salaries	$11.6
Travel	2.5
Contractual	5.0
Supplies	1.7
Equipment	1.2
Subtotal	$22.0
General Administration	2.9
Total	$25.0

RESTORATION PROJECT NUMBER 103 A,B,C,D

Study Title: Recovery Monitoring of Intertidal Oiled Mussel Beds in Prince William Sound and the Gulf of Alaska Impacted by the Exxon Valdez Oil Spill

Lead Agency: NOAA

Cooperating Agencies: ADF&G, NPS, USFWS

INTRODUCTION - R103A

The highest oil concentrations in animals or sediments in 1991 were found in mussels and underlying substrates from oiled mussel beds in Prince William Sound (Babcock, 1991 status report on oiled mussel beds). The oiled mussel bed study of 1991, supported by agency funds, exposed a potential serious pathway of oil to predators higher in the food chain However, the study was cut short by weather and funds before the geographical extent of oiled mussel beds in Prince William Sound could be determined. Analyses on a limited number of samples indicated that the oil concentrations within the underlying substrates were higher than the oil in the mussels and that the oil in the substrates was not weathered, rather surprising since these samples were collected more than two years after the spill

The primary goal of this study is to determine the geographical extent of oiled mussel beds in Prince William Sound, the intensity of oil remaining in mussels and the underlying organic mat This study will provide chemical data to assess the possible linkage of oiled mussel beds with continued injury to harlequin ducks, oystercatchers, juvenile sea otters, and river otters On the surface, the high concentrations of oil in mussels from oiled mussel beds appears to be a possible link (cause) for continued reproductive failure of harlequin ducks in the western Prince William Sound, injury to oystercatchers, and higher than normal mortalities of juvenile sea otters-- all feed heavily on mussels

This study proposes a secondary goal, with minimal logistics costs, that will determine the chemical and biological recovery of these oiled beds without further treatment and the recovery with some mechanical treatment This information is critical in deciding if future clean-up or removal of mussels is appropriate.

Oiled mussel beds will pose a significant and controversial management problem. Treatment, in the form of cleaning, will be difficult and removal will by unpalatable to some people Some biologists fear the impacts of removal of large quantities of mussels to the food availability to some species, even if the mussels are oiled. Other biologists fear the impacts of oiled mussels from the oiled beds on sensitive life stages and reproductive events dependent on specialized behaviors. Partial removal of the beds (removal of strips), to allow water circulation and access to the substrates below packed mussel beds may remove oil and permit biodegradation to occur at faster rates The stripping study will evaluate the feasibility of this action on the chemical and biological recovery of the mussels.

The biological impacts of oiled mussel beds on mussels are unknown at this time. Coastal Habitat Study Number 1A does include random transects into mussel beds, but it is unlikely that many oiled mussel beds were within their randomized design. Furthermore, the chemical analyses from their studies will not be available to evaluate the chemical differences between oiled and non-oiled mussel beds. This study will collect samples to determine biological impacts of the oiled beds on mussels while on site for the primary function of collecting samples for chemical analyses. Mussels fill an important ecological niche and food source There is a need to understand the impacts of oiled mussel beds on mussel biology.

Biological impacts will be measured on mussels by measuring byssal thread production, condition indexes, and reproduction indexes All measurements will be from samples collected in the field, but measurements will be made back at Auke Bay Laboratory All samples will be collected while sampling for the primary objective, geographical extent of oiled mussel beds and assessing their recovery. Several studies report reduced byssal production by mussels from hydrocarbon (HC) impacted areas and in experimental HC exposures. These measurements can assess physiological impact, and can assess biological recovery if rates change after treatments. Reproduction and condition indexes will measure the long-term health of a mussel bed.

This project consists of two primary goals: (1) determine the geographical extent of oiled mussel beds by sampling 30-50 sites within Prince William Sound, and (2) determining the chemical and biological recovery of mussels and oiled mussel beds at a limited number of oiled and non-oiled sites The second goal will require two short follow-up samplings in 1992, and will require the analyses of samples from 1991 that have not yet been analyzed

This project is relatively large, but it did not exist during the Damage Assessment process Preliminary identification of potential sites will be provided by Alaska Department of Environmental Conservation (ADEC). Sampling will occur during other projects Ultraviolet (UV) screening will be used to select samples for detailed analyses by gas chromatography/mass spectrometry (GC-MS)

OBJECTIVES - R103A

Objective 1. Determine the intensity and geographic extent of oiled mussel beds in Prince William Sound

Justification - This study, with input from the spring shoreline survey by the response agencies (ADEC, US Coast Guard and Exxon), will determine the geographical extent of oiled mussel beds and will define the magnitude of this problem in Prince William Sound Ultraviolet (UV) screening of byssal mat substrates for oil will reduce the analytical costs considerably, and will permit large numbers of samples from many sites to be analyzed GC/MS analyses will determine the relationship between oil contamination in mussels with substrates and will permit an evaluation of the degree of weathering of the sample along with absolute concentrations of specific compounds.

Objective 2. Determine variation and correlation of HC concentrations in mussels with substrate HCs within oiled mussel bed sites

Justification - This study will probably confirm the hypothesis that severely contaminated mussels are restricted to heavily contaminated underlying substrates, and that mussels adjacent to the oiled beds are not impacted and probably do not need any treatment. All logistics are within the primary objective to determine geographic extent of oiled mussel beds

Objective 3. Determine the chemical and biological recovery of mussels and oiled mussel beds without treatment (natural recovery) and with treatment (treatment proposed is partial removal of mussels and substrate to enhance natural flushing of hydrocarbons from contaminated beds)

Justification - This part of the study will probably confirm that oiled mussel beds are slow to recover from HC contamination, by comparing data from oiled mussel beds in 1991 and 1992, and will explore the possibility of enhanced recovery by removing small strips of mussels within a bed.

Objective 4 and 5 See R103B

Objectives 6 and 7. See R103C

Objectives 8 to 12 See R103D

METHODS - R103A

Objective 1. Mussels, byssal substrates and sediments from 30-50 sites within Prince William Sound will be sampled. Potential sites with oiled mussel beds will be identified during the spring shoreline survey and by studies associated with harlequin ducks, oystercatchers, and sea otters. Sampling will be repeated at sites that showed high HC in 1991.

UV analyses of approximately 200 byssal mat substrates from 30-50 sites will determine the geographic extent of oiled mussel beds and relative intensities of contamination. The GC/MS analyses of selected samples of mussels, byssal mat substrates, and sediments from 10-15 sites will be analyzed after screening by UV, and will determine absolute concentrations of HC, and the relationship of HC contamination levels between each medium The GC/MS analyses of 18 samples from 3 control sites will be sampled for comparison, and can be related to historic HC contamination changes Sixty-five samples collected in 1991 from oiled mussel beds remain to be analyzed by GC/MS.

<u>Objective 2</u>. Variation and correlation of HC concentrations within two mussel beds will be determined by randomly sampling mussels, substrates, and sediments within each bed and adjacent to oiled mussel beds. The ultraviolet screening of samples will be valuable here because of the high number of samples required for site distribution of HCs.

<u>Objective 3</u>. The treatment will strip one area in three heavily oiled mussel beds and one control mussel bed Stripped areas (≈30 cm wide) will be perpendicular to the water line. Stripping will remove the mussels and immediate underlying byssal thread/substrates. Excess mussels and substrates will be disposed of in an acceptable and legal manner.

A. Chemical Recovery Mussels and substrates will be sampled 30 days later and at the end of the season at varying distances from the stripping. Changes in HC concentrations will be compared with samples taken between the initial sampling and an untreated oiled mussel bed. All substrates will be screened for hydrocarbons by UV, and selected samples will be analyzed by GC/MS. These stripped areas will also be examined to determine the stability of mussels at edges of strips, the movement of adults onto stripped areas, and the settling of juveniles on the strips The initial edges of the strips and/or mussels at strip edge will be marked; marked mussels will be checked at 30 days and at the end of the season

B. Biological Recovery. Biological parameters to measure recovery in mussels can include byssal thread production, general condition, and reproductive condition. Samples for histological examination will be taken, but no histological processing will start in the first year.

Recovery of byssal production in impacted mussels from contaminated substrates will be tested by collecting mussels from the three heavily impacted beds (the stripped beds) and three non-impacted mussel beds. All mussels will be collected and transported to Auke Bay Laboratory in one day. Mussels will be glued to plates and suspended in clean seawater on the second day, and time zero will begin on day 3 (48 hours post collection) Byssal thread production will be measured at 24 hours, 7 days and 30 days to determine rates of recovery. If there are significant differences in byssal production between mussels from heavily oiled mussel beds and non-oiled beds, a second series of byssal trials will be conducted to determine if recovery of byssal production capability occurs following stripping.

C. General Condition. Condition indices of mussels sampled for hydrocarbons and reproductive condition will be determined using methods developed for mussels by NRDA studies Subtidal 3 and CH1B (dry tissue weight/shell volume)

D. Reproductive Condition Mussels will be collected at the six byssal sites in March, May, June, July, and August (three oiled mussel beds, three non-oiled mussel beds) A rough gonadal index will be calculated for each mussel by determining mantle dry weights and total dry weights Some samples from each site may be examined histologically to determine gonadal developmental stage

DELIVERABLES - R103A

The following reports are anticipated

1. Interim report: Geographic extent of oiled mussel beds in Prince William Sound based on UV screening ... . . Nov 1, 1992

2. High concentrations of hydrocarbons in mussels and underlying substrates two and three years after the <u>Exxon Valdez</u> oil spill........ .. . . April 1993

3 Relationship of HC in mussels from contaminated substrate types three years after the oil spill . . . April 1993

4. Contamination recovery of mussels from oiled mussel beds where contaminated mussels and underlying substrates were removed in strips to increase natural flushing of the beds .April 1994

5 Biological impacts of oiled substrates on mussels three and four years after the oil spill.... .. . .April 1994

6. Tech Memo. Oil contamination in mussels from oiled mussel beds in Prince William Sound and the Kenai Peninsula, a geographic look with relative intensities October 1994

7 Final Report· 6 months after HC analyses are completed

SCHEDULES & PLANNING - R103A

A. Data and Report Submission Schedule

ACTIVITY	TIME FRAME
Field Sampling	March - August '92
Reproductive	March, May, June, July, August '92
Stripping	initial May, checks June, August'92
Byssal trials (ABL)	May-July '92
Data Compilation	March '92-fall '93
Biological	March - August '92
Hydrocarbon	May '92-fall '93
Data Analyses	April '92 - winter '93
Report Preparation	
Status	Nov '92
Final	Spring '94

B. Sample and Data Archival

Samples, field notes, data and reports will be retained at Auke Bay Lab by the principal investigators. Samples will be collected, handled and held under protocol established by the NRDA process

C. Management Plan

Overall Manager, Report Preparation GS-14
Field Logistics, Study design, Report Preparation .GS-12
GS-9
Field Work, Study design.......... ... . GS-11
Field Work................ .. .. GS-7

D. Logistics

Field logistics in Prince William Sound are a major cost of this study, and cooperation with the spring beach survey will contribute to reduced costs. A ADEC vessel will be used during the initial stripping. The initial sampling of 30-50 sites will consume approximately 80% of the logistics costs About 20% of the logistics cost will be consumed in re-visiting heavily impacted sites, with and without treatment, to get a time course in sampling which will permit examination of chemical and biological recovery There will be two short trips to 6 sites after the initial stripping (30 day, end of summer) Additional reproductive samples from 6 sites will be collected and mussel beds surveyed for stripping during the March 92 NRDA cruise to pick up mussels and sediment traps (Subtidal 3). A skiff will be used in Auke Bay to service the byssal trial site

E. Analytical Logistics

Screening substrates by UV will cost about one tenth the cost of a sample analyzed by GC-MS. Using UV screening procedures will permit many analyses of substrates from a large number of sites, with follow-up GC-MS analyses on "selected" samples The relative UV determinations will be calibrated relative to the GC-MS. The cost for analyses of approximately 250 GC-MS samples to be analyzed (including samples from 1991), and about 400 - 500 samples screened by UV is about $250 K.

RESTORATION PROJECT 103B

Study Title: Recovery Monitoring of Intertidal Oiled Mussel Beds in the Gulf of Alaska Impacted by the Exxon Valdez Oil Spill

Lead Agency: NPS

Cooperating Agency: NOAA

INTRODUCTION - R103B

The presence of contaminated mussel beds along the outer Kenai Peninsula and the implication of their presence (through the continual oiling of mussels and linkage to higher birds and mammals) is of concern to several governmental agencies With the cooperation of the NPS, ADEC, and ADNR, NOAA will survey the geographical extent and intensity of oiling at mussel beds at sites along the Kenai Peninsula.

In concert with the examination of contaminated mussel beds outside of Prince William Sound, the persistence and fate of Exxon Valdez oil at selected sites along National Park coastline will be examined, since the continued presence of the oil affects the scientific and recreational values and wilderness characteristics of National Park lands These values and characteristics are clearly stated in both Alaska National Interest Land Conservation Act (1980) and the Wilderness Act (1964) Surveys conducted in 1991 indicate that oil continued to persist in the Kenai Fjords and Katmai 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 after the oil spill The presence of oil may further contaminate biological resources, including mussel beds Objective 5 will address these concerns

The two parts of R103B are linked by addressing the continued presence of oil outside the Prince William Sound area and implications for further contamination to higher order consumers Also, mussel beds and boulder areas that are associated with the persistence of oil are similar because they both provide a structural heterogeneity that has allowed for the entrapment of oil and has apparently slowed the weathering of that oil

OBJECTIVES - R103B

Objective 4. Determine the geographical extent and intensity of petroleum hydrocarbon contamination of mussel beds at sites outside of Prince William Sound, along the Kenai and Alaska Peninsula and in the Kodiak region.

Objective 5. Document, quantitatively and qualitatively, the location, persistence and fate of oil from the Exxon Valdez along the Kenai Fjords and Katmai National Park coastlines.

LOGISTICS and ANALYTICAL COSTS - R103B

All field support and logistics will be minimized by close coordination between NPS and NOAA/ABL ABL costs for R103B consist of labor and travel costs associated with collection, and analytical costs. The NPS portion consists of extended logistics, vessel charter, sampling and additional analytical costs

The analytical costs will be minimized by using UV screening of sediments and substrates, then selected mussels, substrates, and sediments will be analyzed by GC/MS.

RESTORATION PROJECT 103C

Study Title: Potential Impacts of Oiled Mussel Beds On Higher Organisms· Harlequin Ducks and Black Oystercatchers

Lead Agency: USFWS

Cooperating Agency: NOAA, ADF&G

INTRODUCTION - R103C

The high concentrations of unweathered crude oil found in some mussel beds in Prince William Sound during 1991 has raised questions regarding the impact of this oil on higher organisms The species of concern include black oystercatchers, harlequin ducks and juvenile sea otters, all of which are known to include mussels as a relatively large portion of their diet Harlequin ducks are apparently not reproducing in Western Prince William Sound, and weaning juvenile sea otters are suffering higher mortality as well It is possible that these injuries are the result of exposure to petroleum hydrocarbons in oiled mussel beds. The goal of this study is to document exposure to and ingestion of contaminated mussels by direct observation of foraging activities, and by analysis of blood and feces of black oystercatchers

Given the relatively large feeding range of sea otters and harlequin ducks, developing field studies that can provide useful information regarding exposure of these species to oiled mussel beds is difficult and would be very expensive In contrast, breeding black oystercatchers establish a limited foraging territory in which they can be studied with relative ease The researchers will study black oystercatchers in areas with oiled mussel beds to determine the extent to which these birds use oiled beds and are constantly exposed to oil Blood and fecal samples will be collected from oystercatcher chicks which consume mussels collected by the adult birds In addition, in cooperation with the Alaska Department of Fish and Game, blood and fecal samples will be collected from harlequin ducks captured in Western Prince William Sound.

The data from these studies will provide an indication of potential exposure of black oystercatchers and harlequin ducks to oil from mussel beds in Prince William Sound Given the methods and financial resources available to address this question, however, it will not be possible to determine with certainty the degree to which oiled mussel beds are injuring higher organisms

OBJECTIVES - R103C

6. Identify potential for exposure of higher organisms to petroleum due to foraging in or around oiled mussel beds by review of relevant NRDA studies, scientific literature, and GIS data.

7. Document exposure to and ingestion of contaminated mussels by direct observation of foraging activities and by analysis of blood and feces.

METHODS - R103C

Objective 6: Identify potential for exposure of higher organisms

The first step in assessing the impact of oiled mussel beds on higher organisms is to determine the potential for key higher species to be exposed to oiled mussel beds This will be accomplished by reviewing existing data from NRDA studies (including GIS layers), and the scientific literature The first goal of this review is to document the species that utilize mussel beds and identify known foraging ranges for key species in the Exxon Valdez oil spill area. These ranges can then be compared to known or suspected locations of oiled mussel beds to identify the potential for exposure. Additional evidence will be sought from other ongoing restoration science studies (e.g , harlequin duck: R71) that indicate use of oiled mussel beds by key species

An ad hoc review of existing information has already been accomplished in 1991 This review has suggested the species of concern are black oystercatchers, harlequin ducks, and river and sea otters. The review of existing information called for in this study will not duplicate the ad hoc effort but will complete and document the review to make sure that all relevant information has been identified and analyzed.

The second part of this review is to gather information regarding the impact of the oil spill on mussel mortality, and mussel density in oiled and unoiled locations The results of the Coastal Habitat Study will be among the sources reviewed for this information

Objective 7: Document exposure to and ingestion of contaminated mussels by direct observation of foraging activities and by analysis of blood and feces.

The review of existing data (Objective 6) will provide information regarding potential field sites for the foraging study Optimal field sites would contain oiled and unoiled mussel beds, and the foraging area for harlequin ducks, black oystercatchers and sea otters. However, the relatively small population of harlequin ducks in Western Prince William Sound, and the relatively large foraging areas used by harlequin ducks when they are not reproducing, will make it difficult to locate suitable field sites to conduct foraging studies. Similarly, any attempts to study sea otter foraging will be exceedingly difficult because of the mobility of sea otters (A. Doroff, personal communication).

In contrast, breeding black oystercatchers establish a limited foraging territory in which they can be studied with relative ease Consequently, foraging studies will be limited to black oystercatchers.

<u>Black Oystercatcher Foraging Study</u>

Sampling Methods

The vast majority of breeding black oystercatchers arrive in Prince William Sound in April The presence of breeding pairs will be noted during the May cruise described under Objective 1 of Part 1 of this study. (One of the criteria for selection of oiled sites for field work will include the location of sites relative to known or likely foraging areas of black oystercatchers) From these observations, and in combination with review of existing information, it should be possible to develop a set of black oystercatcher foraging territories that contain oiled mussel beds.

When a nesting pair is discovered, its location will be marked on a map for subsequent visitation. Subsequent visits will be used to determine the extent of the foraging territory. Once the foraging territory is delineated, mussel densities will be determined and samples will be collected for hydrocarbon analysis. Densities of mussels will be determined by randomly placing three 20x30 cm quadrats in each meter of tidal fall in foraging territory, following the Standard Operating Procedures of the Coastal Habitat Study. Density of prey can influence the choice of patches by intertidal predators (Marsh 1986) and may be an important covariable in discerning effects due to oil Similarly, prey diversity may influence the taking of mussels (Morrell et al 1979) Therefore, all individual invertebrates will be counted and placed into 5mm size classes Barnacles, <u>Fucus</u> and filamentous algae cover also will be estimated for each quadrat.

Foraging behavior observations of adult oystercatchers will be conducted on 10 territories each on impacted and non-impacted sites. Observations periods will begin 2 hours before low tide and end 2 hours after low tide Observations will begin when a bird first arrives at the foraging site. Time intervals from the start of the foraging bout and between each successful prey attack will be recorded. When the focal animal discovers a prey item, the species and size of the prey taken will be recorded. These variables will also be recorded for unsuccessful attacks. Size determination of mussels taken by oystercatchers is determinable in the field (Andres 1991, Cayford and Goss-Custard 1990). However, it may be necessary to train observers and calculate observer differences in estimating size if numerous observers are involved Observer differences can be tested using oystercatchers models and a variety of prey sizes Conversion of shell lengths to biomass can be accomplished using length-weight regressions previously calculated for oystercatcher prey items (Andres 1991) Data on condition index in oiled and unoiled sites (from Part 1 of this study) will be examined to determine if separate length-weight regressions are needed for oiled and unoiled sites

A field test will be conducted to determine if birds can discriminate between oiled and unoiled mussels by presenting a platter of mussels (de-shelled, 35mm) to nesting adults Treatment mussels will be taken from an oiled mussel bed, or soaked in weathered crude oil for 15 minutes. These mussels will be presented to adult oystercatchers along with similar-sized unoiled mussels

The proportional use of prey sites in oiled and unoiled sites will be determined In oiled sites, will birds switch sites more frequently or use more sites within their feeding territory? Difference in diet diversity will also be examined among sites Will birds supplement contaminated mussels with other foods? (This can be measured by direct observation and shell collection at nest sites.) Answering these questions will provide important information regarding the extent to which oystercatchers are dependent upon mussel beds for food. This knowledge will help predict the impact on black oystercatchers of restoration strategies that involve disturbing or destroying mussel beds

Analytical Methods

These data can be used to test the differences in the foraging rate (items/time), foraging bout length, total foraging time, biomass intake and success rate between populations foraging on impacted and non-impacted sites. Model-based and sample-based statistical procedures can be used to determine the likelihood of the differences being attributed to oil effects. Sample-based procedures (randomization, boot-strapping) may be particularly appropriate since using these procedures makes no assumption about the birds studied being a random sample If model-based procedures are used, a covariance model incorporating prey density, shoreline type and prey assemblage diversity with impact would probably be required

<u>Analysis of Blood and Feces</u>

It is possible to document exposure of birds to petroleum hydrocarbons by sampling blood and fecal matter. Leighton et al (1983) detected Heinz-body hemolytic anemia 3-6 days after exposure of herring gull and Atlantic puffin nestlings to various crude oils (including Prudhoe Bay crude oil) Analysis of blood chemistry in birds (Hunt, 1987) exposed to crude oil has been conducted

Petroleum hydrocarbons will also be present in fecal matter of birds that ingest crude oil (Fry, in preparation).

Analysis of hydrocarbons in the blood of sea otters in Prince William Sound has also been conducted on animals brought to rehabilitation centers and animals caught in the wild. Heavily-oiled otters in the rehabilitation centers exhibited total hydrocarbon concentrations in the blood of 20-800 ppm (William et al., 1990), whereas the highest concentrations in the blood of wild otters from Western Prince William Sound was only 1 6 ppm (mean=0 3 ppm) (Bellachey et al., 1991) In addition, there were no significant differences in the concentration of petroleum hydrocarbons between otters in oiled and unoiled areas of Prince William Sound. Given that the USFWS will be collecting blood samples in the summer of '92 and will be continuing their analysis of blood samples from previous years, it is unlikely that a small amount of additional blood sampling from otters will be very valuable Consequently, blood and scat analyses will be limited to the two key birds species, harlequin ducks and black oystercatchers

Sampling Methods

Feces: Bird Feces will be sampled according to the method of Fry (personal communication). Birds will be placed in teflon-lined boxes on a wire shelf until they defecate Feces samples will be collected in Whirlpak bags and kept cold until return to the laboratory.

The collection of fecal samples from harlequin ducks for hydrocarbon analysis will be conducted by ADF&G as part of the harlequin duck restoration study. The best subjects for sampling black oystercatchers will be the chicks. They spend their entire life in the vicinity of the nest-site and are totally dependent upon food brought by adults from the local foraging territory A total of 25 samples from each bird species will be collected for analysis

Blood: 10cc of blood will be taken from birds using a syringe The blood will be injected into a container with a cork stopper containing a pre-measured quantity of methylene chloride, and kept cold until return to the laboratory. Blood samples from otters will be collected in a similar fashion A total of 15 blood samples from each species will be collected for analysis

Analytical Methods

Whirlpak bags containing feces samples will be emptied in the laboratory, and rinsed with distilled water Feces samples will be extracted with methylene chloride. UV fluorescence analysis will be conducted to test for the presence of hydrocarbons in the blood and feces samples. For selected samples showing high UV fluorescence, GC/MS analysis will be conducted to identify the specific petroleum hydrocarbons in the sample.

Limitations of Methods

Determining exposure to the hydrocarbons from blood and feces requires sampling relatively soon after ingestion. Fecal samples will only reflect hydrocarbon ingestion for 24-48 hours, and birds exhibiting Heinz-body anemia begin to recover after 7 days Consequently, it is possible that analysis of blood and feces may not produce evidence of exposure if the animals sampled have not recently ingested hydrocarbons This is unfortunate, as small amounts of weathered crude oil (2ml) have been shown to cause reproductive effects in birds (Fry et al , 1986) This year, blood and feces samples will be collected and kept frozen for future analysis at a later date if it is determined to be appropriate.

It may not be possible to determine the precise source of any hydrocarbons detected. GC/MS analysis allows identification of hydrocarbons as Prudhoe Bay crude oil However, metabolism of hydrocarbons may make determinations difficult, particularly if a relatively long time has elapsed between ingestion and sampling

LITERATURE CITED - 103C

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RESTORATION PROJECT 103D

Study Title: Oiled Mussel Beds - River Otter Component

Lead Agency: ADF&G

Cooperating Agencies: NOAA, USFWS

PROJECT JUSTIFICATION - 103D

River otters (Lutra canadensis) in Prince William Sound have been impacted as a result of the Exxon Valdez oil spill (Faro et al 1991 status report on river otters) Mussels (Mytilus spp.) have been recovered from scats of river otters (unpublished data) and mussels reported in the diet of river otters (Solf, 1989). In 1991 the highest oil concentrations found in Prince William Sound animals or sediments were from mussels and substrates underlying oiled mussel beds (Babcock, 1991 status report on oiled mussel beds). River otters are a species with a documented sensitivity to a number of aquatic pollutants (Table 1) so a connection between contaminated mussels and documented sub-lethal impacts is reasonable.

Table 1. Published literature indicating river otters are especially sensitive to pollutants in aquatic systems

PESTICIDES	HEAVY METALS	CESIUM-137	PCB'S
Clark et al. 1981	Clark et al. 1981	Clark et al 1981	Clark et al 1981
Halbrook et al. 1981	O'Connor and Nielson 1981	Halbrook et al. 1981	Halbrook et al 1981
Henney et al. 1981	Sheffy and Amant 1982		Henney et al 1981
	Wren et al 1980		
	Wren 1984, 1985		

River otters utilize land for many of their life functions but feed exclusively from aquatic habitats, placing them directly at risk to remaining Exxon Valdez oil Although some feeding may occur in fresh water, in Prince William Sound (Faro et al 1991 status report on river otters) and Southeast Alaska (Larsen 1983, Woolington 1984), marine populations are dependent on a diet of fish, gastropods, and bivalves. Foraging occurs in shallow water at depths typically occupied by mussel beds The river otter's sensitivity to pollutants and their high position on the food chain are factors that allow them to serve as an indicator species for the presence of hydrocarbon toxicity in the ecosystem Unlike other species that may directly or secondarily acquire hydrocarbons from mussels, river otters have smaller home ranges and remain year round in close proximity to contaminated mussel beds.

This study will use nonlethal methods to obtain data on the health of river otters and their diet. River otters will be live captured during the spring breeding season when they are most vulnerable to capture. Trapping will occur in oiled habitat in close proximity to mussel beds providing data for interpretation with other information from the oiled mussel bed study The home range of captured river otters should include one or more contaminated mussel bed. For control data, some animals will also be caught in an area with mussel beds present but not exposed to oil. Captured animals will be briefly immobilized, measured and a blood sample drawn. Procedures used will be approved by the Animal Care and Use committee under the authority of the University of Alaska Fairbanks. River otters will be released in the vicinity of their capture site when recovered from the immobilizing agent These techniques were employed in 1991 with no known loss of animals

Blood samples will be analyzed from components that reflect physiological stress in individual animals These data will be compared to control data as well as to data obtained in 1990 and 1991. Weights and measurements will be compared between "control" and "oiled" data and between years

River otter scats will be collected in the two intensive study areas (Esther Passage control area and Herring Bay/Lewis Bay oiled area) established for the impact assessment study These samples will be examined to identify the "species" that are present Data analysis will compare the 1992 diet in the two study areas and test for differences or similarities to dietary information from 1989 and 1990 on oiled and unoiled areas.

When gathering scat materials from the intensive study areas, information on the current use of latrine sites by otters will be recorded. Site use data for 1991 and 1992 in the 2 areas will be compared.

OBJECTIVES - R103D

8 - To test for (α = 0 05) sub-lethal effects of hydrocarbon toxicity on river otters by examining blood components.

9 - To determine if the body mass of adult river otters is significantly different (α = 0.05) in oiled and unoiled habitats and has changed through time

10 - To test (α = 0.05) for differences in food habits of river otters before and after the oil spill on the oiled study area.

11 - To test (α = 0.05) for differences in food habits of river otters on oiled and control study areas

12 - To determine if latrine sites use by river otters are similar between oiled and non-oiled study areas

METHODS - 103D

Methods developed during the three years of the impact assessment study will be employed in 1992 Trapping areas will be keyed to the presence of oiled mussel beds under study by the oiled mussel bed study. The intensive oiled study area will have mussel beds also under study. Results of the mussel bed study will be incorporated into evaluation of river otter data.

Obj. 8, 9 - River otters will be captured in the vicinity of oiled mussel beds also under study. Proposed trapping areas with oiled habitat are Knight, Eleanor, and Naked Islands Control animals will be captured at Unakwik Inlet River otters will be live captured at latrine sites located close to the shore line Modified Hancock live traps and drugging boxes to hold river otters, as described by Melquist and Hornocker (1979) will be used Weather permitting, traps will be checked at least mornings and evenings Traps will be monitored with trap transmitters that signal when the trap has sprung River otters will be held only so long as necessary to obtain body measurements, draw blood, and recover from the immobilizing agent Animals will then be released at their original capture site

Standard procedures will be used to collect and process blood in the field. An Animal Care and Use document under the independent authority of the University of Alaska Fairbanks will be in effect

Obj. 10, 11 - River otter scats will be collected from permanently marked latrine sites (113 sites in unoiled and 131 sites in oiled) located in the intensive study areas Sites will initially cleared of scats in June and then revisited and cleaned two or three times during the summer Collection procedures will be those established for the oil impact assessment study. All scats from a site will be placed in a single plastic bag and labeled with the date, location, and number of scats collected Samples will then be frozen until they prepared for analysis.

Scats (or subsamples from latrine sites) will be placed in nylon stockings, placed in a modified clothes washer, and washed. Samples will be air dried and then sealed in plastic bags prior to analysis.

Each sample will be examined under a dissecting scope and food items identified to the lowest possible taxonomic order. Random subsamples also will be examined to assure that important species are not overlooked Food items will be from reference materials developed for the impact study Additionally, keys to otolith (Morrow 1979), scales (Lagler 1974), mammal hair (Adorjan and Kolenoskey 1969, Day 1966) and bird remains and feathers (Chandler 1916) will be used Identical analysis procedures will be used for oiled and control samples.

Obj. 12 - All permanently marked latrine sites in the two intense study areas will be visited in late summer and recent use by river otters recorded. A site will be considered abandoned if 1) No recent river otter scats are found and 2) growth of herbaceous vegetation or branch gall from the overstory that would be easily removed by river otter use were prevalent on trails and main site areas The sites will be evaluated by the same personnel who evaluated river otter use in 1991 Additional observation on site use will be made concurrent to the 1992 capture program

DATA ANALYSIS - 103D

Obj. 8, 9 - Values for river otters exposed to oil will be compared to those of nonexposed river otters and to values obtained in 1990 and 1991 by the river otter impact assessment study Differences in haptoglobin levels will be tested with multi-response permutation procedures using "Blossom" statistical software (Biondini et al. 1988, Zimmerman et al. 1985). Differences in river otter length and body mass between seasons will be examined with a Kruskal-Wallis test (Zar 1984). Regression lines of length-mass relationship will be compared according to Neter, et al. (1985)

Statistical analysis of blood values and morphometrics of river otters will include a multivariate t-test (Hotelling's T2) to examine difference ($\alpha = 0.05$) in animals between oiled and unoiled areas. Bonferroni tests for *a posteriori* comparisons of individual variables will follow.

Obj. 10, 11 - Because of differential digestibility of prey and variable rates of passage through the gut, volumetric measures of prey remains in river otter feces are meaningless. Consequently, analysis will be confined to the occurrence of prey "species" in latrines samples. A "species" is defined as the lowest taxonomic order that an item can be assigned Data will be compared between oiled versus control area, and through time - 1989, 1990, and 1992. Results will be expressed in terms of percent and latrines with food items, and percent of total food items (Bowyer et al. 1983)

Obj. 12 - Latrine site abandonment will be tested (α = 0 05) with a log-likelihood (G-test)

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BUDGET ($K)

		R103A NOAA	R103B NPS	R103C USFWS	R103D ADF&G	R103 TOTAL
Salaries	$	109.0	13.7	36 6	75 0	234.3
Travel		29 8	4 0	6 5	6.0	46 3
Contracts		329 6	27 5	0 0	74.0	431.1
Supplies		15 2	2 2	45 0	4.4	66 8
Equipment		2 3	0 0	28 0	0.0	30.3
Other		3.2	0.5	0.0	0 0	3 7
Subtotal	$	489.1	47.9	116 1	159 4	812 5
General Admin.		35 5	4 0	5 5	16.5	61 5
Total	$	524 6	51 9	121 6	175 9	874 0

RESTORATION PROJECT NUMBER 104A

Study Title: Archaeological Resource Protection Site Stewardship

Lead Agency: USFWS

Cooperating Agencies: ADNR, USFS

INTRODUCTION

The purpose of this project is to create an archaeological site stewardship program. The Exxon Valdez oil spill and associated clean-up have resulted in an increased public knowledge of archaeological resources in the oil spill area The greater visibility of site locations brought on by oil spill activities has resulted in higher rates of looting and vandalism of these resources (Archaeology Resources Damage Assessment Study Number 1). Local site stewardship will be a powerful tool in deterring such a trend.

Site stewardship is the recruitment, training, coordination, and maintenance of a corps of local interested citizens to watch over threatened archaeological sites located within their home districts. Local citizens' groups and Native Corporations will be brought into the project as cooperators to facilitate communications and operations Successful models for such programs already exist.

This project is technically feasible The Arizona State Historic Preservation Office has conducted a very successful site stewardship program for years. The Kodiak Area Native Association has already demonstrated its feasibility in coastal Alaska.

Long-term site observation by local residents is a desirable method of assisting in the protection of threatened archaeological resources. Change over time is a far stronger indicator of impact than can be obtained through one-time or even occasional observation. Lost information from injured sites is essentially irretrievable. This project will enable us to reduce the magnitude of the ongoing impacts and helps restore site integrity and protection.

OBJECTIVES

The objectives are to reduce or eliminate archaeological site looting and vandalism through the following measures

1. Develop an information program for the general public concerning both the site stewardship program and the importance and sensitivity of archaeological resources.

2. Recruit, educate, and involve local people to protect the archaeological resources in their areas.

METHODS

Data collection under this project will consist of assembling narrative reports from site stewards Information from these reports will include dates and times of observation of sites, physical descriptions of the condition of the sites; photographs, and specifics of any apparent impacts, including the presence of persons involved in site looting Photographic equipment will be given to site stewards to assist in the documentation Site stewards will be provided with existing documentation of known sites in their areas and will also be asked to provide information about any other sites known to them, or subsequently discovered by them, for addition to the data base

Routine reports will be routed to the project coordinator for compilation and all data will be maintained in the files of the project coordinator and be available to all participating agencies The project coordinator will be responsible for passing this information to landowners or managing agencies Any observations of current vandalism will also be provided immediately to agency resource protection personnel.

Current situation reports will be provided to involved agencies on a regular basis throughout the year, this will include notification of law enforcement bodies where appropriate.

The training program will be developed by education personnel and archaeological staff at the U S Fish and Wildlife Service Individual agency archaeological staff will also assist the project coordinator in recruitment, training, and quality control of volunteer stewards

Local site stewards' activities will be primarily confined to those areas in which they find themselves in the course of their normal activities. Mechanisms will be developed to provide transportation assistance (e.g , providing additional boat gas). Other assistance or nominal compensation may be considered to improve effectiveness Logistical arrangements for the project coordinator and other agency staff will be arranged through the agencies or on commercial carriers Logistical arrangements for site stewards attending training sessions will be coordinated by the project coordinator Wherever possible, local arrangements will be facilitated by Native and/or local government groups in conjunction with this project

The project coordinator will also oversee quality control of volunteer stewards' work. Quality control will be accomplished by conducting joint field visits with local site stewards, archaeological and/or resource protection staff, and a representative of the project coordinator.

DATA ANALYSIS

The data analysis requirements of this project component are quite modest and will involve simple statistical analyses. The project coordinator will compile information from the various agency sources, including tabulation of results.

DELIVERABLES

In 1992, deliverables will include the complete training program and public information program described under methods, including preparation of information packages for site stewards. Recruitment of site stewards will be completed as of March 1, 1993.

The project coordinator will prepare a final report

SCHEDULES AND PLANNING

1. (1992) Develop and complete a training program for local site stewards, including development of a comprehensive information package.

2. (1992) Develop an information program for the general public concerning both the site stewardship program and the importance and sensitivity of archaeological resources; conduct a series of local meetings to inform the public about the site stewardship process and to solicit public input into the design of the program.

3. (1992) Recruit a corps of local site stewards in coastal communities.

4. (February 1993) Complete final report

PERSONNEL QUALIFICATIONS

Archaeologist GS-12
Charles Diters - M.A. Anthropology Brown University, specialist in Alaska archaeology, has functioned as Regional Archaeologist with USFWS for the last ten years.

Archaeologist Range 18L
Charles Holmes - Ph.D. Anthropology, Washington State University, specialist in the archaeology of southcentral Alaska, Special Projects Archaeologist in ADNR Office of History for the last

fifteen years acting as principal investigator for National Science Foundation grants and archaeological contracts

Education Specialist GS-11, to be determined

Archaeologist GS-9
Debra Corbett - MA University of Alaska, Fairbanks, specialist in Alaskan archaeology, particularly southwest Alaska and the Aleutians. (And/or substitute to be determined)

BUDGET ($K)

		USFWS	USFS	ADNR	TOTAL
Salaries	$	30.1	2.4	47.2	79.7
Travel		8.2	2.0	5.2	15.4
Contracts		40.5	0.0	0.0	40.5
Supplies		4.9	0.0	0.0	4.9
Equipment		5.7	0.0	0.0	5.7
Subtotal	$	89.4	4.4	52.4	146.2
General Administration		5.4	0.5	7.1	13.0
Total	$	94.8	4.9	59.5	159.2

RESTORATION PROJECT NUMBER 106

Study Title: Technical Support Study for the Restoration of Dolly Varden/Cutthroat Trout

Lead Agency: ADF&G

PROJECT JUSTIFICATION

This closeout budget represents the cost for preparation of a final report for the data collected in this project through 1991

	BUDGET ($K)
Salaries	$27 6
Travel	0.0
Contractual	2.0
Supplies	1.0
Equipment	0 0
Subtotal	$30.6
General Administration	4 3
Total	$34.9

3. BUDGET

SUMMARY BUDGET TABLES

III 1992 *EXXON VALDEZ* ANNUAL WORK PLAN BUDGETS

PROJECT		PROPOSED 3 MONTH COST[1 2]	PROPOSED 12 MONTH COST[1 2]
A Damage Assessment Closeout			
AW1	Surface Oil Maps	10 4	17 0
ARC1	Archaeological Survey	100 8	248 8
B2	Boat Surveys	13 9	48 5
B3	Murres	42 5	75 7
B4	Eagles	32 6	60 6
B6	Marbled Murrelets	16 2	24 8
B7	Storm Petrels	7 5	7 5
B8	Kittiwakes	7 5	7 5
B9	Pigeon Guillemots	18 0	18 0
B11	Harlequin Ducks	22 9	22 9
B12	Shorebirds	13 2	20 7
CH1A	Coastal Habitat	828 5[3]	2,358 5[4]
CH1B	Hydrocarbons in Mussels	14 2	51 4
FS1	Spawning Area Injury	48 3	64 3
FS2	Pre-emergent Fry	22 7	29 3
FS3	Coded-Wire Tags	45 6	126 7
FS4A	Early Marine Salmon	56 0	145 2
FS4B	Juvenile Pinks	24 9	119 4
FS5	Dolly Varden	21 2	22 2
FS11	Herring Injury	144 7	303 6
FS13	Clams	30 1	40 8[5]
FS28	Run Reconstruction	60 1	250 6
MM1	Humpback Whales	0 0	17 3
MM2	Killer Whales	1 7	33 3

[1] Cost in thousands of dollars
[2] Starting March 1, 1992
[3] Number is approximate
[4] A placeholder of $3,021,500 was initially approved pending completion of project review A proposed project cost of $2,358,500 was developed upon completion of project review
[5] For analysis of 1989 & 1990 growth data Approval for additional work at an additional cost of $65,500 may be requested depending on the results of growth analysis

PROJECT		PROPOSED 3 MONTH COST	PROPOSED 12 MONTH COST
MM6	Sea Otters	92 0	199 7
TM3	River Otter & Mink	67 8	74 0
ST1A	Subtidal Sediments	32 6	103 5
ST1B	Subtidal Microbial	12 8	17 1
ST2A	Shallow Benthic	37 4	109 8
ST2B	Deep Water Benthos	11 8	10 7[6]
ST3A	Caged Mussels	10 9	39 1
ST3B	Sediment Traps	40 4	50 9
ST4	Fate and Toxicity	8 6	52 6
ST6	Rockfish	0 0	16 6
ST7	Demersal Fishes	16 8	60 4
	SUBTOTAL	1,914 6	4,849 0
B	**Damage Assessment Continuation**		
FS27	Sockeye Overescapement	154 8	583 0
FS30	Database Management	47 5	202 5
ST5	Shrimp	13 3	22 7[7]
ST8	Sediment Data Synthesis	39 1	205 6
TS1	Hydrocarbon Analysis	388 8	1,028 3
TS3	GIS Mapping & Analysis	102 9	375 2[8]
	SUBTOTAL	746 4	2,417 3
C	**Restoration Technical Support**		
R92	GIS Mapping & Analysis	29 4	125 5[8]
	SUBTOTAL	29 4	125 5
D	**Restoration Recovery Monitoring**		
R11	Murres	192 6	316 7

[6] PI needs to resolve technical issues raised by peer reviewers Approval for project completion, at an additional cost of $76,900, may be requested pending resolution of issues

[7] Amount for final report Approval for additional field work, at an additional cost of $67,900, may be requested depending on final report results

[8] Placeholder Final number to be developed following program approval by the Trustee Council

PROJECT		PROPOSED 3 MONTH COST	PROPOSED 12 MONTH COST
R60C	Pink Salmon Egg/Fry	187 1	389 9
R90	Dolly Varden	91 5	91 5
R102	Coastal Habitat	165 0[3]	485 6[9]
	SUBTOTAL	636 2	1,283 7
E	**Restoration Implementation Planning**		
R105	Instream Survey	74 6	348 1
	SUBTOTAL	74 6	348 1
F	**Restoration Manipulation/Enhancement**		
R113	Red Lake Restoration	0 0	55 9
	SUBTOTAL	0 0	55 9
G	**Restoration Habitat Protection Planning**		
R15	Marbled Murrelets	185 0	419 3
R47	Stream Habitat Survey	76 4	399 6
R71	Harlequin Ducks	130 6	424 5
	SUBTOTAL	392 0	1,243 4
H	**Restoration Management Actions**		
R53	Kenai Sockeye	66 2	674 2
R59	Genetic Stock ID	100 7	320 9
R60AB	Pink Salmon	154 1	1,479 7
R73	Harbor Seals	25 0	25 0
R103	Oiled Mussels	270 6	874 0[10]
R104A	Site Stewardship	46 7	159 2
R106	Dolly Restoration	34 9	34 9
	SUBTOTAL	698 2	3,567 9
	TOTAL	4,491 4	13,890 8

[9] A placeholder of $604,100 was initially approved pending completion of project review A proposed project cost of $485,600 was developed upon completion of project review

[10] A placeholder of $825,000 was initially approved pending completion of project review A proposed project cost of $874,000 was developed upon completion of project review

4. ACRONYMS AND ABBREVIATIONS

4. LIST OF ACRONYMS AND ABBREVIATIONS

ABL	Auke Bay Laboratory
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
ANOVA	Analysis of Variance
CTD	Conductivity/Temperature/Depth
CWT	Coded Wire Tag
DBMS	Database Management System
DEC	Department of Environmental Conservation (Alaska)
DNA	Deoxyribonucleic Acid
DNR	Department of Natural Resources (Alaska)
ESI	Environmental Sensitivity Index
FRED	Fisheries Rehabilitation, Enhancement, and Development Division
F/S	Fish/Shellfish
FWS	Fish and Wildlife Service (US)
FY	Fiscal Year
GC-MS	Gas Chromatography - Mass Spectrometry
GIS	Geographic Information System
GPS	Global Positioning System
GSI	Genetic Stock Identification
HC	Hydrocarbon
HSRG	Habitat Spill Response Group
MDL	Method Detection Limits
MFO	Mixed-function Oxidase
MM	Marine Mammal
mtDNA	Mitochondrial DNA
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRDA	Natural Resources Damage Assessment
OSIAR	Oil Spill Impact Assessment and Recovery Office
PCA	Principal Components Analysis
PHC	Petroleum Hydrocarbon(s)
PI	Principal Investigator
PL	Project Leader
QA/QC	Quality Assurance/Quality Control
RNA	Ribonucleic Acid
RT	Restoration Team
SOP	Standard Operating Procedure
ST	Subtidal
TS	Technical Services
UAF	University of Alaska Fairbanks
UCI	Upper Cook Inlet
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UV	Ultraviolet
WAN	Wide Area Network