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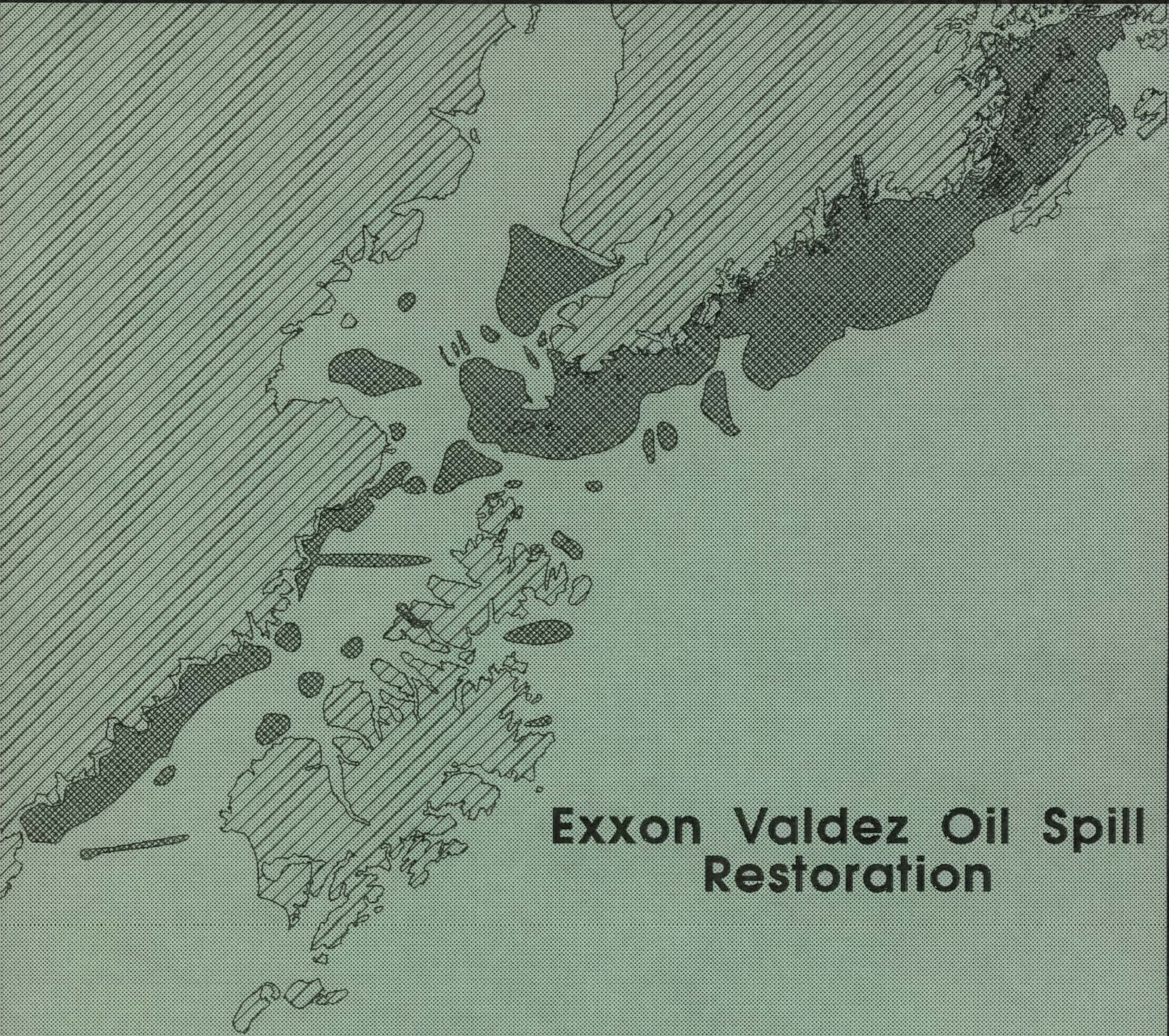

Exxon Valdez Oil Spill Restoration

Volume I
Restoration Framework

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 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 comment 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
Director
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

COMMENTS

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

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: <u>Restoration Framework</u>

Restoration Framework
Table of Contents

EXECUTIVE SUMMARY

In *Exxon Valdez* Oil Spill Restoration, Volume I: Restoration Framework, the Trustees propose a process and structure to guide the restoration of the resources and services injured by the *Exxon Valdez* oil spill. The Restoration Framework also is intended to serve as a "scoping" document as required by the National Environmental Policy Act.

On October 8, 1991 a settlement agreement was approved in United States District Court that required Exxon to pay one billion dollars in criminal restitution and civil damages to the governments. This settlement provides an extraordinary opportunity to address the restoration of injuries resulting from the largest tanker oil spill in United States history.

Post Settlement Administration (Chapter I)

The State and Federal Trustees will receive up to $900 million dollars from Exxon in settlement of the civil claims over the next 10 years. These funds are deposited in the Court Registry Investment Account. Subject to court approval, the Trustees will draw from that fund for restoration.

All decisions about restoration and uses of restoration funds must have the unanimous agreement of six Trustees, three Federal and three State. The Federal Trustees have appointed representatives to an Alaska-based Trustee Council. The State Trustees, unlike their Federal counterparts, serve on the Trustee Council. The Trustee Council has appointed a Restoration Team to administer and manage the restoration process. An Administrative Director will be hired to chair the Restoration Team. The Trustee Council has approved creation of a number of working groups to address specific needs, such as budget, public participation, and habitat evaluation and protection.

Public Participation (Chapter II)

The settlement terms specify that the Trustees shall establish procedures providing for meaningful public participation in the injury assessment and restoration process, which shall include establishment of a public advisory group to advise the Trustees.

The Trustees held a series of public meetings to solicit comments on the role, responsibility and membership of the public advisory group and have approved that group's charter. Public comments are being sought on the Restoration Framework and the draft 1992 Work Plan.

Restoration Planning Before the Settlement (Chapter III)

The Trustees and the Environmental Protection Agency began preliminary restoration planning through the work of the Restoration Planning Work Group from late 1989 until December 1991. This group carried out several scoping activities, including a series of public meetings and consultations with technical experts. The restoration group also developed draft criteria for evaluating restoration options, and began analyzing many restoration options suggested by the public, resource managers and scientists.

Summary of Injury (Chapter IV)

Immediately after the *Exxon Valdez* oil spill, the Trustees began a series of studies--the Natural Resource Damage Assessment--to determine the effects of the oil spill on the environment, both its resources and services (e.g., marine and terrestrial mammals, birds, fish and shellfish, archaeological resources, and subsistence). They provide an assessment of a wide range of injuries, some immediate and acute, some subtle and persistent. Major results of the studies to date are discussed.

Proposed Criteria for Injuries (Chapter V) and Restoration Options (Chapter VI)

The settlement specifies that restoration funds must be spent to restore natural resources and services injured by the *Exxon Valdez* oil spill. The Trustees propose that evidence of consequential injury and the adequacy and rate of natural recovery must be considered in deciding whether it is appropriate to spend restoration dollars on a given resource or service. Once it has been established that a resource or service warrants restoration action, there may be a number of effective restoration options. The Trustees propose criteria to help evaluate such options, including technical feasibility, cost effectiveness, and the potential for additional injury resulting from the proposed restoration option.

Restoration Alternatives and Options (Chapter VII)

The restoration planning process to date has yielded a variety of ideas, which are presented for comment as restoration options in Appendix B. These restoration options, and others identified by the public, will be considered by the Trustee Council in a draft restoration plan.

For purposes of this scoping document, six possible alternative sets of options have been identified. These are:

- no-action;
- management of human uses;
- manipulation of resources;

- habitat protection and acquisition;
- acquisition of equivalent resources; and
- combination.

An analysis of a proposed action and various alternatives will be presented for public comment in a draft restoration plan and draft environmental impact statement.

Appendices A and B

Two appendices are attached: life histories and backgrounds on injured resources and services, and a series of potential restoration options.

CHAPTER I
INTRODUCTION

The intent of Exxon Valdez Oil Spill Restoration, Volume I: Restoration Framework (hereafter referred to as the Restoration Framework) is to propose a process to guide the Trustees and the public in the restoration of the environment injured by the *Exxon Valdez* oil spill. This document contains information on *Exxon Valdez* oil spill restoration activities to date, background information on the legal settlement that provides funding for restoration, and a description of the Trustees' structure for administration of the restoration program. Information is also provided on the injuries to natural resources and services, proposed criteria for determining when injury is sufficient to warrant restoration actions, proposed criteria and procedures for evaluating specific restoration options, and an initial description of possible restoration alternatives. Life history and background on injured natural resources and services are presented in Appendix A. Potential restoration options are presented in Appendix B.

The Restoration Framework also serves the Trustees as a "scoping" document pursuant to the National Environmental Policy Act 42 U.S.C. 4321-4370c. As such, the document presents and discusses the proposed action and the main issues known at this time. The document also invites public comment on these issues and any additional issues related to the proposed action. The Trustees will, as part of a planned draft restoration plan, issue a draft environmental impact statement to ensure that environmental effects are considered as part of restoration planning.

Proposed Action

The Trustees propose to restore natural resources and natural resource services in the areas affected by the *Exxon Valdez* oil spill to their pre-spill condition. This may include the restoration of natural resources injured, lost or destroyed and the services provided by these resources or which replace or substitute for the injured, lost or destroyed resources and affected services. The Trustees will develop a restoration plan considering restoration options described in Appendix B and others identified subsequently. The Restoration Plan will establish management direction in a programmatic manner and guide all activities to restore injured natural resources and services. Specific restoration activities will be developed annually and may be implemented if consistent with the Restoration Plan.

Identification of Issues

The Trustees are addressing a number of issues as they develop the oil spill restoration program. Among the issues identified in the Restoration Framework are the following:

- establishing an administrative structure that enables the maximum amount of settlement funds to be spent on effective restoration (Chapter I);

- providing meaningful public involvement and establishing a public advisory group (Chapter II);

- determining when injuries are sufficient to warrant restoration actions (chapters IV and V);

- evaluating potential restoration options, including the use of objective criteria (Chapter VI); and

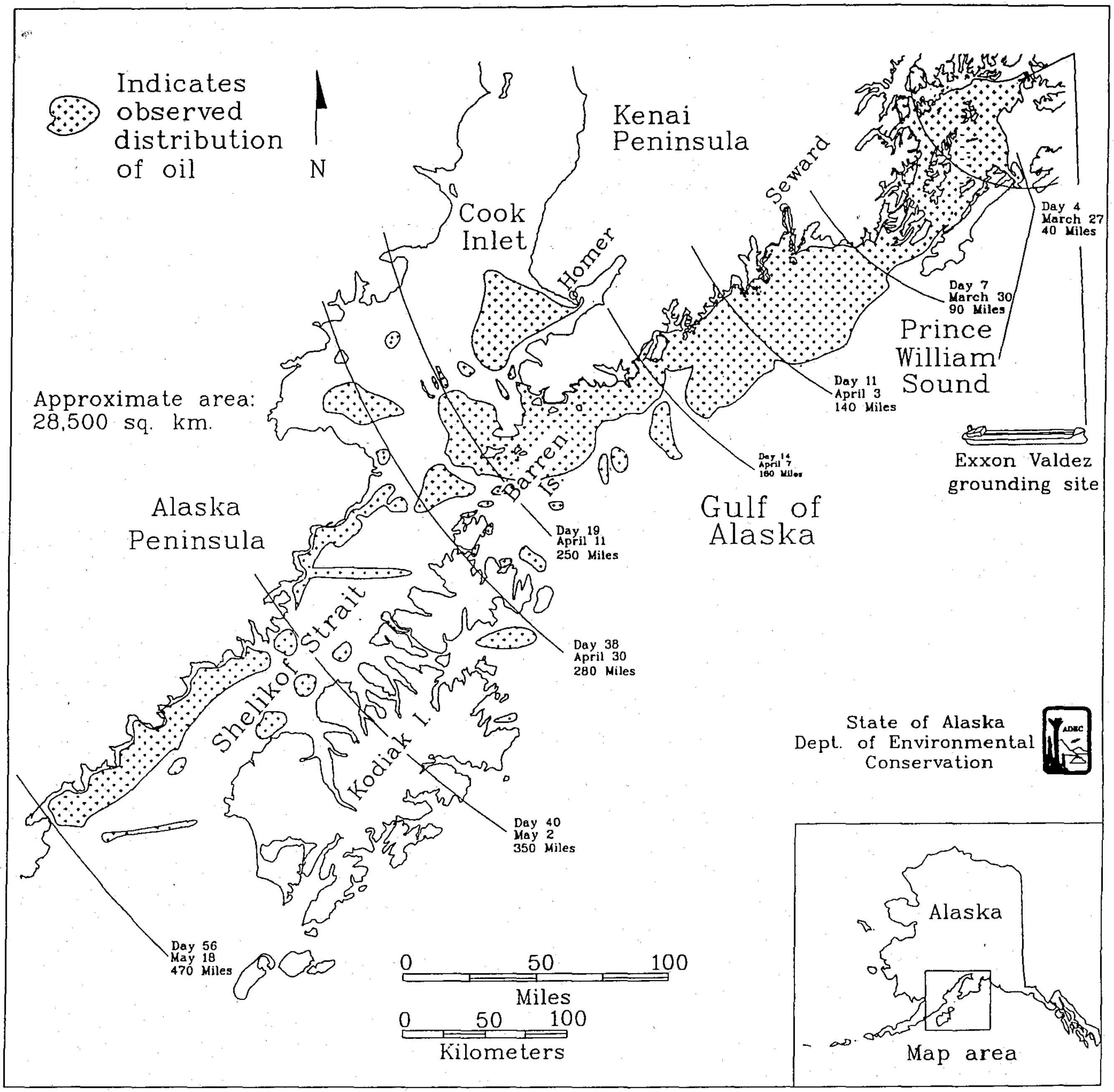
- developing a reasonable range of alternatives for restoration options and establishing priorities for use of settlement funds (Chapter VII, Appendix B).

Background

Shortly after midnight on March 24, 1989 the T/V *Exxon Valdez* ran aground on Bligh Reef in Prince William Sound spilling approximately 11 million gallons of North Slope crude oil, making this the largest tanker oil spill in United States history. For the first three days after the spill the weather was calm and the slick lengthened and widened, but stayed in the waters of the Sound and did not go ashore. Even with these favorable conditions for oil recovery, the amount of oil in the water completely overwhelmed the manpower and equipment available to contain and recover the oil. A major windstorm on March 26-27, 1989 pushed the oil in a southwesterly direction and oiled beaches on Smith, Naked and Knight islands. The oil continued to spread, contaminating islands, beaches and bays in Prince William Sound. Six days into the spill, oil entered the Gulf of Alaska. The leading edge of the slick reached the Chiswell Islands off the coast of the Kenai Peninsula on April 2, and the Barren Islands in the Gulf of Alaska on April 11, 19 days after the spill. By May 18, oil had moved some 470 miles and had contaminated shorelines of Prince William Sound, the Kenai Peninsula, lower Cook Inlet, the Kodiak Archipelago, and the Alaska Peninsula. Portions of 1,200 miles of coastline were oiled, including segments of the Chugach National Forest, Alaska Maritime, Kodiak and Alaska Peninsula/Becharof national wildlife refuges, Kenai Fjords National Park, Katmai National Park and Preserve, and Aniakchak National Monument and Preserve. Oil reached shorelines, nearly 600 miles from Bligh Reef (Figure 1).

The magnitude of the efforts of the State and Federal governments, the public and Exxon to contain and clean up the oil, rescue oiled birds and sea otters, and study the effects of the spill was unprecedented. During 1989, efforts focused on containing and cleaning up the spill and rescuing oiled wildlife. Skimmer

Figure 1. Composite overview of oil-spill tracking from March 24, 1989 to June 20, 1989. All degrees of oiling are represented.



ships were sent throughout the spill zone to remove oil from the water. Booms were positioned to keep oil from reaching important commercial salmon hatcheries in Prince William Sound and Kodiak. A fleet of fishing vessels known as the "Mosquito Fleet" played an important role in protecting these hatcheries, in corralling oil to assist the skimmer ships, and in capturing and transporting oiled wildlife to rehabilitation centers. Exxon began a beach cleanup under the direction of the U.S. Coast Guard with input from Federal and State agencies and local communities on the areas that should receive priority for clean up. Several thousand workers cleaned shorelines, using techniques ranging from cleaning rocks by hand to high pressure hot-water washing. Fertilizers were applied to some oiled shorelines to increase the activity of oil-metabolizing bacteria in a procedure known as bioremediation. When the anticipation of deteriorating weather brought an end to clean-up work in the fall of 1989, a large amount of oil remained on the shorelines. Although winter storms proved extremely effective in cleaning many beaches, spring shoreline surveys indicated that much work remained to be done in 1990. Crews operating from boats and helicopters cleaned oiled shorelines in Prince William Sound, along the Kenai and Alaska peninsulas, and on the Kodiak Archipelago. Manual pick up of remaining oil was the principal method used during 1990, but bioremediation and relocation of oiled berms to the active surf zone were also used in some areas. A shoreline survey and limited clean-up work took place during 1991, and another shoreline survey will be conducted in 1992 to determine if further cleanup is needed.

During the first summer after the spill, the State and Federal Trustee agencies planned and mobilized the Natural Resource Damage Assessment (hereafter referred to as damage assessment) field studies to determine the nature and extent of the injuries that were being sustained in the oil-spill area. Even with the rapid deployment of studies, some opportunities to gather injury data were irretrievably lost during the early weeks of the spill due to the complexity and volume of the work at hand and the scarcity of available resources. Shortly after the spill, a legal framework was established and expert peer reviewers were retained to provide independent scientific review of on-going and planned studies and assist with synthesis of results. Most damage assessment field studies were completed during 1991, although some laboratory data analyses are still underway. In the latter part of 1989, the Trustee agencies, with the assistance of the Environmental Protection Agency, initiated restoration planning activities to identify restoration alternatives and procedures and to implement restoration technical and feasibility studies and projects during 1990 and 1991.

Summary of the Settlement

On October 8, 1991 an agreement was approved by the United States District Court that settled the claims of the United States and the State of Alaska against Exxon Corporation and Exxon Shipping Company for various criminal violations and for recovery of civil damages resulting from the oil spill.

Exxon and Exxon Shipping entered guilty pleas to criminal charges filed in the

United States District Court. The companies admitted violating provisions of the Federal Water Pollution Control Act (Clean Water Act), the Migratory Bird Treaty Act and the Rivers and Harbors Act (Refuse Act). The sentences entered by United States District Judge H. Russel Holland included the largest fine ever imposed for an environmental crime--$150 million.

Exxon Corporation and its subsidiary companies also entered into a civil settlement agreement with the United States and the State of Alaska. The governments had filed lawsuits against the Exxon companies, seeking to recover damages for injuries to natural resources and the restoration and replacement of natural resources. The Exxon companies agreed to pay up to $900 million to the State and Federal governments. This was the largest sum ever recovered in the United States in an environmental enforcement civil action.

Thousands of private individuals and other litigants are still pursuing claims in Federal and State courts against the Exxon companies and others, seeking to collect billions of dollars in damages. The litigation in the Alaska Superior Court has been tentatively set for trial during April 1993. No trial date has been set for the litigation in the United States District Court.

Criminal Plea Agreement

Exxon and Exxon Shipping were fined $150 million. Of this amount, the sum of $125 million was remitted (i.e., forgiven) due to their cooperation with the governments during the cleanup, timely payment of many private claims, and environmental precautions taken since the spill. The remaining $25 million was paid as follows:

- $12 million deposited into the North American Wetlands Conservation Fund; and

- $13 million deposited into the Victims of Crime Act Account

The Exxon companies also agreed to pay $100 million as restitution. Fifty million dollars was paid to the United States and $50 million to the State of Alaska. The State and Federal governments will separately manage the $50 million payment that each has received. These criminal restitution funds must, by order of the United States District Court, be used "exclusively for restoration projects, within the State of Alaska, relating to the *Exxon Valdez* oil spill." The court order states that "restoration includes: restoration, replacement, and enhancement of affected resources, acquisition of equivalent resources and services; and long-term environmental monitoring and research programs directed to the prevention, containment, cleanup and amelioration of oil spills."

The Civil Settlement and Restoration Fund

The terms of the civil settlement can be found in the Agreement and Consent Decree. This document details the agreement among the United States, the State of Alaska, Exxon Corporation, Exxon Shipping Company, Exxon Pipeline Company, and the T/V *Exxon Valdez* that settled the civil claims asserted by the governments. The document was approved in civil actions A91-082 (United States v. Exxon Corp.) and A91-083 (State of Alaska v. Exxon Corp.) by United States District Judge H. Russel Holland on October 8, 1991. The period for consideration of appeals ended on December 9, 1991.

The Exxon companies agreed to pay the United States and the State of Alaska up to $900 million over a period of 10 years, according to the following schedule:

SCHEDULED DATE	AMOUNT
December 1991	$90 Million
December 1992	$150 Million[1]
September 1993	$100 Million
September 1994	$70 Million
September 1995	$70 Million
September 1996	$70 Million
September 1997	$70 Million
September 1998	$70 Million
September 1999	$70 Million
September 2000	$70 Million
September 2001	$70 Million

These monies, less certain allowable reimbursements, will be deposited in the registry account of the United States District Court for the District of Alaska and then transferred to the Federal Court Registry Investment System in Houston. As funds are needed for restoration, the Trustees will apply to the Court for disbursement of these funds. The money deposited in the Houston account will be invested and accrue interest for the restoration fund.

The settlement with Exxon also has a reopener provision, that allows the governments to claim up to an additional $100 million between September 1, 2002 and September 1, 2006 to restore one or more populations, habitats or species that suffered a substantial loss or decline as a result of the spill.

[1]Exxon's cleanup costs for the 1991 and 1992 field season may be deducted from this payment.

Restoration projects funded with this money must have costs that are not grossly disproportionate to the magnitude of the benefits anticipated, and the injury could not reasonably have been known or anticipated from information available at the time of settlement.

The spending guidelines for the civil settlement monies (up to $900 million) are set forth in the Memorandum of Agreement and Consent Decree (hereafter referred to as Memorandum of Agreement), which was filed in the United States District Court for the District of Alaska in civil action A91-081 (United States v. State of Alaska) and approved and entered by United States District Judge H. Russel Holland on August 28, 1991. Through this document the United States and the State of Alaska resolved their claims against each other and agreed to act as co-trustees in the collection and joint use of all natural resource damage recoveries resulting from the *Exxon Valdez* oil spill.

The Memorandum of Agreement provides that the governments shall jointly use such monies for purposes of "restoring, replacing, enhancing, rehabilitating or acquiring the equivalent of natural resources injured as a result of the *Exxon Valdez* oil spill and the reduced or lost services provided by such resources." The Trustees also may use the money to reimburse expenses the governments have incurred due to the oil spill, including costs of litigation, response and damage assessment. The following table summarizes the major points of the Memorandum of Agreement:

MEMORANDUM OF AGREEMENT GUIDELINES

- all decisions shall be made by the unanimous agreement of the six Trustees;

- a joint trust fund will be established;

- within 90 days after the receipt of funds, the Trustees shall agree to an organizational structure for decision making;

- within 90 days after the receipt of funds, the Trustees shall establish procedures for meaningful public participation, which shall include a public advisory group;

- the Trustees "...shall jointly use all natural resource damage recoveries for purposes of restoring, replacing, enhancing, rehabilitating, or acquiring the equivalent of natural resources injured as a result of the Oil Spill and the reduced or lost services provided by such resources..." (except for the reimbursement of certain expenses to the governments); and

- all natural resource damage recoveries will be expended on restoration of natural resources in Alaska unless the Trustees unanimously agree that spending funds outside of the state is necessary for effective restoration.

Organization

The post-settlement organization is largely guided by the Memorandum of Agreement. Under this agreement, the natural resource Trustees are responsible for making all decisions regarding funding, injury assessment and restoration.

The State of Alaska Trustees are:

- Commissioner of the Department of Environmental Conservation;
- Commissioner of the Department of Fish and Game; and
- Alaska Attorney General, Department of Law.

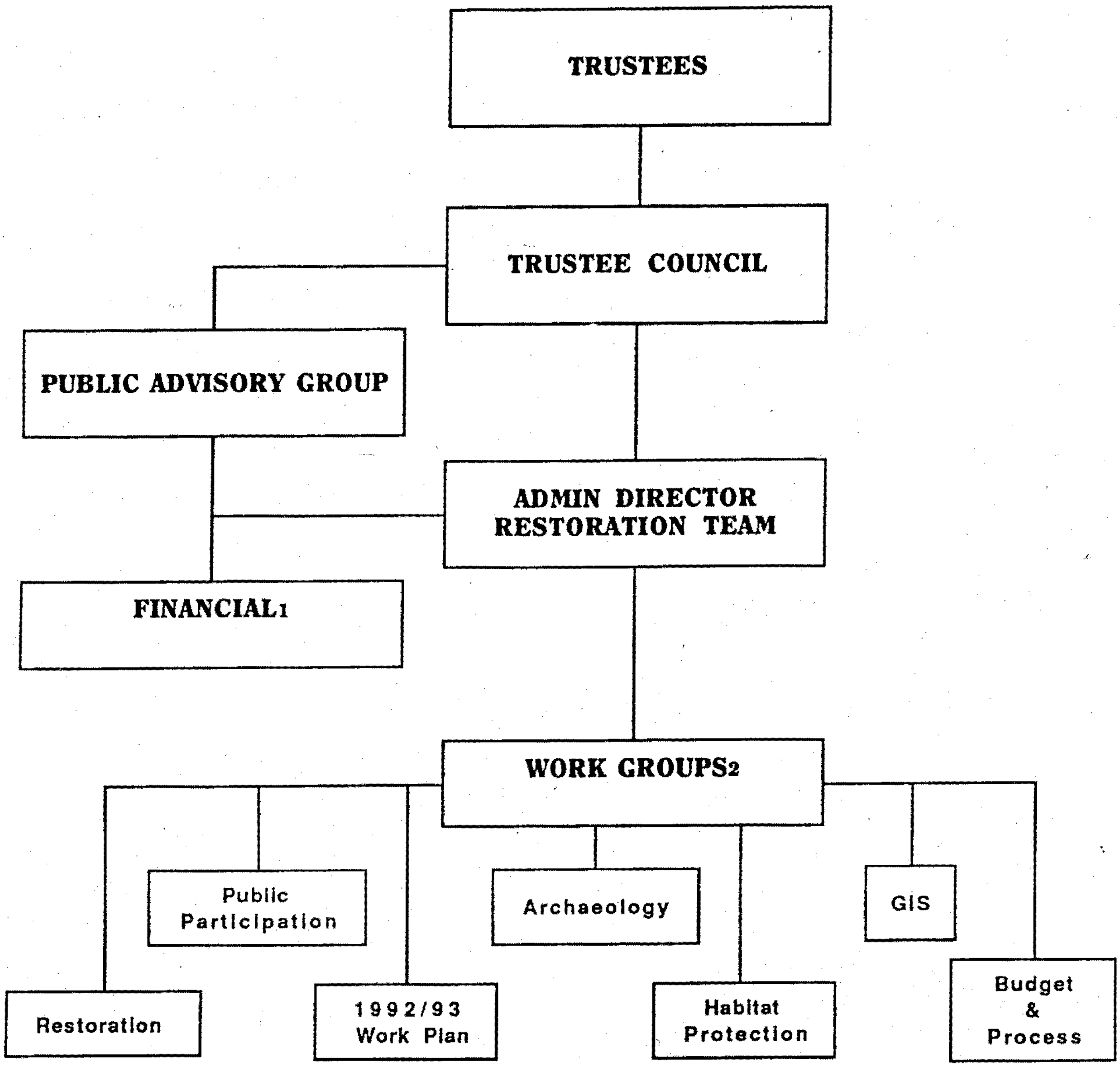
The Federal Trustees are:

- Secretary of the U.S Department of the Interior;
- Secretary of the U.S. Department of Agriculture; and
- Administrator of the National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

The Federal Trustees have appointed representatives to the Alaska-based Trustee Council. These representatives are the Alaska Regional Forester for the Department of Agriculture, the Special Assistant to the Secretary of the Interior, and the Regional Director for the National Marine Fisheries Service, National Oceanic Atmospheric Administration. The State Trustees, unlike their Federal counterparts, serve on the Trustee Council.

The Trustee Council appointed an interim Administrative Director and a Restoration Team to take on the day-to-day management and administrative functions for implementation of the restoration program. Each Trustee has appointed one representative to the Restoration Team. The Attorney General of Alaska appointed a representative from the Department of Natural Resources. The Trustee Council will approve the hiring of a permanent full-time Administrative Director to chair and support the Restoration Team. The Trustee Council has formed various subgroups from agency staff to work on components of the restoration program, such as finance, public participation, and habitat evaluation and protection. The organization chart approved by the Trustee Council on February 5, 1992 is shown below (Figure 2).

Figure 2. Organization chart approved by the Trustee Council on February 5, 1992.



1 Does not include audit function. A proposal for this function will be developed.
2 Groups will be formed and disband as appropriate.

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CHAPTER II
PUBLIC PARTICIPATION

Public Participation Plan

The importance of public participation in the restoration process was recognized during the Exxon settlement and is an integral part of the agreement between the State and Federal governments. The Memorandum of Agreement (MOA) approved by the court on August 28, 1991 specifies that:

> "... the Trustees shall agree to an organizational structure for decision making under this MOA and shall establish procedures providing for meaningful public participation in the injury assessment and restoration process, which shall include establishment of a public advisory group to advise the Trustees...."

This chapter outlines the goals of the public participation program, the type of information available to the public, and provides a brief description of the public advisory group.

Goals and Objectives

The goals and objectives of the public participation program are as follows:

- invite and encourage public review and comment on the development and implementation of restoration programs;
- provide the public with information and resources to evaluate proposals and programs independently;
- involve relevant constituencies;
- disseminate information to the public concerning the restoration process in a timely manner;
- help identify the issues to be addressed in the draft environmental impact statement and the significant issues related to restoration; and
- ensure that the Trustee Council receives and understands the advice and comments from the public.

Information Availability

Although detailed results of the damage assessment studies are still confidential (as of April 1992), there is significant information available about injuries and restoration. Examples of the types of information currently available to the public are:

- the 1989, 1990 and 1991 Natural Resource Damage Assessment and Restoration plans;
- 1991 restoration study plans;
- restoration reports and bibliographies; and
- settlement documents.

These documents, as well as an extensive collection of other information on the *Exxon Valdez* oil spill, are available at:

Oil Spill Public Information Center
645 "G" Street
Anchorage, Alaska 99501
(907) 278-8008
800-478-SPIL (Inside Alaska)
800-273-SPIL (Outside Alaska)
907-276-7178 (Facsimile)

Information on the restoration program is also available through public meetings and mailings. Mailing lists will be maintained and updated on a regular basis. Mailings to the people and organizations on these lists will be used along with community meetings and the public advisory group as major components of the public participation program. In addition, the following information will be made available routinely to the public:

- meeting agendas;
- transcripts of Trustee Council meetings; and
- planning and other documents (e.g., for studies and implementation projects).

Community Meetings

In December 1991 the Trustee Council directed the Restoration Team to conduct public meetings and solicit written comments on a public participation program. This process began in January 1992 with meetings held in Homer, Seward, Valdez, Cordova, Chenega Bay, Kodiak, Juneau, Anchorage and Fairbanks.

Comments received were evaluated for recommendations to the Trustee Council regarding the role, structure and operating procedures for the public advisory group.

A second series of meetings will provide an opportunity for review and comment on the Restoration Framework. These meetings will be scheduled for April and May 1992, and the public will be notified through newspapers and other means.

Additional meetings will be conducted to provide opportunity for comment on the draft Restoration Plan and draft environmental impact statement. Thereafter, it is anticipated that annual work plans will be developed to implement the Restoration Plan. Each year's draft work plan will be the subject of additional public participation and comment.

Public Advisory Group

As noted above, public meetings were conducted to receive input on the public participation program in general, and the public advisory group in particular. Issues included the role, responsibilities and membership of the public advisory group. The Trustees have identified the following interests and constituencies to be represented on the public advisory group: aquaculture, commercial fishing, commercial tourism, environmental, conservation, forest products, local government, Native landowners, recreation users, sport hunting and fishing, subsistence and scientific/academic. Single seats will be reserved for representatives of local government and Native interests. One representative each of the Alaska House of Representatives and Senate may serve as *ex-officio* members.

The members of the advisory group will be nominated by various organizations and the public and be appointed with unanimous consent of the Trustees. The Trustees will formally solicit nominations for membership on the public advisory group. If you are interested in receiving an announcement, please contact the Administrative Director at 645 "G" Street, Anchorage, Alaska, 99501.

Restoration Plan

In this first year following settlement the Trustees will develop a draft restoration plan and draft environmental impact statement. The draft plan will present in detail the options and alternative sets of options that will best achieve the restoration of injured resources and services, based on scientific and agency recommendations, public comments, and the judgment of the Trustees.

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CHAPTER III RESTORATION PLANNING TO DATE

Restoration planning to date has been a process of identifying, evaluating and integrating information about the nature, extent and persistence of injuries to natural resources and services, the rate and adequacy of natural recovery, and the opportunities for restoration. This is a dynamic process which changes as new information is received. The damage assessment studies are the primary sources of information on injuries. Other sources include data gathered during the oil-spill cleanup, public comments and studies conducted outside of the damage assessment program.

Scoping Activities

Public Involvement

Late in 1989 the Trustees and the Environmental Protection Agency established a Restoration Planning Work Group. This group began the process of determining the issues to be addressed in the restoration program.

In March 1990 a public symposium was held in Anchorage, and the proceedings were published in Restoration Following the *Exxon Valdez* Oil Spill, Proceedings of the Public Symposium, July 1990. In April and May public meetings were held in Cordova, Valdez, Whittier, Homer, Kodiak, Seward, Anchorage and Kenai-Soldotna. People were invited to ask questions and put forward their ideas about restoration needs and priorities. In August the work group issued a report, Restoration Planning Following the *Exxon Valdez* Oil Spill: August 1990 Progress Report, that described the planning activities to date, summarized the public comments and presented ideas for restoration. Opportunities for public participation prior to the settlement, however, were limited due to pending litigation with the parties responsible for the oil spill and the need for the results of damage assessment studies to remain confidential.

Technical Workshop

In April 1990 a three-day technical workshop was held in Anchorage, providing the first opportunity for an organized exchange of ideas on restoration among Federal and State resource managers and selected scientists and technical experts under contract to the governments. This workshop was closed to the public because confidential damage assessment information was discussed.

Guided by an overview of preliminary results from the damage assessment studies, a broad range of restoration options were explored to help restore injured resources and services in the oil-spill area. Potential restoration options were identified and evaluated and feasibility studies were suggested. Participants also identified other information required to aid restoration planning.

Issues and Concerns Identified

The restoration planning and scoping process has generated a wide array of issues and concerns regarding the restoration of resources and services in the oil-spill area. The following list summarizes these issues and concerns:

- the use of restoration monies for prevention of future spills;
- determining what clean-up activities should continue to occur;
- the need for continued natural resource damage assessment;
- the need for continued long-term research on injuries;
- the need for long-term monitoring;
- how much reliance should be placed on natural processes to ensure recovery of injured natural resources and services;
- what management practices can be taken by the governments to speed recovery;
- the need to support educational efforts so the general public can understand what happened and what they can do;
- the effect restoration activities have on the local economy of the spill area;
- the need to protect habitat as a direct means of restoration;
- the idea of removing other (not *Exxon Valdez* oil) sources of contamination from the affected area as a means of aiding restoration;
- how to determine the most effective use of restoration monies;
- how to provide for meaningful public involvement; and
- how to establish and operate a public advisory group to the Trustees.

Peer Review

In addition to the technical workshop described above, there have been ongoing consultations with selected nationally recognized scientists and technical experts. Some of these experts continue to provide advice for the restoration planning and damage assessment process, identify information needs and review study proposals.

Review of Recovery Literature

The rate and adequacy of natural recovery may be considered when evaluating restoration measures. In some cases it may be most appropriate to allow natural recovery to proceed without further human intervention.

To supplement damage assessment data on natural recovery, a review and critical synthesis of the scientific literature on the recovery of marine mammals, marine birds, commercially important fish and shellfish, and invertebrates following environmental perturbations, including oil spills, was initiated in 1991. The reviews are being conducted under contract by the Point Reyes Bird Observatory (marine birds), University of Washington Fisheries Research Institute (fish and commercially important shellfish), and Hubbs-Sea World Research Institute and the Pacific Estuarine Research Laboratory at San Diego State University (marine mammals and intertidal and subtidal invertebrate communities). These syntheses will be completed in 1992.

Field Studies

As damage assessment results were reviewed in 1990 and 1991, the restoration planning staff consulted with scientists who were conducting the studies, Federal and State resource managers, and outside experts to identify and evaluate potential restoration options. In some cases lack of information prevented the evaluation or implementation of a restoration option, and field studies were proposed to provide needed information. Thus, the Trustee Council approved a series of small-scale restoration studies in 1990 and 1991.

Three types of studies were conducted:

- feasibility studies, to test the practicality and effectiveness of proposed direct restoration techniques;

- technical support studies, to provide biological or other information necessary to identify, evaluate or conduct potential restoration activities; and

- monitoring studies, to document the extent and rate of natural recovery of an injured resource.

The studies conducted were described in the 1990 and 1991 versions of the State/Federal Natural Resource Damage Assessment and Restoration Plan for the *Exxon Valdez* Oil Spill and in three Federal Register notices (55 Fed. Reg. 8160, [November 19, 1990], 56 Fed. Reg. 8898, [March 1, 1991], and 56 Fed. Reg. 36160, [July 31, 1991]).

Habitat Protection

Resource experts and the public have identified the protection of fish and wildlife habitats and recreation sites as a method of preventing further harm to, and assisting the recovery of, natural resources and services injured by the oil spill. Suggested approaches have included changes in management practices on public lands and land acquisition. Accordingly, the restoration planning staff conducted special projects concerning the protection of marine and upland habitats.

First, a workshop was held in August 1991 to evaluate State and Federal marine habitat protection designations and their potential usefulness in the restoration program. The designations reviewed included national marine sanctuaries, estuarine research reserves and Alaska State marine parks. The workshop participants included managers and administrators of various protected areas who provided first-hand information on the areas for which they are responsible. Each type of designation and specific unit has a different purpose, management approach, historical funding level and track record. Participants suggested that marine habitat protection designations help maintain ecosystem integrity by controlling activities that disrupt ecological processes or that physically damage the environment, thereby minimizing further stress on recovering resources. These designations accommodate conservation objectives as well as other pre-existing uses.

Second, The Nature Conservancy was invited to provide technical assistance in developing methodologies for identifying key upland habitats that are linked to the recovery of injured resources and services and evaluating potential protection strategies. In cooperation with the restoration planning staff, The Nature Conservancy prepared a handbook entitled, Options for Identifying and Protecting Strategic Fish and Wildlife Habitats and Recreation Sites (December 1991). The handbook provides a menu of identification and protection tools, techniques and strategies that may be applicable to restoration planning efforts associated with private lands within the oil-spill area.

CHAPTER IV SUMMARY OF INJURY

Introduction

The *Exxon Valdez* oil spill occurred just prior to the most biologically active season of the year in southcentral Alaska. During the four-month period after the spill, seaward migrations of salmon fry, major migrations of birds, and the primary reproductive period for most species of birds, mammals, fish, and marine invertebrate species took place. The organisms involved in these critical periods of their life cycles encountered the most concentrated, volatile, and potentially damaging forms of spilled oil. Oil affected different species differently. Resources continue to be exposed to oil remaining in the intertidal zone, as well as to oil transported to the subtidal zone. The following general account summarizes the main results from the Natural Resource Damage Assessment studies carried out after the spill.

Oil spill injuries can be estimated in several ways: Dead animals, such as birds and sea otters, can be counted and used to estimate the total number of each species lost. Where carcasses are not found and counted, injuries to populations can be based either on comparisons before and after a spill, or between oiled and unoiled environments. Measurements of physiological and biochemical changes due to oil exposure provide further evidence that may support changes observed in populations. Because populations fluctuate from year to year and there are natural differences from place to place, the most accurate estimates of injury are those in which the exact population is known just before the spill and then after the injury occurred. Although scientists studying the effects of oil spills may carry out excellent studies under difficult conditions, there are always uncertainties, especially where good pre-spill population data are lacking.

The injuries summarized here may change as the results of additional sampling and data analysis become available. It is also possible that injuries to populations of long-lived species may not be manifested for some time.

Marine Mammals

Introduction

Following the spill, humpback whales, Steller sea lions, sea otters, harbor seals, and killer whales were studied. Field work on Steller sea lions and humpback whales was completed in 1990. Humpback whale studies included photo-identification of individual whales, estimations of reproductive success, and documentation of possible displacement of whales from their preferred habitat within Prince William Sound. Exposure of this species to oil was not observed, nor were tissues sampled and analyzed for hydrocarbons. The data do not indicate an effect of the spill on mortality or reproduction of humpback whales in Prince William Sound. However, in 1989 humpback whales were not seen in Lower Knight Island Passage, a preferred habitat.

Results from the sea lion study were inconclusive. Several sea lions were observed with oiled pelts, and petroleum hydrocarbons were found in some tissues. Determining if there was an effect of the spill on the sea lion population was complicated by seasonal movements of sea lions in and out of the spill area, an ongoing population decline and a pre-existing problem with premature pupping.

Based on several photo-identification censuses a significant number of killer whales are missing from at least one and possibly two pods in Prince William Sound. Changes also have been observed in killer whale distribution and social structure. Some male whales have drooping dorsal fins. The cause of the mortalities and fin problems is uncertain.

Injuries to harbor seals and sea otters, described below, have been more evident. Studies of these species are continuing.

Sea Otters

The population of sea otters in Prince William Sound before the spill was estimated to have been as high as 10,000. The total sea otter population of the Gulf of Alaska was estimated to have been at least 20,000. Statewide, the sea otter population is estimated at 150,000. As the oil moved through Prince William Sound and the Gulf of Alaska, it covered large areas inhabited by otters. Sea otters were particularly vulnerable to the spill. When sea otters become contaminated by oil, their fur loses its insulating capabilities, leading to death from hypothermia. Sea otters also may have died as a result of oil ingestion and perhaps inhalation of toxic aromatic compounds that evaporated from the slick shortly after the spill. The effects of oil were documented by repeated surveys of populations in the spill area, recovery of beach-cast carcasses, analysis of tissues for petroleum hydrocarbons and indicators of reduced health, tracking sea otters outfitted with radio transmitters (including those released from rehabilitation centers), and estimating total mortality from the number of sea otter carcasses recovered following the oil spill. These studies concentrated on developing an estimate of sea otter mortality in Prince William Sound and along the Kenai Peninsula, the populations believed to have been most affected by the spill. During 1989, 1,011 sea otter carcasses were recovered in the spill area, cataloged and stored in freezers. Of these, 876 otters were recovered dead from the field and 135 died in rehabilitation centers or other facilities. It is estimated that 3,500 to 5,500 sea otters died from acute exposure to the oil in the entire affected area.

Heavy initial and continuing long-term exposure to petroleum hydrocarbons may be resulting in a chronic effect on sea otters. Significantly elevated concentrations of petroleum hydrocarbons have been detected in intertidal and subtidal sediment samples within the spill zone in western Prince William Sound and in intertidal mussels and benthic marine invertebrates and staples of the sea otter diet. Analyses of blood from sea otters in 1990 and 1991 indicated slight but significant differences in several blood measures in exposed animals. For example, higher eosinophil counts, total hemocrits and hemoglobin concentrations occurred in males in western Prince William Sound, the area that was oiled, compared to males in the eastern Prince William Sound, the unoiled area, suggesting systemic hypersensitivity reactions. These changes are not sufficient to indicate that the individuals that were sampled had health problems likely to result in death.

Abnormal patterns of mortality are continuing in sea otters. Based on pre-spill data from Prince William Sound, very few prime-age sea otters (animals between 2 and 8 years old) die each year and most mortality occurs among otters less than two years old. In 1990 and 1991 a high proportion of carcasses of prime-age sea otters were found on beaches, suggesting a chronic effect of the spill on sea otters.

Results of boat surveys indicate continued declines in sea otter abundance within oiled areas in Prince William Sound. Pre-spill estimates of sea otter abundance in Prince William Sound were carried out in 1984 and 1985 using similar survey techniques. Comparisons of pre- and post-spill estimates of sea otter abundance show that sea otter populations in unoiled areas experienced a 13.5 percent increase in abundance, while sea otter populations in oiled areas underwent a 34.6 percent decrease. In addition, the post-spill population in the oiled area is significantly lower than the pre-spill estimate, indicating a real decline of 1,600 sea otters in Prince William Sound in the first year after the spill, and up to 2,200 in the first three years after the spill.

Pupping rates and survival of pups through weaning in 1990 and 1991 were similar in eastern and western Prince William Sound sea otter populations. Weaned sea otter pups with radiotags died at a faster rate in western than in eastern Prince William Sound (Figure 3). In contrast, survival of tagged adult female sea otters was significantly higher in western Prince William Sound than in eastern Prince William Sound.

Sea otters released from rehabilitation centers had higher mortality and significantly lower pupping rates than those measured in the wild population before the spill. Of the 193 sea otters released from rehabilitation centers, 45 were fitted with radio transmitters. As of July 31, 1991, 14 of these animals were still alive, 14 were known to be dead, and 16 were missing. One radio transmitter is known to have failed.

The observed changes in the age distributions of dying sea otters, continued declines in abundance, higher juvenile mortality, and higher mortality and lower

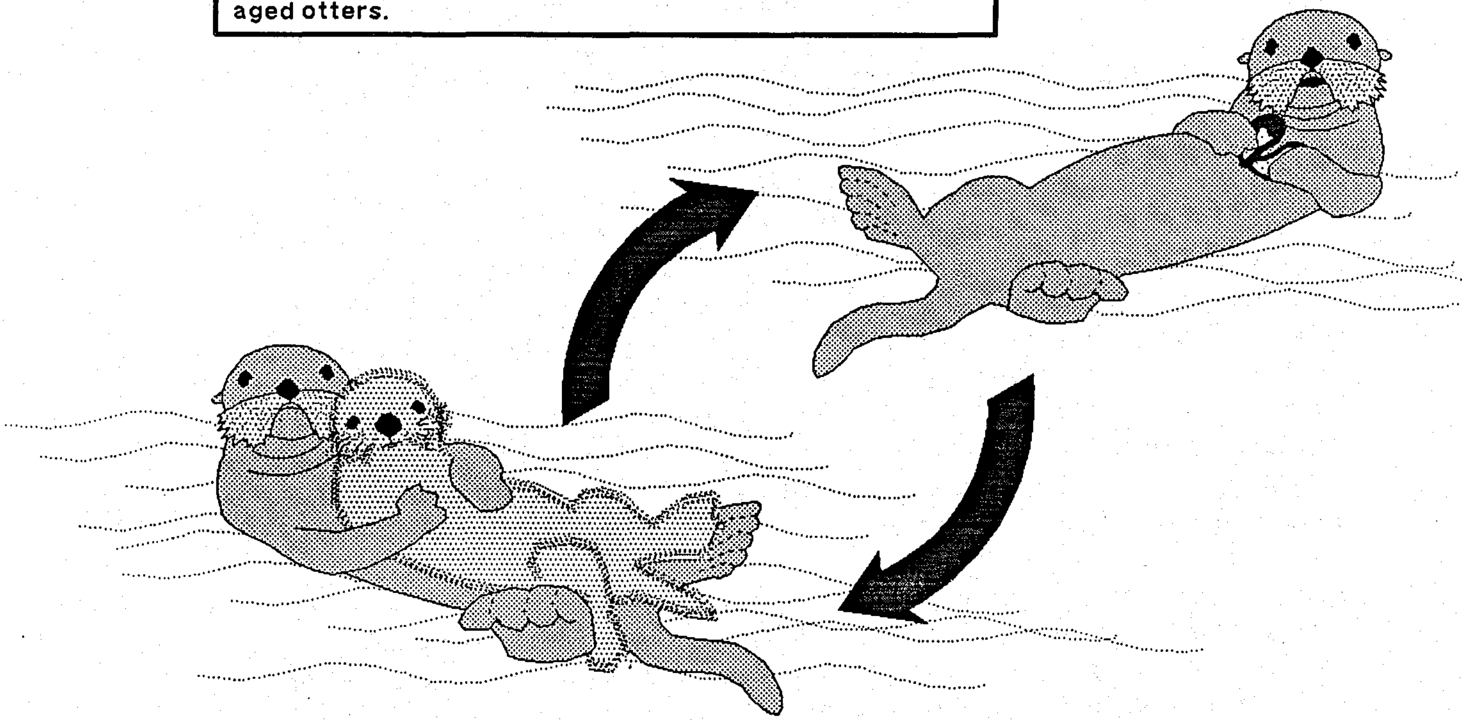
Figure 3. Summary of the major injuries in relation to the life history of sea otters.

Sea Otters

Adults

Sea otters prefer shallow coastal waters with abundant molluscs and crustaceans for prey. Intertidal rocks and exposed beaches are used for haulout sites. Otters become sexually mature in 4 - 7 years. Most otters in Prince William Sound mate from September through October, but they are capable of breeding throughout the year.

INJURY: Heavy direct mortality of all age classes during the Exxon Valdez oil spill; continuing high mortality of prime aged otters.



Pups

Within Prince William Sound, most sea otter pups are born May through June. The single pup is dependent on its mother for 5 - 7 months. High quality, shallow habitats are used by female-pup pairs.

INJURY: High post-weaning mortality within the Exxon Valdez oil spill area.

pupping rates suggest a prolonged, spill-related effect on the western Prince William Sound sea otter population.

Harbor Seals

Two hundred harbor seals are estimated to have been killed by the spill in Prince William Sound. Only 19 seal carcasses were recovered following the spill, since seals sink when they die. Population changes were documented by summer and fall aerial surveys of known haul-out areas. Toxicological and histopathological analyses were conducted to assess petroleum hydrocarbon accumulation and persistence and to determine toxic injuries to tissues. Severe and potentially debilitating lesions were found in the thalamus of the brain of a heavily oiled seal collected in Herring Bay, Prince William Sound, 36 days after the spill. Similar but milder lesions were found in five other seals collected three or more months after the spill. During 1989, oiled harbor seals were abnormally lethargic and unwary. Petroleum hydrocarbon concentrations in bile were 5 to 6 times higher in seals from oiled areas than in seals from unoiled areas one year after the spill. This indicates that seals were still encountering oil in the environment, were mobilizing fat reserves containing petroleum hydrocarbons, or both.

A complete census of harbor seals in Prince William Sound had not been conducted before the spill. However, trend index locations have been intermittently surveyed since the 1970s. Counts at the trend index sites declined by 40 percent between 1984 and 1988, with similar declines in what were subsequently oiled and unoiled areas. From 1988 to 1990, however, the decline at oiled sites, 35 percent, was significantly greater than at unoiled sites (13 percent). Trend surveys conducted in 1991 continue to indicate similar differences between oiled and unoiled areas, although mean numbers of seals in trend counts have increased since the spill. The increases in seals at unoiled sites have been significant, while those at oiled sites have risen only slightly. The first complete survey of Prince William Sound was completed during August 1991, resulting in a count of 2,875 harbor seals.

Killer Whales

Approximately 182 killer whales, forming nine distinct family units or "pods", used Prince William Sound before the spill. These whales were studied intensively before the spill, and their social structure and population dynamics are well known. Damage assessment studies of killer whales involved extensive boat-based surveys in Prince William Sound and adjacent waters. Whales were photographed, and the photographs were compared to the Alaskan killer whale photographic database for the years 1977 to 1989 to determine changes in whale abundance, seasonal distribution, pod integrity and mortality and natality rates.

The AB pod had 36 whales when last sighted before the spill in September 1988. When sighted on March 31, 1989, seven days after the spill, seven individuals were missing. Six additional whales were missing from the AB pod in 1990. Assuming that whales missing for two consecutive years are dead, the mortality rates for the AB pod were 19.4 percent in 1988-1989 and 20.7 percent in 1990-1991. The average annual mortality in AB pod from 1984 to 1988 was 6.1 percent. An additional whale was missing in 1991, but a calf also was born into the pod. The approximate calving interval of killer whales is four years. Accordingly, some long-term effects may not be obvious for many years.

Several of the missing whales from AB pod were females that left behind calves; such abandonment of calves is unprecedented in killer whales. As a consequence the social structure of AB pod has changed. Calves normally spend time with their mothers, but AB pod calves have been observed swimming with adult bulls. The occurrence of collapsed dorsal fins on two adult bulls after the spill is an indication of possible physiological injury. Very little is understood about the likely mechanisms of death from the spill. Various explanations, including oil exposure and other causes, continue to be explored. During the mid-1980s photographic evidence was obtained of bullet wounds in individuals in the AB pod, though there is no recent evidence of such shootings.

Another Prince William Sound pod, AT pod, is missing 11 whales. A subgroup of four AT pod members was photographed behind the *Exxon Valdez* three days after the grounding on Bligh Reef and three of these animals are among the missing AT pod whales. This is a transient pod and it is possible that the missing whales left the pod.

Terrestrial Mammals

Terrestrial mammals that may have been exposed to oil through foraging in intertidal habitats were studied. These species included brown bear, mink, black bear, Sitka black-tailed deer and river otters.

Brown bears forage seasonally in the intertidal and supratidal areas of the Alaska Peninsula and the Kodiak Archipelago. Preliminary analysis of fecal samples from brown bears in the spill area showed that some bears were exposed to petroleum hydrocarbons. High concentrations of petroleum hydrocarbon metabolites were found in bile from a yearling brown bear found dead in 1989. The normal rate of mortality in yearling cubs is close to 50 percent for the first two years, so it is uncertain if this death was due to oil or other causes.

Black bears also forage in the intertidal zone in the spill area and therefore could have been affected by the spill. No field studies were carried out, however, due to the difficulty of finding, collaring or otherwise investigating these animals in the dense underbrush that is their habitat.

Mink and other small mammals living in coastal areas may feed in and spend part or all of their time in the intertidal zone. When mink are sick or injured, they are known to crawl into inaccessible burrows or the brush. For this reason the effect of the spill on mink populations could not be determined. Also, information on pre-spill populations of mink and other small mammals is minimal. To determine if mink reproduction may have been affected by oil in their diet, a laboratory exposure study of ranch-bred mink was conducted. The mink were fed food mixed with small, non-lethal amounts of weathered oil. No changes in reproductive rates or success resulted from this exposure. It was found, however, that oil-contaminated food moved through the intestines of the animals at a more rapid rate than did clean food, possibly providing less nutrition to the animals.

Intensive searches of beaches revealed no Sitka black-tailed deer whose deaths could be attributed to the spill. However, deer taken for purposes of testing for human consumption (not part of the damage assessment) were found to have had slightly elevated concentrations of petroleum hydrocarbons in tissues of some individuals that fed on kelp in intertidal areas. It was determined that the deer were safe to eat.

River Otters

A few river otter carcasses were found by clean-up workers. River otters forage in streams and shallow coastal habitats that were contaminated by the spill. Analysis of river otter bile and blood samples indicated that petroleum hydrocarbons were being accumulated by this species. Moderately elevated concentrations of haptoglobin and activities of amino transferase enzymes in the blood of river otters from oiled areas in 1991 indicate a lingering toxic effect of oil on this species. Studies of radio-tagged animals in Prince William Sound showed that home ranges in oiled areas were twice that of unoiled areas, suggesting that in oiled areas otters must forage over a larger area to obtain sufficient food. In 1991, body lengths, body weights and dietary diversity were lower in oiled areas. River otters often feed on mussels, which continue to be contaminated with oil in many areas of Prince William Sound.

Birds

Introduction

Birds were among the most conspicuous victims of the oil spill. Seabirds are particularly vulnerable to oil, as they spend much of their time on the sea surface while foraging. Oiled plumage insulates poorly and loses its buoyancy, and oiled birds often die from hypothermia or drowning. Birds surviving initial acute exposure to oil may ingest oil by preening. About 36,000 dead birds were recovered after the spill; at least 31,000 of these deaths were attributable to oil. In addition to the large number of murres, sea ducks and bald eagles recovered after the spill, carcasses of loons, cormorants, pigeon guillemots, grebes, murrelets and other species were also recovered. The recovered birds represent only a small proportion of the total number of birds killed by the spill. Many oiled birds undoubtedly floated out to sea and sank. Many oiled birds that were washed onto beaches may have been scavenged, hidden in masses of oil buried under sand and gravel by wave actions, decomposed or simply washed onto a beach that was not searched. In a number of cases carcasses found shortly after the spill were not turned in to receiving stations. The results of analyses using computer models that account for some of these variables suggest that the total number of birds killed by the spill ranged from 300,000 to 645,000, with the best approximation that between 375,000 and 435,000 birds. These estimates reflect only direct mortality occurring in the months immediately following the spill, and do not address chronic effects or loss of reproductive output.

<u>Common and thick-billed Murres</u>

Approximately 1,400,000 murres reside in the Gulf of Alaska region, which stretches from Unimak Pass at the tip of the Alaskan Peninsula to the Canadian border in southeastern Alaska. The total population of murres in Alaska is approximately 12,000,000. The murre colonies on the Chiswell Islands are the colonies most visited by tourists in Alaska. Most of the pre-spill data on murre abundance in the Gulf of Alaska colonies affected by the spill were gathered in the mid-1970s to the early 1980s. In 1989 and 1990 murres were the most heavily affected bird species. As oil moved out of Prince William Sound and along the Kenai Peninsula and the Alaska Peninsula, it encountered major seabird nesting areas, such as the Chiswell and Barren islands, as well as numerous smaller colonies. The oil contaminated these areas in the Gulf of Alaska at the same time that adult murres were congregating on the water near their colonies in anticipation of the nesting season. Approximately 22,000 murre carcasses were recovered following the spill. At the major colonies in the spill area surveys indicated that an estimated minimum of 120,000 to 140,000 breeding adult murres were killed by the spill. Extrapolating this information to other known murre colonies affected by the spill, but not specifically studied, the mortality of breeding adult murres is estimated to have been 172,000 to 198,000 birds. The spill also affected wintering and non-breeding birds and the total area-wide mortality of murres is estimated to be about 300,000. Numbers of breeding murres declined in 1989 from pre-spill counts or estimates at Alaska Peninsula sites (50-60 percent), the Barren Islands (60-70 percent) and the Triplet Islands (35 percent). These decreases persisted in 1990 and 1991. No significant changes in murre numbers were noted for the Semidi Islands and Middleton Island, colonies which are in the Gulf of Alaska, but outside the spill zone. Murres exhibit strong fidelity to traditional breeding sites and infrequently immigrate to new colonies.

Normally, murres breed on cliff faces in densely packed colonies. Each murre colony initiates egg laying almost simultaneously. Synchronized breeding helps repel predators such as gulls and ravens. In oiled areas, murre colonies have fewer breeding individuals than before the spill, breeding is later than normal and breeding synchrony has been disrupted.

These changes in numbers of birds and their behavior have caused complete reproductive failure in several of the large colonies during 1989, 1990 and 1991, and thus lost production of at least 300,000 chicks. There are some indications that normal breeding occurred in isolated areas of the Barren Island colonies in 1991, but it is uncertain when the whole colony will start to produce significant numbers of viable chicks. Murre colonies in unoiled areas displayed none of these injuries and had normal productivity in the years since the spill.

Bald Eagles

Of the estimated Alaskan bald eagle population of 39,000 birds (27,000 adults and 12,000 fledglings), an estimated 4,000 reside in Prince William Sound, and an estimated 8,000 to 10,000 reside along the northern Gulf of Alaska coast. One hundred fifty-one (151) dead bald eagles were found following the spill. Although there is considerable uncertainty regarding the total mortality of bald eagles, several times this number may have been killed initially by the spill. Seventy-four percent of radio-tagged bald eagles that died of natural causes during subsequent studies ended up in the forest or in other places away from the beaches where they would likely not have been found had they not been tagged. If this pattern of carcass deposition is representative of what happened following the oil spill, then as many as 580 bald eagles may have been killed directly by the spill. However, since eagles dying of acute exposure to oil probably behave differently than those dying naturally and the population trend counts did not indicate a significant decline following the spill, the number of eagles killed is certainly less than this number.

To assess injuries to bald eagles, helicopter and fixed-wing surveys were flown to estimate populations and productivity. Radio transmitters were attached to bald eagles to estimate survival, distribution and exposure to oiled areas. Bald eagles in Prince William Sound were most intensively studied. Productivity surveys in 1989 indicate a failure rate of approximately 85 percent for nests adjacent to moderately or heavily oiled beaches compared to 55 percent on unoiled or lightly oiled beaches. This resulted in a lost production of at least 133 chicks in Prince William Sound in 1989. Nest success and productivity on the Alaska Peninsula were also lower in 1989 than in 1990, but differences between these years for eagles residing in other coastal areas affected by the spill were less apparent. Nest occupancy was lower in oiled areas than in unoiled areas in both 1989 and 1990. Reproduction returned to normal in 1990 and population indices from surveys in 1982, 1989, 1990 and 1991 suggest that the spill has not measurably affected the bald eagle population in Prince William Sound.

Sea Ducks

More than 2,000 sea duck carcasses were recovered after the spill, including more than 200 harlequin ducks. Studies concentrated on harlequins, goldeneyes, and scoters--species that use the intertidal and shallow subtidal habitats most heavily affected by the spill. All of these species feed on invertebrates, such as mussels, which in 1991 continued to show evidence of petroleum hydrocarbon contamination. Harlequin ducks, which feed in the shallowest water of all these species, were most affected. In 1989 and 1990 about 40 percent of the harlequin ducks sampled had tissues contaminated with petroleum hydrocarbons, and about 33 percent of the harlequins collected in the spill area had poor body condition and reduced body fat. The 1991 survey indicates harlequin population declines and a near total reproductive failure in oiled areas of Prince William Sound (Figure 4). Oil-contaminated mussel beds may be the source of this apparent continuing problem.

Other Birds

Changes in populations of waterbirds in the spill area were assessed with boat surveys, the same technique used in surveys carried out in 1972 and 1973, and then, again in 1984. Changes were assessed on the basis of both the earlier and later pre-spill data. Declines occurred in 16 of the 39 species or groups examined for the entire Prince William Sound area between 1972-1973 and post-spill. Declining species or groups of species include: grebes, cormorants, northern pintail, harlequin duck, old squaw, scoters, goldeneyes, bufflehead, black oystercatcher, Bonaparte's gull, black-legged kittiwake, Arctic tern, pigeon guillemot, *Brachyramphus* (marbled and Kittlitz's) murrelets, and northwestern crow. The following species or group of species declined more in oiled areas than in unoiled areas since the early 1970s: harlequin duck, black oystercatcher, pigeon guillemot, northwest crow, and cormorants. Comparisons of post-spill survey data with 1984 pre-spill data indicate that harlequin duck, black oystercatcher, murres, pigeon guillemot, cormorants, Arctic tern, and tufted puffin populations declined more in oiled areas than in unoiled areas.

Marbled and Kittlitz's murrelet populations declined greatly in Prince William Sound since 1972 and 1973. In 1973, the estimated murrelet population in the Sound was 304,000 birds, while murrelet populations were estimated to be 107,000 in 1989, 81,0000 in 1990, and 106,000 in 1991. The length of time between pre-spill and post-spill surveys makes it difficult to determine the relative contribution of the spill to this decline. However, a high proportion of murrelets present in Prince William Sound were killed by the spill. Also, internal contamination of apparently healthy murrelets by petroleum hydrocarbons in the spill area opens the possibility that there were significant effects on murrelets beyond the initial mortality. Disturbance associated with clean-up activities may have influenced the number of murrelets observed in the spill area in 1989.

Nine black oystercatcher carcasses were found after the spill. This species feeds intertidally and breeds on rocky shores throughout the spill zone. In addition to mortality caused directly by the spill, oiling affected their reproductive success. Egg volume and weight gained by chicks raised on oiled sites were substantially lower than chicks raised on unoiled sites. The difference in weight gain by chicks may have resulted from differences in food supply, as the amount of food delivered to chicks raised on oiled sites was significantly less than that delivered to chicks at unoiled sites. Hatching success, fledging success, and productivity of young birds were not significantly different between oiled and unoiled sites. Direct disturbance by clean-up activities significantly reduced oystercatcher productivity on Green Island during 1990.

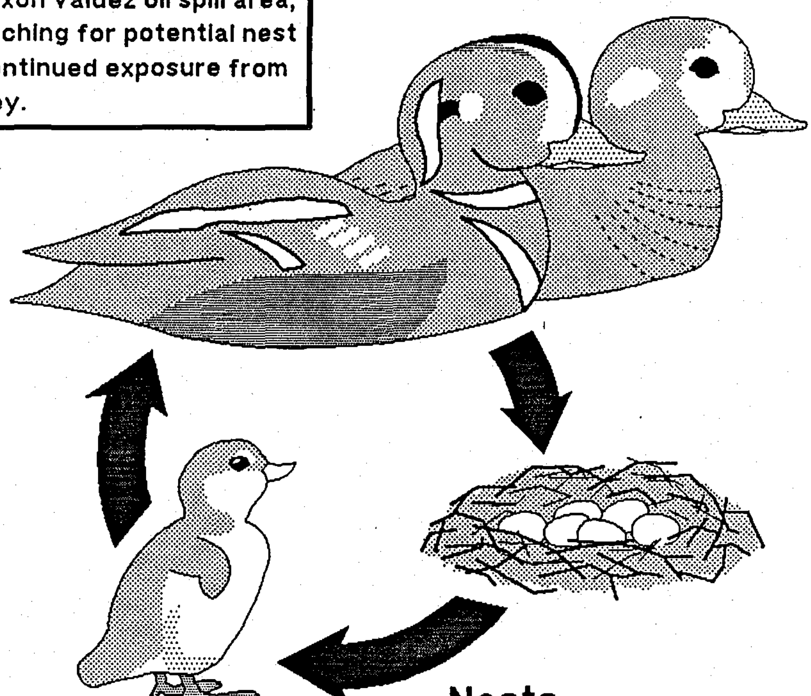
Figure 4. Summary of the major injuries in relation to the life history of harlequin ducks.

Harlequin Ducks

Adults

In early May, paired harlequins congregate at the mouths of anadromous fish streams. The pairs fly upstream to search for suitable nest sites. Wintering harlequins feed on mussels and crustaceans in intertidal waters.

INJURY: Pairs are not congregating at streams in the Exxon Valdez oil spill area, nor are they searching for potential nest sites. Possible continued exposure from contaminated prey.



Broods

Broods hatch in July. They remain on freshwater with the female until August when they return to coastal waters.

INJURY: No broods observed within the Exxon Valdez oil spill area in 1990, and only one brood found in 1991, indicating reproductive failure at nesting and/or poor brood survival.

Nests

Located along shallow and swift rivers and streams. 3 to 7 eggs are laid in May and incubated for 28 - 30 days.

INJURY: No nests discovered in the Exxon Valdez oil spill area.

Pigeon guillemots are nearshore diving seabirds that gather daily on intertidal rocks near their colonies during the breeding season and forage by probing into intertidal and subtidal recesses and kelp. Five hundred sixteen (516) guillemot carcasses were recovered following the spill. Between 1,500 and 3,000 guillemots were estimated to have been killed by the spill, representing as much as 10 percent of the known pigeon guillemot population in the Gulf of Alaska. Boat surveys indicate that in 1973 the Prince William Sound guillemot population was approximately 14,600; while in 1989, 1990 and 1991, the estimated populations were, respectively, 4,000, 3,000 and 6,600. These data indicate that the Prince William Sound guillemot population was declining prior to the spill. The declines were significantly greater, however, in oiled areas. For the four islands of the Naked Island group, post-spill surveys showed a 40 percent decline in guillemots present during peak colony attendance hours compared to pre-spill surveys. Declines corresponded to the degree of shoreline oiling.

The extent of injury to certain species, including loons, cormorants and gulls, will never be known because pre-spill population estimates for these species in the spill area are not available. Although Peale's peregrine falcons did not appear to be directly affected by the oil spill, disturbance from nearshore activities appears to have affected rates of nest occupancy and reduced clutch and brood sizes in 1989. Studies of song birds did not document an injury from the spill.

Fish and Shellfish

Introduction

No massive kills of adult open-water fish were observed following the spill. Adult salmon, for example, were able to migrate as expected to spawning areas after the spill. The early life stages of some fish species and adults of others depend on the intertidal and shallow subtidal areas and the upper layers of the sea where the greatest concentrations of oil occurred. In addition the eggs and larvae of fishes are more sensitive to oil contamination than are adults.

It is not surprising, therefore, that the available evidence from this spill indicates that the greatest damage was to the eggs and larvae of some species of fish, especially those that inhabit and spawn in the intertidal zone (salmon) and shallow subtidal zone (herring) or that forage in shallow water (Dolly Varden and cutthroat trout). Many species of fish produce large numbers of eggs and only a relatively small number reach adulthood. Since natural factors affecting such survival change from year to year it is difficult to estimate or measure the effects of oil on adult fish populations whose early stages were injured. Nevertheless, during 1991, data were gathered that would potentially help clarify the effects on adult fish exposed to oil as eggs or larvae. These data are still being analyzed.

The deaths of some rockfish, a deepwater species, also were attributed to oil. Several species of coastal and offshore fish, including pollock, halibut, sablefish, cod, yellowfin and flathead sole and rockfish, showed evidence of continuing exposure to petroleum hydrocarbons over a large geographic area, but significant injury has not been documented. Because salmon and other fish species can metabolize petroleum hydrocarbons, these contaminants are unlikely to concentrate in fish tissues. Indicators of exposure in fish include increased concentrations of hydrocarbon metabolites in bile and activities of mono-oxygenates in liver tissue.

Pink Salmon

The full extent of short-term injury to pink salmon cannot be assessed until after the 1991 run returns have been analyzed. As predicted before the spill, the catch of pink salmon in Prince William Sound during 1990 was an all-time record high and the 1991 run was also quite high. These catches were primarily due to strong runs of hatchery-produced salmon. Survival to adulthood of salmon fry released from the Armin F. Koerning hatchery, located in the middle of a heavily oiled area of the spill zone, was half that of Esther Hatchery, located outside the spill area. Wild production of pink salmon did not mirror the record production of hatchery fish.

Seventy-five percent of wild pink salmon in Prince William Sound spawn in the intertidal portion of streams. Wild salmon did not shift spawning habitat following the spill and many salmon deposited their eggs in intertidal areas of oiled streams. In the autumn of 1989 egg mortality in oiled streams averaged about 15 percent, compared to about 9 percent in unoiled streams. Subsequently, egg mortality has generally increased. In 1991 there was a 40 to 50 percent egg mortality in oiled streams, and about an 18 percent mortality in unoiled streams. The relative roles of the spill and other factors, including natural variability, in causing the increased 1991 egg mortality are being analyzed. In general the number of spawning fish in streams of Prince William Sound indicates that the more viable spawn that is produced, the more adults will return to spawn from that year class. If this is true, then it is likely that mortality at the egg stage is additive with other sources of mortality in later stages and that the increased egg mortality observed since the spill is a threat to wild pink salmon in Prince William Sound. Eggs and larvae of wild populations continue to be exposed to oil in intertidal gravel in some areas.

Pink salmon juveniles were exposed to petroleum hydrocarbons from the spill in nearshore marine habitats in oiled portions of Prince William Sound in 1989. The survival of pink salmon to adulthood is directly related to growth rates during the initial marine residency. Growth rates of juvenile pink salmon were lower in oiled locations in 1989, but there was no evidence of continued reduced growth of juvenile salmon in nearshore waters in 1990. Laboratory experiments in 1991 confirmed that ingestion of food contaminated with oil can cause reduced growth and increased mortality of juvenile pink salmon.

Fry growth was decreased in oiled streams as compared to unoiled streams over the winter of 1989-1990 and larvae from some heavily oiled streams showed gross morphological abnormalities, including club fins and curved vertebral columns. The pink salmon that returned to Prince William Sound in the summer of 1990 were hatched prior to the spill and were exposed to oil as larvae. Although there is great uncertainty, some analyses suggest that the 1990 return of both wild and hatchery pink salmon was 20 to 25 percent lower than expected without the spill, resulting in a return of 15 to 25 million fewer fish. Fish that returned in 1991 were the first that were exposed to oil as eggs. The returns of wild salmon to oiled and unoiled streams in 1991 are still being analyzed.

Sockeye Salmon

Commercial harvest of sockeye salmon was curtailed in portions of Cook Inlet, Chignik, and Kodiak in 1989 because of the spill, resulting in an unusually high number of adults returning to spawn in certain lake systems--for example, Kenai and Skilak lakes, Red and Akalura lakes. The number of adults returning to the spawning areas is referred to as the "escapement." Commercial salmon fisheries are actively managed to maintain high production, and large overescapements resulting in low smolt production are a threat to the maintenance of sustained good production. In this case overescapement has resulted in poor survival to the smolt stage in the Kenai and Skilak lakes system. This overescapement is expected to result in a return of adults in 1993 and 1994 that is less than needed for adequate production. Total closure or severe reduction of the commercial and sport sockeye fisheries may be necessary in those years to enable recovery of this species in the Kenai and Red lakes systems. These fisheries account for up to half the commercial sockeye harvest in the Kodiak and Cook Inlet areas.

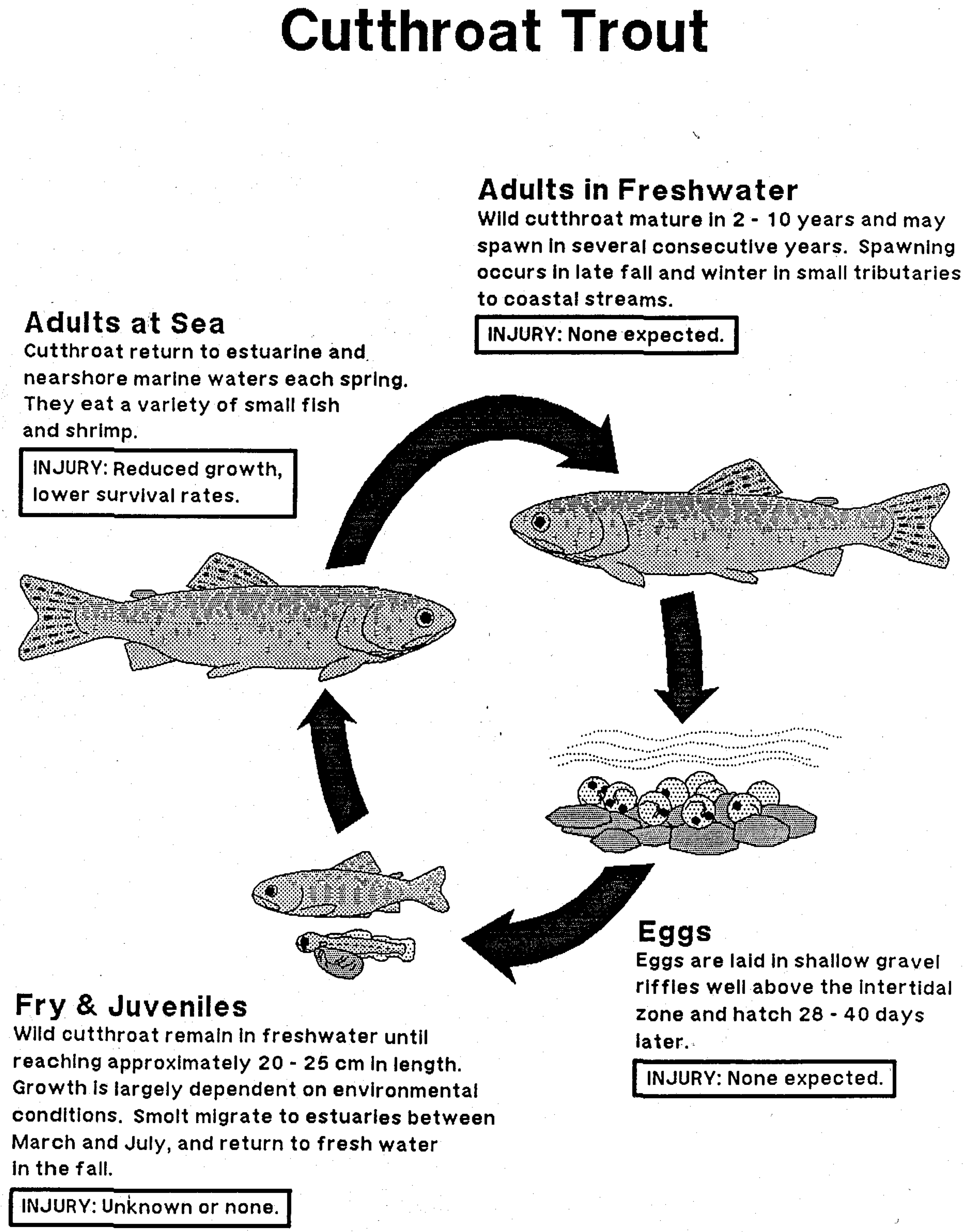
Dolly Varden and Cutthroat Trout

Prince William Sound is the northern extent of the range of cutthroat trout (Figure 5). Both cutthroat trout and Dolly Varden use nearshore and estuarine habitat for feeding throughout their lives, although they overwinter and spawn in freshwater. The highest concentrations of petroleum hydrocarbon metabolites in bile of all fish sampled in 1989 were found in Dolly Varden. Tagging studies demonstrated that the annual mortality of adult Dolly Varden in oiled areas was 32 percent greater than in unoiled areas. The larger cutthroat trout also showed higher levels of mortality in oiled than in unoiled areas. In 1989-1990, there was 57 percent greater mortality, and in 1990-1991, a 65 percent greater mortality, in oiled streams versus unoiled streams. Additionally, cutthroat trout growth rates in oiled areas were 68 percent in 1989-1990 and 71 percent in 1990-1991 of those in unoiled areas. Although concentrations of bile hydrocarbons were greatly reduced in 1990 and 1991, indicating less exposure to oil, it is unclear why differences persist in survival rates between oiled and unoiled streams.

Pacific Herring

Populations of Pacific herring were spawning in shallow eelgrass and algal beds at the time of the spill. The effects of oil on egg survival, hatching success,

Figure 5. Summary of the major injuries in relation to the life history of cutthroat trout.



larval development and recruitment to the spawning population were studied. A large percentage of abnormal embryos and larvae were found in samples from oiled areas of Prince William Sound collected during the 1989 reproductive season. Larvae in oiled areas also had a greater incidence of eye tumors. Analysis of histopathological abnormalities in tissues of adult herring reveal the occurrence of some lesions whose presence would be consistent with exposure to oil. Whether the adult population has been affected by these larval injuries and lesions will not be determined until the 1989 and 1990 cohorts return to spawn in 1992 and 1993. It will be difficult, however, to measure a change in the adult population, beyond the bounds of the natural variability.

Evidence of oil contamination in adult herring was found in 1989 and 1990. In 1989, hydrocarbon metabolites occurred in the bile of adult fish. There were significant changes in the incidence of histopathological lesions and in the parasite burden of adults found in oiled as compared to unoiled sites. The parasite burden of adult herring returned to pre-spill incidences in 1991.

Rockfish and Other Fish

A small number of dead rockfish were found after the spill; this was the only type of fish observed dying after the spill. Five rockfish were recovered soon enough after death to establish oil exposure as the probable cause of death. Analyses of rockfish bile indicated exposure to oil in a significant portion of the samples collected from oiled areas in 1989, only one individual in 1990 and none in 1991. Histopathological liver lesions were evaluated in 1990 and two types of lesions (liver lipidosis and liver sinusoidal fibrosis) were found to be significantly elevated in oiled areas. Other species that had measurable amounts of petroleum hydrocarbon metabolites in the bile in 1989 included halibut, pollock, rock sole, yellowfin sole, flathead sole and Pacific cod, and in 1990, Dover sole and sablefish.

Coastal Habitat

Introduction

The coastal tidal zone, commonly known as the "intertidal zone," was the most severely contaminated habitat. Intertidal habitats are highly productive and biologically rich. The intertidal zone is particularly vulnerable to the grounding of oil, its persistence and effects of associated clean-up activities.

Supratidal

The supratidal zone is above the high tide but still within the influence of the ocean from storm surges and wave spray. Results of studies from the Kodiak Island and Alaska Peninsula areas suggest that oil in the supratidal habitat and beach clean-up disturbance decreased the productivity of grasses and other vegetation, including beach rye, a grass that helps stabilize beach berms. In one instance, clean-up activities completely removed the supratidal vegetation.

Increased production of supratidal vegetation was found in Prince William Sound in 1989. Increased production as a result of decreased browsing by terrestrial mammals or a fertilizing effect of the oil are possible causes.

Intertidal

Populations of intertidal organisms were significantly reduced along oiled shorelines in Prince William Sound, on Kodiak Island and Cook Inlet, and along the Alaskan Peninsula. Densities of intertidal algae (*Fucus)*, barnacles, limpets, amphipods, isopods, and marine worms were decreased. Although there were increased densities of mussels in oiled areas, they were significantly smaller than mussels in the unoiled areas, and the total biomass of mussels was significantly lower. Sediment traps collected significant concentrations of petroleum hydrocarbons during the winter of 1990-1991, indicating that oil is continuing to be removed from the beaches by cleaning and natural processes and is being transported subtidally. Intertidal organisms continue to be exposed to petroleum hydrocarbons from subsurface oil in beaches.

In 1991 relatively high concentrations of oil were found in mussels and in the dense underlying mat (byssal substrate) of certain oiled mussel beds. These beds were not cleaned or removed after the spill and are potential sources of fresh oil for harlequin ducks, black oystercatchers, river otters and juvenile sea otters--all of which feed on mussels and show signs of continuing biological injury. The extent and magnitude of oiled mussel beds are unknown and continue to be investigated.

Intertidal fishes were less abundant in oiled areas than in unoiled areas in 1990. No such differences were documented in 1991.

Fucus, the dominant intertidal plant, was severely affected by the oil and subsequent clean-up activities. The percentage of intertidal areas covered by *Fucus* was reduced following the spill, but the coverage of opportunistic plant species that characteristically flourish in disturbed areas was increased. The average size of *Fucus* plants 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. Recruitment of *Fucus* at oiled sites was also reduced.

Subtidal Habitat

Between 1989 and 1991, oil concentrations declined in intertidal sediments sampled at most oiled locations, while the concentration in shallow subtidal sediments at depths of 3-20 meters remained about the same or in some cases, rose slightly. Petroleum hydrocarbon accumulation in filter-feeding mussels experimentally placed in the water column in various oiled areas was significant during the summer of 1989, but decreased in 1990. Patterns of sediment toxicity to marine amphipods and larval bivalve molluscs, used as test organisms, reflected similar patterns. In 1990 significant toxicity to these organisms 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 current evidence from analyses of petroleum hydrocarbons in the bile of bottom-dwelling fishes suggests that animals living on or near the sea floor continue to be exposed to petroleum hydrocarbons. In this connection the analysis of samples of bottom-dwelling organisms at the 100-m depth is continuing to see if there was a detectable effect of oil deep communities.

Clams exposed to oil actively take up hydrocarbons, but metabolize them very slowly. Hydrocarbons are consequently accumulated in high concentrations in clams. Studies of clam growth rates were initiated after the spill and analyses are still being conducted. Contaminated clams and other invertebrates are a potential continuing source of petroleum hydrocarbons for harlequin ducks, river otters, sea otters and other species that forage in the shallow subtidal zone. Samples from pollock, which feed in the water column, taken 500 miles from the T/V *Exxon Valdez* grounding site on Bligh Reef, showed elevated petroleum hydrocarbon metabolite concentrations in their bile. These data indicate that surface oil affected the water column or food supply at great distances from the spill.

No pre-spill data were available to directly determine if the oil spill had altered shallow subtidal communities, so the effects of hydrocarbons were investigated by comparison of oiled and unoiled areas. Data are available for 1990. The greatest differences between oiled and unoiled areas have been observed in the shallow-water eelgrass beds and their associated habitat. Within the oiled eelgrass beds there were lower densities of eelgrass, fewer *Telmessus* crabs and fewer amphipods, but more small mussels and juvenile cod. Even greater differences were observed, however, in the abundance of fauna at depths from 6-20 meters below the oiled eelgrass beds, where there were far fewer individuals in oiled areas. In the shallow subtidal rocky areas (less than 20m) *Laminaria* communities were studied, both in bays and around points on the open coast. In the *Laminaria* habitat fewer differences were noted between oiled and unoiled areas. The most noticeable difference was the greater abundance of young *Laminaria* plants, but fewer large older plants in oiled areas. In shallow-water sandy areas, eelgrass beds and areas around them were studied.

Post-spill populations of spot shrimp were studied in oiled and unoiled areas of Prince William Sound. Some differences were found between populations in these areas. The results of these studies are still being evaluated.

Other Resources and Services

The spill directly impacted archaeological resources, subsistence, recreation, wilderness qualities and aesthetic and other indirect uses. Clean-up activities and the associated significant increases in human activity throughout the spill zone resulted in additional injuries to these resources and services.

Archaeological Resources

Archaeological resources along the shoreline were injured by the spill. Review of spill response data revealed injuries occurred at a minimum of 35 archaeological sites, including burial and home sites. These injured sites are distributed on both Federal and State lands. While injury to these 35 sites was documented during cleanup, a spill-wide assessment of injuries to archaeological resources has yet to be completed. In addition to oil contamination, increased knowledge of the location of archaeological sites puts them at greater risk from looting. Additional injury due to erosion caused by oil-spill response activities was documented.

A study was conducted to determine impacts caused by oil contamination on radiocarbon dating of archaeological resources and to investigate the potential for cleaning artifacts and materials to allow such dating. Results indicate significant injury to the ability to date artifacts and materials by Carbon ^{14} analysis.

Subsistence

Surveys undertaken by State researchers before the spill and in 1990 indicated that subsistence users in the oil-spill area significantly reduced their use of subsistence resources after the spill, primarily because of concern about contamination of these resources. The oil spill disrupted the subsistence lifestyle of some communities that have historically relied upon these resources for a significant portion of their diet. Some communities virtually or entirely ceased subsistence harvests in 1989 and have only gradually begun to resume harvests, while other communities continued some reduced level of subsistence harvest in 1989 and thereafter. Warnings were issued by the State in 1989 for people to avoid consumption of intertidal invertebrates (such as mussels and clams, which accumulate petroleum hydrocarbons) found along shorelines contaminated by oil. After the spill, an oil-spill health task force was formed, including representatives of the State and Federal governments, subsistence users, and Exxon. This group helped oversee studies conducted by the State and others in conjunction with the Food and Drug Administration and National Oceanic Atmospheric Administration in 1989, 1990 and 1991, on subsistence foods, such as seals, deer, salmon, ducks, clams and bottomfish. Based upon the test results these resources, with the exception of clams and mussels in certain oiled areas, such as Windy Bay, were determined to be safe for human consumption.

Recreation

Following the oil spill, recreational use of public lands and waters declined. Recreationists (e.g., sport fishermen, hunters, campers and sea kayakers) avoided oiled areas and many adjacent areas that were affected by clean-up activity. Many users canceled their plans or pursued their activities in other areas within the state. For example, visitor use in the coastal area of the Kenai Fjords National Park dropped by about 50 percent in 1989, compared to 1988. This disruption continued in 1990, because oil remained present in many areas and some clean-up activity continued. In 1991 oil remained in many areas used by recreationists.

Wilderness and Intrinsic Values

There are designated "wilderness areas" in Kachemak Bay State Wilderness Park, Katmai National Park, and Becharof National Wildlife Refuge. In addition Federal "wilderness study" areas are located in Kenai Fjords National Park and the Chugach National Forest. Portions of these areas were oiled by the *Exxon Valdez* spill. The Wilderness Act of 1964 requires that Federal wilderness areas be "administered for the use and enjoyment of the American people in such a manner as will leave them unimpaired..." Thus, the presence of oil, which was most recently documented by the 1991 May Shoreline Assessment, may be perceived as an injury to these areas. In addition to the injury from the oil, hundreds of workers, motorized machinery and support equipment were used in the wilderness areas during the cleanup. These clean-up activities disrupted uses of the wilderness, such as camping and fishing. These lands and resources may have intrinsic or nonuse values, as well as uses, which also were affected by the oil spill.

CHAPTER V
PROPOSED INJURY CRITERIA

Settlement Guidance

The settlement documents specify that the use of the restoration trust funds must be linked to injuries resulting from the *Exxon Valdez* oil spill. Specifically, the settlement requires that funds recovered for natural resource damages be spent to restore, replace, enhance, rehabilitate or acquire the equivalent "of natural resources injured as a result of the oil spill and the reduced or lost services provided by such resources."

"Natural resources" are defined as the land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to or managed by Federal and State governments. The services provided by natural resources include such activities as subsistence hunting and fishing and recreation.

Proposed Criteria

How do we determine which natural resources and natural resource services warrant further restoration activities? The following criteria are proposed to assist in these determinations:

- evidence of consequential injury, and
- adequacy and rate of natural recovery.

The concepts underlying these criteria are described below.

Injury to Natural Resources

The following definition of injury is proposed to be applied to natural resources in the spill area:

> A natural resource has experienced "consequential injury" if it has sustained a loss (a) due to exposure to oil spilled by the T/V *Exxon Valdez*, or (b) which otherwise can be attributed to the oil spill and clean up. "Loss" includes:
>
> - significant direct mortality;
> - significant declines in populations or productivity;

- significant sublethal and chronic effects to adults or any other life history stages; or

- degradation of habitat, due to alteration or contamination of flora, fauna and physical components of the habitat.

This definition covers a wide range of potential natural resource injuries. Consequential loss is most certain where there was significant direct mortality or if studies revealed a population decline linked to the oil spill. Where only eggs or juvenile life history stages are known to have been harmed, it is more difficult to establish consequential injury. In such cases, however, if the injury is manifested or inferred at the population level, the injury can be considered consequential. This definition also includes injury to the underlying habitats that were oiled (e.g., intertidal zone), some of which were in specially designated areas, such as parks, forests and refuges.

Important archaeological resources, protected by both Federal and State laws, were oiled. Inherent values could be irretrievably lost as oil continues to contaminate additional resources at some sites. Archaeological resources, such as sites and artifacts, are not living, renewable resources and have no capacity to heal themselves. Increased public knowledge of exact archaeological site locations also continues to foster looting and vandalism.

In some cases our knowledge of the degree of injury and linkage to the oil spill are imperfect, due to the difficulty of obtaining the desired documentation or the restricted scope or duration of the damage assessment studies. In these cases, judgments concerning injuries to natural resources as a result of the oil spill will have to be determined by the weight of the evidence or best professional judgment.

Injury to Natural Resource Services

The following definition of injury is proposed to be applied to natural resource services in the spill area:

> A natural resource service has experienced "consequential injury" if the *Exxon Valdez* oil spill or clean up:
>
> - has significantly reduced the physical or biological functions performed by natural resources, including loss of human uses; or
>
> - has significantly reduced aesthetic, intrinsic or other indirect uses provided by natural resources; or, in combination with either of these,

- has resulted in the continued presence of oil on lands integral to the use of special-purpose lands[1].

This definition covers a wide range of potentially injured natural resources services. Examples are commercial fishing, subsistence hunting, fishing and gathering, wildlife viewing, sport fishing, and recreation, which includes a variety of activities, such as kayaking and backcountry camping.

Indirect uses, such as aesthetics or appreciation of wilderness qualities, were also affected by the spill. This is a particular concern for those areas which formally have been designated as wilderness areas by the United States or the State of Alaska.

Recovery Concept

To maximize the benefits of restoration expenditures, the Trustees may consider the effects of natural recovery before investing restoration dollars. In a scientific sense, full ecological recovery has been achieved when the pre-spill flora and fauna are again present, healthy and productive, and there is a full complement of age classes. A fully recovered ecosystem is one which provides the same functions and services as were provided by the pre-spill, uninjured system.

The ability to determine scientifically if recovery has occurred or when it will occur may be limited, due to such problems as the quality and quantity of information on pre-spill, "baseline" conditions. For each injured resource and service, however, an estimation of the rate of natural recovery will be considered based on the best information available from the damage assessment and restoration studies, the scientific literature and other sources. If it appears that recovery will be nearly complete before the benefits of a restoration study or project can be realized, then the Trustees may determine that spending restoration dollars is not justified. On the other hand, if it appears that the time to recovery is prolonged, it may be worth considering technically feasible, cost-effective restoration options.

[1] "Special-purpose" lands have been designated by the State of Alaska or the United States for the protection and conservation of natural resources and services.

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CHAPTER VI
EVALUATION OF RESTORATION OPTIONS

To aid in determining which of the many restoration alternatives and options are appropriate and most beneficial, objective criteria are needed. The following are proposed for public comment (not in order of priority):

- The effects of any other actual or planned response or restoration actions:

  Are there other actions, such as additional clean-up work, that bear on the recovery of a resource targeted by the restoration option?

- Potential to improve the rate or degree of recovery:

  Will implementation of the restoration option make a difference in the recovery of an injured resource or service? What is the prospect for success?

- Technical feasibility:

  Are the technology and management skills available to successfully implement the restoration option in the environment of the oil-spill area?

- Potential effects of the action on human health and safety:

  Are there hazards to or adverse impacts on humans associated with implementation of the restoration option?

- The relationship of the expected costs of the proposed actions to the expected benefits:

  Do benefits equal or exceed costs? (This is not intended to be a straight cost/benefit analysis, but a broad consideration of the direct and indirect costs [including lost uses] and the primary and secondary benefits associated with implementation of the restoration option.)

- Cost effectiveness:

  Does the restoration option achieve the desired objective at the least cost?

- Consistency with applicable Federal and State laws and policies:

  Is the restoration option consistent with the directives and policies with which the Trustee agencies must comply? Potential conflicts must be resolved prior to implementation.

- Potential for additional injury resulting from proposed actions, including long-term and indirect impacts:

  Will implementation of the restoration option result in additional injury to target or nontarget resources or services? Is the project of net environmental benefit?

- Degree to which the proposed action enhances the resource or service:

  Would the restoration option improve on or create additional natural resources or services?

- Degree to which proposed action benefits more than one resource or service:

  Would the restoration option benefit multiple resources and services, both injured target resources and services, as well as secondary resources and services?

- Importance of starting the project within the next year:

  Would delay in the project result in further injury to a resource or service or would we forego a restoration opportunity?

Further Evaluation of Restoration Options

As an example of the preliminary application of these criteria, some potential restoration activities are presented as options in Appendix B. Following public comment on the Restoration Framework, including any suggestions of additional criteria and options, there will be more detailed evaluations of all potential options. The draft Restoration Plan and draft environmental impact statement will present the results of these evaluations, including restoration alternatives, for further public comment.

Information Review and Evaluation

To develop the draft Restoration Plan and draft environmental impact statement, the restoration planning staff will review existing databases for each injured resource or service. Data relevant to this evaluation may be found in the scientific literature, geographic information systems and the reports of damage assessment and restoration studies. Subject areas include:

- the nature and severity of injury;
- the rate of natural recovery;
- life history requirements;
- factors limiting recovery;
- persistence of contaminants;
- opportunities to accelerate the rate of recovery;
- costs and environmental impacts of accelerating recovery; and
- land status and existing management practices.

For some injured resources and services, much of the above information is in hand; in other cases there are substantial deficiencies in the databases that could impede the evaluation and timely implementation of restoration options. To remedy this, additional field work is being recommended to provide the needed information. Detailed study plans for work considered in 1992 are found in the 1992 Work Plan. These study plans were developed in consultation with scientists representing the Trustee agencies, outside peer reviewers and the Chief Scientist.

Evaluation of Options for Identifying and Protecting Marine and Upland Habitats

All restoration options, including habitat protection and acquisition options, will be evaluated using basic criteria such as those outlined in the first section of this chapter (VI). By necessity, however, there are additional steps needed to properly evaluate habitat protection and acquisition options.

In its draft 1991 Restoration Work Plan (56 Fed Reg. 8902-8903, [March 1, 1991]), the Trustees set forth a preliminary sequence of steps for use in identifying and protecting strategic fish and wildlife habitats and recreation sites. While the Trustees are developing a final process for evaluating habitat protection and acquisition options, they again invite public comment on the steps that were published in the March 1, 1991 Federal Register notice:

1. Identification of key upland habitats that are linked to the recovery of injured resources or services by scientific data or other relevant information.

2. Characterization and evaluation of potential impacts from changed land use in relation to their effects on recovery of the ecosystem and its components; comparative evaluation of recovery strategies not involving acquisition of property rights (e.g., redesignation of land use classification), including an assessment of protection afforded by existing law, regulations and other alternatives.

3. Evaluation of cost-effective strategies to achieve restoration objectives for key upland habitats, identified through steps one and two above. This would include evaluation of other restoration alternatives for these resource injuries.

4. Willing seller/buyer negotiations with private landowners for property rights.

5. Incorporation of acquired property rights into public management.

Recovery Monitoring

In 1991 the Restoration Planning Work Group began to develop an integrated long-term monitoring strategy to assess the recovery of injured natural resources in the oil-spill area. Development of a monitoring plan requires the identification of goals and objectives and then technical designs and costs for monitoring target resources and services. If the Trustees implement a program of this type, it would determine if and when injured resources have been restored to their pre-spill baseline conditions. The program also could monitor the effectiveness of restoration activities, detect latent injuries and reveal long-term trends in the environmental health of ecosystems affected by the oil spill. The duration of the monitoring program would depend on the severity and duration of effects resulting from the spill and the time necessary to establish a trend for recovery.

Some limited monitoring studies are proposed to be conducted in the field in 1992 (see draft 1992 Work Plan). At the same time, efforts will continue to develop a comprehensive and integrated monitoring program as part of the draft Restoration Plan.

CHAPTER VII
SCOPE OF POTENTIAL RESTORATION ALTERNATIVES

The restoration-related activities conducted by the Trustees and the Environmental Protection Agency to date have involved the public, technical experts and resource managers from agencies in Alaska (See Chapters I and III). Through these preliminary scoping efforts, a broad array of ideas for restoration activities has been suggested. The ideas listed in Restoration Planning Following the *Exxon Valdez* Oil Spill: 1990 Progress Report (Chapters II and VI) were evaluated by the planning staff using the criteria outlined in Chapter VI of this document. The results of this evaluation, which incorporate what has been learned from the damage assessment and restoration studies, are presented as restoration options in Appendix B.

The draft Restoration Plan and draft environmental impact statement will contain a more detailed presentation of restoration alternatives and options after further technical review and consideration of the public comments received on this framework document. The restoration options presented in Appendix B will be considered by the Trustees in developing restoration alternatives, which will be presented for public comment.

Possible Restoration Alternatives

Paragraphs A-F identify possible conceptual restoration alternatives. These alternatives are provided for discussion purposes only and do not indicate any preference by the Trustees.

A. No Action

A possible alternative that will be addressed in the draft environmental impact statement is for the Trustees to rely upon the natural recovery process to restore the ecosystem. Monitoring would assess whether natural recovery is proceeding as anticipated.

B. Management of Human Uses

This alternative uses Federal and State management authorities (statutes and regulations) to modify human uses of resources or habitats. The goal is to reduce mortality or stress on injured resources and thereby to accelerate their recovery.

Examples:

- restrict or eliminate legal harvests of marine and terrestrial mammals and sea ducks (Option 8, Appendix B); and

- intensify management of fish and shellfish (Option 2).

C. Manipulation of Resources

This alternative includes measures taken directly, usually on-site, to rehabilitate or replace an injured species population, restore a damaged habitat or enhance services provided by a damaged resource.

Examples:

- improve or supplement stream and lake habitats for spawning and rearing of wild salmonids (Option 11); and

- accelerate recovery of upper intertidal *Fucus* zone (Option 14).

D. Habitat Protection and Acquisition

This alternative includes changes in management practices on public or private lands and creation of "protected" areas on existing public lands in order to prevent further damage to resources injured by the *Exxon Valdez* oil spill. Going beyond land management practices, there also are options that involve the acquisition of damaged habitats or property rights short of title by public agencies to protect strategic wildlife, fisheries habitat or recreation sites.

Examples:

- designate protected marine habitats (Option 22); and

- acquire additional marine bird habitats (Option 23).

E. Acquisition of Equivalent Resources.

"Acquisition of equivalent resources means to compensate for an injured, lost, or destroyed resource by substituting another resource that provides the same or substantially similar services as the injured resource" (56 Federal Register 8899 [March 1, 1991]). Restoration approaches, such as the manipulation of resources and habitat protection and acquisition, can be implemented on an equivalent-resource basis.

Another possible alternative, therefore, would be to place primary emphasis upon the acquisition of equivalent resources as opposed to options that attempt to directly restore or rehabilitate specific injured resources or services.

Examples:

- creation of new recreation facilities (Option 12); and

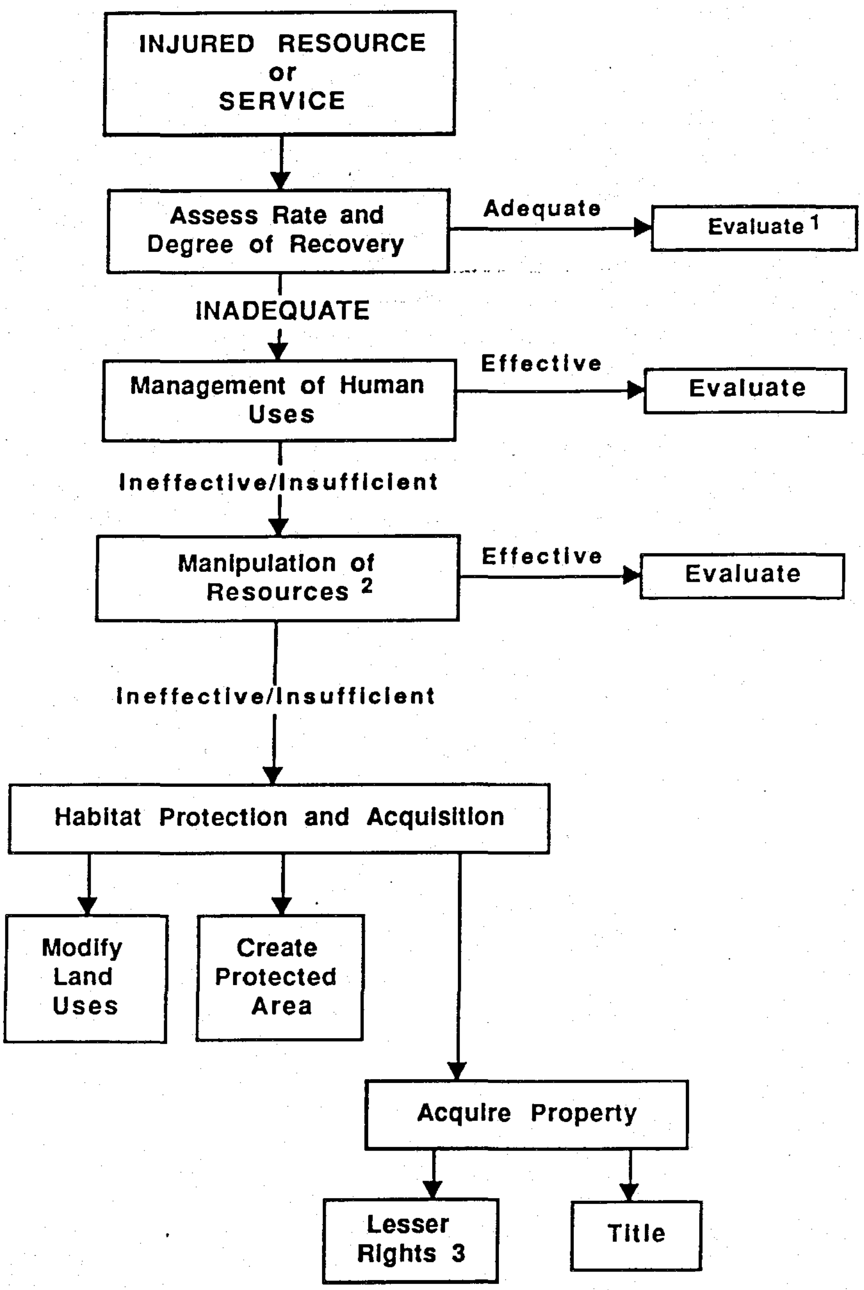
- acquire tidelands (Option 21).

F. Combination Alternatives

Each of the alternatives above, A-E, may be considered strictly in its own right, or mixed in any number of ways, depending on priorities and methods. For example, Figure 6 depicts a hierarchical analysis, through which the Trustees could consider "habitat protection and acquisition" options only after considering whether options under "management of human uses" and "manipulation of resources" were inadequate. In the analysis illustrated in Figure 7, the Trustees would give equal weight to all approaches, proceeding to those restoration options deemed most desirable based on professional and scientific judgment and public comments.

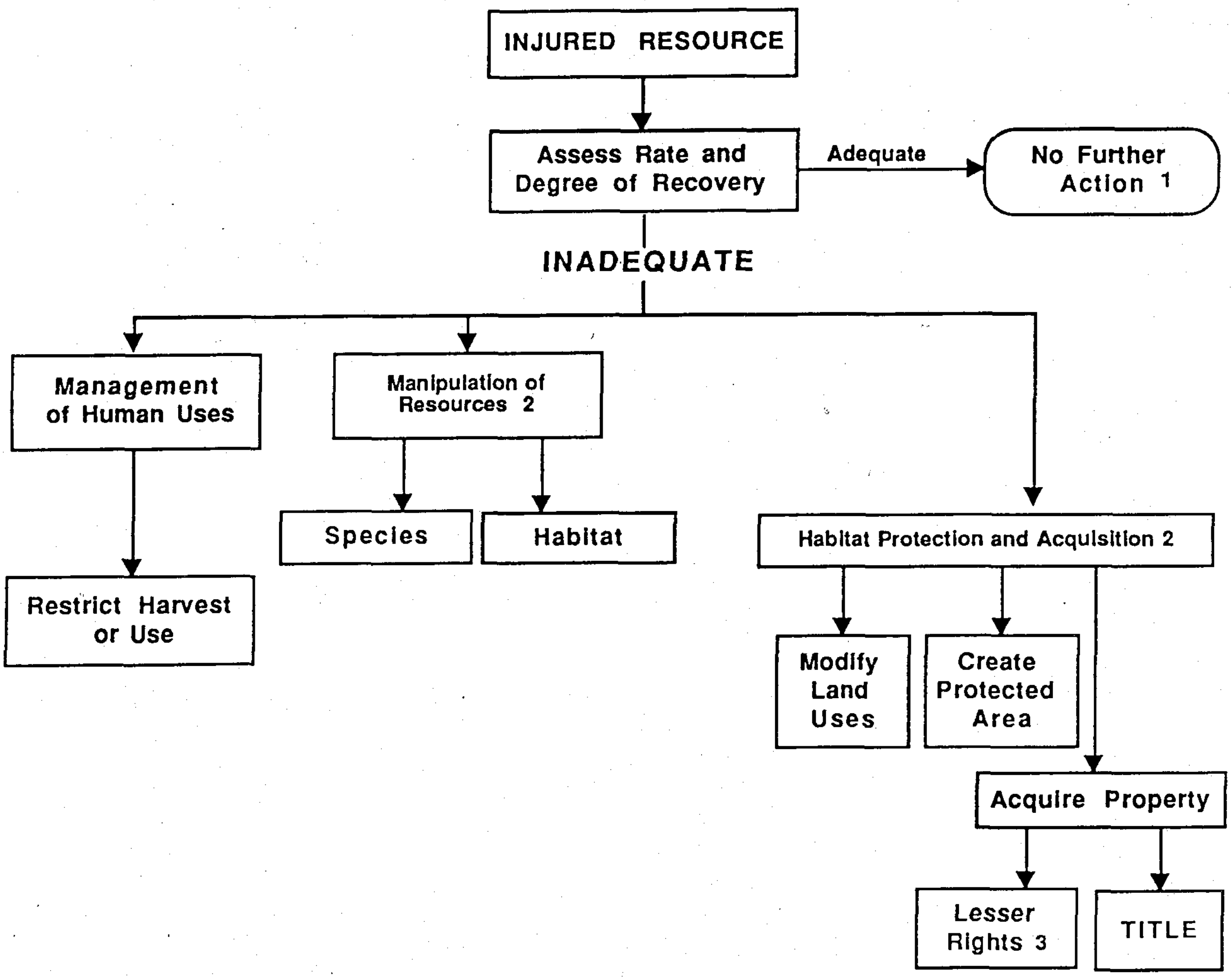
The Trustees seek comment about the likely feasibility and efficacy of these possible restoration alternatives, and any other alternatives and approaches that should be considered in a draft environmental impact statement.

Figure 6. Possible conceptual approach to the analysis of restoration options. This approach considers options in an hierarchical fashion.



1 All restoration actions will be evaluated to assess their effectiveness on the recovery rate of the target injured resource.
2 These approaches can be implemented on a direct-restoration or equivalent-resource basis.
3 Acquisition of full title or lesser rights exclusive of full ownership of title (partial interests), e.g., conservation easement, timber rights, access rights, etc.

Figure 7. Possible conceptual approach to the analysis of restoration options. This approach does not involve an hierarchical analysis of restoration options.



1 All restoration actions will be evaluated to assess their effectiveness on the recovery rate of the target injured resource.
2 These approaches can be implemented on a direct-restoration or equivalent-resource basis.
3 Acquisition of full title or lesser rights exclusive of fullownership of title (partial interests), e.g., conservation easement, timber rights, access rights, etc.

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APPENDIX A

BACKGROUND ON INJURED RESOURCES AND SERVICES

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APPENDIX A
BACKGROUND ON INJURED RESOURCES AND SERVICES

The success of developing and implementing restoration options depends, in large measure, on our understanding of the injured resources and services. This appendix provides a summary of the basic life history traits of the injured species and the characteristics and values of other injured or lost resources and services. This information provides a basis to better understand and evaluate the restoration options and alternatives (Chapter VI and Appendix B).

Life History Summaries

Many of the species affected by the *Exxon Valdez* oil spill have not been extensively studied, especially in subarctic environments. Each species has developed a unique set of characteristics enabling it to survive in its environment. Biologically informed decisions will decrease the chances of causing additional injury and increase the probability of successfully restoring populations. The following life histories are included:

- sea otter
- harbor seal
- brown bear
- river otter
- killer whale
- common murre
- harlequin duck
- black oystercatcher
- marbled murrelet
- pigeon guillemot
- bald eagle
- coastal cutthroat trout
- pink salmon
- sockeye salmon
- pacific herring
- rockfish
- Dolly Varden
- spot shrimp

Sea Otter *(Enhydra lutris)*

Range

Sea otters presently occur in the coastal waters of central California throughout the southern coast of Alaska from Southeast to the Aleutian Islands. The range extends to the Kamchatka Peninsula and south to Japan. Sea otter habitat is found throughout the oil-spill area.

Reproduction

Male sea otters reach sexual maturity at 5-7 years of age; females are capable of breeding at 4-5 years of age and possibly younger. Mating and pupping occur throughout the year, although in Prince William Sound most otters mate in September-October with pups born from May-June. They are capable of reproducing annually, although the reproductive period varies among individuals and areas. Sea otters give birth to a single pup, rarely twins. Pups are generally weaned by mid-November.

Habitat Use and Requirements

Sea otters prefer shallow coastal waters that are generally less than 40 meters deep, with soft substrates as well as rocky substrates. Sea otters will use kelp beds as resting areas, but their geographic distribution is not dependent on kelp. Intertidal rocks, exposed beaches and algal covered rocks are used by some otters for resting. The importance of haul-out sites is poorly understood. They are not considered essential to otter survival in California, but may be very important for otters in northern climates. Males and females tend to segregate except during breeding. Immature and non-breeding males often congregate in large groups. Resident males defend territories during the breeding season. Protected waters on lee shorelines are often used by sea otters during storms.

Food Habits

Sea otters eat a wide variety of prey, and can greatly influence prey availability. They prefer benthic invertebrates, but in some areas they prey heavily on benthic fishes. In Prince William Sound, clams, mussels and crabs are the dominant prey. There is a lot of variation in individual diets. Females with pups tend to forage in shallower areas where smaller mussels and clams are available in short dives from the surface.

Human Interactions

By the late 1800s, sea otters were eliminated from most of their historic range due to excessive fur harvesting by the Russian and American fleets. In 1911, commercial sea otter harvesting was stopped and the remnant populations began to expand. The Marine Mammal Protection Act of 1972 placed a moratorium on harvesting marine mammals, including sea otters. An exemption for Alaska

Natives allows take for subsistence purposes.

References

Alaska Department of Fish and Game. 1985. Sea otter. pages 119-130 *in* Alaska habitat management guide. Life histories and habitat requirements of fish and wildlife. Alaska Dept. Fish Game, Juneau, AK 429 pp.

Jameson, R.J. 1989. Movements, home range, and territories of male sea otters off central California. Marine Mammal Science 5:159-172.

Reidman, M.L. and J.A. Estes. 1990. The sea otter (*Enhydra lutris*): behavior, ecology, and natural history. U.S. Fish and Wildlife Service, Biological Report 90(14). 126 pp.

Harbor Seal *(Phoca vitulina richardsi)*

Range

Harbor seals are found in coastal waters of the North Pacific Ocean from northern Mexico to Alaska as far north as the Bering Sea. In the western Pacific they occur from Japan to Siberia.

Reproduction

Males and females become sexually mature when they are 3-7 years old. Breeding occurs from late June through July. Harbor seals have a delayed implantation of about 11 weeks, with an actual gestation period of about 225 days. Pups are born between late May and mid-July. Usually a single pup is born. Pups are generally nursed for 3-6 weeks. Sexually mature adults breed annually.

Habitat Use and Requirements

Harbor seals usually occupy coastal waters less than 60 meters deep. Seasonally, they may enter coastal rivers and lakes. They have been recorded as far as 100 kilometers away from the coast. Haul-out areas are especially important for harbor seals. Rocks, isolated beaches with protective cliffs, ice floes, and sand or mud bars are used for resting, pupping and nursing young. Haul-out sites are especially important during the molt, which occurs throughout the summer from June-October, but peaks in late July-September.

Harbor seals have been declining in much of Alaska for unknown reasons since about the mid-1970s.

Food Web Interrelationships

Harbor seals are opportunistic predators and consume a wide variety of fish and invertebrates. Walleye pollock, herring, salmon, eulachon and cephalopods are important prey for seals in the Gulf of Alaska.

Predation - Killer whales, sharks and steller sea lions are known predators. Predation combined with other causes of mortality (disease, starvation, entanglement and hunting) kill about 75 percent of all harbor seals in their first three years of life.

Human Interactions

The Marine Mammal Protection Act of 1972 placed a moratorium on harvesting marine mammals, including harbor seals. An exemption for Alaska Natives allows take for subsistence. Harbor seals are harvested by numerous Alaska villages, but the magnitude of the subsistence harvest is not known. Conflicts with commercial fishermen, competition with humans for food, and disturbance from haul-out sites pose the greatest threats to harbor seals. Seals are especially vulnerable to disturbance during the molt and during pupping, when a separation may cause the mother-pup bond to weaken resulting in the death of the pup.

References

Alaska Department of Fish and Game. 1985. Harbor seal life history and habitat requirements Southwest and Southcentral regions. pages 55-61 in Alaska habitat management guide. Life histories and habitat requirements of fish and wildlife. Alaska Dept. Fish Game, Juneau, AK 429 pp.

Pitcher, K.W. 1980. Food of the harbor seal, *Phoca vitulina richardsi*, in the Gulf of Alaska. Fishery Bulletin 78:544-549.

Brown Bear (*Ursus arctos*)

Range

Brown bears (grizzly bears) once ranged from the Great Plains to northern Alaska. They are still abundant in Alaska and parts of Canada, but they have been eliminated from most of the southern part of their range. They are found throughout Alaska except on some islands in specific regions of the state.

Reproduction

Brown bears reach sexual maturity between 3.5-9.5 years of age. Females typically produce cubs every 3-4 years, but the breeding interval may be longer for some individuals. Mating occurs between May and July, peaking in early June. The gestation period lasts about 6 months and the cubs, usually two, are born in January during hibernation. Survival of cubs to yearlings (1.5 years old) ranges from 45-69 percent, depending on location. Cubs generally remain with their mother for 2.5 years.

Habitat Use

Bears inhabiting coastal habitats in southcentral/southwest Alaska tend to have home ranges of approximately 32 km^2 for females and 170 km^2 for males. These home ranges cover a wide variety of habitat types, supply food throughout the year and provide denning sites in winter. In the spring, the bears often search the coastline for food. In summer, anadromous fish streams provide important food sources for the bears and many bears may be found congregated together at streams with exceptionally large salmon runs (e.g., in Katmai National Park). In late summer and fall, upland sites with abundant berries are used in addition to salmon streams. Dens are generally located on well drained moderately sloping mountain sides, leeward of the prevailing winds. Dens are seldom used in consecutive years. Brown bears enter their dens in late October and November and emerge between early April and late May.

Food Habits

Brown bears are omnivores. They eat a wide variety of plants including roots and berries of some species and eat sedges and grasses in wetlands. During the spring, brown bears often prey upon young moose, deer and caribou. They feed on clams and mussels in the intertidal zone and scavenge the beaches for dead marine mammals. They are capable of killing adult ungulates. Spawning salmon also provide an important component of their diets.

Human Interactions

Brown/grizzly bears are harvested throughout their range on a limited basis. Habitat alterations and human disturbance near food sources can impact local populations.

References

Alaska Department of Fish and Game. 1985. Brown bear life history and habitat requirements Southwest, Southcentral, and Arctic regions. pages 149-163 _in_ Alaska habitat management guide. Life histories and habitat requirements of fish and wildlife. Alaska Dept. Fish Game, Juneau, AK 429 pp.

Ballard, W.B. 1982. Home range, daily movements, and reproductive biology of brown bear in Southcentral Alaska. Canadian Field Naturalist 96:1-3.

Jonkel, C.J. 1987. Brown Bear. _in_ M. Novak, J.A. Baker, M.E. Obbard and B. Malloch, eds. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario

Peterson, J. 1991. Swikshak coastal report. Unpublished report. Katmai National Park and Preserve.

Smith, R.B. and L.J. VanDoele. 1991. Final report on Brown Bear Studies (1982-1986) Terror Lake Hydroelectric Project, Kodiak Island, Alaska. Alaska Department of Fish and Game, Juneau, AK. 188 pp.

River Otter (*Lutra canadensis*)

Range

Historically, river otters were found throughout North America with the exception of the arid southwest. In Alaska they are found in all areas except the Aleutian Islands, the off-shore islands of the Bering Sea, and the Arctic coast east of Point Lay. Their Alaskan distribution remains unchanged, although they are no longer found in parts of their original range in the contiguous United States.

Reproduction

River otters reach sexual maturity in 2-3 years, although males are usually unsuccessful breeders until they are 5-7 years old. Mating occurs in early spring with adult females breeding shortly after giving birth. Otters have delayed implantation with an actual gestation period of 60-63 days. Most births in Alaska occur in May. Litter size varies from 1-6, but litters of 2 to 3 are most common. Pups remain in the den for about 2 months before accompanying the mother in daily activities. Family groups often include one or more females who help with training the new pups. These females are probably offspring of the mother's previous litters. Male pups probably leave the family group at about 1 year of age. Otters can breed annually once they become mature and they may live to be 20 years old.

Habitat Use

In coastal Alaska, river otters tend to have elongated home ranges which follow the coastline. Rocky shorelines of small inlets and coves are preferred. Ranges of males may overlap with females, but otters generally avoid contact except during the breeding season. Riparian vegetation along the coast and inland by streams and lakes are important areas for otters. These sites provide resting and denning places, as well as protective cover for traveling. Den sites are located in natural cavities in old-growth forests or in rock cavities, or in burrows or lodges of other animals. Latrine sites are established along the shoreline in areas of old growth forest and adjacent to suitable feeding areas. These sites are used as resting areas as otters travel along their home ranges. Home ranges vary with the quality of habitat. Ranges reported for southeastern Alaska varied from 7 to 40 kilometers. Family groups have smaller ranges than adult males.

Food Habits

River otters in coastal Alaska feed primarily in intertidal and shallow subtidal areas, but they also feed in fresh water streams and lakes if fish are available. Boney fish are the most important part of their diet but crusteans and molluscs are also important. In British Columbia, surfperch, sculpin, flounder, rockfish and greenling were the primary prey of coastal otters.

Human Interactions

River otters are trapped for their fur.

References

Larsen, D.N. 1983. Habitats, movements, and foods of river otters in coastal southeastern Alaska. Unpublished M.S. Thesis, University of Alaska Fairbanks. 149 pp.

Melquist, W.E. and A.E. Dronkert. 1987. River otter. Pages 627-641 *in* M. Novak, J.A. Baker, M.E. Obbard and B. Malloch, eds. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario.

Reid, D.G., W.E. Melquist, J.D. Woolington, and J.M. Noll. 1986. Reproductive effects of intraperitoneal transmitter implants in river otters. Journal of Wildlife Management 50:92-94.

Solf, J.D. 1989. Land otter. Wildlife Notebook Series, Alaska Dept. Fish and Game.

Stenson, G.B., G.A. Badgero and H.D. Fisher. 1984. Food habits of the river otter *Lutra canadensis* in the marine environment of British Columbia. Canadian Journal of Zoology 62:88-91.

Woolington, J.D. 1984. Habitat use and movements of river otters at Kelp Bay, Baranof Island, Alaska. Unpublished M.S. Thesis, University of Alaska Fairbanks, 147 pp.

<u>Killer Whale</u> <u>(*Orcinus orca*)</u>

Range

Killer whales have been documented in all the oceans of the world. They appear to be abundant in the coastal waters from Washington through the Gulf of Alaska.

Reproduction

Killer whales are a long-lived species with lifespan estimates ranging from 25-40 years. Females reach sexual maturity when they reach about 5 meters in length (approximately 15 years old). They give birth to a single calf after an estimated gestation period of 17 months. Cows will nurse their calves for 12 months and provide additional care for 2 years or longer. The interval between calves varies among individuals with a mean of about 5 years (range 2-12).

Social Structure and Habitat Use

Killer whales live in social groups called pods. Pods usually consist of less than 40 animals. There are two types of pods. Transient pods do not occupy a defined home range. They move in and out of areas occupied by resident pods and may cover great distances throughout the year. Resident pods have home ranges which may encompass several hundred square miles. In resident pods the whales form matrilineal subgroups. The matrilineal group consists of a female and her offspring. New matrilineal groups may form as a female calf matures and produces her own offspring, but the group remains within the original pod. Matrilineal groups of the same pod interact with each other on a regular basis.

Food Habits

Killer whales are opportunistic predators. Fish are the primary food source for whales in resident pods, but marine mammals and birds are also prey. Salmon, cod, Pacific herring, flatfish, blackcod, squid, pinnipeds and other cetaceans have all been documented as food sources for killer whales. Transient pods may prey on marine mammals more than do whales in resident pods.

Human Interactions

The Marine Mammal Protection Act of 1972 placed a moratorium on harvesting marine mammals, including killer whales. Some whales are still shot, and sometimes killed, by fishermen. Their striking appearance have made them an attraction for tourist industries.

References

Bigg, M.A, P.F. Olesiuk, G.M. Ellis, J.K.B. Ford and K.C. Balcomb III. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Paper SC/ADD/ID39 in Individual recognition of cetaceans: Use of photo-identification and other techniques to estimate population parameters. Report of the International Whaling Commission (Special Issue 12). pp. 383-405.

Loh-Lee Low (editor). 1991. Status of living marine resources off Alaska as assessed in 1991. National Oceanic and Atmospheric Administration Technical Memo. NMFS-F/NWC-211. 95 pp.

Heyning, J.E. and M.E. Dahlheim. 1988. *Orcinus orca.* pages 1-9 in Mammalian Species. American Society of Mammologists.

Olesiuk, P.F., M.A. Bigg, and G.M. Ellis. 1990. Life history and population dynamics of resident killer whales *(Orcinus orca)* in the coastal waters of British Columbia and Washington State. Paper SC/A88/ID3 in Individual recognition of cetaceans: Use of photo-identification and other techniques to estimate population parameters. Report of the International Whaling Commission (Special Issue 12). pp. 209-243.

Common Murre (*Uria aalge inornata*)

Range

The species has a holarctic distribution primarily south of the Arctic Circle. The subspecies *U. a. inornata* is found from Oregon to Point Hope, Alaska.

Migration

Murres winter in offshore waters before returning to their nesting colonies in the spring.

Breeding Chronology

Murres arrive at nesting colonies in April and May. A single egg is laid in June and incubated by both adults for 28-34 days. Hatching occurs between July 10 and early August. Chicks fledge to the ocean in August. Little is known about the behavior of fledged chicks and subadults. Common murres do not breed until they are 5 years old or older, and subadults do not return to visit the colonies until they are 2-3 years old.

Breeding Behavior

The breeding success of common murres is dependent on the physical characteristics of the colony site, which typically is on a cliff face, and the density of murres nesting on each ledge. Since murres do not build nests, the slope of the nesting ledge is important to prevent the eggs from rolling off the cliff. The width of the ledge influences the number of birds that can nest and therefore, their vulnerability to predation. High nesting densities (greater than 10 birds per meter^2) have the greatest breeding success. Higher densities help to synchronize breeding behavior so that eggs are laid over a short period of time and chicks hatch and fledge together. This increases the ability of the murres to protect their young from predators. Most murres return to the same ledge to breed each year.

Food Web Interrelationships

Common murres eat a variety of fish and shrimp. Primary species include capelin, sand lance, walleye pollock and euphausiids.

Predation - Predatory birds, particularly gulls and bald eagles, can have a significant impact on the breeding success of the colonies. Low nesting densities of murres, chicks which hatch and fledge later than their neighbors, and eggs or chicks exposed when the adults are disturbed from the ledges are especially vulnerable.

Human Interaction

Entanglement in fishing nets does not appear to be a problem for murre colonies within the *Exxon Valdez* oil spill area. Fishing and tourism activities which disturb the murres at their nesting ledges can exacerbate predation. Subsistence harvest of the eggs and murres is not common within the oil-spill area.

References

Birkhead, T.R. 1977. The effect of habitat and density on breeding success in the common guillemot (*Uria aalge*). Journal of Animal Ecology. 46:751-764.

Birkhead, T.R., E. Greene, J.D. Biggins, and D.N. Nettleship. 1985. Breeding site characteristics and breeding success in thick-billed murres. Canadian Journal of Zoology 63:1880-1884.

Hatch, S.A. and M.A. Hatch. 1989. Attendance patterns of murres at breeding sites: implications for monitoring. Journal of Wildlife Management 53:483-493.

Sanger, G.A. 1986. Diets and food web relationships of seabirds in the Gulf of Alaska and adjacent marine regions. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, OCSEAP Final Report 45:631-771.

Tuck, L.M. 1960. The murres. Canadian Wildlife Series:1. Queen's Printer, Ottawa.

Williams, A.J. 1974. Site preferences and interspecific competition among guillemots *Uria aalge* (L) and *Uria lomvia* (L.) on Bear Island. Ornis Scandinavia. 5:113-121

Wynne, K., D. Hicks and N. Munro. 1991. 1990 Salmon gillnet fisheries observer programs in Prince William Sound and South Unimak Alaska. Report to National Marine Fisheries Service. Saltwater Inc. Anch. Alaska. 72 pp.

Harlequin Duck *(Histrionicus histrionicus)*

Range

In North America, the western population is found from the Seward Peninsula and the Alaska Range, throughout the Aleutian Islands and south to central California and the northern Rocky Mountains.

Migration

In Alaska, harlequin ducks begin arriving on their wintering grounds in the Aleutian Islands and in the Gulf of Alaska in mid to late September. Adults begin congregating at the mouths of suitable breeding streams in May.

Breeding Chronology

Harlequins do not breed until their second year. Egg laying begins between May 20 and June 10. Three to 7 eggs are incubated by the female for 28-30 days. The males leave the females early in the incubation period and begin congregating for the molt. Hatching occurs from early to mid-July. Females with broods remain in freshwater streams until August when they migrate to marine habitats. Adults breed annually after reaching maturity.

Habitat Use

Paired harlequins congregate at the mouths of anadromous fish streams in May. The pairs fly inland to search for nesting sites but return to estuaries to feed. Typically nests are located along shallow rivers and streams with gravel or rocky substrates, and nest sites are located under dense vegetation on steep banks in mature forests. Harlequins may return to the same nest site in consecutive years. Slow stretches on lee sides of stream bends are used by broods for feeding and resting. Turbulent stretches of streams are preferred feeding places for adults in freshwater. Shallow coastal areas and intertidal reaches are used by non-breeders and males during the summer and by molting females in late summer. Wintering harlequins forage in small groups along exposed coasts and in bays.

Food Web Interrelationships

Breeding birds and broods feed mostly on aquatic invertebrates and larvae. When available, salmon roe may be an important food source for harlequins in Alaska. Wintering harlequins feed predominately on molluscs and crustaceans.

Human Interactions

Harlequin ducks can be legally harvested each fall. Disturbance to molting flocks may stress individuals, and both disturbance and loss of nesting habitat can affect populations.

References

Bellrose, F.C. 1980. Ducks, Geese, and Swans of North America. Stackpole Books. 540 pp.

Bengtson , S.-A. 1966. Field studies on the harlequin duck in Iceland. Wildfowl Trust 17th Annual Report, pp. 79-94.

______ **. 1972.** Breeding ecology of the Harlequin Duck (*Histrionicus histrionicus* L.) in Iceland. Ornis Scandinavia. 3:1-19.

Dzinbel, K. A. and R. L. Jarvis. 1982. Coastal feeding ecology of harlequin ducks in Prince William Sound, Alaska, during summer. pages 6-10. *in* D.N. Nettleship, G.A. Sanger and P.F. Springer Eds. Marine Birds: Their feeding ecology and commercial fisheries relationships. Proceedings of the Pacific Seabird Group Symposium, Seattle, WA.

Kuchel, C.R. 1977. Some aspects of the behavior and ecology of Harlequin ducks breeding in Glacier National Park, Montana. Unpublished M.S. Thesis. University Montana. 130 pp.

Forsell, D.J. and P.J. Gould. 1981. Distribution and abundance of marine birds and mammals wintering in the Kodiak area of Alaska. U.S. Fish and Wildlife Service. OBS-81/13 72 pp.

Inglis, I. R., J. Lazarus, and R. Torrance. 1989. The pre-nesting behavior and time budget of the harlequin duck (*Histrionicus histrionicus*). Wildfowl 40:55-73.

Wallen, R. L. 1987. Habitat utilization by harlequin ducks in Grand Teton National Park. Unpublished M. S. Thesis, Montana State University, Bozeman MT.

<u>Black Oystercatcher (*Haematopus bachmani*)</u>

Range

Inhabits coastal areas from the Aleutian Islands to Baja California.

Migration

Black oystercatchers are generally believed to be year-round residents at their breeding areas. Observations from Alaska, however, indicate that some birds may disperse in the winter.

Breeding Chronology

Nest scrapes are built on rock outcroppings and gravel beaches, and are sometimes lined with broken shells. One to 3 eggs are laid and incubated by both adults for 24-29 days. Eggs are laid from mid-May to early July; second clutches may be laid if the first clutch is destroyed. Although the chicks are precocious, they are fed by the adults. Feeding can continue even after the chicks have fledged. Survivorship of chicks to fledging can be very low, less than 20 percent. They are particularly vulnerable to predation in the first week after hatching. Chicks are capable of flying in about 40 days. Oystercatchers might take 2 or 3 years to reach sexual maturity.

Habitat Use

Oystercatchers occupy rocky and gravelly coastal areas. The highest breeding densities occur on low elevation, gravel shorelines, with little wave action. The eggs and young are cryptically colored and rely on camouflage to protect them from predators. Adults feed in the intertidal zone. During the first week after hatching, chicks remain near the nest site and adults bring food from the intertidal zone. After the first week, chicks follow the adults to the intertidal zone at low tide.

Food Web Interrelationships

Black oystercatchers feed primarily on intertidal invertebrates. Mussels and limpets are the primary prey species, but they also eat clams and chitons.

<u>Predation</u> - Flightless chicks are vulnerable to predation, especially in the first week after hatching. During this time the adults brood the chicks and their movements may alert predators to the location of the chicks. Young chicks react by freezing whereas older chicks will run from predators. Gulls, ravens, mink and river otters are known predators.

Human Interactions

Black oystercatchers are not harvested. Destruction of or disturbance at nesting habitats can adversely impact local populations.

References

Groves, S. 1984. Chick growth, sibling rivalry, and chick production in American black oystercatchers. Auk 101:525-531.

L'Hyver, M. and E.H. Miller. 1991. Geographic and local variation in nesting phenology and clutch size of the black oystercatcher. Condor 93:892-903.

Purdy, M.A. and E.H. Miller. 1988. Time budget and parental behavior of breeding American black oystercatchers (*Haematopus bachmani*) in British Columbia. Canadian Journal of Zoology 66:1742-1751.

Webster, J.D. 1941. Feeding habitats of the black oystercatcher. Condor 43:175-180

______. 1941. The breeding of the black oystercatcher. Wilson Bulletin. 53:141-156.

Marbled Murrelet (*Brachyramphus marmoratus*)

Range

North Pacific Coast, from central California to the Aleutian Islands, and from the Kamchatka Peninsula to northern Japan.

Migration

Marbled murrelets return to coastal waters near breeding areas each spring. The dates are variable, usually occurring in Alaska from April to May. The adults and fledged young leave the breeding areas in the fall for unidentified wintering areas. Between 10-25 percent of the summer breeding population of Prince William Sound remain throughout the winter and probably concentrate in protected bays and straits during storms.

Breeding Chronology

Documented evidence of breeding chronology is based primarily on follicle development of collected birds, documented nests and movements of breeding adults. These data suggest that laying can occur as early as late April in the southern part of their range. Egg laying in the Gulf of Alaska probably occurs in late May or June. Marbled murrelets lay a single egg that is incubated by both adults for about 30 days. Fledged chicks begin to appear with the adults on coastal waters from mid-July to early August. Adult survivorship, life span, reproductive period and age at first breeding are unknown.

Habitat Use and Requirements

During the breeding season, marbled murrelets make crepuscular (twilight) flights between inland and coastal areas. Searches for marbled murrelet nests were unsuccessful until 1974. A total of 23 tree nests have been discovered in North America. Current data suggest that most marbled murrelets nest in mature forests. Most of the nests have been located in large conifers, but ground nests also have been recorded. Marbled murrelets are solitary nesters, and have been located as far as 40-50 kilometers from the coast. Marbled murrelets feed in coastal waters, and occasionally in large lakes. They have been known to dive to a depth of 50 meters.

Food Web Interrelationships

Marbled murrelets eat small fishes and crustaceans. Important species within the Gulf of Alaska and Cook Inlet include capelin, cod, sand lance and a variety of shrimp.

Human Interactions

In 1990 marbled murrelets were the most commonly caught seabird in salmon gillnets in the Prince William Sound Copper River flats drift fishery. Although the number caught represent a very small proportion of the population, these incidental catches may have local significance. The loss of nesting habitat due to logging or development of mature forests could also affect murrelet populations. Population declines over the southern portion of their range have caused the species to be considered for listing under the Federal Endangered Species Act as "threatened" in the Pacific Northwest. The species is already listed as "endangered" in California under State law.

References

Carter, H.R. and S.G. Sealy. 1986. Year-round use of coastal lakes by marbled murrelets. Condor 88:473-477.

______**. 1987.** Inland records of downy young and fledgling marbled murrelets. Murrelet 68:58-63.

Kuletz, K.J. 1988. Relative distribution of Marbled and Kittlitz's murrelets in Kachemak Bay, Alaska. Abstract. Pacific Seabird Group Bulletin 16:60.

Nelson, S. K., and T. Hamer. 1992. Nest site characteristics of marbled murrelets in the Pacific Northwest. Abstract. Pacific Seabird Group, Annual Meeting.

Reed, P., and C. Wood. 1991. Marbled murrelet chick and eggshell fragment from inland Washington. Northwest Naturalist. 72:77-78.

Sanger, G.A. 1986. Diets and food web relationships of seabirds in the Gulf of Alaska and adjacent marine regions. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, OCSEAP Final Report 45:631-771.

Sealy, S.G. 1974. Breeding phenology and clutch size in the marbled murrelet. Auk 91:10-23

Wynne, K., D. Hicks and N. Munro. 1991. 1990 Salmon gillnet fisheries observer programs in Prince William Sound and South Unimak Alaska. Report to National Marine Fisheries Service. Saltwater Inc. Anch. Alaska. 72 pp.

Pigeon Guillemot (*Cepphus columba*)

Range

Pigeon guillemots are found along the north Pacific coast from southern California to the Bering Sea and Aleutian Islands in Alaska. They are also found from the Chukchi Sea to northern Japan.

Migration

Migration patterns are largely unknown in Alaska. They arrive at breeding areas in late April and early May, and depart from Prince William Sound for wintering grounds in late August. Some guillemots remain in the Sound throughout the winter.

Breeding Chronology

In Prince William Sound, pigeon guillemots have been documented on their breeding areas in late April and the peak of egg laying occurs in June. Clutches normally consist of two eggs which are laid 3 days apart. Eggs are incubated for 30-32 days by both adults. Chicks hatch between late June and late July. Fledging occurs approximately 38 days after hatching. Pigeon guillemots probably do not begin breeding until they are 3-5 years of age.

Habitat Use and Requirements

Guillemot nests are usually located in natural cavities beneath boulders at the base of cliffs, in talus slopes, or in rock or soil cavities at the tops of cliffs. They are also known to nest in abandoned puffin burrows, and are probably the only alcid known to regularly use man-made structures (e.g., docks and bridges) for nesting. Guillemots typically nest in small colonies of a few to 50 pairs; some pairs nest solitarily. At some locations adequate nest sites probably determine the breeding bird density, but they do not appear limiting in Prince William Sound. The adults use the supratidal and intertidal areas in front of the nest sites for social activities (e.g., pair-bond maintenance) and feeding throughout the breeding season.

Pigeon guillemots feed in nearshore waters, generally no more than a few kilometers from land. During the breeding season they tend to feed near their colony, and individuals are often site specific. During winter most of the population leaves for unknown waters. In Prince William Sound an estimated 27-43 percent of the summer population were present in March.

Food Habits

This species has a generalist feeding behavior, consuming a variety of fish and shellfish. Capelin, sand lance, Pacific sandfish, sculpin and herring are some of the more important species, as well as shrimp and small crabs. Dietary preference can vary significantly between individuals.

Human Interactions

Because of their nearshore foraging habits and small, stable colonies, pigeon guillemots are considered a good indicator species for the nearshore marine environment.

References

Divoky, G.J. 1992. Age of recruitment and recruitment potential in relation to nest-site availability in the black guillemot. Pacific Seabird Group. Abstract 7. Charleston, OR.

Eldridge, W.D. and K.J. Kuletz. 1980. Breeding and feeding ecology of pigeon guillemots (*Cepphus columba*) at Naked Island, Alaska. Unpubl. Report U.S. Fish and Wildlife Service.

Kuletz, K.J. 1981. Feeding ecology of the pigeon guillemot (*Cepphus columba*) at Naked Island, Prince William Sound, Alaska and surveys of the Naked Island complex. Unpublished Report U.S. Fish and Wildlife Service.

Kuletz, K.J. 1983. Mechanisms and consequences of foraging behavior in a population of breeding pigeon guillemots. Unpublished M.S. Thesis. University of California, Irvine, 79 pp.

Sanger, G.A. 1986. Diets and food web relationships of seabirds in the Gulf of Alaska and adjacent marine regions. U.S. Dep. Commerce, National Oceanic and Atmospheric Administration, OCSEAP Final Report 45:631-771.

Bald Eagle (*Haliaeetus leucocephalus*)

Range

Bald eagles are found from Alaska and Canada to the northern edge of Mexico. Within Alaska, they are most numerous in the southern coastal regions.

Migration

Eagles in coastal Alaska winter near their nesting territories. Interior nesting birds may move to large open rivers or the ocean. Most will wander during the late fall and early winter in search of prey, such as late spawning salmon.

Reproduction

Adults do not overwinter near their nesting sites that return to the same nesting territory each year. Nests are usually used for more than one breeding season. In high density nesting areas, defended territories are approximately 1 linear mile of coastline, but not all nests will be active or successful. Egg laying begins in early April when the female lays 1-3 eggs with two being the most common clutch size. Incubation lasts about 34 days. In late August, or about 75 days after hatching, the fully feathered young are ready to leave the nest. Fifty percent nest failure is not uncommon. Few eagles successfully fledge their young, and even though the adults continue to feed them for several weeks, survival after fledging is low. Bald eagles become sexually mature when they are 6 years old or older.

Habitat Use

Bald eagles in Alaska nest along lakes, rivers and the coast. Along the coast, nests are usually located in the older, larger trees. Coastal areas with more than one nest per mile are considered to be good nesting areas. This high-nest density is associated with undisturbed habitat, a clean environment, abundant food resources and minimal human disturbance. Bald eagles have few predators other than humans.

Food Habits

Fish are the primary prey of bald eagles, but they will also feed on waterfowl, carrion, sea birds and even on garbage at landfills. Winter and spring can be the critical periods for bald eagles. During the late fall and early winter, eagles will often be seen feeding along rivers where they have access to spawning and dead salmon. During spring they feed on eulachon, spawning herring and sand lance.

Human Interaction

A bounty for bald eagles was in effect in Alaska from 1917 to 1953. With statehood in 1959, bald eagles in Alaska received federal protection under the Bald Eagle Protection Act of 1940. This Act prohibits harming or harassment of eagles. Land management agencies have included additional restrictions on activity near nest sites which has further helped the stability of populations. For example, the Chugach National Forest currently requires a 330 feet buffer zone around any bald eagle nest tree, with an additional 330 feet of restricted activity; the U.S. Fish and Wildlife Service proposes extending restrictions to 990 feet from bald eagle nests.

References

Alaska Department of Fish and Game. 1985. Bald eagle life history and habitat requirements Southwest and Southcentral regions. pages 229-240 *in* Alaska habitat management guide. Life histories and habitat requirements of fish and wildlife. Alaska Department Fish Game, Juneau, AK. 429 pp.

Gerrard, J.M. and G.R. Bortolotti. 1988. The bald eagle, haunts and habits of a wilderness monarch. Smithsonian Institute Press, Washington D.C. 177 pp.

Hodges, J. I. and F. C. Robards. 1982. Observations of 3,850 bald eagle nests in southeast Alaska. Pages 37-46 in W. N. Ladd and P. F. Schempf, eds., Proceedings of a symposium and workshop: Raptor management and biology in Alaska and western Canada. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Imler, R.H., and E.R. Kalmbach. 1955. The bald eagle and its economic status. USDI, Fish and Wildlife Service Circular 30.

Schoen, J. W., M. D. Kirchhoff and J. F. Hughs. 1988. Wildlife and old-growth forests in Southeast Alaska. Natural Areas Journal. Volume 8 (3).

Stalmaster, M.V. 1987. The Bald Eagle. Universe Books. New York, NY. 227 pp.

Coastal Cutthroat Trout (*Onchorhynchus clarki*)

Range

California to Prince William Sound, Alaska

Migration

Smolts and adults migrate to sea between March and July. The time spent at sea varies from 12 to 150 days. While at sea cutthroat trout travel along shorelines rarely migrating farther than 70 kilometers from their natal streams. Adults return to freshwater lakes to overwinter and then migrate to their natal streams to spawn in the spring.

Reproductive Period

Sexual maturity is reached at 2-3 years for males and between 3-6 years for females.

Spawning/Hatching

Spawning takes place from February to May depending on location; hatching occurs 6 to 7 weeks after spawning.

Survival/Life Span

Cutthroat trout have a relatively high rate of survival for adults. Survival rates between spawning migrations were 39 percent from first to second spawning migrations, 17 percent between second and third, and 11 percent from third to fourth.

Habitat Use and Requirements

Adults - In marine environments cutthroat inhabit inshore areas foraging along gravel beaches, mouths of creeks and in eelgrass beds. Adults return to freshwater lakes to overwinter, and then spawn in small coastal streams or small tributaries to coastal streams and rivers.

Fry and Juveniles - Young-of-the-year cutthroat inhabit low-velocity margins, backwaters and side channels adjacent to main channel pools and riffles. They tend to stay close to where they were spawned. Older juveniles have a greater range of movement within their natal stream.

Food Web Interrelationships

Adults - Adults in marine waters feed on a variety of small fish and shrimp.

Fry and Juveniles - Fry feed primarily on insects and crustaceans. Larger sized juveniles prey on small sticklebacks and salmon.

Predation - In marine waters cutthroat may be preyed upon by Pacific hake, spiny dogfish, harbor seals and adult salmon.

Human Interactions

Cutthroat trout are not fished commercially in Alaska. They are a highly prized sport fish and are susceptible to overharvest due to small stock sizes. Anadromous cutthroat populations have declined during the past 15-20 years. Reasons cited for these declines include loss of stream habitat due to logging activities and increased urbanization.

References

Emmett, R.L., S.L. Stone, S.A. Hinton, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries, Volume II: species life history summaries. ELMR Report No. 8. National Oceanic and Atmospheric Administration/NOS Strategic Environmental Assessments Division, Rockville, MD, 329 pp.

Pauley, G.P., K. Oshima, K.L. Bowers, and G.L. Thomas. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) -- Sea-run cutthroat trout. U.S. Fish and Wildlife Service Biological Report 82(11.26). U.S. Army Corps of Engineers TR EL-82-4. 21 pp.

Giger, R. 1972. Ecology and management of coastal cutthroat trout in Oregon. Oregon State Game Commission, Fishery Research Report No. 6. Corvallis, OR.

Sumner, F. H. 1953. Migrations of salmonids in Sand Creek, Oregon. American Fisheries Society 82:139-150.

Armstrong, R. H. 1971. Age, food, and migration of sea-run cutthroat trout, *Salmo clarki*, at Eva lake, southeastern Alaska. Transaction American Fisheries Society 2:302-306.

Trotter, P. C. 1989. Coastal cutthroat trout: a life history compendium. Transactions American Fisheries Society. 118:463-473.

<u>Pink Salmon (*Oncorhynchus gorbuscha*)</u>

Range

Pacific Ocean north of 40° N Latitude.

Migration

Fry emerge from streams from late March through June and rapidly move to feeding areas in nearshore migratory corridors. After about 8 weeks, fry move to offshore waters where they mature for 12-15 months before returning to natal streams to spawn.

Reproductive Period

Mature at 2 years. Adults die after spawning.

Spawning/Hatching

Spawning occurs from June to mid-September; hatching occurs in October - January.

Survival/Life Span

Typical egg to fry survival is 5-10 percent; fry to adult survival is from 2-5 percent. The life cycle is complete in 2 years.

Habitat Use and Requirements

<u>Adults</u> - Migrate to the high seas where they mature. Adult pink salmon return to natal streams to spawn and some travel considerable distances upstream. However, in Prince William Sound as much as 75 percent may spawn in the intertidal zone. Spawning redds (egg nests) are mostly built in riffles with gravelly substrates and water velocity of 35-45 centimeters per second. All adults die after spawning.

<u>Fry and Juveniles</u> - Fry spend very little time in freshwater; they migrate to nearshore marine waters soon after emerging. When they reach approximately 7 centimeters in length, in approximately 8 weeks, they migrate to offshore waters. Virtually all fry in Prince William Sound migrate and feed along the western shore of the sound.

Food Web Interrelationships

<u>Adults</u> - Primary prey include euphausiids, squid and other invertebrates and small fishes.

<u>Fry and Juveniles</u> - In nearshore nursery areas, fry feed on copepods and other

zooplankton. Juveniles eat larger invertebrates and small fishes.

Predation - Eggs, alevins and fry are eaten by cutthroat trout, Dolly Varden, coho salmon, other fishes and aquatic birds. Juvenile and adult salmon in offshore areas are consumed by a variety of predatory birds, marine mammals, and predatory fishes including other salmon. Bears, otters, other mammalian and avian predators eat spawning salmon.

Human Interactions

Wild and hatchery pink salmon are the basis for multi-million dollar fisheries and often occur together in mixed stock harvests. Hatchery runs established to augment natural production and enhance fisheries can sustain a higher harvest rate, and may pose a threat to important wild pink salmon populations if stock-specific management practices are not implemented to protect wild stocks.

References

Alaska Department of Fish and Game. 1985. Pink salmon life history and habitat requirements Southwest and Southcentral, Arctic, Western and Interior regions. pages 519-536 *in* Alaska habitat management guide. Life histories and habitat requirements of fish and wildlife. Alaska Department Fish Game, Juneau, AK 429 pp.

Emmett, R.L., S.L. Stone, S.A. Hinton, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries, Volume II: species life history summaries. ELMR Report No. 8. National Oceanic and Atmospheric Administration/NOS Strategic Environmental Assessments Division, Rockville, MD, 329 pp.

Pauley, G.P., K. Oshima, K.L. Bowers, and G.L. Thomas. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) -- Pink salmon. U.S. Fish and Wildlife Service Biological Report. 82(11.26). U.S. Army Corps of Engineers TR EL-82-4. 18 pp.

Sockeye Salmon (*Oncorhynchus nerka*)

Range

Sockeye salmon occur from northern California to Point Hope, Alaska. They are also found from northeastern Siberia to northern Japan.

Migration

Smolts outmigrate in late spring or early summer, usually after spending 1-2 years in freshwater. For the first few months smolts rear in nearshore marine areas, and by early winter they begin feeding in offshore areas such as the Gulf of Alaska. The fish remain offshore until returning to their natal streams between May and September.

Reproductive Period

They commonly mature in their fifth or sixth year of life, and they die after spawning.

Spawning/Hatching

Spawning typically occurs between July and October. Hatching occurs in mid-winter to early spring with fry emerging from April to June.

Habitat Use and Requirements

Adults - Migrate to offshore waters to feed for 2-3 years before returning to their natal streams to spawn. They spawn on lake shoals and in rivers and streams with lakes or slow moving reaches as part of the system. Spawning occurs over small to medium-sized gravels with good water flow. The adults die after spawning, and their carcasses contribute to the nutrient level of the system.

Juveniles - Soon after emerging from the redds (egg nests), young sockeye migrate to lakes or slow flowing reaches of streams. For the first few weeks they reside in shallow water at the lake edge. They then move to deeper water where they feed in schools in the upper 20 meters of the lake at night. They remain in freshwater for 1-2 years before outmigrating to coastal waters as smolt. For the first 6 months in marine waters, they are found within 50 kilometers of the shoreline.

Food Web Interrelationships

Adults - Euphausiids, amphipods, copepods and young fishes are the primary prey while in the high seas. Adults do not feed once they near freshwater.

Juveniles - In freshwater, young juveniles feed on small insects and insect larvae.

Juveniles in pelagic lake water feed on zooplankton. After migrating to saltwater the smolts feed on a variety of small crustaceans, plankton and fish larvae.

Predation - Predatory fishes and marine mammals prey upon sockeye salmon in saltwater. Bears and gulls are the primary predators of spawning adults. Juveniles are preyed upon by other anadromous fish species including Dolly Varden and rainbow trout. Juveniles are also an important prey species of some bird species.

Human Interaction

Sockeye salmon are recreationally and commercially harvested. They receive the highest market price of any salmon species and support multi-million dollar fisheries in Alaska.

References

Alaska Department of Fish and Game. 1985. Sockeye salmon life history and habitat requirements Southwest and Southcentral, Arctic, Western and Interior regions. pages 537-553 *in* Alaska habitat management guide. Life histories and habitat requirements of fish and wildlife. Alaska Department Fish Game, Juneau, AK. 429 pp.

Emmett, R.L., S.L. Stone, S.A. Hinton, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries, Volume II: species life history summaries. ELMR Report No. 8. National Oceanic and Atmospheric Administration/NOS Strategic Environmental Assessments Division, Rockville, MD, 329 pp.

Pacific Herring (*Clupea pallasi*)

Range

North Pacific Ocean, from Baja California to the Beaufort Sea and to Japan.

Migration

Migrates from offshore coastal areas to nearshore coastal waters near natal spawning areas in early spring.

Reproductive Period

First breeds between 2-4 years old. Spawns annually.

Spawning/Hatching

Spawn in March - early June in Prince William Sound; hatching occurs 14-25 days after laying depending on water temperatures during incubation.

Survival/Life Span

Egg-to-juvenile mortality is probably over 99 percent; lifespan is up to 19 years.

Habitat Use and Requirements

Adults - Little information is available about the offshore distribution of adults. They are found to depths of 150 meters. Adults return to nearshore waters to spawn in early spring where they remain until moving to nearshore rearing areas to feed. In early fall, the herring move offshore to deeper waters where they remain until spring. Herring spawn in intertidal and subtidal areas. Spawning substrates include kelp, eelgrass, prominent rocks or artificial substrates, such as nets and other debris.

Larvae and Juveniles - Larvae are easily dispersed by local currents. Juveniles probably remain in shallow waters, but may follow food sources to deep water, until they migrate to offshore waters in the fall.

Food Web Interrelationships

Adults - Primary prey include planktonic crustaceans, euphausiids and fish larvae.

Larvae and Juveniles - Larvae eat a variety of zooplankton including crustacean, mollusc and insect larvae, as well as copepods and fish eggs. Juveniles primarily feed on crustaceans, mollusc and fish larvae.

Predation - Herring are an important prey base for a large number of species.

The eggs provide food for a variety of shorebirds, diving birds, gulls, invertebrates and some fish. Larvae are eaten primarily by jellyfish, as well as amphipods, fish and others. Adults are food for larger fish, sharks, seals, sea birds and whales.

Human Interactions

Herring are the basis for a multi-million dollar fishery and a long standing subsistence harvest. In addition, they are an important prey of many species of birds, mammals and other fishes.

References

Emmett, R.L., S.L. Stone, S.A. Hinton, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries, Volume II: species life history summaries. ELMR Report No. 8. National Oceanic and Atmospheric Administration/NOS Strategic Environmental Assessments Division, Rockville, MD, 329 pp.

Pauley, G.P., K. Oshima, K.L. Bowers, and G.L. Thomas. 1988. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) -- Pacific herring. U.S. Fish and Wildlife Service Biological Report. 82(11.26). U.S. Army Corps of Engineers TR EL-82-4. 14 pp.

Rockfish (*Sebastes spp.* and *Sebastolobes spp.*)

There are over 50 different species of rockfish with highly variable life history characteristics. These genera are not well studied and specific information is limited. Yelloweye rockfish (*Sebastes ruberrimus*) is a commercially important species in Alaska and has been used here to illustrate the life history characteristics of rockfish.

Range

Yelloweye rockfish range from Baja California to the Cook Inlet in the Gulf of Alaska.

Migration

Movement and migration patterns are unknown for the species. Seasonal migrations may not exist, though some species move long distances throughout their lifetime. Movement to deeper water is common with size and age.

Reproductive Period

Yelloweye rockfish first breed between 14 and 19 years of age. They breed annually after reaching maturity.

Spawning/Hatching

Rockfish do not lay eggs, but release live planktonic larvae. Yelloweye rockfish release larvae from April through June in southeastern Alaska.

Survival/Life Span

Yelloweye males have reached 103 years of age, and females at 114 have been documented. Males tend to be fewer at older ages.

Habitat Use and Requirements

Very little life history information is available.

Adults - Yelloweye rockfish are found around coastal reefs and were abundant over varied rocky bottoms that included ragged, steep pinnacles and boulder fields at 90-100 meter depths of southeastern Alaska. Depths vary by species, age and size, with depths up to 365 meters recorded. Most yelloweyes are caught at depths of 75-135 meters.

Larvae and Juveniles - Very little is known about these life stages which are highly variable between species. Some are pelagic, some drift with kelp, others quickly become demersal. Some juvenile yelloweye were noted in boulder fields at 90-100 meter depths in southeastern Alaska.

Food Web Interrelationships

Yelloweye rockfish are opportunistic predators. They feed on a variety of crabs, shrimp, snails and fish.

Predation - Small rockfish and rockfish larvae are eaten by other fishes, including larger rockfish.

Human Interactions

Rockfish provide an important secondary fishery in the Gulf of Alaska.

References

Carlson, H. R., and R. R. Straty. 1981. Habitat and nursery grounds of Pacific rockfish, *Sebastes* spp. in rocky coastal areas of southeastern Alaska. Marine Fisheries Review 43:13-19.

Hart, J. L. 1973. Pacific fishes of Canada. Fisheries Res. Board of Canada Bulletin. 180. 740 pp.

O'Connell, V. M. and F. C. Funk. 1987. Age and growth of yelloweye rockfish (*Sebastes ruberrimus*) landed in southeastern Alaska. Proceedings International Rockfish Symposium, Anchorage, AK. October 1986. Alaska Sea Grant Report 87-2:171-186.

O'Connell, V. M., B. E. Bracken, and D. W. Carlile. 1991. Demersal shelf rockfish. *in* Stock assessment and fishery evaluation report for the 1992 Gulf of Alaska groundfish fishery. Gulf of Alaska Groundfish Plan Team. North Pacific Fisheries Management Council, Section 7. pp. 7-1 to 7-18.

Quast, J. C., and E. L. Hall. 1972. List of fishes of Alaska and adjacent waters with a guide to some of their literature. National Oceanic and Atmospheric Administration Technical Report NMFS SSRF-658, 48 pp.

Dolly Varden (*Salvelinus malma*) - Anadromous populations

Range

Dolly Varden are found from the Arctic coast of Alaska to southern British Columbia.

Migration

Anadromous Dolly Varden spend summers in nearshore marine environments. From October through November they migrate to freshwater streams and lakes to spawn. Dolly Varden overwinter in freshwater until spring, returning to coastal waters following ice-breakup.

Reproductive Period

Maturation age is variable, occurring usually between 4 and 7 years. Although post-spawning mortality is high, some females have survived to spawn four times.

Spawning/Hatching

Spawning activity occurs from September through November for most Dolly Varden populations. Hatching occurs 4-5 months later, with free swimming fry emerging in April or May.

Survival/Life Span

Egg to alevin survival has been estimated to be 40.7 percent; alevin to smolt, 1.1 percent; and smolt to spawning adult, 23.5 percent. Life span can range up to 12 years.

Habitat Use and Requirements

Adults - Outmigration from freshwater to marine environments occurs each spring. Adults stay in estuary and nearshore coastal habitats until returning to freshwater streams to spawn. Immature fish and nonspawning adults return to freshwater later than spawning adults. Spawning occurs in streams with gravel substrates, slow to moderate water velocities, and temperatures between 0.5 and 13°C. Adults overwinter in deep lakes or river pools, and near groundwater spring areas.

Fry and Juveniles - Younger fry rely on logs, undercut stream banks and other debris to provide cover from predators. Juveniles prefer quiet pools near swift currents. They overwinter in deep pools and lakes.

Food Web Interrelationships

Adults - Smelt, herring, juvenile salmon, sandlance and other small fish and invertebrates are eaten while the Dolly Varden are in marine water. Juvenile salmon, sticklebacks and invertebrates are preyed on in freshwater.

Fry and Juveniles - Aquatic invertebrates, larvae and fish eggs are the primary prey. Fry and juveniles feed primarily near the stream and lake bottoms.

Human Interactions

Dolly Varden are an important sport fish.

References

Alaska Department of Fish and Game. 1985. Arctic char life history and habitat requirements Southwest and Southcentral, Arctic, Western and Interior regions. pages 317-338 *in* Alaska habitat management guide. Life histories and habitat requirements of fish and wildlife. Alaska Department Fish Game, Juneau, AK. 429 pp.

Armstrong, R. H. 1974. Migration of anadromous Dolly Varden *Salvelinus malma* in southeastern Alaska. Journal of Fisheries Research Board Canada. 31:435-444.

Armstrong, R. H., and James E. Morrow. 1980. The Dolly Varden char, *Salvelinus malma.* *in* Charrs: Salmonid fishes of the genus *Salvelinus.* E. K. Balon, Ed., Dr. Junk bv Publishers, Hague, Netherlands. pp. 99-140.

Morrow, J. E. 1980. The freshwater fishes of Alaska. Alaska Northwest Publishing Company, Anchorage, Alaska. 248 pp.

Spot Shrimp *(Pandalus platyceros)*

Range

North Pacific Ocean, from southern California to the Bering Strait, and to Japan and Korea.

Migration

Long-range movements of spot shrimp are unlikely. However, daily movements bring the shrimp to shallow waters at dusk and to deeper waters during the day.

Life Cycle

Spot shrimp are hermaphroditic. They are juveniles for 1-2 years after hatching, then become functional males until 3-5 years of age. They reach a transitional phase from 6-7 and remain as females until they die between 7-10 years of age.

Reproductive Period

Studies in Prince William Sound indicate that spot shrimp may lay multiple egg clutches before death. Conversely, studies from British Columbia have indicated a shorter life span and a single clutch of eggs per female.

Mating/Hatching

Mating occurs in the fall and females carry the eggs for 5-6 months. The eggs hatch from March-April.

Habitat Use and Requirements

Spot shrimp are found at depths ranging from 4 to 487 meters, but they are most common in shallower marine waters. The adults prefer areas with rocky bottoms and fairly steep slopes. Rock crevices, cracks and small caves are used as hiding places; shrimps will also use vegetation as cover against predators. The larvae are pelagic when they first hatch and become demersal as juveniles. Movements between depths and distance from shore occur daily as adults.

Food Web Interrelationships

Spot shrimp feed on detritus and worms (annelids), and on other crustaceans.

Predation - Spot shrimp are an important prey item for many other species. They are an important component in the diet of fish, e.g. salmon, rockfish, Pacific cod, and octopus as well as diving seabirds.

Human Interactions

Spot shrimp are of commercial and recreational importance. They are primarily caught in traps, but are incidentally caught in trawls. In the late 1980s, the Alaska Department of Fish and Game reduced the allowable harvest in parts of Prince William Sound. This change was due to information from experimental fishery management areas which raised concerns about over-harvest.

References

Donaldson, W. 1991. Prince William Sound management area 1990 shellfish annual management report. Alaska Department of Fish and Game. Regional Informational Report No. 2C91-04. 48 pp.

Holthuis, L. B. 1980. Shrimps and prawns of the world: an annotated catalogue of species of interest to fisheries. Food and Agriculture Organization species catalogue No. 125, Volume 1.

Kruse G. H. and M. C. Murphy. 1989. Review of biology and life history of shrimps. Alaska Department of Fish and Game, Regional Informational Report No. 5J89-05. 34 pp.

The *Exxon Valdez* oil spill affected several resources and services normally provided to the public. These include: archaeological resources, recreation, wilderness and intrinsic values, subsistence and commercial fisheries.

Archaeological Resources

Archaeological resources, including sites and the artifacts, constitute an important part of our national and state heritage. They also have international importance in that they constitute a significant link in our knowledge and understanding of Native peoples who have inhabited Arctic and subarctic regions for many thousands of years. These resources help us understand our ancestors' past and enable greater appreciation for the richly varied cultures found in Alaska. The oil-spill area contains both ancient and more recent archaeological resources.

The U.S. Congress recognized the significance of archaeological resources when it passed the Archaeological Resources Protection Act of 1979. In that act they recognized that:

> "Archaeological resources on public lands and on Indian lands are an accessible and irreplaceable part of the Nation's heritage."

Similarly, the Alaska State Legislature passed the Alaska Historic Preservation Act. That law states:

> "It is the policy of the state to preserve and protect the historic, prehistoric and archaeological resources of Alaska from loss, desecration and destruction so that the scientific, historic and cultural heritage embodied in these resources may pass undiminished to future generations. To this end...historic, prehistoric and archaeological resources of the state are properly the subject of concerted and coordinated efforts exercised on behalf of the general welfare of the public..."

Recreation and Wilderness and Intrinsic Values

Alaska has the most significant assemblage of park, refuge and forest lands in the United States, and much of this land is still wild. Large portions of lands under Federal management in the spill area have been designated wilderness areas by the Congress. Such lands are included within Katmai National Park and the Becharof National Wildlife Refuge, both areas were contaminated with *Exxon Valdez* oil. Areas within the Chugach National Forest and Kenai Fjords National Park are in wilderness study area status. Under state management, the Kachemak Bay State Wilderness Park lies on the outer coast of the Kenai Peninsula and it too, felt the effects of the oil spill.

These designated wilderness lands and thousands more acres of undesignated wildlands and developed lands provide, in part, the basis for Alaska's tourist economy. A wide range of activities take place on these lands, some by individuals or small groups seeking a personal experience, and others with the aid of businesses that provide a variety of professional services enabling visitors to use and enjoy the wilderness. Recreational activities include: hunting, fishing, hiking, camping, skiing, sightseeing, power boating, kayaking and photography.

Beyond those who actively use these lands, many Americans benefit by knowing that in Alaska large areas of undeveloped lands provide habitat for natural, healthy populations of wildlife.

<u>Subsistence Use</u>

Many people, most notably rural residents of Prince William Sound, the Kenai Peninsula, lower Cook Inlet and the entire Kodiak archipelago use a wide variety of subsistence resources to provide for essential needs. Many communities in the oil-spill area have mixed subsistence-cash economies. Considerable subsistence harvest occurs on State, Native and Federal lands within the spill area. Subsistence resources, such as fish, birds, and marine and terrestrial mammals, provide vital food resources without which people could not live. Many of these same resources provide products that serve important functions in daily life and play a significant role in cultural practices and traditions. Several resources are shared with members of the communities unable to obtain them or are traded for other needed items.

Although no single Federal or State statute defines the full range of subsistence uses or users, both the Alaska Constitution and the Alaska National Interest Lands Conservation Act address the value and importance of subsistence.

The Alaska Constitution, in Article VIII, Section 3 states:

> "Wherever occurring in their natural state, fish, wildlife, and waters are reserved to the people for common use."

In 1980 Congress approved the Alaska National Interest Lands Conservation Act. Title VIII, "Subsistence Management and Use" recognizes two important concepts: the need for continued opportunity for subsistence, and the uniqueness of the Alaska situation. ANILCA Section 801 (1) states:

> "the continuation of the opportunity for subsistence uses by rural residents of Alaska, including both Natives and non-Natives, on the public lands and by Alaska Natives on Native lands is essential to Native physical, economic, traditional, and cultural existence and to non-Native physical, economic, traditional, and social existence."

ANILCA Section 801 (2) states:

> "the situation in Alaska is unique in that, in most cases, no practical alternative means are available to replace the food supplies and other items gathered from fish and wildlife which supply rural residents dependent on subsistence uses."

Commercial Fisheries

The seafood industry is the second largest generator of revenue in the state. The industry provides nearly 70,000 seasonal jobs, which translates to 33,000 direct, indirect and induced year-round jobs. Total current investment by the Alaska seafood industry is estimated at $4 billion.

In Kodiak, one of the major fishing ports impacted by the oil spill, seafood landings ranked third in both cash value and volume in the United States from 1988 to 1990. Kenai landings (Cook Inlet) ranked 23rd in volume, but 8th in value during the same time period. Cordova landings were 14th and 13th in value.

All five species of Pacific salmon, herring, bottomfish, including halibut, cod and several species of sole, and king, tanner and dungeness crab comprise the Kodiak fisheries. Herring support a food and bait and a sac roe fishery. Pink and sockeye salmon are of major ecological as well as economic importance.

In Cook Inlet all five species of Pacific salmon are caught as well as herring and shellfish, especially razor clams. Herring support two sac roe fisheries, the Kamishak and the Outer and Eastern Districts. Sockeye are the most abundant salmon, ecologically and economically.

Pacific herring are the most abundant species of ecological importance in Prince William Sound. These populations support a fall food and bait fishery, a purse seine and gill net sac roe fishery, and a wild and pound spawn-on-kelp fishery. Together they constitute the second largest herring fishery in the state.

The pink salmon fishery, however, constitutes the major volume and value of the annual commercial harvest. Groundfish landings are increasing as that fishery develops. Shellfish, including tanner crab and spot shrimp, are also important fisheries in the Sound.

References

Archaeological Resources Protection Act of 1979, 16 USC 470.

Alaska Historic Preservation Act, Alaska Statute 41.35.010.

1916 Organic Act, 16 USC 1, 39 Stat. 535.

1916 Organic Act legislative history, ARA Leisure Services v U.S., 831 F.2d 193 (9th Cir. 1987).

Wilderness Act, 16 USC 1131.

Kachemak Bay State Park Wilderness Act, Alaska Statute 41.21.140.

Alaska Constitution, Article VIII, Section 3.

Alaska National Interest Lands and Conservation Act (ANILCA), 16 USC 3101.

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APPENDIX B

POTENTIAL RESTORATION OPTIONS

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APPENDIX B
POTENTIAL RESTORATION OPTIONS

NOTE: The following options are presented for the purpose of public comment and are not recommendations by the Trustees.

TABLE OF CONTENTS FOR APPENDIX B

13. eliminate sources of persistent contamination of prey and spawning substrates

14. accelerate recovery of upper intertidal zone

15. supplement intertidal substrates for spawning herring

16. test feasibility of enhancing murre productivity

17. eliminate introduced foxes from islands important to nesting marine birds

18. replace fisheries harvest opportunities by establishing alternative salmon runs

Habitat Protection and Acquisition

19. update and expand the State's Anadromous Fish Stream Catalog

20. establish an *Exxon Valdez* oil spill "special management area"

21. acquire tidelands

22. designate protected marine areas

23. acquire additional marine bird habitats

24. acquire "inholdings" within parks and refuges

25. protect or acquire upland forests and watersheds

26. acquire extended buffer strips adjacent to anadromous fish streams

27. designate and protect "benchmark" monitoring sites

28. acquire access to sport-fishing streams

29. establish or extend buffer zones for nesting birds

Other Options

30. test subsistence foods for hydrocarbon contamination

31. develop comprehensive monitoring program

32. endow a fund to support restoration activities

33. develop integrated public information and education program

34. establish a marine environmental institute

35. replacement of archaeological artifacts

II. Restoration Options Rejected (listed by resource and service categories)

1. sea otters and harbor seals
2. killer whales
3. river otters
4. common murres and marbled murrelets
5. marbled murrelets
6. harlequin ducks
7. harlequin ducks and black oystercatchers
8. bald eagles
9. pink salmon and sockeye salmon
10. rockfish
11. spot shrimp
12. coastal habitat
13. archaeological resources
14. multiple resources

OPTION 1: Archaeological Resource Protection

APPROACH CATEGORY: Management of Human Uses

INJURED RESOURCES AND SERVICES: Archaeological sites and artifacts

BACKGROUND AND JUSTIFICATION:

Beach clean-up activities resulted in increased public knowledge of exact locations of archaeological sites. Consequently, loss of these resources from vandals has increased. Inherently, archaeological resources injured by the oil spill are not restorable and the remoteness of sites makes enforcement of archaeological protection laws difficult. A site steward program could be developed to establish a corp of local citizens to watch over threatened archaeological sites. Additionally, agency monitoring and public education efforts could be expanded to discourage vandalism. The agencies also could develop cooperative management plans for archaeological resources to better coordinate their activities in the oil-spill area.

ACTION:

- create an archaeological site stewardship program;
- increase number of public contact patrols in the oil-spill area; and
- expand public education efforts.

INFORMATION NEEDED TO IMPLEMENT OPTION:

No further information is needed to accomplish this work.

OPTION 2: Intensify Management of Fish and Shellfish

APPROACH CATEGORY: Management of Human Uses

INJURED RESOURCES AND SERVICES: Pink and sockeye salmon, Dolly Varden, coastal cutthroat trout, Pacific herring, rockfish, and spot shrimp

BACKGROUND AND JUSTIFICATION:

Managing the human uses of fisheries resources, including both commercial and recreational, is fundamental to the restoration of oil-spill injuries. Intensive fisheries management could temporarily reduce human pressure on injured wild stocks or populations to speed their recovery. As a means of minimizing impacts on the fisheries, existing fisheries could be restricted or redirected to alternative sites. In the case of sockeye salmon, for example, one objective is to relieve pressure on what are anticipated to be small runs in the Kenai River system in the next several years, without shutting down other Upper Cook Inlet fisheries.

ACTION:

- develop and implement program to upgrade and intensify management of injured fisheries resources throughout oil-spill area.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Intensive management of injured fish and shellfish resources will be difficult, especially in mixed-stock (i.e., wild and hatchery) fisheries. Improved population modeling, application of genetic and other techniques to separate stocks, and other research and monitoring studies are needed to support intensified fisheries management.

OPTION 3: Increase Management for Fish and Shellfish that Previously Did Not Require Intensive Management

APPROACH CATEGORY: Management of Human Uses

INJURED RESOURCES AND SERVICES: Rockfish, spot shrimp

BACKGROUND AND JUSTIFICATION:

Prior to the oil spill, commercial fishing did not require comprehensive management plans for some species. This was true for rockfish (various species) and spot shrimp, both of which were to some degree injured by the oil spill itself. The directed harvest and by-catch of rockfish increased significantly in 1990 and 1991, because fishing efforts were shifted from salmon and herring to groundfish. Rockfish are of particular concern; they are long-lived and slow-growing and overharvest could greatly exacerbate oil-spill injuries. Development and implementation of management plans will aid the recovery of rockfish and spot shrimp by ensuring that human harvests are consistent with the status and productivity of post-oil-spill populations.

ACTION:

- develop and implement a fishery management plan for rockfish and spot shrimp. The management plans should establish harvest levels, times and areas that are appropriate to allow for recovery from oil-spill injuries.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Considerable information is needed to develop management plans, including data on commercial and sport catches to describe age and size composition, natural mortality rates, general seasonal movements, stock abundance and recruitment. Separation of discrete stocks through genetic and other studies are also needed to enable management on a targeted rather than broad-scale basis.

OPTION 4: Reduce Disturbance at Marine Bird Colonies and Marine Mammal Haul-Out Sites and Rubbing Beaches

APPROACH CATEGORY: Management of Human Uses

INJURED RESOURCES AND SERVICES: Marine birds and marine mammals

BACKGROUND AND JUSTIFICATION:

Human disturbance can adversely affect the fitness or reproductive success of marine birds and mammals. Especially vulnerable are species that gather in large numbers and traditionally make use of small, discrete sites. Examples include colonies of common murres, which typically nest on cliffs, haul-out sites frequented by harbor seals, and rubbing beaches used by killer whales. In the case of common murres, recent reports have indicated specific problems with the shooting of halibut landed by charter-boat operators in the Barren Islands. The sound of the gunshots causes murres to flush in a panic from the nesting cliffs, kicking eggs off the cliffs and leaving eggs and chicks vulnerable to avian predators. Problems such as these can be approached through the education of tour- and charter-boat operators and the fishing industry. Designation of buffer zones around particularly sensitive areas and stricter enforcement of harassment provisions in the Marine Mammal Protection Act and the Migratory Bird Treaty Act also are possibilities.

ACTION:

- educate tour- and charter-boat operators about appropriate behavior near sensitive marine bird and mammal areas;
- increase the field presence of Trustee agencies at such areas;
- consider restrictive measures, such as the designation of buffer zones; and
- consider greater enforcement of Federal and State laws.

INFORMATION NEEDED TO IMPLEMENT OPTION:

There is need to determine the specific areas and times in which birds and mammals are sensitive to disturbance. No additional information is needed to implement the education component of this option.

OPTION 5: Reduce Harvest by Redirecting Sport-Fishing Pressure

APPROACH CATEGORY: Management of Human Uses

INJURED RESOURCES AND SERVICES: Dolly Varden and cutthroat trout

BACKGROUND AND JUSTIFICATION:

Spill-related injuries to cutthroat trout and Dolly Varden have resulted in a loss of sport fishing opportunities in Prince William Sound. Both of these species are important components of recreational fisheries in this area. Moreover, because the affected population of cutthroat trout is at the extreme northern limit of its geographic range, it is important to protect the genetic integrity of these populations. The proposed option is designed to manage this recreational fishery in a manner that would redirect pressure away from impacted populations, maintain sport fishing opportunities and, at the same time, conserve the unique gene pool of these wild stocks.

ACTION:

- prepare a fisheries management plan that includes some or all of the following alternatives:

  - close oiled streams in Prince William Sound;

  - redirect recreational fishing to non-oiled streams and drainages; and

  - reduce creel limits in the affected area.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Results from recovery monitoring studies will provide timing data for management actions. Results of survey and inventory studies will provide locations for alternative sport-fishing opportunities. Stock status data on Dolly Varden and cutthroat trout populations will aid in the development of the management plan.

OPTION 6: Redesignate a Portion of the Chugach National Forest as a National Recreation Area or Wilderness Area

APPROACH CATEGORY: Management of Human Uses

INJURED RESOURCES AND SERVICES: Recreation, fish, including salmon, coastal cutthroat trout, and Dolly Varden

BACKGROUND AND JUSTIFICATION:

The waters of Prince William Sound are surrounded by the Chugach National Forest. The area is recognized as biologically rich and it provides a variety of resources, including significant opportunities for private and commercial recreation. The National Forest System contains several national recreation areas and designated wilderness areas. Management of national recreation areas emphasizes recreational values and the habitats needed to sustain recreational opportunities. Management of wilderness areas emphasizes the preservation of pristine qualities and opportunities for nonmechanized recreation. Within the Chugach National Forest, Congress previously designated the Nellie Juan/College Fjords wilderness study area, but has never resolved its permanent status. Changing the designations of all or parts of the Chugach National Forest would alter management directions to favor recreational opportunities and wilderness qualities.

ACTION:

- recommend that the Forest Service integrate consideration of national recreation area and wilderness area designations into its management planning process for the Chugach National Forest; and

- if redesignation is determined to be appropriate, that recommendation must be forwarded to Congress for legislative approval.

INFORMATION NEEDED TO IMPLEMENT OPTION:

The Forest Service must gather some new data on the changes brought about by the oil spill on forest resources.

OPTION 7: Increase Management in Parks and Refuges

APPROACH CATEGORY: Management of Human Uses

INJURED RESOURCES AND SERVICES: Coastal habitat, wildlife, fisheries and recreation within State and Federal parks and refuges

BACKGROUND AND JUSTIFICATION:

There are many parks and refuges scattered throughout the oil-spill area. Because of the size and location of these areas, managing agencies are limited in their ability to provide an extensive field presence. It may be desirable to increase the staff capability and frequency of patrols to ensure that human use activities are conducted in a manner that safeguards the recovery potential of injured resources.

ACTION:

- hire and train additional staff to patrol and monitor spill-affected public lands; and
- provide interpretive services to educate the public about the spill and explain how they can minimize their chances of impeding resource recovery.

INFORMATION NEEDED TO IMPLEMENT OPTION:

This option needs no additional information to implement.

OPTION 8: Restrict or Eliminate Legal Harvest of Marine and Terrestrial Mammals and Sea Ducks

APPROACH CATEGORY: Management of Human Uses

INJURED RESOURCES AND SERVICES: Sea otter, harbor seal, brown bear, river otter, and harlequin duck

BACKGROUND AND JUSTIFICATION:

Continued harvest of several species could slow or negate recovery from oil-spill injuries. Legal hunting and trapping of these species represents a controllable source of mortality that can be considered in developing a restoration strategy. Brown bears are taken by sport hunters in the oil-spill area and river otters are trapped for their furs. Under the Marine Mammal Protection Act, subsistence users are allowed to take sea otters and harbor seals. Recently, some subsistence users have voluntarily reduced their take of marine mammals. Harlequin ducks are shot by both sport and subsistence users. In 1991 the Alaska Department of Fish and Game delayed the open season on harlequin ducks in Prince William Sound and along the outer Kenai Coast to protect the small resident breeding population prior to an influx of a much larger number of migrant and wintering ducks.

ACTION:

- if necessary, recommend that the Alaska Department of Fish and Game temporarily restrict or close harvests of brown bear, river otter, and harlequin ducks in the oil-spill area; and

- convey information to subsistence users about the status of injured species of marine mammals and other resources and, if appropriate, encourage voluntary reductions in harvest levels.

INFORMATION NEEDED TO IMPLEMENT THE OPTION:

Monitor population levels of injured species, establish harvest levels in oil-spill area and estimate the influence of annual harvests on the recovery of these species.

OPTION 9: Minimize Incidental Take of Marine Birds by Commercial Fisheries

APPROACH CATEGORY: Management of Human Resources

INJURED RESOURCES AND SERVICES: Marine birds

BACKGROUND AND JUSTIFICATION:

Large numbers of marine birds are susceptible to being tangled and drowned in commercial fishing gillnets. Local, nearshore fisheries can cause the death of significant numbers of marine birds as evidenced with common murres in a halibut/croaker fishery in California and with marbled murrelets in a salmon gillnet fishery in British Columbia. Research on marine bird mortalities due to commercial fisheries in Alaska has been limited. Data from the National Marine Fisheries Service's observer program in 1990 suggested that the annual mortality from Prince William Sound drift gillnets was 836-2100 marine birds, most of which were marbled murrelets. This mortality is not high relative to the overall size of the murrelet population, but on a local basis it could slow recovery from oil-spill related injuries. Management strategies, such as reducing hours of night-time fishing during critical times in discrete areas, may reduce the mortality.

ACTION:

- if necessary, develop and implement strategies to reduce the incidental mortality of marbled murrelets in drift gillnets.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Design and implement a sampling program throughout the spill area to obtain data on the significance, level and distribution of annual driftnet mortalities.

OPTION 10: Preservation of Archaeological Sites and Artifacts

APPROACH CATEGORY: Manipulation of Resources

INJURED RESOURCES AND SERVICES: Archaeological sites and artifacts

BACKGROUND AND JUSTIFICATION:

Important archaeological sites, protected by Federal and State laws, were oiled. At some sites oil continues to degrade artifacts, to spread further within sites and to contaminate additional artifacts. Erosion also may be a problem at some sites. The information within some sites could be totally lost, especially since petroleum residues interfere with $Carbon^{14}$ dating techniques. Additionally, increased public knowledge of exact archaeological sites locations is encouraging vandalism. Since these injured archaeological resources are not restorable, excavation may be the best option available to retrieve valuable information from some of the key sites and artifacts before they are rendered useless. It may be necessary to develop cleaning techniques so that standard radiocarbon dating procedures can be used to establish age of artifacts.

ACTION:

- excavate and document (e.g., photographic record) the most threatened and significant archaeology sites.[1]

INFORMATION NEEDED TO IMPLEMENT OPTION:

Completion of damage assessment studies will enable managers to more fully understand the effects of oiling on a site-specific basis. Thereafter, possible excavation sites can be ranked, based upon their value and ability to contribute knowledge.

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[1] Artifacts collected during excavations will be curated, or distributed to appropriate institutions, by the responsible agency.

OPTION 11: Improve or Supplement Stream and Lake Habitats for Spawning and Rearing of Wild Salmonids

APPROACH CATEGORY: Manipulation of Resources

INJURED RESOURCES AND SERVICES: Pink and sockeye salmon

BACKGROUND AND JUSTIFICATION:

There are a variety of established techniques for improving or supplementing spawning and rearing habitats to restore and enhance injured wild salmonids. These include construction of spawning channels and fish passes, removal of barriers impeding access to spawning habitats and addition of woody debris. In-stream productivity can be improved by placement of egg boxes and use of net pens for rearing fry. Unlike pink and chum salmon which swim to sea in their first year, young sockeye salmon grow in lakes for 1-3 years before emigrating to sea. One restoration technique for sockeye is to add chemical fertilizers to lakes to temporarily supplement the natural nutrients needed to sustain prey on which the fry feed. Once a run is restored, the decomposition of the carcasses of spawned salmon are a natural source of the nutrients needed to sustain the food chain.

ACTION:

- construct or implement stream and lake improvements for the spawning and rearing of wild salmonids.

INFORMATION NEEDED TO IMPLEMENT THE OPTION:

Although stream and lake enhancement techniques are well established, there is need for site-specific analyses to determine which techniques are appropriate. An overall enhancement plan is needed to ensure an efficient, coordinated approach throughout the oil-spill area.

OPTION 12: Creation of New Recreation Facilities

APPROACH CATEGORY: Manipulation of Resources

INJURED RESOURCES AND SERVICES: Recreation

BACKGROUND AND JUSTIFICATION:

The oil-spill area contains an important assemblage of public lands that provide recreational services to the public. These lands include a national forest, several state and national parks and national wildlife refuges. A full range of private and commercial recreational activity occurs in these areas, supported by facilities like mooring buoys, boat ramps, recreational-use cabins, camping sites, and trails.

ACTION:

- replace or construct new recreational facilities within the oil-spill area.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Identify facilities and sites that have been damaged, destroyed or rendered unusable by the *Exxon Valdez* oil spill or clean up. The agencies then need to identify what actions may be taken to restore, replace or enhance recreation sites and opportunities.

OPTION 13: Eliminate Sources of Persistent Contamination of Prey and Spawning Substrates

APPROACH CATEGORY: Manipulation of Resources

INJURED RESOURCES AND SERVICES: Coastal habitat, blue mussels, harlequin ducks, sea otters, black oystercatchers, river otters, fisheries, subsistence

BACKGROUND AND JUSTIFICATION:

Continued oil contamination in substrate used for spawning may affect fish-egg deposition and survival. Mussel beds throughout the spill area were not cleaned during the oil spill cleanup because of the uncertainty of appropriate cleaning techniques. Mussels are an important food resource for a variety of injured species and the acute, chronic or sublethal effects of this continuing contamination are poorly understood. However, there is potential for movement into higher trophic levels, such as birds and mammals. This may cause chronic, sublethal effects at both the individual and population levels, further affecting the health and survival of injured resources.

ACTION:

- determine and implement, if necessary, the most effective and least destructive method of cleaning mussel beds and other critical oiled areas.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Conduct field surveys and sampling of oiled mussel beds and other areas throughout the spill area and chemical analyses of sediments and mussel tissue to determine the extent of the problem and the toxicity of the oil. Conduct additional field tests to determine the most effective and least destructive method of cleaning oiled mussel beds.

OPTION 14: Accelerate Recovery of Upper Intertidal Zone

APPROACH CATEGORY: Manipulation of Resources

INJURED RESOURCES AND SERVICES: Upper intertidal community of invertebrates and algae, especially the brown alga (*Fucus*)

BACKGROUND AND JUSTIFICATION:

Much of the upper intertidal zone within the oil-spill area was heavily oiled and subjected to intensive cleanup. This zone is dominated by the brown alga *Fucus gardneri* (popweed) which is not recovering rapidly. Moreover, many of the other life forms that use the upper intertidal are dependent upon this alga and associated invertebrate fauna for food and cover. The scientific literature indicates that *Fucus* is slow to recover and that its recovery is very important to the rest of the intertidal community. It is also important to evaluate the long-term effects of the various clean-up techniques that were used in the intertidal zone. Conclusions derived from the assessment of these techniques may have significant bearing on clean-up decisions for future spills.

ACTION:

- implement ways to expedite the recovery of the upper intertidal community, especially *Fucus*; and

- design and implement a monitoring program that will assess the effects of the various methods that were used to remove oil from the intertidal zone.

INFORMATION NEEDED TO IMPLEMENT OPTION:

There is need to conduct feasibility studies to test alternative methods of accelerating recovery of *Fucus* in the field.

OPTION 15: Supplement Intertidal Substrates for Spawning Herring

APPROACH CATEGORY: Manipulation of Resources

INJURED RESOURCES AND SERVICES: Pacific herring

BACKGROUND AND JUSTIFICATION:

Pacific herring spawn on a variety of intertidal and subtidal substrates, including *Fucus* and *Laminaria*. Herring eggs, larvae and spawning substrates were adversely impacted by the spill and cleanup. Attempts to supplement spawning habitat in the United States and abroad with both artificial and cultured macroalgal substrates have successfully increased herring egg survival and populations. In Russia, spawning habitat enhancement has been successful in substantially increasing herring egg survival.

ACTION:

- enhance and replace spawning substrates in areas used by spawning herring.

INFORMATION NEEDED TO IMPLEMENT OPTION:

It will be necessary to test the feasibility of implementing this option on a scale sufficient to benefit the herring population.

OPTION 16: Test Feasibility of Enhancing Murre Productivity

APPROACH CATEGORY: Manipulation of Resources

INJURED RESOURCES AND SERVICES: Common murres

BACKGROUND AND JUSTIFICATION:

Numerically, common murres suffered the greatest direct mortality from the oil spill of any vertebrate species. Although murre populations have been damaged by previous oil spills and other human-related perturbations, there have been no documented attempts at direct restoration of murre colonies. Based on restoration work with related species and an understanding of murre behavior, there are several techniques that hold some promise of increasing murre productivity. Methods that could be considered include enhancing social stimuli (e.g., use of decoys and recorded calls) to encourage nesting activity and improving the physical characteristics of nest sites (e.g., adding sills to ledges) to increase productivity. These techniques are experimental and possibly intrusive, but if effective, have the potential to reduce the recovery time of murres nesting in colonies in such places as the Barren Islands. Without intervention, the time to recovery is now estimated to be in the decades.

ACTION:

- conduct field study to determine the feasibility of techniques to enhance the productivity of common murres.

INFORMATION NEEDED TO IMPLEMENT OPTION:

It will also be important to consider the practicality of implementing successful techniques on a scale sufficient to reduce the recovery time of the murre population.

OPTION 17: Eliminate Introduced Foxes from Islands Important to Nesting Marine Birds

APPROACH CATEGORY: Manipulation of Resources

INJURED RESOURCES AND SERVICES: Marine birds

BACKGROUND AND PURPOSE:

Foxes are not indigenous to many of the islands of the Aleutian chain and Gulf of Alaska. Foxes were introduced on more than 400 islands to be raised and trapped for their furs. Introduced foxes reduced and eliminated populations of surface, burrow and in some cases cliff-nesting birds in a matter of years. More than 50 islands still have introduced foxes, and bird populations on these islands have never recovered. Where foxes have died out naturally or been eliminated through trapping and shooting, recovery of marine bird populations has been dramatic. Elimination of introduced foxes on selected islands may result in increased numbers and diversity of marine birds in Alaska and be viewed as "acquiring" resources equivalent to the estimated several hundred-thousand marine birds lost due to the oil spill. If selected as a restoration option, introduced foxes can be eliminated successfully on smaller islands using traps and guns. Most of the target islands would be in the Aleutian Islands, west of the oil-spill area.

ACTION:

- eradicate red and arctic ("blue") foxes on islands in the western Gulf of Alaska and in the Aleutians where such foxes are not indigenous, and the island is or was important to nesting alcids (murres, puffins, auklets, murrelets), storm-petrels, gulls and terns, and waterfowl, such as eiders and Canada geese.

INFORMATION NEEDED TO IMPLEMENT OPTION:

No additional information is needed to implement this project other than to select target islands where successful, cost-effective programs can be instituted.

OPTION 18: Replace Fisheries Harvest Opportunities by Establishing Alternative Salmon Runs

APPROACH CATEGORY: Manipulation of Resources

INJURED RESOURCES AND SERVICES: Pink and sockeye salmon

BACKGROUND AND JUSTIFICATION:

Establishing alternative salmon runs can relieve pressure on injured wild stocks or replace harvest opportunities curtailed due to the restoration needs of injured wild stocks. For example, pink salmon produced in hatcheries are comprised largely of late-run stocks that return at the same time as most wild stocks of injured pink salmon in Prince William Sound. Harvest of the hatchery stocks in this mixed hatchery-wild stock fishery increases pressure on the wild stocks. Early runs of hatchery salmon could be established to alleviate pressure on the injured wild stocks without reducing harvest opportunities. Another example is to temporarily stock hatchery-reared smolts to replace loss of sockeye fishing opportunities that resulted from overescapement when most Kodiak-area commercial salmon fishing was closed in 1989. This would only be appropriate in situations where injured wild stocks would not be affected by the replacement fishery.

ACTION:

- establish alternative salmon runs as appropriate and necessary to relieve pressure on injured wild stocks or to replace lost harvest opportunities during the recovery of wild stocks.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Establishing early-run hatchery salmon requires identification and development of the appropriate brood stock. In all cases, care must be taken to not further harm or complicate the management of injured wild stocks.

OPTION 19: Update and Expand the State's Anadromous Fish Stream Catalog

APPROACH CATEGORY: Habitat Protection and Acquisition

INJURED RESOURCES AND SERVICES: Anadromous fish, streams and intertidal spawning habitat

BACKGROUND AND JUSTIFICATION:

Numerous anadromous streams were affected by the spill and cleanup. Many of these streams are listed in the Anadromous Waters Catalog and Atlas maintained by the Alaska Department of Fish and Game. Additional streams were identified as part of the response survey effort following the oil spill and were added to the catalog. These new additions, as well as a number of previously identified streams, need to be surveyed as part of their evaluation as anadromous fish habitat. Evaluation of management or protection and acquisition options for restoring anadromous fish and their habitats will need the information acquired as part of these surveys. Under the State Forest Practices Act, streamside buffers are required bordering certain anadromous streams. This may be an important tool in the restoration of any stream-related species.

ACTION:

- survey and catalog anadromous streams located within the affected area.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Field surveys of anadromous streams within the affected area will provide the necessary information for documentation.

OPTION 20: Establish an *Exxon Valdez* Oil Spill "Special Management Area"

APPROACH CATEGORY: Habitat Protection and Acquisition

INJURED RESOURCES AND SERVICES: All

BACKGROUND AND JUSTIFICATION:

Restoration of injured resources and services may require special sensitivity or emphasis in making permit decisions on land uses and activities in the spill zone. This may be achieved by requiring that permits for such activities as anadromous stream crossings, log transfer sites, and mariculture projects be subject to a finding of compatibility with the recovery of injured resources and services. The duration of special management would be limited, depending upon the rate of recovery of the injured resources and services. A period of 5 to 15 years might be an appropriate time frame. Amendments to the State of Alaska's program under the Coastal Zone Management Act could be a vehicle for implementation of special management objectives. In all cases it would be essential to consider and minimize impacts on human uses of lands and resources.

ACTION:

- recommend creation of a special management area within the oil-spill area. Activities requiring State permits within the zone will be regulated to assure compatibility with the recovery of injured resources and services.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Identify State and Federal permit decisions bearing directly on the recovery of injured resources and services, and evaluate the adequacy of the existing standards for issuing such permits. If a special management area is warranted, the process for establishing a special management area must be identified and initiated. Implementation would require action by the State legislature.

OPTION 21: Acquire Tidelands

APPROACH CATEGORY: Habitat Protection and Acquisition

INJURED RESOURCES AND SERVICES: Coastal habitat, including intertidal flora, fauna and various species of birds, mammals, fish and shellfish that use the intertidal areas

BACKGROUND AND JUSTIFICATION:

Tidelands and their associated flora and fauna were the habitat most injured by the spill. Most tidelands (below mean high water) are owned by the State or Federal governments. Some are owned privately or by municipalities, have high fish and wildlife values and are heavily used by the public for such activities as clam digging and wildlife viewing. Examples suggested by the public are Mud Bay at Homer and the Duck Flats at Valdez. Acquisition of such areas would preserve ecologically-important habitats and maintain the services such habitats provide for both consumptive and nonconsumptive public users. Services provided to the public could be enhanced by interpreting an area's natural history and providing additional access and viewing opportunities. Acquired areas could be designated as critical habitat areas, wildlife refuges or sanctuaries, or could be managed as part of State-owned, unclassified tidelands.

ACTION:

- acquire one or more tideland properties for public ownership and management to benefit wildlife resources.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Identify tidelands eligible for acquisition and subsequent special designation.

OPTION 22: Designate Protected Marine Areas

APPROACH CATEGORY: Habitat Protection and Acquisition

INJURED RESOURCES AND SERVICES: Coastal habitat, marine birds and mammals, seabirds, fisheries, invertebrates, algae and seagrasses, recreation

BACKGROUND AND JUSTIFICATION:

Virtually all species injured by the oil spill live in or use the nearshore and intertidal marine environment for feeding or reproduction. These marine habitats also provide many recreational and research opportunities. The recovery of injured marine resources and services may require long-term efforts and carefully coordinated management. The Trustees have recognized the importance of the marine environment and the potential value of increased, coordinated management for restoration purposes. In 1991, a two-day work shop exploring the subject was conducted. Possible designations include national marine sanctuaries, estuarine research reserves, marine parks, critical habitat areas, sanctuaries and refuges.

ACTION:

- if appropriate, recommend candidate areas for consideration and designation as marine protected areas by the Trustee agencies, the Alaska State Legislature and Congress.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Candidate areas must be identified and evaluated based on such factors as the habitat requirements of injured species and the type of designation needed to achieve restoration objectives.

OPTION 23: Acquire Additional Marine Bird Habitats

APPROACH CATEGORY: Habitat Protection and Acquisition

INJURED RESOURCES AND SERVICES: Marine birds, sea ducks, sea otters, harbor seals

BACKGROUND AND JUSTIFICATION:

There are a number of sites that are important to the recovery of marine species injured by the oil spill. These include various small rocky islands and cliffs used by colonies of nesting marine birds, riparian habitats used by nesting harlequin ducks and forested areas used by nesting marbled murrelets. Adjacent nearshore waters and tidelands are frequented by harbor seals and sea otters. The Alaska Maritime National Wildlife Refuge specifically was established for the conservation and management of marine birds, marine mammals, and other wildlife and fish. Examples of privately-owned islands with important marine bird and waterfowl habitats within the Maritime refuge are Afognak, East Amatuli and Gull. Protecting key habitats in areas such as these would result in increased management, monitoring and research for the benefit of injured species. Bringing additional areas into public ownership could replace and enhance wildlife viewing services and public education opportunities.

ACTION:

- acquire and incorporate high-value marine bird and waterfowl habitats into public ownership.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Gather additional information on habitats relevant to injured species and integrate into the Trustees' overall effort to evaluate and acquire strategic fish and wildlife habitats.

OPTION 24: Acquire "Inholdings" Within Parks and Refuges

APPROACH CATEGORY: Habitat Protection and Acquisition

INJURED RESOURCES AND SERVICES: All

BACKGROUND AND JUSTIFICATION:

Several State and Federal conservation system units exist within the oil-spill area. These areas provide habitats for several injured species and various other resources or services. There have been many suggestions to acquire privately owned "inholdings" within existing conservation system units as a restoration action. For example, the Alaska Native Claims Settlement Act provided for several Native corporations to select lands inside the boundary of the Kenai Fjords National Parks. Those selections have been made (although not conveyed) and now overlay a significant portion of the park's coastline.

ACTION:

- acquire, on a willing seller basis, inholdings within existing parks and refuges to restore and enhance resources and services injured by the oil spill.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Gather additional information on habitats relevant to injured species and integrate into the Trustees' overall effort to evaluate and acquire strategic fish and wildlife habitats.

OPTION 25: Protect or Acquire Upland Forests and Watersheds

APPROACH CATEGORY: Habitat Protection and Acquisition

INJURED RESOURCES AND SERVICES: Harlequin ducks, marbled murrelets, river otters, anadromous fish, bald eagles, brown bears, recreation, wilderness and intrinsic uses

BACKGROUND AND JUSTIFICATION:

Although upland areas were not directly affected by the spill, they provide feeding and reproductive habitat for many of the injured species. Populations of salmonids and harlequin ducks are specifically dependent upon anadromous streams and their adjacent riparian lands. Undisturbed uplands and riparian lands provide important habitats and natural buffers that protect the quality of watersheds, streams and rivers. Uplands in the oil-spill area are also important recreation areas and contribute to the aesthetic experience enjoyed by recreational users throughout the spill area. Both recreation and tourism are dependent upon the pristine nature of these areas. By acquiring easements, property rights or fee-simple title to these strategic areas, injured species can be safeguarded during recovery and various resources and services can be restored and enhanced.

ACTION:

- acquire upland areas adjacent to anadromous streams, that are relied upon by injured species; and
- develop and implement a management plan for acquired or protected lands.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Gather additional information on habitats relevant to injured species and integrate into the Trustees' overall effort to evaluate and acquire strategic fish and wildlife habitats.

OPTION 26: Acquire Extended Buffer Strips Adjacent to Anadromous Streams

APPROACH CATEGORY: Habitat Protection and Acquisition

INJURED RESOURCES AND SERVICES: Anadromous fish, harlequin duck, river otter

BACKGROUND AND JUSTIFICATION:

Undisturbed riparian lands are important natural buffers that protect the water quality of streams and rivers and provide cover and food for wildlife. Injured populations of salmonids and harlequin ducks depend upon anadromous streams as feeding and reproductive habitat. Adverse human impacts to the lands adjacent to this habitat could retard the rate of their recovery. The State Forest Practices Act provides for 66-foot buffer strips along certain anadromous fish streams. One concept is to acquire wider buffer strips, as needed to maintain habitat for injured species.

ACTION:

- acquire title or property rights to riparian lands not currently protected under existing law.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Identify anadromous stream habitats important to injured species and evaluate degree of protection afforded under existing law.

OPTION 27: Designate and Protect "Benchmark" Monitoring Sites

APPROACH CATEGORY: Habitat Protection and Acquisition

INJURED RESOURCES AND SERVICES: All

BACKGROUND AND JUSTIFICATION:

A comprehensive monitoring plan has been suggested for consideration by the Trustees [Restoration Option No. 31]. Integral to the comprehensive monitoring plan is the designation of discrete and permanent monitoring sites within the oil-spill area. Permanent monitoring sites will allow for the establishment of a baseline environmental condition to use as a reference standard. These sites could include oiled, representative habitat types and unoiled control sites, set aside untreated sites in 1989, damage assessment study sites, and Exxon study sites. There are several designations appropriate for monitoring sites, including "research natural areas" (U.S. Forest Service) and "estuarine research reserves" (National Oceanic and Atmospheric Administration). The Forest Service presently is considering several research natural areas in Prince William Sound, including one on Green Island. The National Science Foundation's program for long-term ecological research sites is also a possibility.

ACTION:

- recommend designation of permanent study sites and control areas for long-term monitoring of marine, intertidal and upland habitats and selected indicator parameters.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Establishment of monitoring sites should be integrated with development of a comprehensive monitoring plan. Ownership, management and other uses of potential sites must also be considered.

OPTION 28: Acquire Access to Sport Fishing Streams

APPROACH CATEGORY: Habitat Protection and Acquisition

INJURED RESOURCES AND SERVICES: Recreation, anadromous fish

BACKGROUND AND JUSTIFICATION:

Anadromous fish species, such as coastal cutthroat trout, and the recreation services provided by these fish were injured by the oil spill. Although most of the oil-spill area is in public ownership, some areas that provide important sport-fishing opportunities are not. Acquiring access to such areas can replace or enhance the injured services and also relieve pressure on streams with injured fish stocks. Acquisition of access for sport fishing might be achieved by various mechanisms, including fee-simple title, easements or other property rights. Candidate sites can be identified based on the knowledge of resource managers in the agencies, nominations from the public and proposals from interested landowners.

ACTION:

- acquire, on a willing-seller basis, access to strategic areas that provide significant sport-fishing opportunities.

INFORMATION NEEDED TO IMPLEMENT OPTION:

The identification and acquisition of access to such areas must be integrated into the Trustees' overall plan for identifying strategic fish and wildlife habitats and recreation sites. Management plans must be developed for any sites acquired.

OPTION 29: Establish or Extend Buffer Zones for Nesting Birds

APPROACH CATEGORY: Habitat Protection and Acquisition

INJURED RESOURCES AND SERVICES: Marine birds, sea ducks and bald eagles

BACKGROUND AND JUSTIFICATION:

Most bird species have specific nesting requirements. Actions that alter nesting habitat or disturb nesting birds may disrupt nesting birds, thus reducing productivity and slowing the recovery of injured species. Examples of nesting habitats for injured bird species are rocky cliffs and headlands for marine birds, large trees along coastlines or streams for bald eagles, upland stands of large trees for marbled murrelets, and upland wooded streamsides for harlequin ducks. During the period these injured species are recovering from spill injuries, it may be appropriate to adopt special management practices to ensure the integrity of nesting habitats and minimize disruption during breeding and rearing times. Extended buffer zones around nest sites or restrictions on certain activities at critical times could be considered. Implementation of this option is most easily accomplished on lands which are publicly managed, but, through cooperative agreements and other mechanisms, privately owned lands could be included as well.

ACTION:

- recommend implementation of special management practices, including buffer zones and time/area restrictions; and

- explore and negotiate cooperative mechanisms for achieving similar management practices on private lands.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Relate results from restoration studies now underway to current and proposed land uses and management directions on public and private lands.

OPTION 30: Test Subsistence Foods for Hydrocarbon Contamination

APPROACH CATEGORY: Other Options

INJURED RESOURCES AND SERVICES: Finfish, shellfish, sea ducks and marine mammals

BACKGROUND AND JUSTIFICATION:

People living within the oil-spill area use subsistence resources obtained from the intertidal zone and from nearshore waters. Finfish, shellfish, marine mammals, and sea ducks are a substantial part of the diet of these local residents. Damage assessment studies documented the contamination of certain of these resources by petroleum hydrocarbons. For example, mussel and sediment samples collected during the summer of 1991 revealed persistent contamination of mussels and mussel beds. An oil-spill health task force was formed in 1989 to oversee analyses of subsistence food resources. These studies tested for petroleum hydrocarbon contamination in seals, deer, salmon, ducks, clams and bottomfish. This option proposes to monitor subsistence foods for residual petroleum hydrocarbon contamination and to disseminate the results to the public.

ACTION:

- develop a program designed to monitor for the presence of petroleum hydrocarbons in subsistence foods; and

- disseminate the results of the monitoring project to subsistence users.

INFORMATION NEEDED TO IMPLEMENT OPTION:

The design and results of the previous food-testing program must be evaluated.

OPTION 31: Develop Comprehensive Monitoring Program

APPROACH CATEGORY: Other Options

INJURED RESOURCES AND SERVICES: All

BACKGROUND AND JUSTIFICATION:

Monitoring is necessary in order to assess the adequacy of natural recovery. Resources that are found to be recovering at an unacceptable rate may have to be reconsidered as candidates for restoration action. Likewise, resources which are recovering faster than anticipated may allow for the early completion of a restoration action. Monitoring of physical, chemical and biological parameters will establish a baseline for the affected area. This baseline then can be used as a reference standard to evaluate the effects of future disturbances to the oil-spill area, e.g., earthquakes and oil spills. This standard could also be used to assess the anticipated effects of human development and to guide management programs.

ACTION:

- design and implement a program that will monitor:

  - natural recovery of injured resources;

  - monitor recovery of restored resources; and

  - monitor selected parameters to establish an environmental baseline condition.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Initially, target resources and specific objectives of a monitoring program must be established. A determination must be made on the best and most cost-effective methods to be used for monitoring the selected resources.

OPTION 32: Endow a Fund to Support Restoration Activities

APPROACH CATEGORY: Other Options

INJURED RESOURCES/SERVICES: All

BACKGROUND AND JUSTIFICATION:

Ensuring that the spill-affected area will recover fully from the *Exxon Valdez* oil spill is a complex, long-term task that involves many interests, significant funding and much initial uncertainty. There will be a continuing need to identify, protect and manage key habitat areas in the future. Monitoring of natural recovery and the efficacy of restoration activities will be needed. Restoration activities will be implemented as injury and technical information indicate. Continued research into the effects of the spill will help the development of improved clean-up methods. In making a long-term commitment to the oil spill environment, it is important to recognize the need for continuing financial support. Contributions from Exxon for restoration activities terminate in 2001; the Trustees may consider spending mechanisms that will continue that support after 2001.

ACTION:

- establish a restoration endowment or trust fund using all of the available proceeds from Exxon. There are numerous spending alternatives available such as:

  - spending only the investment income;

  - spending principal at a given level for a number of years and then spending only the investment income after that; and

  - spending principal at a given level through the life of the settlement and reinvesting the balance annually.[2]

INFORMATION NEEDED TO IMPLEMENT OPTION:

Identify the process and institutional structure needed to implement and manage the fund.

[2] One scenario would allow expenditure of approximately $24 million a year for restoration through 2001, reimburse the governments for expenditures to date, and still have an endowment fund principal of approximately $600 million. By the year 2020 approximately $900 million would have been spent on restoration with a remaining endowment fund principle of over $1200 million.

OPTION 33: Develop Integrated Public Information and Education Program

APPROACH CATEGORY: Other Options

INJURED RESOURCES AND SERVICES: All

BACKGROUND AND JUSTIFICATION:

This project would design and develop information available from the damage assessment and restoration process to inform the public of ways they can help injured resources recover from the effects of the spill and the resulting clean-up efforts. Specifically, the information would explain changes to the ecosystem and how people can lessen their potential for creating additional harmful human disturbance. The information would be delivered through brochures, posters, video, enhancement of school curricula, and other informational media. The materials would be delivered to state and federal visitor centers, state ferries, and cooperating private businesses and organizations throughout the entire spill zone. The project would seek to recognize restoration within the context of the entire ecosystem, rather than through a species-specific approach.

ACTION:

- provide updated summaries of oil-spill injuries and make available to the public;
- produce brochures, posters and other informational products for distribution to local, state and federal visitor facilities throughout the spill zone; and
- consider constructing or supplementing interpretive facilities in oil-spill communities.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Conduct feasibility study in regard to anticipated need, use and sites of any interpretive facilities.

OPTION 34: Establish a Marine Environmental Institute

APPROACH CATEGORY: Other Options

INJURED RESOURCES AND SERVICES: All

BACKGROUND AND JUSTIFICATION:

Restoration of the oil-spill area will require a long-term commitment by the Trustees. Establishing a marine environmental institute to conduct long-term research and monitoring activities could be a means to foster long-term restoration goals. Any information gained also will serve as an environmental baseline and help guide the use and management of the oil-spill area. The institute could be based in a field station in an oil-spill community. Funding for the institute could come either directly from the joint fund or from an endowment, as described in Restoration Option 32.

ACTION:

- establish and equip a marine environmental science institute.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Evaluation of this option requires consideration of a number of factors. The objectives of such an institute must be established and such questions as funding mechanisms and locations must be reviewed in light of those objectives. The relationships to established academic and research entities must be reviewed thoroughly.

OPTION 35: Replacement of Archaeological Artifacts

APPROACH CATEGORY: Other Options

INJURED RESOURCES AND SERVICES: Archaeological sites and artifacts

BACKGROUND AND JUSTIFICATION:

Important archaeological resources, protected by Federal and State laws, were oiled. At some sites oil continues to degrade the resources, while at other sites increased looting and vandalism are occurring. Since archaeological resources are not inherently restorable, a direct replacement of artifacts may be a logical method to restore the injuries sustained. One method could be to purchase privately-owned artifacts that originated in the region and put them into public collections. Another complementary approach would be to retrieve artifacts removed from the spill zone to public institutions and to actively track down other artifacts that were illegally collected during the spill and subsequent clean-up activity.

ACTION:

- identify institutions and individuals with artifacts from the spill area and offer to purchase specific pieces for public institutions; and

- investigate the incidents of looting and vandalism and strive to regain possession of publicly owned artifacts.

INFORMATION NEEDED TO IMPLEMENT OPTION:

Completion of damage assessment studies will enable managers to more fully understand the effects of looting and vandalism and may help lead to the recovery of illegally taken artifacts.

This section provides a brief description of the rationale for recommending the rejection of some options as follows:

<u>Sea Otters and Harbor Seals:</u>

Option: Supplementing winter foods

The technical feasibility of this option is questionable and the methodology is untested. Prey would have to be distributed over a large area in order to be effective and it would encourage unnatural dependence on the part of the predator. The cost of implementing this option would be extremely high, with only a marginal likelihood of success.

Option: Translocating sea otters or harbor seals to augment injured populations

Although translocating otters and seals is technically feasible, there is a risk of causing further damage to the populations by introducing disease and of impacting the donor population through lost individuals. In addition, there are source populations adjacent to the oil-spill area that will naturally expand as the habitat improves.

Option: Reduce incidental loss through buying back limited-entry gillnet permits

This would be extremely costly and may require legislative permission from the State of Alaska. It is unlikely to result in a population-level increase because the incidental take of sea otters or harbor seals is currently low.

Option: Establish international wildlife rehabilitation/public education center

Rehabilitation of oiled sea otters and harbor seals, while technically feasible, has been relatively ineffective. After heroic efforts to save the hundreds of otters brought to the Valdez rehabilitation center post release survival has been relatively low. There is question in the scientific community whether the additional stress related to capture, transportation and handling may contribute to the mortality in these situations. Costs of rehabilitation are very high, with an upper range of $80,000 per animal. To now create a rehabilitation center would do nothing to restore otter and seal populations impacted by the *Exxon Valdez* oil spill. Although use of restoration funds for education has merit, such efforts do not have to be linked to establishing a wildlife rehabilitation center.

Killer Whales:

Option: Reduce marine debris and expand stranding and entanglement rescue operations

Although this option has been used in other areas to benefit different whale species, it is unlikely to produce noticeable benefits to killer whales in the oil-spill area. Incidents of stranding and entanglement of killer whales in the oil-spill area are rare, and the opportunities to implement rescue operations are limited by the remoteness of the area.

River Otters:

Option: Translocating river otters to augment populations within and outside of the oil spill area

Sufficient source populations exist for natural recolonization to occur. Translocating river otters may result in the introduction of disease into the injured population.

Common Murres and Marbled Murrelets:

Option: Augment natural reproduction through captive breeding, fostering and related techniques

The technical feasibility of this option is unknown because of the difficulty of introducing young murres and murrelets back into the wild. This would have to be done on a very large scale in order to have an effect on the populations. This option would require extensive research, at great cost, in order to determine its effectiveness.

Marbled Murrelets:

Option: Provide artificial nest sites to enhance productivity or redirect nest activities to alternative sites

Marbled murrelets often nest in large trees in old growth forests. If sufficient mature forest remains available, nest sites will not be a limiting factor in recovery.

Harlequin Ducks:

Option: Augment natural reproduction through captive breeding, fostering and related techniques

Although this method has been used effectively for other species of waterfowl, it has not been tested for harlequins. Population problems within the oil-spill area appear to be contaminant related and cannot be altered by augmenting the population of harlequins.

Harlequin Ducks and Black Oystercatchers:

Option: Mariculture of shellfish to supplement prey base

The cost:benefit ratio of this option is extremely poor. Mariculture operations would have to occur over an extremely large area to be effective, and the birds may still be exposed to oil from other food sources.

Bald Eagles:

Option: Augment natural reproduction through captive breeding, fostering and related techniques

Natural recovery is expected to be adequate when combined with habitat protection measures. Source populations for natural recovery exist near the oil-spill area.

Pink Salmon and Sockeye Salmon:

Option: Control predators on fish eggs and juveniles

This option would be difficult to implement over a large area. It also conflicts with the restoration of other injured species which may rely on salmon for food. Predator reduction may not be consistent with State and Federal laws.

Option: Buy back limited entry fishing permits to reduce pressure on resources

Identical results could be obtained through management practices.

Rockfish:

Option: Construct artificial habitat structures (e.g., artificial reefs)

Habitat does not appear to be a limiting factor in the recovery of rockfish.

Option: Buy back limited entry fishing permits to reduce pressure on resources

Identical results could be obtained through management practices.

Spot Shrimp:

Option: Mariculture and shore/intertidal habitat enhancements

The technical feasibility of this option for supplementing spot shrimp populations has not been demonstrated.

Coastal Habitat:

Option: Erosion control using rip-rap, revegetation and other methods

Shoreline assessment studies and other observations in the field indicate that erosion problems are minimal.

Archaeological (Cultural) Resources:

Option: Inventory beach and upland sites for cultural resources

Potentially injured archaeological resource sites are being surveyed under the damage assessment process.

Option: Encourage oral history and video tape projects concerning regional/local history and traditions

This option is not relevant to the restoration of archaeological resources as specified by the civil settlement.

Multiple Resources:

Option: Assist coastal communities and boat operators with environmentally-sound waste disposal and waste recycling programs

Option: Determine whether old community and military dump sites add to cumulative effects

Option: Reduce chronic oil pollution associated with boats, harbors, and transportation of petroleum

Option: Remove mining and logging debris to minimize cumulative effects of pollution

For any or all of the above options it would be difficult to establish direct linkage to the recovery of injured resources. If such a linkage is established, these options may become appropriate. Meanwhile, public education may be an avenue for addressing chronic pollution problems.

Option: Initiate reforestation programs wherever logging has occurred (e.g. Afognak Island)

The injured species which utilize forested habitats rely primarily on mature forests. For this reason, reforestation practices will not help the near-term restoration of populations injured by the *Exxon Valdez* oil spill.

Option: Establish stronger regulations, improved planning, and better response in order to minimize additional effects from future oil spills

The criminal court settlement provisions allow for expenditures towards planning for, and response to, future oil spills. This option is beyond the scope of the civil settlement. In addition, the Oil Pollution Act of 1990 will require new regulations and contingency planning.

Option: Reduce energy consumption through improved efficiency and conservation

This is beyond the scope of the civil settlement.

Option: Buy back Bristol Bay oil leases

This does not apply to the restoration of resources injured by the *Exxon Valdez* oil spill.

Option: Buy "net operating losses" (NOLs) of timber sales or change laws to disallow NOLs

Legislative action has already disallowed "net operating losses" of timber sales.

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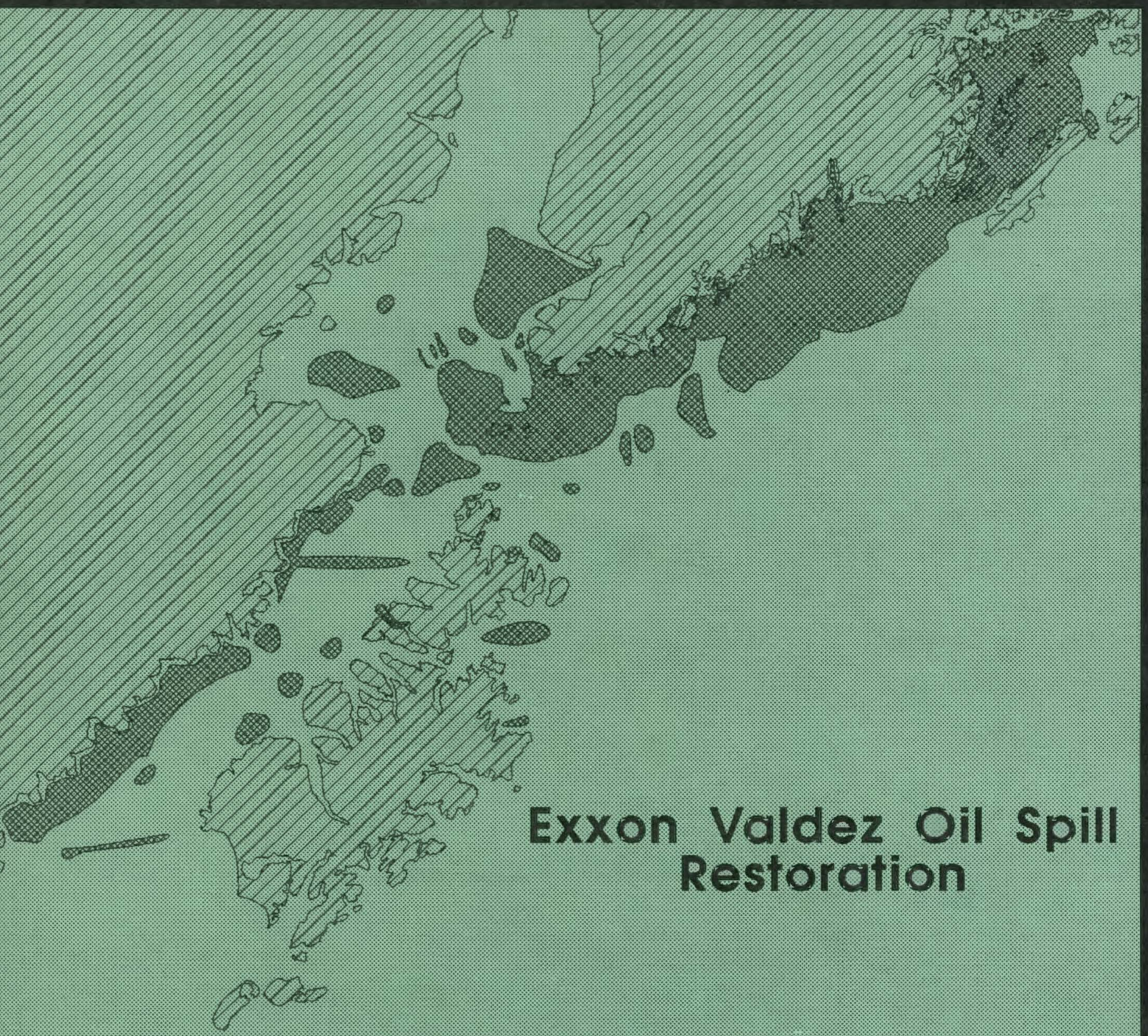

Exxon Valdez Oil Spill Restoration

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
Director
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

COMMENTS

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

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:

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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.

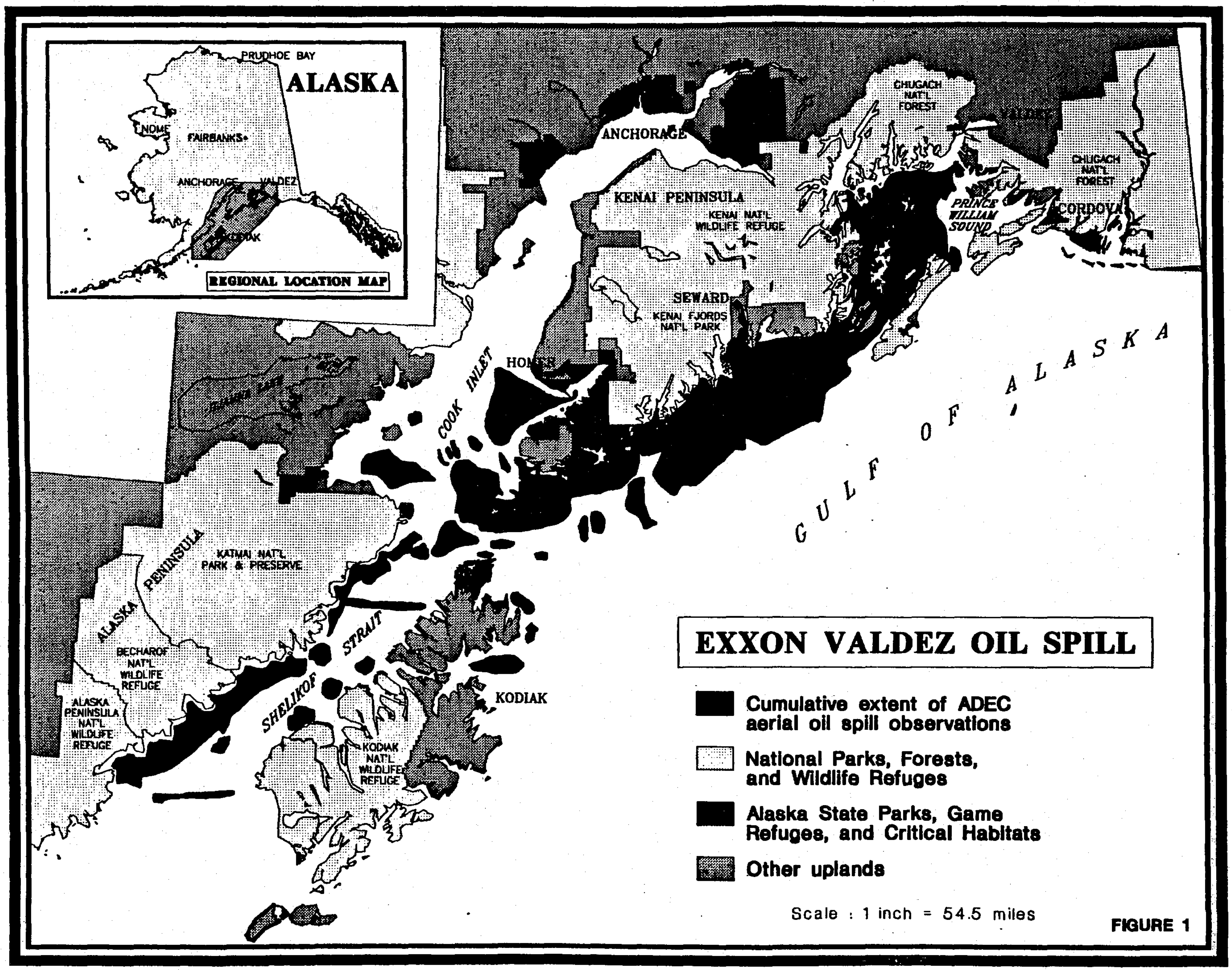
On December 9, 1991, the State and Federal governments and Exxon Corporation agreed to settlement terms of $1.1025 billion for both criminal restitution and civil damage claims. Of these monies the State and Federal Trustees will jointly receive up to $900 million from Exxon over the next 10 years. These 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
CHUGACH NAT'L FOREST
ANCHORAGE
KENAI PENINSULA
KENAI NAT'L WILDLIFE REFUGE
SEWARD
KENAI FJORDS NAT'L PARK
PRINCE WILLIAM SOUND
CHUGACH NAT'L FOREST
CORDOVA
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 NAT'L WILDLIFE REFUGE
KODIAK
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 southwestern 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 (<u>Fucus</u>), 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.

<u>Fucus</u>, the dominant intertidal plant, was severely affected by the oil and subsequent cleanup activities. In 1991, <u>Fucus</u> 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 <u>Fucus</u> 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 <u>Fucus</u> 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 <u>Fucus</u> 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.

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

	j	1	2	3	4	5	6
i	district	221	222	223-24	225-26	227	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

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

where k is the number of days in the Prince William Sound (see the <u>Data Analysis</u> 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.

LITERATURE CITED

Carpenter, S.R., J.F. Kitchell, and J.R. Hodgson. 1985. Cascading trophic interactions and lake productivity. BioScience 35:634-639.

Geiger, H.J., and J.P. Koenings. 1991. Escapement goals for sockeye salmon with informative prior probabilities based on habitat considerations. Journal of Fisheries Research (in press).

Koenings, J.P., and R.D. Burkett. 1987. Population characteristics of sockeye salmon (Oncorhynchus nerka) smolts relative to temperature regimes, euphotic volume, fry density, and forage base within Alaskan Lakes. p. 216-234. In H. D. Smith, L. Margolis, and C. C. Wood [ed.] Sockeye salmon (Oncorhynchus nerka) population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96.

Koenings, J.P., J.E. Edmundson, G.B. Kyle, and J.M. Edmundson. 1987. Limnology field and laboratory manual: Methods for assessing aquatic production. Alaska Department of Fish and Game, FRED Division Report Series No. 71:212 p.

Koenings, J.P., R.D. Burkett, M. Haddix, G.B. Kyle, and D.L. Barto. 1989. Experimental manipulation of lakes for sockeye salmon (<u>Oncorhynchus nerka</u>) rehabilitation and enhancement. Alaska Department of Fish and Game, FRED Division Report Series No. 96:18p.

Kyle, G.B. 1983. Cresent Lake sockeye salmon smolt enumeration and sampling, 1982. Alaska Department of Fish and Game, FRED Division Report Series No. 17:24 p.

Kyle, G.B. 1989. Summary of acoustically-derived population estimates and distributions of juvenile sockeye salmon (<u>Oncorhynchus nerka</u>) in 17 nursery lakes of Southcentral Alaska. Alaska Department of Fish and Game, FRED Division Report Series No. (In review).

Kyle, G.B., J.P. Koenings, and B.M. Barrett 1988. Density-dependent, trophic level responses to an introduced run of sockeye salmon (<u>Oncorhynchus nerka</u>) at Frazer Lake, Kodiak Island, Alaska. Canadian Journal of Fisheries and Aquatic Sciences 45:856-867.

Mills, E.L., and A. Schiavone, Jr. 1982. Evaluation of fish communities through trophic assessment of zooplankton populations and measures of lake productivity. North American Journal of Fisheries Management 2:14-27.

Rawson, K. 1984. An estimate of the size of a migrating population of juvenile salmon using an index of trap efficiency obtained by dye marking. Alaska Department of Fish and Game, FRED Division Report Series No. 28:23 p.

Tarbox, K.E., and B.E. King. 1989. An estimate of juvenile fish densities in Skilak and Kenai Lakes, Alaska through the use of dual beam hydroacoustic techniques in 1989. Alaska Department of Fish and Game, Commercial Fish Division Regional Information Report No. 2S90-1.

Townsend, C.R. 1989. Population cycles in freshwater fish. Journal of Fish Biology 35 (Supplement A):125-131.

	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:

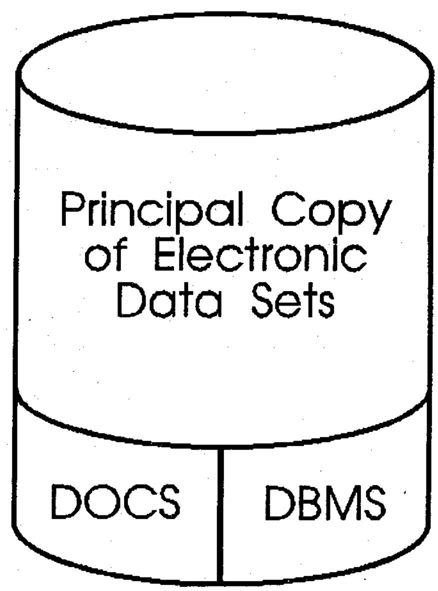
- Catalogues, archives, and maintains the principal copy of raw electronic data sets for FS-1, 2, 3, 4A, 11, 13, 27, 28, ST-5, (FS-5, ST-2AB, ST-6).

- 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.

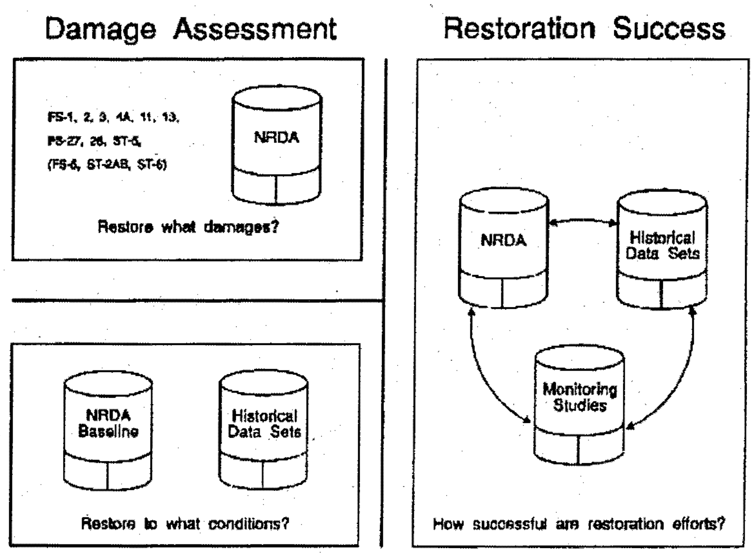
- Proposes to catalogue, archive, and maintain the principal electronic data sets for R-53, 58, 59, 60ABC, 105, 113, (R-90 and 106).



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. <u>Exxon Valdez</u> oil spill settlement monies are not used to develop this network.

<u>NRDA Project Data Sets</u>

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.

<u>Commercial Fisheries Historical Data</u>

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, (<u>Pandalus platyceros</u>), due to oil spilled from the T/V <u>Exxon Valdez</u>, 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 <u>Exxon Valdez</u> 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

LITERATURE CITED

Anderson, J.W., S.L. Kiesser, R.M. Bean, R.G. Riley, and B.L. Thomas. 1981. Toxicity of chemically dispersed oil to shrimp exposed to constant and decreasing concentrations in a flowing system. In: 1981 Oil Spill Conference (Prevention, Behavior, Control, Cleanup), Proceedings. Washington D.C. American Petroleum Institute. pp. 69-75.

Barr, L. 1973. Studies of spot shrimp, (Pandalus platyceros), at Little Port Walter, Alaska. Marine Fisheries Research 35: 65-66.

Barr, L. 1971. Methods of estimating the abundance of juvenile spot shrimp in a shallow nursery area. Trans. American Fisheries Society 4: 781-786.

Brodersen, C.C., S.D. Rice, J.W. Short, T.A. Mecklenburg, and J.F. Karinen. 1977. Sensitivity of larval and adult Alaskan shrimp and crabs to acute exposures of the water-soluble fraction of Cook Inlet crude oil. In: 1977 Oil Spill Conference (Prevention, Behavior, Control, Cleanup), Proceedings. Washington D.C. American Petroleum Institute. pp. 575-578.

Brodersen, C.C. 1987. Rapid narcosis and delayed mortality in larvae of king crabs and kelp shrimp exposed to the water-soluble fraction of crude oil. Marine Environmental Research. 22(1987):233-239.

Butler, T.H. 1980. Shrimps of the Pacific Coast of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences No. 202. 280 p.

Butler, T.H. 1964. Growth, reproduction, and distribution of pandalid shrimps in British Columbia. Journal of Fisheries Research Board of Canada. 21: 1403-1452.

Donaldson, W. 1989. Synopsis of the Montague Strait experimental harvest area 1985 - 1988. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. C89-04. 21 pp.

Donaldson, W., and C. Trowbridge. 1989. Effects of rigid mesh panels on escapement of spot shrimp (Pandalus platyceros) from pot gear. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 2C89-05. 22 pp.

Kimker, A., and W. Donaldson. 1987. Summary of 1986 streamer tag application and overview of the tagging project for spot shrimp in Prince William Sound. Alaska Department of Fish and

Game, Division of Commercial Fisheries, Prince William Sound Management Area Data Report 1987-07.

Kruse, G. and P. Murphy. 1989. Summary of statewide shrimp workshop held in Anchorage during October 24-26, 1988. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 5J89-##.

Mecklenburg, T.A., S.D. Rice, and J.F. Karinen. 1977. Molting and survival of king crab (Paralithodes camtschatica) and coonstripe shrimp (Pandalus hypsinotus) larvae exposed to Cook Inlet crude oil water-soluble fraction. in: D.A.Wolfe (ed), Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms. Pergamon Press, New York, NY. pp. 221-228.

Rice, S.D., D.A. Moles, J.F. Karinen, S. Korn, M.G. Carls, C.C. Brodersen, J.A. Gharrett and M.M. Babcock. 1984. Effects of Petroleum Hydrocarbons on Alaskan Aquatic Organisms: A Comprehensive Review of All Oil-Effects Research on Alaskan Fish and Invertebrates Conducted by the Auke Bay Laboratory, 1970-81. NOAA Technical Memorandum NMFS/NWC-67, p. 127.

Rice, S.D., D.A. Moles, T.L. Taylor and J.F. Karinen. 1979. Sensitivity of 39 Alaskan Marine Species to Cook Inlet crude oil and No. 2 Fuel oil. In Proceedings of the 1979 Oil Spill Conference, American Petroleum Institute, Washington , D.C., pp. 549-554.

Sanborn, H.R. and D.C. Malins. 1980. The disposition of aromatic hydrocarbons in adult spot shrimp (Pandalus platyceros) and the formation of metabolites of naphthalene in adult and larval spot shrimp. Xenobiotica. 10(3):193-200.

Stickle, W.B., M.A. Kapper, T.C. Shirley, M.G. Carls, and S.D. Rice. 1987. Bioenergetics and tolerance of the pink shrimp (Pandalus borealis) during long-term exposure to the water-soluble fraction and oiled sediment from Cook Inlet crude oil. In: W.B. Vernberg, A. Calabrese, F.P. Thurberg, and F.J. Vernberg (eds.). Pollution Physiology of Estuarine Organisms. Belle W. Baruch Libr. Mar. Sci. 17, Univ. S. C. Press, Columbia. pp. 87-106.

Vanderhorst, J.R., C.I. Gibson, and L.J. Moore. 1976. Toxicity of No. 2 fuel oil to coonstripe shrimp. Marine Pollution Bulletin. 7(6):106-108.

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:

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

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:

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

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:

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

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.

LITERATURE CITED

Brodersen, C.C., S.D. Rice, J.W. Short, T.A. Mecklenburg, and J.F. Karinen. 1977. Sensitivity of larval and adult Alaskan shrimp and crabs to acute exposures of the water-soluble fraction of Cook Inlet crude oil. In Proceedings of the 1977 Joint Conference (Prevention, Behavior, Control, Cleanup), Am. Pet. Inst. Wash., D.C. pp. 575-578

Cheatham, D.L., R.S. McMahon, S.J. Way, J.W. Short, and S.D. Rice. 1977. The relative importance of evaporation and biodegradation, and the effect of lower temperature on the loss of some mononuclear and dinuclear aromatic hydrocarbons from seawater. Environ. Ass. Alas. Cont. Shelf. 12:44-65

Gauch, H.G. 1982. Multivariate analysis in community ecology.

Cambridge University Press. Cambridge U.K. 298 pp.

Rice, S.D., M.M. Babcock, C.C. Brodersen, M.G. Carls, J.A. Gharrett, S. Korn, A. Moles and J.W. Short. 1986. Lethal and sublethal effects of the watersoluble fraction of Cook Inlet crude oil on Pacific herring (Clupea harengus pallasi) reproduction. U. S. Dept. Comm., NOAA, OCSEAP Final Report 63(1989):423-490

Rice, S.D., R.E. Thomas, and J.W. Short. 1977. Effect of petroleum hydrocarbons on breathing and coughing rates and hydrocarbon uptake-depuration in pink salmon fry. In: Vernberg, F. John, Anthony Calabrese, Frederick P. Thurberg, and Winona B. Vernberg, (eds.), Physiological Responses of Marine Biota to Pollutants. Academic Press. N. Y. pp. 259-277

Rice, S.D., J.W. Short and J.F. Karinen. 1977. Comparative oil toxicity and comparative animal sensitivity. In: Wolfe, Douglas A., (ed), Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems. Pergamon Press. N. Y. pp. 78-94.

Rice, S.D., J.W. Short, C.C. Brodersen, T.A. Mecklenburg, D.A. Moles, C.J. Misch, D.L. Cheatham, and J.F. Karinen. 1976. Acute Toxicity and Uptake-Depuration Studies with Cook Inlet Crude Oil, Prudhoe Bay Crude Oil, No. 2 Fuel Oil and Several Subarctic Marine Organisms. NWFC Processed Report, National Marine Fisheries Service. Seattle. 90 p.

Rice, S.D., J.W. Short, and J.F. Karinen. 1976. Toxicity of Cook Inlet crude oil and No. 2 fuel oil to several Alaskan marine fishes and invertebrates. In Sources, Effects and Sinks of Hydrocarbons in the Aquatic Environment Proc. Symp., American University, Washington, D. C., American Institute of Biological Sciences. Washington, D.C. pp. 394-406

Rice, S.D., D.A. Moles, and J,W. Short. 1975. The effect of Prudhoe Bay crude oil on survival and growth of eggs, alevins, and fry of pink salmon, Oncorhynchus gorbuscha. In: Proceedings of the 1975 Joint Conference on Prevention and Control of Oil Pollution Am. Pet. Inst. Wash., D.C. pp. 503-507

Short, J.W., S.D. Rice, and D.L. Cheatham. 1976. Comparison of two methods for oil and grease determination. In: Hood, D. W., and D. C. Burrell, (ed.), Assessment of the Arctic Marine Environment. Institute of Marine Science, University of Alaska, Fairbanks, Ak., pp. 451-462

	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 <u>1992 Work Plan</u>. 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.

LITERATURE CITED

ESRI. 1989. Users guide ARC/INFO. Vol. 1. Environmental Systems Research Institute, Inc. (ESRI), Redlands, California.

GIS Technical Group. 1989. Technical Services Study Number 3 Mapping of damage assessment data and information. NRDA Detailed Study Plan, Alaska Dept. of Natural Resources and U.S. Fish & Wildl. Serv., Anchorage, Alaska.

_____. November 1991. Technical services #3 GIS mapping and statistical analysis. NRDA Technical Services Study #3 Report, Alaska Dept. of Natural Resources and U.S. Fish & Wildl. Serv., Anchorage, Alaska.

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.

LITERATURE CITED

Byrd, G.V. 1989. Seabirds in the Pribilof Islands, Alaska: trends and monitoring methods. M.S.thesis, Univ. of Idaho, Moscow, Idaho, 96pp.

Dragoo, D.E. and B.K. Bain. 1990. Changes in colony size, and reproductive success of seabirds at the Semidi Islands, Alaska, 1977-1990. U.S. Dept. Interior, U.S. Fish and Wildl. Serv., Homer, Alaska, Unpubl. Rept.

Fowler, J. and L. Cohen. 1986. Statistics for Ornithologists. British Trust for Ornithology, BTO Guide No. 22, Tring, Hertfordshire. 175 pages.

Garton, E.O. 1988. A statistical evaluation of seabird monitoring programs at three sites on the Alaska Maritime National Wildlife Refuge. Univ. of Idaho, Moscow, Idaho. Unpubl. Rept. from contract with the refuge, 15pp.

Hatch, S.A. and M.A. Hatch. 1989. Attendance patterns of common and thick-billed murres at breeding sites: implications for monitoring. J. Wildl. Mgmt. 53(2):483-493.

Hatch, S.A. and M.A. Hatch. 1988. Colony attendance and population monitoring of black-legged kittiwakes on the Semidi Islands, Alaska. Condor 90:613-620.

Irons, D.B., D.R. Nysewander, and J.L. Trapp. 1987. Changes in colony size and reproductive success of black-legged kittiwakes in Prince William Sound, Alaska, 1972-1986. U. S. Dept. Interior, Fish and Wildl. Serv., Anchorage, Alaska, Unpubl. Rept. 37pp.

King, J.G. and G.A. Sanger. 1979. Oil vulnerability index for marine oriented birds. Pp. 227-239 in J.C. Bartonek and D.N. Nettleship eds. Conservation of marine birds of northern North America. U. S. Fish and Wildl. Serv., Washington D.C. 319pp.

Mendenhall, V.M. (ed.). 1991. Monitoring seabird populations in areas of oil and gas development on the Alaskan continental shelf: monitoring of populations and productivity of seabirds at St. George Island, Cape Pierce, and Bluff, Alaska, 1989. U.S. Dept Interior, Minerals Mngt. Serv., Anchorage, Alaska, OCS Study, MMS 90-0049. 125pp.

Nishimoto, M. and B. Rice. 1987. A re-survey of seabirds and marine mammals along the south coast of the Kenai Peninsula, Alaska during the summer of 1986. U. S. Fish and Wild. Serv., Alaska Maritime National Wildl. Refuge, Homer, Alaska. Unpubl. Rept. 79pp.

Nysewander, D.R. 1990. Population surveys of seabird nesting colonies in Prince William Sound, the outside coast of the Kenai Peninsula, Barren Islands, and other nearby colonies. U.S. Dept. Interior, U.S. Fish and Wildl Serv., Homer, Alaska, Unpubl. Rept. 35pp.

Nysewander, D.R. and C.H. Dippel. 1990. Population surveys of seabird nesting colonies in Prince William Sound, the outside coast of the Kenai Peninsula, Barren Islands, and other nearby colonies with emphasis on changes of numbers and reproduction of murres. U.S. Dept. Interior, U.S. Fish and Wildl Serv., Homer, Alaska, Unpubl. Rept. 47pp.

Nysewander, D.R. and C.H. Dippel. 1991. Population surveys of seabird nesting colonies in Prince William Sound, the outside coast of the Kenai Peninsula, Barren Islands, and other nearby colonies with emphasis on changes of numbers and reproduction of murres. U.S. Dept. Interior, U.S. Fish and Wildl Serv., Homer, Alaska, Unpubl. Rept. 70pp.

U. S. Fish and Wildlife Service. 1986. Catalog of Alaskan seabird colonies--computer archives. U.S. Fish and Wildl. Serv., Migratory Bird Management, Anchorage, Alaska 99503.

	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 (Oncorhynchus gorbuscha) 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, Exxon Valdez 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 Exxon Valdez 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)].

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

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 ($\alpha = 0.05$), four contrasts (oil vs. unoiled for the four stream zones) and corresponding Bonferroni family confidence intervals ($\alpha = 0.10$ 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 $\alpha = 0.05$, 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.

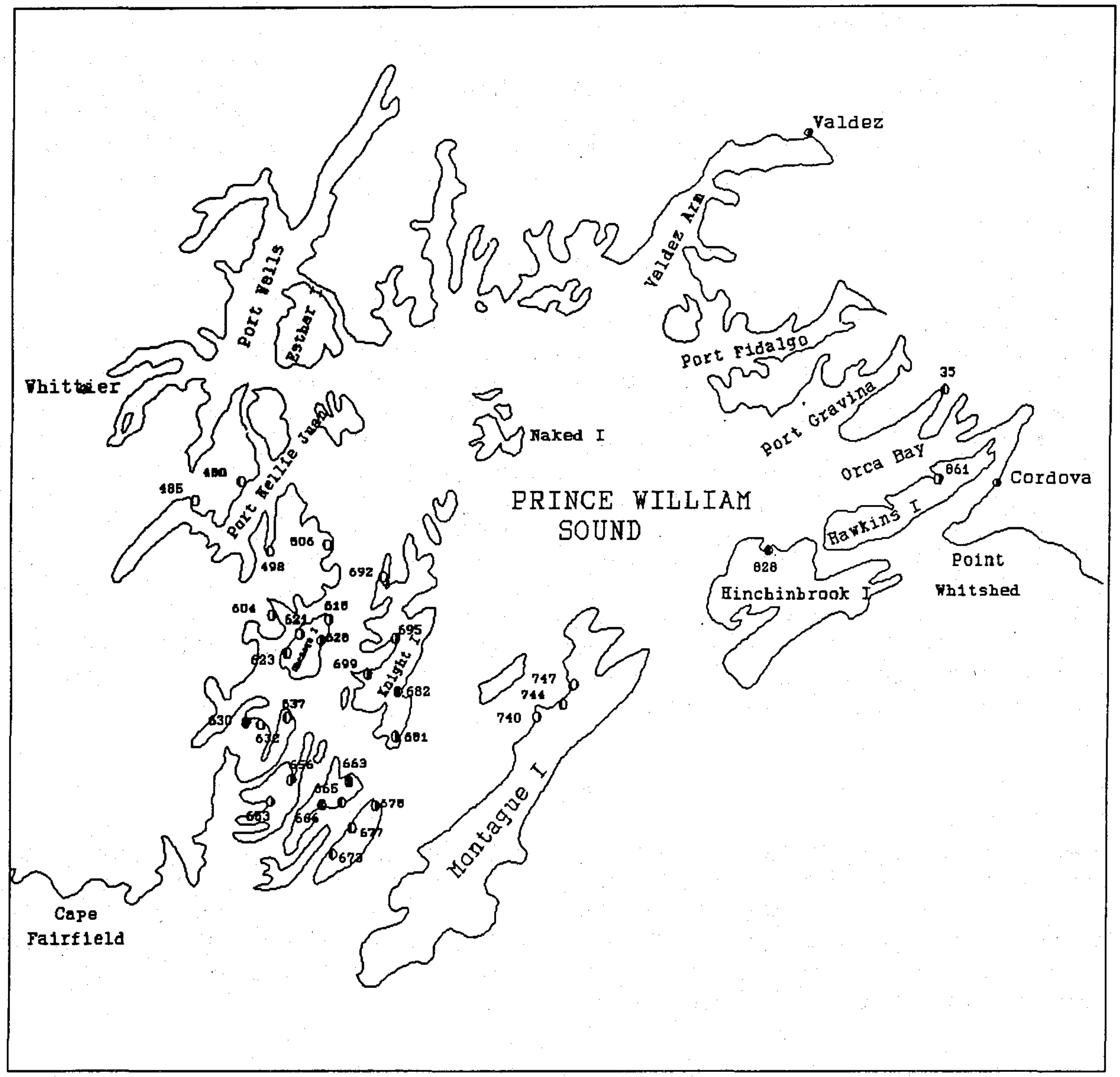


Figure 1. Location of streams to be sampled for egg deposition.

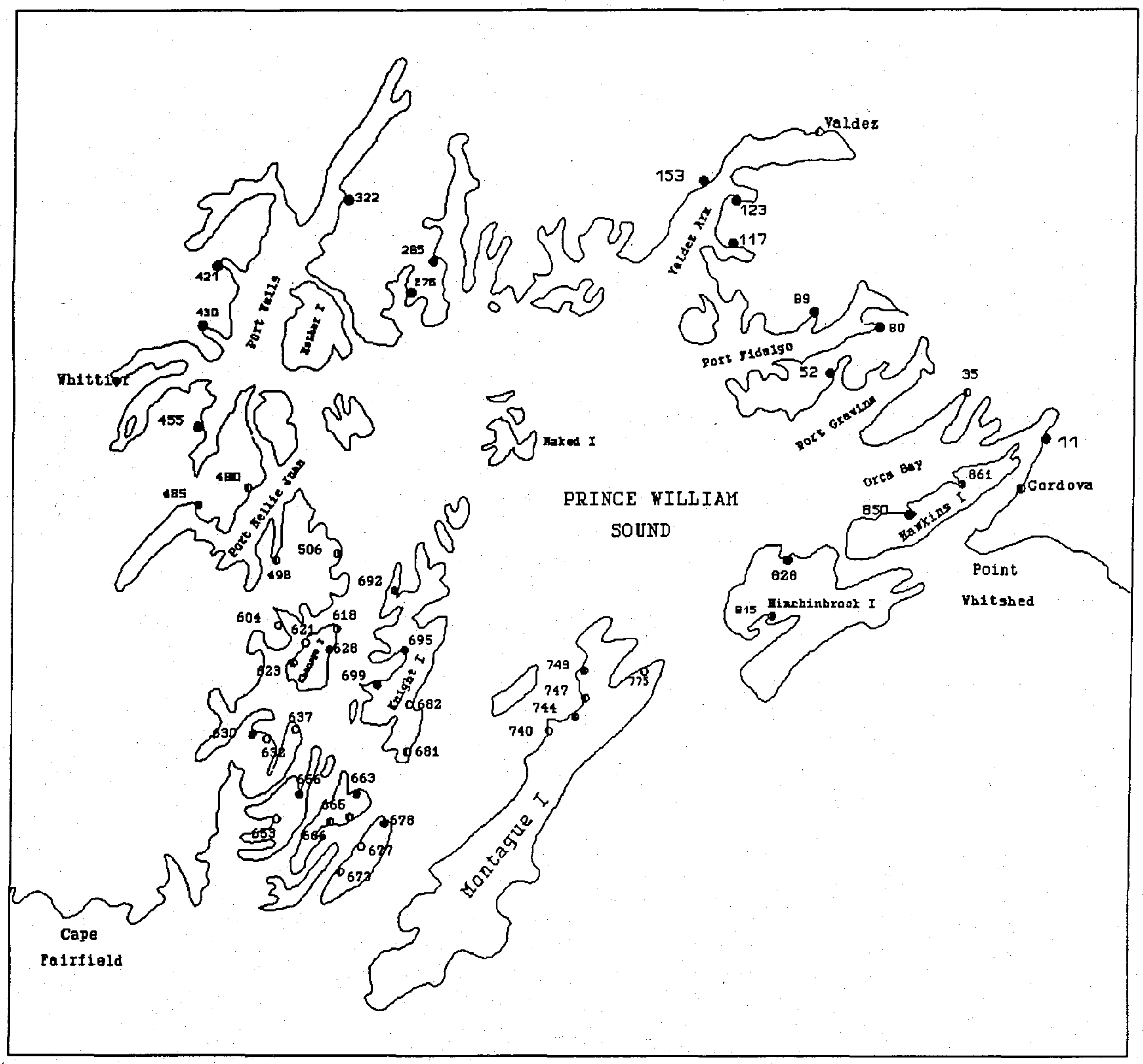


Figure 2. Locations of streams to be sampled for pre-emergent fry.

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.

LITERATURE CITED

Chambers, J.M., W.S. Cleveland, B. Kleiner, P.A. Tukey. 1983. Graphical methods for data analysis. Duxbury Press, Boston, Mass. USA.

Moles, A., M.M. Babcock, and S.D. Rice. 1987. Effects of oil exposure on pink salmon (*O. gorbuscha*) alevins in a simulated intertidal environment. Marine Environment Research, 21:49-58.

Neter, J., W. Wasserman, and M.H. Kutner. 1985. Applied Linear Statistical Models. Irwin, Homewood, Illinois, USA.

Pirtle, R.B. and M.L. McCurdy. 1977. Prince William Sound general districts 1976 pink and chum salmon aerial and ground escapement surveys and consequent brood year egg deposition and pre-emergent fry index programs. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 9, Juneau.

Sokal, R.R., and F.J. Rohlf. 1969. Biometry. W.H. Freeman and Company, San Francisco, California, USA.

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 Exxon Valdez 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 northwest 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.

LITERATURE CITED

Blanchet, D. 1979. Potential fisheries enhancement projects for Prince William Sound. USFS Report, 29p.

Cooper, A.C. 1977. Evaluation of the production of sockeye and pink salmon at spawning and incubation channels in the Fraser River system. INPDFC. Rep. 36: 80p.

Cowan, L. 1987. Physical characteristics and intragravel survival of chum salmon in developed and non-developed groundwater channels in Washington. In: Proceedings of the 1987 Northeast Pink and Chum salmon Workshop. pp. 162-172.

Deitz, K.G. 1968. Chum salmon survival in three tributaries of the Harrison River. Unpubl. Memorandum Rep. (File No. 31-1-h9). Dept of Fisheries & Oceans, Vancouver, Canada, 5p.

Doyle, J. 1978. Operational plan for the monitoring and evaluation program for fish habitat improvement and enhancement projects on the Chugach National Forest. USFS report, 60p.

Fedorenko, A.Y. and D.D. Bailey. 1980. Inches Creek chum pilot project 1970-1978. Fish. Mar. Serv. Manuscript Rep. no. 1562: 47p.

Fraser, F.J. and A.Y. Fedorenko 1983. Jones Creek pink salmon spawning channel: A biological assessment, 1954-1982. Can. Tech. Rep. Fish. Aquat. Sci. no. 1188.

Heard, W.R. 1978. Probable case of streambed overseeding-1967 pink salmon, Oncorhynchus gorbuscha, spawners and survival of their progeny in Sashin Creek, Southeastern Alaska. Fish. Bull. 76(3): 569-582.

Jenkins, G.M. and D.G. Watts. 1968. Spectral Analysis and its Applications. Holden Day, San Francisco, California.

Lim, P.G. and D.T. Barrett. 1982. A review of pink salmon (Oncorhynchus gorbuscha) transplants to Robertson Creek (1959-1964). Can. Man. Rep. Fish. Aquat. Sci. no. 1696.

Lister, D.B. and C.E. Walker. 1966. The effect of flow control on freshwater survival of chum, coho, and chinook salmon in the Big Qualicum River. Can. Fish Culturist 37: 3-25.

McDaniel, T.R. 1981. Evaluation of pink salmon (Oncorhynchus gorbuscha) fry plants at Seal Bay Creek, Afognak Island, Alaska ADF&G Informational Leaflet no. 193, 9p.

McNeil, W.J. 1966. Distribution of spawning pink salmon in Sashin Creek, Southeastern Alaska, and survival of their progeny. USFWS, Spec. Sci. Rpt.-Fisheries NO. 538.

Novak, P. and C. Denton. 1989. Progress Report: Marx Creek Spawning Channel (1985-1987). Alaska Dept. of Fish and Game, FRED Report no. 94, 25p.

Olsen, R.A. and M. Wenger. 1991. Cooper Landing Cooperative Project, Stream Habitat Monitoring. USFS Internal Report.

Quimby, A. and N. Dudiak. 1986. Paint River fish pass feasibility studies, 1978-1983. ADFG FRED Report 72.

Sanner, C. 1982a. Economic evaluation of fishways constructed in the Anchorage ranger district, Chugach Forest. USFS Report, 2p.

Sanner, C. 1982b. Potential spawning channel site selection survey, Coghill Lake area, Prince William Sound. USFS Report, 40p.

Sheridan, W. 1965. Salmon habitat improvement reconnaissance Prince William Sound, Cordova and Anchorage ranger districts. USFS Report, 7p.

Sweet, M. 1975. Fish habitat improvement information for the Alaska region 10. USFS Report, 12p.

Thompson, K. 1982. Groundwater Spawning Channels. Internal Report, USFS Chugach NF.

U.S. Forest Service. 1987. Final Construction Report for the Mile 25.25 Spawning Channels. USFS, Cordova Ranger District.

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.

LITERATURE CITED

Malloy, L., 1988. Annual Management Report, Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak, 100 pages.

Schmidt, D., 1991. State/Federal Natural Resource Damage Assessment, Draft

FRED Division, 1983. Fish Culture Manual, Reference Manual, 90 pages.

Drucker, B. 1970. Red Salmon Studies at Karluk Lake, 1968. U.S. Bur. Comm. Fish., Auke Bay Biol. Lab., Admin. Rep. 55 pages.

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.

LITERATURE CITED

Becking, R.W. 1991. Eggshell fragments of the Marbled Murrelet (Brachyramphus marmoratus) in San Mateo County, California. Northwestern Naturalist 72:75.

Binford, L.C., B.G. Elliot and S.W. Singer. 1975. Discovery of a nest and the downy young of the Marbled Murrelet. Wilson Bulletin 87:303-319.

Ford, R.G., M.L. Bonnell, D.H. Varoujean, G.W. Page, B.E. Sharp, D. Heinemann and J.L. Casey. 1991. Assessment of direct seabird mortality in Prince William Sound and the Western Gulf of Alaska resulting from the Exxon Valdez oil spill. Ecological Consulting, Inc. Portland, Oregon.

Hamer, T.E. and E.B. Cummins. 1990. Forest habitat relationships of Marbled Murrelets in western Washington. Final report. Wildlife Management Division, Nongame Program, Washington Dept. of Wildlife, Olympia.

Hamer, T.E. and E.B. Cummins. 1991. Relationships between forest characteristics and use of inland sites by Marbled Murrelets in northwestern Washington. Draft report. Wildlife Management Division, Nongame Program, Washington Dept. of Wildlife, Olympia.

Irons, D.B., D.R. Nyeswander and J.L. Trapp. ca. 1987. Prince William Sound waterbird distributions in relation to habitat type. Unpubl. report. U.S. Fish and Wildlife Service. Anchorage, Alaska.

Klosiewski, S.P. and L.A. Hotchkiss. 1990. Surveys to determine distribution and abundance of migratory birds in Prince William Sound and the northern Gulf of Alaska. Preliminary status report. U.S. Fish and Wildlife Service, Migratory Bird Management, Anchorage, Alaska.

Kuletz, K.J. 1991. Restoration feasibility study number 4 - identification of upland habitats used by wildlife affected by the EVOS: Marbled Murrelets. Final report. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Kuletz, K.J. 1992a. Assessment of injury to Marbled Murrelets from the Exxon Valdez Oil Spill. Draft report. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Kuletz, K.J. 1992b. 1991 restoration feasibility study for identification of upland habitat used by Marbled Murrelets in Prince William Sound, Alaska. Preliminary draft report. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Laing, K. 1991. Assessment of injury to waterbirds from the Exxon Valdez oil spill: boat surveys to determine distribution and abundance of migratory birds in Prince William Sound. NRDA Bird Study No. 2. Draft report. Migratory Bird Management, U.S. Fish and Wildlife Service. Anchorage, Alaska.

Manley, I. and J. Kelson. 1991. The discovery of a Marbled Murrelet nest in the Walbran Valley, Vancouver Island, British Columbia. Abstract. Pacific Seabird Group Bulletin 18.

Manley, I. and J. Kelson. 1992. Marbled Murrelets in the Walbran Valley: inland behavior and discovery of Canada's second nest. Abstract. Pacific Seabird Group annual meeting January 15-19 1992.

Marshall, D.B. 1988. Status of the Marbled Murrelet in North America with special emphasis on populations in Washington, Oregon and California. USFWS Biol. Rep. 88(30).

Mendenhall, V.M. 1988. Distribution, breeding records and conservation problems of the marbled murrelet in Alaska. Unpubl. Rep., U.S. Fish and Wildlife Service, Anchorage, Alaska.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley & Sons, New York.

Naslund, N.L., J.L. Schear and D.P. Costa. 1990a. Behavior of Marbled Murrelets at two tree nests in central California. Abstract. Pacific Seabird Group Bulletin 17:27.

Naslund, N.L., S.W. Singer and S.A. Singer. 1990b. A proposed ground search technique for finding tree nests of the Marbled Murrelet in open canopy forest. Abstract, Pacific Seabird Group Bulletin 17:28.

Nelson, S.K. 1989. Development of inventory techniques for surveying Marbled Murrelets (Brachyramphus marmoratus) in the central Oregon Coast Range. Final Rept. to Oregon Dept. of Fish & Wildlife. Oregon Cooperative Wildlife Research Unit, Oregon State University, Corvallis.

Nelson, S.K. 1991. Interim management guidelines for Marbled Murrelet habitat conservation in Washington, Oregon and

California. Draft. Oregon Cooperative Wildlife Research Unit, Oregon State University, Corvallis.

Nelson, S.K., T.E. Hamer and K. Holtrop. 1992. Nest-site characteristics of Marbled Murrelets in the Pacific Northwest. Abstract. Pacific Seabird Group annual meeting January 15-19 1992.

Paton, P.W.C., C.J. Ralph, H.R. Carter and S.K. Nelson. 1990. Surveying Marbled Murrelets at inland forested sites: a guide. Gen. Tech. Rep. PSW-120. Berkeley, CA. Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.

Piatt, J.F., C.J. Lensink, W. Butler, M. Kendziorek and D. Nyswander. 1990. Immediate Impact of the Exxon Valdez Oil Spill on Marine Birds. Auk 107(2):387.

Quinlan, S.E. and J.H. Hughes. 1990. Location and description of a Marbled Murrelet tree nest site in Alaska. Condor 92:1068-1073.

Reed, P. and C. Wood. 1991. Marbled Murrelet chick and eggshell fragments from inland Washington. Northwestern Naturalist 72:77-78.

Singer, S.W., N.L. Naslund, S.A. Singer and C.J. Ralph. 1991. Discovery and observations of two tree nests of the Marbled Murrelet. Condor 93:330-339.

Singer, S.W., D.L. Suddjian, S.A. Singer and R. Norden. 1992. Fledging of a Marbled Murrelet from a redwood tree nest. Abstract. Pacific Seabird Group annual meeting January 15-19 1992.

Varoujean, D.H. and H.R. Carter. 1989. The Pacific Seabird Group's 1989 Marbled Murrelet nest site sampling protocol. Unpubl. Rept. MARZET, North Bend, Oregon.

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.

LITERATURE CITED

Bengston, S.A.1972. Breeding ecology of the harlequin duck. Ornis Sand. 3:1 pp 1-9.

Crowley, D.W. 1991. Preliminary status report of the Harlequin Duck Restoration Project in Prince William Sound. Unpubl. report. Alaska Dept. Fish and Game. Anchorage, Alaska. 34 pp.

Dzinbal, K.A. 1982. Ecology of harlequin ducks in Prince William Sound, Alaska, during summer. M.S. Thesis, Oregon State University, Corvallis. 89 pp.

Klett, A.T. and D.H. Johnson. 1982. Variability in nest survival rates and implications to nesting studies. The Auk. 99:77-78.

Kuchel, C.R. 1977. Some aspects of the behavior and ecology of harlequin ducks breeding in Glacier National Park, Montana. M. S. Thesis. Univ. Montana. 130 pp.

Patten, S.M. 1991. unpublished. Injury assessment of hydrocarbon uptake by sea ducks in Prince William Sound and the Kodiak Archipelago, Alaska. Draft, Preliminary NRDA Status Report. Bird Study No. 11. Alaska Dept. Fish and Game. Anchorage, AK. 75 pp.

Savard, J.P.L. 1988. Use of nest boxes by Barrow's goldeneyes: nesting success and effect on the breeding population. Wildl. Soc. Bull. 16:125-132.

Weller, M.W. 1956. A simple field candler for waterfowl eggs. J. Wildl. Manage. 20(2):11-13.

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.

LITERATURE CITED

Dzinbal, K.A. and R.L. Jarvis. 1982. Coastal feeding ecology of harlequin ducks in Prince William Sound, Alaska, during summer. pp. 6 - 10 in Marine birds: their feeding ecology and commercial fisheries relationships. Nettleship, D.A., G.A. Sanger, and P.F. Springer, eds. Proc. Pacific Seabird Group Symp., Seattle, WA., 6 - 8 Jan. 1982. Can. Wildl. Serv. Spec. Publ.

Fry, D.M., J. Swenson, L.A. Addiego, C.R. Grau, and A. Kang. 1986. Reduced reproduction of wedge-tailed shearwaters exposed to weathered Santa Barbara crude oil. Arch. Environ. Contam. Toxicol. 15, 453-463.

Grau, C.R., T. Roudybush, J. Dobbs, J. Wathen. 1977. Altered yolk structure and reduced hatchability of eggs from birds fed single doses of petroleum oils. Science 195, 779-781.

Hall, R.J., and N.C. Coon. 1988. Interpreting residues of petroleum hydrocarbons in wildlife tissues. U.S. Fish and Wildl. Serv., Biol. Rep. 88(15). 8 pp.

Hogan, M.E. 1980. Seasonal habitat use of Port Valdez, Alaska by marine birds. Unpublished administrative report. U.S. Fish and Wildl. Serv., Anchorage, Ak. 25 pp.

Isleib, M.E. and B. Kessel. 1973. Birds of the North Gulf Coast-Prince William Sound Region, Alaska. Biol. Pap. Univ. Alaska 14.

King, J.G. and G.A. Sanger. 1979. Oil vulnerability index for marine oriented birds. pp. 227-239 in J.C. Bartonek and D.N. Nettleship (eds.). Conservation of marine birds in northern North America. U.S. Fish and Wildl. Serv., Wildl. Res. Rep. 11. Washington, D.C.

Koehl, P.S., T.C. Rothe, and D.V. Derksen. 1982. Winter food habits of Barrow's goldeneyes in southeast Alaska. pp. 1 - 5 in Marine birds: their feeding ecology and commercial fisheries relationships. Nettleship, D. N., G.A. Sanger, and P.F. Springer, eds. Proc. Pacific Seabird Group Symp., Seattle, WA., 6-8 Jan. 1982. Can. Wildl. Serv. Spec. Publ.

Sanger, G.A. and R.D. Jones, Jr. 1982. Winter feeding ecology and trophic relationships of oldsquaws and white- winged scoters on Kachemak Bay, Alaska. pp. 20-28 in Marine birds: their feeding ecology and commercial fisheries relationships. Nettleship, D.N., G.A. Sanger, and P.F. Springer, eds. Proc. Pacific Seabird Group Symp., Seattle, WA., 6-8 Jan. 1982. Can. Wildl. Serv. Spec. Publ.

Shaw, D.G., A.J. Paul, L.M. Cheek, and H.M. Feder. 1976. Macoma balthica: an indicator of oil pollution. Mar. Poll. Bull. 7 (2): 29-31.

Stekoll, M.S., L.E. Clement, and D.G. Shaw. 1980. Sublethal effects of chronic oil exposure on the intertidal clam Macoma balthica. Mar. Biol. 57: 51-60.

Vermeer, K. and N. Bourne. 1982. The white-winged scoter diet in British Columbia: resource partitioning with other scoters. pp. 30 - 38 in Marine birds: their feeding ecology and commercial fisheries relationships. Nettleship, D.A., G.A. Sanger, and P.F. Springer, eds. Proc. Pacific Seabird Group Symp., Seattle, WA., 6-8 Jan. 1982. Can. Wildl. Serv. Spec. Publ.

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^{0}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^{0}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

$$p_j \geq 0 \text{ and } \sum_j p_j = 1.$$

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 ($H_o : b_1 = 0$; 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 ($H_o : b_1 = 1.0$). 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.

LITERATURE CITED

Allendorf, F.W. and S. R. Phelps. 1981. Use of allelic frequencies to describe population structure. Can. J. Fish. Aquat. Sci. 38: 1507 - 1514.

Bethe, M., P. Krasnowski, and S. Marshall. 1980. Origins of sockeye salmon in the upper Cook Inlet fishery of 1978 based on scale pattern analysis. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 186, Juneau.

Cross, B., et. al. 1981. Origins of sockeye salmon in the upper Cook Inlet fishery of 1979 based on scale pattern analysis. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 58, Juneau.

Cross, B., S. Marshall, G. Oliver, and S. Sharr. 1982. Origins of sockeye salmon in the upper Cook Inlet fishery of 1980 based on scale pattern analysis. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 68, Juneau.

Cross, B., W. Goshert, and D. Hicks. 1986. Origins of sockeye salmon in the fisheries of upper Cook Inlet, 1983. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 181, Juneau.

Fournier, D.A., T.D. Beacham, B.E. Riddell, and C.A. Busack. 1984. Estimating stock composition in mixed stock fisheries using morphometric, meristic, and electrophoretic characteristics. Canadian Journal of Fisheries and Aquatic Science. 41:400-408.

Koo, T.S.Y. 1955. Biology of the red salmon, Oncorhynchus nerka (Walbaum), of Bristol Bay, Alaska as revealed by a study of their scales. Doctoral dissertation, University of Washington, Seattle.

McPherson, S.A. 1986. Contribution, exploitation, and migratory timing of Chilkat and Chilkoot River runs of sockeye salmon (Oncorhynchus nerka Walbaum) in the Lynn Canal drift gillnet fishery of 1984. Alaska Department of Fish and Game, Technical Data Report.

Millar, R.B. 1987. Maximum likelihood estimation of mixed stock fishery composition. Canadian Journal of Fisheries and Aquatic Science. 44: 583-590.

Pella J.J. and G.B. Milner. 1987. Use of genetic marks in stock composition analysis. Pages 247 to 276 in Nils Ryman and Fred Utter editors. Population genetics & fishery management. Washington Sea Grant Program, University of Washington Press, Seattle, Washington.

Tarbox, K.E. 1992. An estimate of the migratory timing of sockeye salmon into Upper Cook Inlet, Alaska, in 1991 using a test fishery. Alaska Department of Fish and Game, Regional Information Report 2S92-1.

Tarbox, K.E., A. Moles, and D.L. Waltemyer. 1991. Presence of parasites in sockeye salmon of Upper Cook Inlet, Alaska. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report 2S91-5. Anchorage.

Waples, R.S. 1990. Temporal changes of allele frequency in Pacific salmon: implications for mixed stock fishery analysis. Can. J. Fish. Aquat. Sci. 47:968-976

Williams, T., and B.C. Bedford. 1974. The use of otoliths for age determination. Pages 114 to 123 in T.B. Bagenal, editor. The Proceedings of an International Symposium on The Aging of Fish. University of Reading. England.

Wood, C.C., S. McKinnell, T.J. Mulligan, and D.A. Fournier. 1987. Stock identification with the maximum-likelihood mixture model: Sensitivity analysis and application to complex problems. Canadian Journal of Fisheries and Aquatic Science. 44: 866-881.

Wood, C.C., D.T. Rutherford, S. McKinnell. 1989. Identification of sockeye salmon in mixed-stock fisheries in British Columbia and Southeast Alaska using biological markers. Canadian Journal of Fisheries and Aquatic Science. 46: 2108-2120

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 Exxon Valdez 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 Exxon Valdez 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 $-80^{\circ}C$ storage in Soldotna or Anchorage. Soldotna samples will be transferred to the Anchorage laboratory on dry ice or liquid nitrogen and again placed in $80^{\circ}C$ 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
Fisheries Rehabilitation Enhancement and Development
Alaska Department of Fish and Game
Anchorage, Alaska 99518 (907) 267-2385

EDUCATION: B.S., Biology, 1974, University of Puget Sound
M.S., Fisheries, 1982, University of Washington
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

Lisa W. Seeb
Statewide Geneticist, Division of Commercial Fisheries
Alaska Dept. of Fish and Game
Anchorage, Alaska 99518 (907) 267-2249

EDUCATION:

A.B. Zoology, 1973, University of California, Berkeley
M.A. Zoology, 1977, University of Montana
Ph.D. Fisheries, 1986, University of Washington

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
1977-1979 Geneticist, National Marine Fisheries Service, Seattle

LITERATURE CITED

Aebersold, P.B., G.A. Winans, D.J. Teel, G.B. Milner, and F.M. Utter. 1987. Manual for starch gel electrophoresis: A method for the detection of genetic variation. NOAA Technical Report NMFS 61, U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, 19 p.

Allendorf, F.W. and S.R. Phelps. 1981. Use of allelic frequencies to describe population structure. Can. J. Fish. Aquat. Sci. 38:1507-1514.

Bermingham, E. 1990. Mitochondrial DNA and the analysis of fish population structure. p. 197-221 In D. H. Whitmore, ed. Electrophoretic and isoelectric focusing techniques in fisheries management. CRC Press, Boca Raton, FL.

Bermingham, E., S.H. Forbes, K. Friedland, and C. Pla. 1991. Discrimination between Atlantic salmon (Salmo salar) of North American and European origin using restriction analyses of mitochondrial DNA. Can. J. Fish. Aquat. Sci 48:884-893.

Carr, S.M. and H.D. Marshall. 1991. Detection of intraspecific DNA sequence variation in the mitochondrial cytochrome *b* gene of Atlantic cod (Gadus morhua) by the polymerase chain reaction. Can. J. Fish. Aquat. Sci 48:48-52.

Chapman, R.W. and B.L. Brown. 1990. Mitochondrial DNA isolation methods. p. 107-129 In D. H. Whitmore, ed. Electrophoretic and isoelectric focusing techniques in fisheries management. CRC Press, Boca Raton, FL.

Cooper, D.W. 1968. The significance level in multiple tests made simultaneously. Heredity 23:614-617.

Dempster, A.P., N.M. Laird, and D.B. Rubin. 1977. Maximum likelihood from incomplete data via the EM algorithm. Stat. Soc. B39:1-39

Efron, B., and R. Tibshirani. 1986. Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. Statistical Science 1:54-77.

Fournier, D.A., T.D. Beacham, B.E. Riddell, and C.A. Busack. 1984. Estimating stock composition in mixed-stock fisheries using morphometric, meristic, and electrophoretic characters. Can. J. Fish. Aquat. Sci. 41:400-408.

Gall, G.A.E., B. Bentley. C. Panattoni, E. Childs, C.F. Qi, S. Fox, M. Mangel, J. Brodziak, and J. Gomulkiewicz. 1989. Chinook mixed fishery project, 1986-1989. Executive Summary, University of California, Davis.

Grant, W.S., G.B. Milner, P. Krasnowski, and F.M. Utter. 1980. Use of biochemical genetic variants for identification of sockeye salmon (Oncorhynchus nerka) stocks in Cook Inlet, Alaska. Can. J. Fish. Aquat. Sci. 37: 1236-1247.

Harris, H. and D.A. Hopkinson. 1976. Handbook of enzyme electrophoresis in human genetics. American Elsevier, NY.

Kessing, B., H. Croom, A. Martin, C. McIntosh, W.O. McMillan and S. Palumbi. 1989. The simple fool's guide to PCR, Ver. 1.0, unpublished report, Department of Zoology, University of Hawaii, Honolulu.

Kocher, T.D., W.K. Thomas, A. Meyer, S.V. Edwards, S. Paabo, F.X. Villablanca and A.C. Wilson. 1989. Dynamics of mitochondrial DNA evolution in animals: Amplification and sequencing with conserved primers. Proc. Natl. Acad. Sci. USA 86:6196-6200.

Lansman, R.A., R.O. Shade, J.F. Shapira, and J.C. Avise. 1981. The use of restriction endonucleases to measure mitochondrial DNA sequence relatedness in natural populations. J. Mol. Evol. 17:214-226. .

Lanyon, S.M. 1985. Detecting internal inconsistencies in distance data. Syst. Zool. 34:397-403.

Marshall, A.R., M. Miller, C. Busack, and S.R. Phelps. 1991. Genetic stock identification analysis of three 1990 Washington ocean and Strait of Juan de Fuca chinook salmon fisheries, GSI Summary Report 91-1, Washington Dept. of Fisheries, Salmon Research and Development, Olympia, WA, 48 pp.

Masuda, M., S. Nelson, and J. Pella. 1991. The computer programs for computing conditional maximum likelihood estimates of stock composition from discrete characters. USA-DOC-NOAA-NMFS, Auke Bay Laboratory, Auke Bay, Alaska.

May, B., J.E. Wright and M. Stoneking. 1979. Joint segregation of biochemical loci in Salmonidae: Results from experiments with Salvelinus and review of the literature on other species. J. Fish. Res. Board Can. 36:1114-1128.

Milner, G.B., D.J. Teel, F.M. Utter, C.L. Burley. 1991.

Columbia River stock identification study: Validation of genetic method. Annual report of research (FY80) NOAA,Northwest and Alaska Fisheries Center, Seattle, Wash.

McElroy, D., P. Moran, E. Bermingham, and I. Kornfield. 1991. REAP, the restriction enzyme analysis package, Ver. 4.0. Dept. Zoology, University of Maine, Orono.

Nei, M. 1978. Estimation of average heterozygosity and genetic distance from a small number of individuals. Genetics 9:583-590.

Nei, M. 1987. Molecular Evolutionary Genetics. Columbia University Press, New York.

Nei, M. and W.H. Li. 1979. Mathematical model for studying genetic variation in terms of restriction endonucleases. Proc. Natl. Acad. Sci. 76:5269-5273.

Pella, J.J., and G.B. Milner. 1987. Use of genetic marks in stock compositions analysis. p. 247-276 in N. Ryman and F.M. Utter, eds. Population genetics and fishery management. University of Washington Press, Seattle, WA.

Roff, D.A., and P. Bentzen. 1989. The statistical analysis of mitochondrial DNA polymorphisms: X^2 and the problem of small samples. Mol Biol. Evol. 6:539-545.

Sambrook, J., E.F. Fritsch, and T. Maniatis. 1989. Molecular cloning: A laboratory manual, 2nd. Ed. 3 Volumes. Cold Spring Harbor Laboratory, Cold Spring Harbor, NY.

Seeb, J.E., L.W. Seeb, D.W. Oates and F.M. Utter. 1987. Genetic variation and postglacial dispersal of populations of northern pike (Esox lucius) in North America. Can. J. Fish. Aquat. Sci. 44:556-561.

Seeb, J.E., L.W. Seeb and F.M. Utter. 1986. Use of genetic marks to assess stock dynamics and management programs for chum salmon. Transactions of the American Fisheries Society 115:448-454.

Seeb, J. and L. Wishard. 1977. The use of biochemical genetics in the management of Pacific salmon stocks: Genetic marking and mixed fishery analysis. Final report of research to Washington Dept. of Fisheries, Service Contract #792, Olympia, WA, 65 pp.

Seeb, L.W., J.E. Seeb and J. Gharrett. 1990. Genetic marking of fish populations. Pp. 223-239 in Whitmore, D. H., eds. Electrophoretic and isoelectric focusing techniques in fisheries management. CRC Press, Boca Raton, FL.

Shaklee, J.B., F.W. Allendorf, D.C. Morizot and G.S. Whitt. 1990. Gene Nomenclature for Protein-Coding Loci in Fish. Transactions of the American Fisheries Society 119:2-15.

Shaklee, J.B. and S.R. Phelps. 1990. Operation of a large-scale, multi-agency program for genetic stock identification. Amer. Fish. Soc. Symp. 7:817-830.

Smouse, P.E. and R.H. Ward. 1978. A comparison of the genetic infrastructure of the Ye'cuana and Yanomama: a likelihood analysis of genotypic variation among populations. Genetics 8: 611-631.

Sneath, P.H. and R.R. Sokal. 1973. Numerical taxonomy. W.H. Freeman and Co., San Francisco.

Sokal, R.R., and F.J. Rohlf. 1981. Biometry, 2nd ed. W.H. Freeman, San Francisco.

Swofford, D.L. and R.L. Selander. 1981. BIOSYS-1: A FORTRAN program for the comprehensive analysis of electrophoretic data in population genetics and systematics. J. Here 72:281-283.

Tarbox, K.E., A. Moles, and D.L. Waltemyer. 1991. Presence of parasites in sockeye salmon of upper Cook Inlet, Alaska. Regional Information Report 2S91-5, Alaska Dept. Fish and Game, Anchorage, 6 p.

Utter, F.M., P. Aebersold, and G. Winans. 1987. Interpreting genetic variation detected by electrophoresis. p. 21-45 in N. Ryman and F. M. Utter, eds. Population genetics and fishery management. University of Washington Press, Seattle, WA.

Waples, R.S. 1990. Temporal changes of allele frequency in Pacific salmon: implications for mixed-stock fishery analysis. Can. J. Fish. Aquat. Sci. 47:968-976.

White, B.A., and J.B. Shaklee. 1991. Need for replicated electrophoretic analyses in multi-agency genetic stock identification (GSI) programs: examples from a pink salmon (*Oncorhynchus gorbuscha*) GSI fisheries study. Can. J. Fish. Aquat. Sci. 48:1396-1407.

Wilmot, R.L. and C.V. Burger. 1985. Genetic differences among populations of Alaskan sockeye salmon. Trans. Amer. Fish. Soc. 114:236-243.

Wood, C.C., D.T. Rutherford, and S. McKinnell. 1989. Identification of sockeye salmon stocks in mixed-stock fisheries in British Columbia and Southeast Alaska using biological markers. Can. J. Fish. Aquat. Sci. 46:2108-2120.

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):

$$\hat{V}(\hat{C}_t) = \Sigma_i X_{ti}(N_i/S_i p_t)^2[1 - (N_i/S_i p_t)^{-1}].$$

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.

Cochran, W.G. 1977. Sampling Techniques, 3rd ed. John Wiley and Sons, New York, New York.

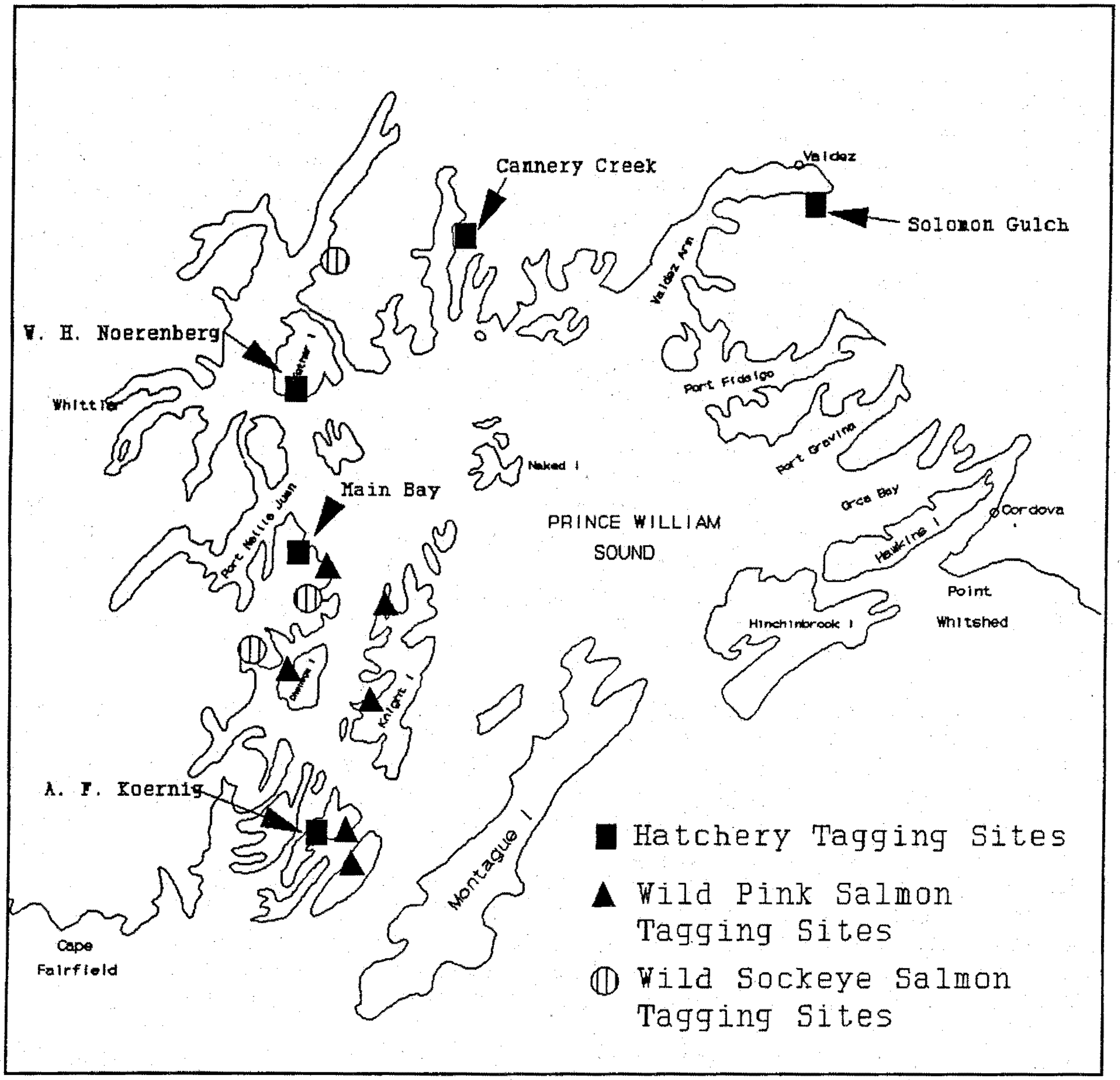
Geiger, H.J. 1988. Parametric bootstrap confidence intervals for estimates of fisheries contribution in salmon marking studies. Proceedings of the international symposium and educational workshop on fish-marking techniques. University of Washington Press, Seattle. In press.

Geiger, H.J., and S. Sharr. 1989. A tag study of pink salmon from the Solomon Gulch Hatchery in the Prince William Sound fishery, 1988. Alaska Department of Fish and Game, Division of Commercial Fisheries. In press.

Peltz, L., and H.J. Geiger. 1988. A study of the effect of hatcheries on the 1987 pink salmon fishery in Prince William Sound, Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries. In press.

Peltz, L., and J. Miller. 1988. Performance of half-length coded-wire tags in a pink salmon hatchery marking program. Proceedings of the international symposium and educational workshop on fish-marking techniques. University of Washington Press, Seattle. In press.

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

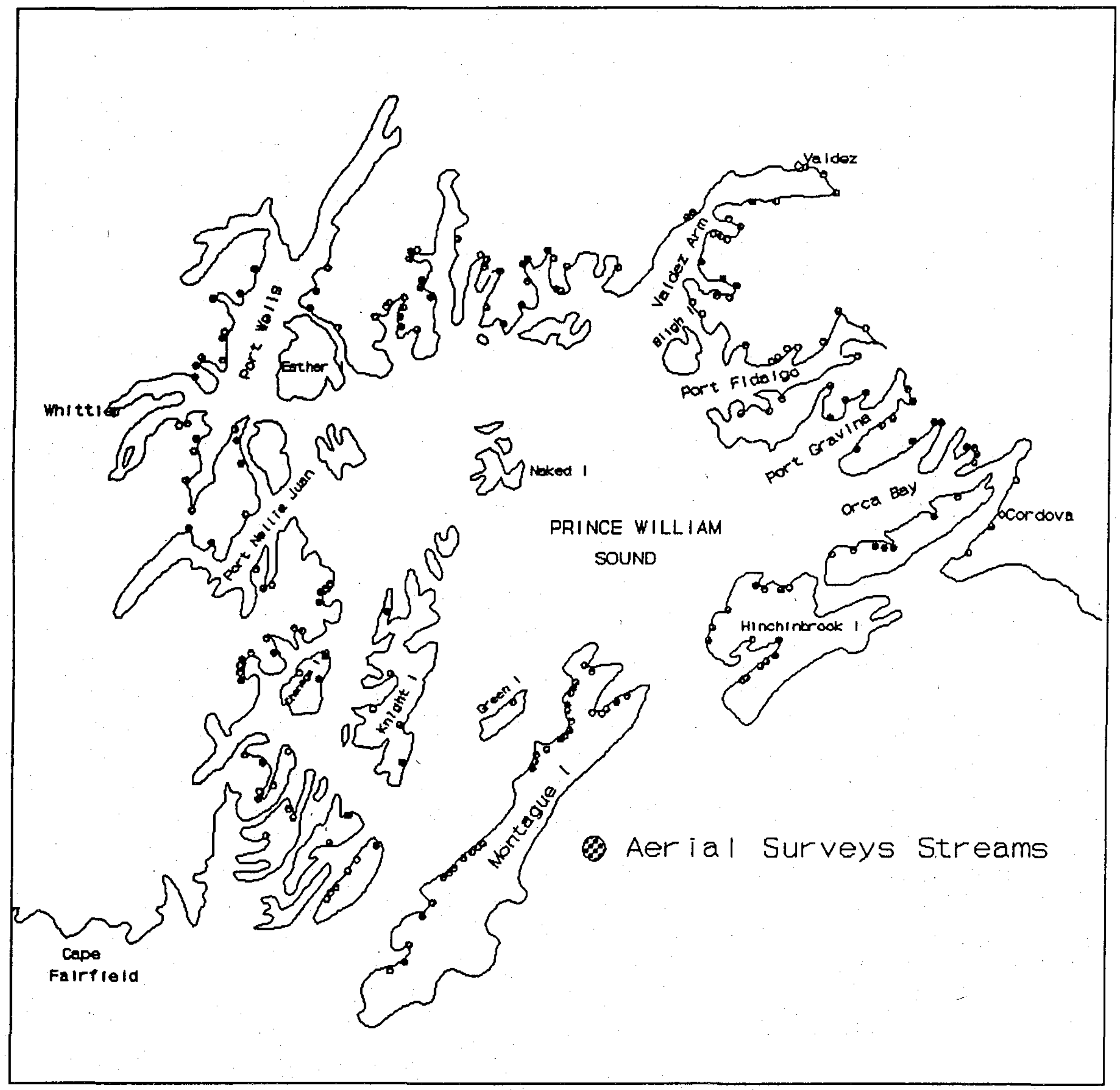


FIGURE 1. Streams included in the aerial survey programs for estimating pink and chum salmon escapement to Prince William Sound.

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.

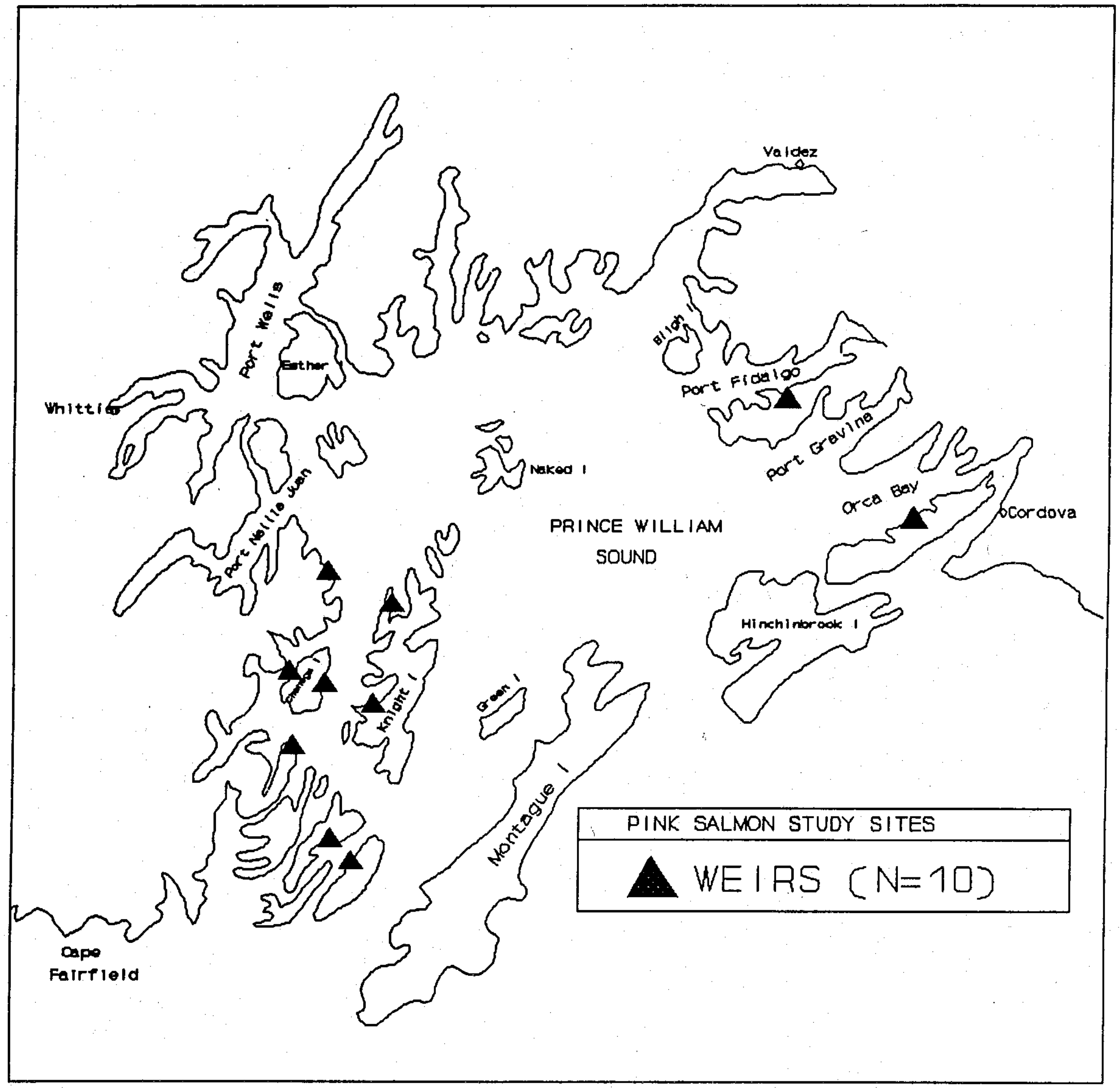


FIGURE 2. Streams proposed for weir, ground survey, and stream life studies in 1992.

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:

$$S = \frac{\sum D_i J_i}{\sum D_i} - \frac{\sum [((L_i - L_{(i-1)}) + D_i) J_i]}{\sum [(L_i - L_{(i-1)}) + D_i]} , \qquad \textbf{(17)}$$

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:

$$S = \frac{\sum [(J_i - J_{(i-1)}) \sum (W_i - D_i)]}{\sum W_i} , \qquad \textbf{(18)}$$

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_i) 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 <u>Montague</u> 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 <u>Montague</u> 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.

LITERATURE CITED

Helle, J.H., R.S. Williamson, J.E. Bailey. 1964. Intertidal ecology and life history of pink salmon at Olsen Creek, Prince William Sound, Alaska. U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries. Special Scientific Report - Fisheries No. 483. Washington D.C.

Johnson, B.A., B.S. Barrett. 1986. Estimation of salmon escapement based on stream survey data: a geometric approach. Alaska Department of Fish and Game, Division of Commercial Fisheries. Regional Information Report No. 4K88-35. Kodiak.

McCurdy, M.L. 1984. Eshamy District Pink Salmon Stream Life Study, 1984. Alaska Department of Fish and Game, Division of Commercial Fisheries. Prince William Sound Data Report No. 84-18. Cordova.

Pirtle, R.B. 1977. Historical pink and chum salmon estimated spawning escapements from Prince William Sound, Alaska streams 1960-1975. Alaska Department of Fish and Game, Division of Commercial Fisheries. Technical Data Report No. 35. Juneau.

Raymond, J., A. Wertheimer, T. Cooney. 1990 Early Marine Salmon Injury Assessment in Prince William Sound. State/Federal Natural Resources Damage Assessment Draft preliminary Status Report. Cordova.

Sharr, S., B. Bue, S. Moffitt, J. Wilcock. 1990. Injury to salmon spawning areas in Prince William Sound. State/Federal Natural Resources Damage Assessment Draft preliminary Status Report. Cordova.

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.

Sharr, S., D. Sharp. 1991. Injury to salmon spawning areas in Prince William Sound. State/Federal Natural Resources Damage Assessment Draft Preliminary Status Report. Cordova.

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.

Objective 2. 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.

Objective 3. 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 Exxon Valdez 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

<u>Objective</u> <u>6:</u> 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 <u>Exxon</u> <u>Valdez</u> 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.

<u>Objective</u> <u>7:</u> 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.

Black Oystercatcher Foraging Study

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, Fucus 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.

Analysis of Blood and Feces

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

Andres, B.A. 1991. Feeding ecology and reproductive success of black oystercatchers in Prince William Sound. Unpubl. Rept. U.S. Fish and Wildl. Serv.

Bellachey, B.E., J.L. Bodkin, and D. Bum. 1991. Assessment of magnitude, extent, and duration of oil spill impacts on sea otter populations in Alaska. Draft Preliminary Status Report, Natural Resources Damage Assessment (Marine Mammal Study #6), U.S. Fish and Wildl. Serv., Anchorage.

Cayford, J.T. and J.D. Goss-Custard. 1990. Seasonal changes in the size selection of mussels, Mytilus edulis, by oystercatchers Haematopus ostralegus: an optimality approach. Anim. Behav. 40:609-624.

Fry, D.M. and L.J. Lowenstine. 1985. Pathology of common murres and Cassin's auklets exposed to oil. Arch. Environ. Contam. Toxicol. 14:725-737.

Fry, D.M., J. Swenson, L.A. Addiego, C.R. Grau, and A. Kang. 1986. Reduced reproduction of wedged-tailed shearwaters to weathered Santa Barbara crude oil. Arch. Environ. Contam. Toxical. 15:453-463.

Hunt, G.L. 1987. Offshore oil development and seabirds: the present status of knowledge and long term research needs. pp. 539-586 in: Long-Term Environmental Effects of Offshore Oil and Gas Development. Boesch, D.F. and N.N. Rabalias, eds, Elsevier Applied Science Publishers, New York.

Leighton, F.A., D.A. Peakall and R.G. Butler. 1983. Heinz-body hemolytic anemia from the ingestion of crude oil: a primary toxic effect in marine birds. Science 120:871-873.

Marsh, C.P. 1986. Rocky intertidal community organization: the impact on avian predators on mussel recruitment. Ecol. 67:771-786.

Morrell, S.H., H.R. Huber, T.J. Lewis and D.G. Ainley. 1979. Feeding ecology of black oystercatchers on South Farallon Island, California. Studies in Avian Biol. 2:185-186.

Williams, T.M. and R.W. Davis (eds). 1990. Sea Otter Rehabilitation Program: 1989 Exxon Valdez Oil Spill. Program sponsored by Exxon Company USA.

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 ($\alpha = 0.05$) 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 ($\alpha = 0.05$) with a log-likelihood (G-test).

LITERATURE CITED - 103D

Adorjan, A.S. and G.B. Kolenosky. 1969. A manual for the identification of hairs of selected Ontario mammals. Ontario Dept. Lands and Forest, Res. Rep. (Wildlife) No. 90, 64 pp.

Biondini, M.E., P.W. Mielke, Jr., and E.F. Redent. 1988. Permutation techniques based on Euclidean analysis spaces: A new and powerful statistical method for ecological research. Coenoses 3:155-174.

Bowyer, R.T., S.A. McKenna, and M. E.Shea. 1983. Seasonal changes in coyote food habits as determined by fecal analysis. Amer. Midland Nat. 109:266-273.

Chandler, A.C. 1916. A study of the structure of feathers with reference to taxonomic significance. Univ. of California Publ. Zool. 13:243-446.

Clark, J.D., J.H. Jenkins, P.B. Bush, and E.B. Moser. 1981. Pollution trends in river otter of Georgia. Proc. Southeast Assoc. Fish and Wildl. Agencies 35:71-79.

Day, M.G. 1966. Identification of hair and feather remains in the gut and feces of stoats and weasels. J. Zool. (Lond.) 148:201-217.

Faro, J.B., R.T. Bowyer, and J.W. Testa. 1991. Assessment of the effects of the Exxon Valdez oil spill on river otters in Prince William Sound. Terrestrial Mamml. Study No. 3. Unpublished, Alaska Department of Fish and Game.

Halbrook, R.S., J.H. Jenkins, P.B. Bush, and N. D. Seabolt. 1981. Selected environmental contaminants in river otters (Lutra lutra) of Georgia and their relationship to the possible decline of otters in North America. Proc. Worldwide Furbearer Conf. 3:1752-1762

Henney, C.J., L.J. Blus, S.V. Gregory, and C.J. Stanford. 1981. PCB's and organochlorine pesticides in wild mink and river otters from Oregon. Proc. Worldwide Furbearer Conf. 3:744-755.

Lagler, K.F. 1947. Lepidological studies. 1. Scale characteristics of families of Great Lakes fishes. Am. Microsc. Soc. 66:149-171.

Larsen, D.N. 1983. Habitats, movements, and foods of river otters in coastal southeastern Alaska. Unpubl. M. S. Thesis, Univ. of Alaska Fairbanks. 149 pp.

Melquist, W.E. and A.E. Dronkert. 1979. Methods and techniques for studying and censusing river otter populations. Forest, Wildlife and Range Experimental Station Technical Rep. 8, University of Idaho, Moscow. 17 pp.

Morrow, J.E. 1979. Preliminary keys to otolith of some adult fishes of the Gulf of Alaska, Bering Sea, and Beaufort Sea. NOAH Tech Report NMFS Circ. No. 420.

Neter, J., W. Wasserman, and M.K. Kutner. 1985. Applies linear statistical models. Irwin, Homewood, IL. 1127 pp.

O'Connor, D.J. and S.W. Nielson. 1981. Environmental survey of methylmercury levels in wild mink (_Mustela vison_) and otter (_Lutra canadensis_) from the Northeast United States and experimental pathology of methylmercurialism in the otter. Proc. Worldwide Furbearer Conf. 3:1728-174.

Sheffy, T.B. and J.R. St. Amant. 1982. Mercury burdens in furbearers in Wisconsin. J. Wildl. Manage. 46:1117-1120.

Solf, J.D. 1987. Land otter. Wildl. Notebook Ser. Alaska Dept. Fish & Game.

Woolington, J.D. 1984. Habitat use and movements of river otters at Kelp Bay, Baranof Island, Alaska. Unpubl. M. S. Thesis, Univ. of Alaska Fairbanks. 147 pp.

Wren, C.D. 1984. Distribution of metals in tissues of beaver, racoon, and otter from Ontario, Canada. Sci. Total Environ. 43:177-184.

Wren, C.D. 1985. Probable case of mercury poisoning in wild otter, _Lutra canadensis_, in Northwest Ontario. Can Field-Nat. 99:112-114.

Wren, C., H. MacCrimmon, R. Frank, and P. Sida. 1980. Total and methylmercury levels in wild mammals from the precambrian shield area of South Central Ontario, Canada. Bull. Environ. Contam. Toxicol. 25:100-15.

Zar, J.H. 1984. Biostatistical Analysis. Prentice-Hall, Englewood Cliffs, NJ. 718 pp.

Zimmerman, G.M., H. Goetz, and P.W. Mielke, Jr. 1985. Use of an improved statistical method for group comparisons to study effects of prairie fire. Ecology 66:606-611.

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

Response to Public Comment on the 1991 State/Federal Natural Resource Damage Assessment and Restoration Plan for the Exxon Valdez Oil Spill

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COMMENTS AND RESPONSES CONCERNING THE 1991 STATE/FEDERAL NATURAL RESOURCE DAMAGE ASSESSMENT AND RESTORATION PLAN FOR THE EVOS

The 1991 Plan was made available to the public for review and comment. Seven reviewers representing industry, environmental groups, and the general public submitted comments on the Plan. The reviewers included: Alyeska Pipeline Service Company (APSC), American Petroleum Institute (API), Exxon Shipping Company (ESC), National Wildlife Federation (NWF), and Natural Resources Defense Council (NRDC). Reviewers commented on the overall nature and content of the Plan and provided technical remarks concerning many of the individual studies. All comments will be considered by the Trustees during their evaluation of the 1991 data and the formulation of the 1992 Plan.

The comments and responses are organized into two categories--those dealing with the general nature of the plan and those concerning a specific category of studies or individual studies. This section provides a synthesis of the comments and their respective responses, while the following sections address the categories of studies. For the information of the reader, the reviewers have been identified with their comments.

General Comments on the Plan

Comment: The Trustees are continuing to study resources for which they have no conclusive evidence of injury, such as brown bear, or for which they have no documented significant injury, such as several species of coastal and offshore fish (see 56 Fed. Reg. at 14690 and 14692, Apr. 11, 1991). These studies should be discontinued. Also, the Trustees should release data so that the public can determine whether there are other studies which should be discontinued. (APSC)

Response: The process by which conclusive and significant injuries can be demonstrated is frequently slow because sublethal injuries often have substantial but not acute effects to populations and must be investigated over an extended period in order to be determined. Acute effects, when they occur in remote locations, are often difficult to document, and evidence of their occurrence must be extrapolated from the observations of sublethal effects. The Federal Register notice referenced was an interim report of the findings. The report does not predict that conclusive and significant injury will not be established. In fact, if the Trustee's believed that the likelihood of establishing significant injury were poor, such studies would be discontinued as some have been.

Comment: Several studies violate the regulatory requirement that their costs not exceed the amount of damage anticipated. The studies that fall into this category are Fish/Shellfish Study No. 11 and Terrestrial Mammals Studies Nos. 3 and 4. The Trustees' view that the overall cost of damage assessment must be cost-effective (rather than each project being cost effective) subverts the safeguards against irrational spending that appear in the DoI regulations. (ESC)

Response: The regulations require a determination that the assessment is likely to be obtained at reasonable cost. In each of these instances there exists substantial evidence of injury. The current studies are designed to determine the extent of that injury following which it will be possible to value it. In the judgement of the Trustees, the costs of the studies are reasonably related to the probable damage.

Comment: Contingent valuation is not an appropriate method for valuing natural resource injuries, as the Trustees suggest in their response to public comments on the 1990 Plan. It was not "approved" by the court in Ohio v. Department of the Interior: the court would not have endorsed a methodology that does not work, and contingent valuation has not been shown to be a reliable or valid measure of non-use damages. Thus, it should not be used to produce the non-use or the total value of injured resources. (ESC)

Response: In Ohio v. Department of the Interior the court upheld DOI's decision to include the contingent valuation method in the Natural Resource Damage Assessment Regulations. Contingent valuation has been recognized by leading experts in the field as a valid method for measuring non-use damages.

Comment: Although the Trustees have agreed to consider NEPA in future restoration projects, there is no reason for excepting NRDA studies from NEPA's purview. (NWF)

Response: Restoration projects that have already been implemented by the Trustees have met NEPA requirements. The application of NEPA to future projects will continue to be considered by the Trustees.

Comment: The Trustees' request for public comment on the 1991 Plan is ill-timed. Most of the studies have already commenced by the time public comments are received and therefore can have little impact on study designs and implementation. (NRDC) DOI's regulations require public involvement before implementation of the assessment plan. (APSC)

Response: While it is true that some studies are implemented in the spring, most were not begun until the summer season and could be modified where appropriate. Public comment can also be used to benefit the subsequent years' planning efforts as well. Likewise, analysis of samples and data is an ongoing process, and can be responsive to meaningful public comment at any time.

Comment: There is no suggestion in either CERCLA or the Clean Water Act that the Trustees may ignore the DOI regulations or vary from them, and they have not provided any justification for doing so. Their departure from the regulations is unlawful and will result in the scientific invalidity and the legal indefensibility of the final assessment. (APSC)

Response: Scientific validity arises from the scientific methods used and the scientific scrutiny applied to the results. The Trustees have employed the best available scientists to conduct the damage assessment studies. The Trustees therefore believe the assessment is legally defensible.

Comment: The rebuttable presumption does not apply in the event that the Trustees selectively use the DOI regulations. According to the preamble to the regulations, only the dollar figure representing damage assessment is entitled to the presumption, not the method used for reaching that figure. (APSC)

Response: The rebuttable presumption applies to damage assessments performed in accordance with the DOI regulations. While the Trustees have not made a final decision regarding the extent to which they will apply the DOI regulations, those aspects of the assessment conducted in accordance with the regulations are entitled to a rebuttable presumption.

Comment: The State's game management policies are not consistent with the Trustee's claims of effects on wildlife: the brown bear and waterfowl studies fail to acknowledge that continued sport hunting of these species is a tacit recognition of harvestable surplus. (ESC)

Response: The presence of a huntable surplus does not mean that injury did not occur. Populations may have been reduced due to EVOS related mortality, but perhaps not to a level requiring hunting season closures.

Comment: The study designs do not reflect the fact that natural variability can alter population trends. This is especially true of the Terrestrial Mammal Studies Nos. 3 and 4 and the harbor seal study (Marine Mammal Study No 5). (ESC)

Response: The studies were designed to account for significant natural variation that could influence results, and, therefore are expected to detect injury from oil contamination. The cause of much of this variability is identifiable through empirical field observations, laboratory testing of tissues, through the use of control site study areas or other scientific controls. It is unlikely that biological communities in oiled study areas and unoiled areas would respond differently to a natural perturbation that was not detected by biologists.

Comment: The Trustees are obscuring the fact that the environment is recovering rapidly by attempting to maximize their legal claims through the publication of the Summary of Injuries, which disregards scientific evidence of the ecological health of the area. (ESC)

Response: While the Summary of Injuries was filed in the Federal District Court for Alaska, it was prepared in response to a request from three U.S. House of Representatives Subcommittees of the Committee on Merchant Marine and Fisheries. The Subcommittees were considering the merits of the proposed settlement agreement among the Trustees and Exxon that was negotiated, but rejected, in early 1991. The Subcommittees specifically requested a summary that described the scope and severity of known injuries caused by the EVOS, which did not disregard any known evidence of recovery. If the reviewer wishes to provide scientific data supporting its statement regarding the ecological health of the area, the Trustees will consider this data in conducting the damage assessment.

Comment: The Trustees' response to commentators' suggestions that archaeological sites and other man-made artifacts are not appropriate subjects of study under either the Clean Water Act or CERCLA relies on a stilted interpretation of the term "natural resources." (API)

Response: The Trustees believe a study of injuries to archaeological resources is properly within the damage assessment process and disagree that their interpretation of the term "natural resources" is stilted.

Comment: The Trustees have focused their efforts on point-by-point rebuttal of public comments rather than ensuring that the process is redesigned to correct its procedural and substantive deficiencies. (ESC)

Response: Where appropriate, while implementing the studies the Trustees have incorporated recommendations made by the public. The Trustees do not seek to rebut comments made by reviewers, but rather seek to be responsive to concerns raised by the public.

Comment: The potentially responsible parties have been excluded from participating in the process, which is contrary to the Department of Interior regulations. This has produced an ill-focused project that will not link measured differences between spill and reference sites to specific restoration needs; a prolonged process that will delay implementation of restoration activities and limit their effectiveness; and a process in which monies are spent on ill-advised studies that have little chance of identifying cost-effective restoration activities. (ESC)

Response: Under the NRDA regulations, the degree of participation by potentially responsible parties in the damage assessment process is within the discretion of the Trustees. See 43 C.F.R. 11.32. In this damage assessment, the potentially responsible parties have been given a full opportunity to review and comment upon the damage assessment plan. If the commentator wishes to provide scientific data supporting its statements that the current damage assessment studies do meet the needs of identifying appropriate restoration activities, the Trustees will consider this data in conducting the assessment.

Comment: It cannot be discerned from the Scientific Peer Review Outline whether peer reviewers, including a Chief Scientist, have already been designated and, if so, whether they have been reviewing 1989-90 study plans and data. Nor is there any indication whether the Trustees have been following the advice of the peer reviewers. The budget for peer review does not indicate the purposes for the intended expenditures, and there is some question as to whether NOAA will be a contributor to this funding for the peer review process or will rely solely on reimbursement from the remaining federal trustees. (NWF, NRDC)

Response: Federal and state peer reviewers with expertise in all major resource areas were contracted in 1989 and have been fully involved in reviewing study plans and data. The study plans have been modified, where necessary, based on expert review. The chief scientist position was established in 1990. The Chief Scientist has been very active in providing expertise and direction for all NRDA and Restoration activities. Funding for all peer review activities has been shared among the Trustees.

Comment: It is not clear whether the Chief Scientist referred to in the Plan is NOAA's Chief Scientist or someone else. Nor does the Plan indicate what is the role of the State of Alaska vis-a-vis the Chief Scientist. (NRDC)

Response: The Chief Scientist serves all of the Trustees. The position is contracted through NOAA for the Federal Trustees, but funding is shared among the Trustees.

Comment: The damage assessment process undertaken by the Trustees fails to take into account the overall vitality of the ecosystem and fails to identify steps needed for restoration. This approach will give a biased view of the environment because the damages assessment studies are focused on chemical and biological differences at the microscopic level. (ESC)

Response: The 1991 damage assessment plan has been reviewed extensively by appropriate experts to ensure the study designs will measure injury and determine links to potential restoration activities. The NRDA studies have been devised to allow for an ecosystem approach to injury determination, not merely a superficial approach.

<u>Comment</u>: The Trustee Council's program of scientific inquiry is a chase for phantom injuries. Even after $70 million worth of scientific studies, no significant restoration needs have been identified; the Trustees' approach presumes injury and a need for active restoration. (ESC)

<u>Response</u>: As demonstrated by the summary of effects that was filed with the Federal District Court in Alaska and made available to the public on April 8, 1991, the injuries to natural resources caused by the oil spill are not phantom injuries. Once an ecosystem has suffered such an assault, it is time consuming to review the injuries and develop a comprehensive restoration program. To date, the resources needed to accomplish restoration planning and implementation have been supplied by public funds and not by the responsible parties. The Trustee Council has planned and executed restoration planning programs during 1990 and 1991 that provide information for comprehensive restoration planning.

<u>Comment</u>: The study designs fail to take into account the potential for natural recovery, which the DOI regulations clearly anticipate as a restoration option. The Trustees also fail to put the injuries in perspective: they have ignored the vast amounts of shoreline that were untouched by the spill, the vast wildlife populations that inhabit the spill area and the evident of recolonization of the areas previously oiled. Without taking these factors into account, the Trustees' restoration options will be meaningless. (ESC)

<u>Response</u>: The study designs do not fail to consider the potential for natural recovery. The Trustee Council has attempted to provide a perspective of the injury by providing the total mileage of oiled shoreline and the extent to which those shores were oiled, the number of mortalities of species and the estimated fraction of the population in that area. In addition, the commentator errs in equating magnitude of unaffected shoreline and large wildlife populations with a certainty that the ecosystem and individual species are unaffected. While some areas that were despoiled by the oil spill are now being recolonized by opportunistic species, full recovery is neither certain nor complete.

<u>Comment</u>: The 1991 Plan continues the deficiencies of the previous years' plans in that it: fails to focus on restoration and ignores the role of natural recovery in restoration; improperly calculates natural resources damages; conducts studies that will produce the double-counting of damages; and fails to follow the DOI regulations. (ESC)

<u>Response</u>: The 1991 Plan continues to follow a comprehensive approach to identifying injuries to natural resources and developing a comprehensive restoration program. Consideration of the role of natural recovery is an element of this approach. While the Trustees are not required to comply with the DOI regulations,

they have followed a process that is very similar to the DOI provisions.

Comment: The 1991 Plan fails to include basic information about the restoration studies such as the nature, extent and location of the injured resources that are the subject of the restoration projects and the restoration alternatives that were considered. The restoration Work Plan also fails to justify the cost-effectiveness of the proposed projects. (ESC)

Response: Information concerning the restoration studies has been provided in two Federal Register notices. The first notice provided a description of the planned restoration work for 1991. 56 Fed. Reg. 8898 (March 1, 1991). The second announced the availability of work plans for these restoration activities. 56 Fed. Reg. 36150 (July 31, 1991). Cost effectiveness was one of the factors used to evaluate the selection of these activities.

Comment: Many of the studies make no effort to investigate and define restoration options and methodologies. This is a misuse of statutory and regulatory authority. (ESC)

Response: The studies mentioned are focused to assess the extent and type of injury as the first step in developing restoration measures. Restoration measures either have been or will be considered as injury is more defined.

Comment: Where studies have been combined or reorganized, there is too little information given as to the manner in which the new studies will meet the goals of the studies they replaced. (NWF)

Response: Most of the goals of the reorganized studies remain the same. The new combinations of elements is believed to be a more logical representation of the overall study objectives than previously. For example, the deep and shallow benthic studies were elements of previous studies (Air/Water 2 and 4, and Coastal Habitat) that were combined as one subtidal benthic study (Subtidal 2).

Comment: Study objectives are not uniformly presented in terms of a null hypothesis. The hypothesis proposed to be tested are most often stated in terms of whether a particular change/difference is due to EVOS rather than the classic null hypothesis, i.e. that the change/difference is due to chance. It may be advisable for the peer reviewers to consider whether these discrepancies affect study design or the legal import of the NRDA studies. (NWF)

Response: The point is well taken. Detailed study designs have been subject to scrutiny of statisticians and are believed appropriate. In cases where the null hypothesis may have been misstated in the study plan, this will be corrected for data analysis to conform to the accepted definition of the null hypothesis.

Comment: The scientific studies do not establish or document an obvious and continuing pathway for exposure to the oil. Continued exposure to hydrocarbons is unlikely, as shown by Dr. Neff's water quality report. The studies do not distinguish between EVOS and other natural and/or anthropogenic sources of hydrocarbons. (ESC)

Response: In the case of the subtidal studies, determining pathways of exposure are important elements of these studies. When exposure is no longer detected or an issue, these studies will be discontinued. The hydrocarbon chemistry data will be used to establish the source of the oil.

Comments on Marine Mammals Studies - General

Comment: Marine Mammals Studies No. 5 and 6F and 6G are unlikely to quantify injury from EVOS because it will be difficult to establish a clear and unequivocal cause and effect relationship between chemical residue data and histologic changes in those marine mammals.

Response: Determining that harmful pathological conditions resulted does not require that residue levels be elevated. Pathological changes may or may not be associated with elevated residues depending on what residues are tested, time and duration of exposure to oil, length of time after exposure that samples were taken, etc. Pathological conditions may have been caused by volatile substances that were gone by the time the seals were collected.

Comments on Marine Mammals Studies - Specific

Marine Mammal Study No. 2 - Killer Whales

Comment: It appears that the data being collected in Marine Mammal Study No. 2 will not be sufficient to address all of its objectives. (API)

Response: The data to be collected during the third year of this study will be sufficient to address all the objectives. Sighting effort is more than adequate to encounter all killer whale pods occurring in Prince William Sound (PWS) during the study period. Once each pod is observed, photographs are obtained of each individual within the pod. These photographs, and other data collected at the time of the encounter, allow assessment of the number of animals present and to identify individuals (Objective A), to note the various locations in PWS where animals occur (Objective B), to characterize the individuals within each pod (Objective C), to note the relative physical size of all pod members and the presence of new, young animals (Objective D), and the absence of any members known to be in that pod from previous years (Objective E).

Comment: The potential for the observations being made in the killer whale study to be intrusive is not adequately addressed in the Plan. (API)

Response: The observations made during the study are not intrusive but passive. Some disturbance may occur as the study vessels approach the pods for counting and to obtain photographs. All the activities in the study are conducted under a MMPA permit issued to the researchers. MMPA permits are reviewed by the Marine Mammal Commission, and the public prior to issuance by the National Marine Fisheries Service.

Comment: The cost is unwarranted given that killer whale population impacts attributable to EVOS are unlikely. (ESC)

Response: Similar studies conducted by non-government entities may cost twice as much, or more, because the government absorbs most of the salary, administrative, and data analysis costs associated with such studies. The assertion that killer whale impacts attributable to EVOS are unlikely is invalid. Killer whale impacts attributed to the EVOS probably occurred in the form of injury (loss of animals), but this must be confirmed by year three studies.

Comment: The normal distribution pattern of this species has not been established sufficiently to permit meaningful comparisons with post-spill data. There is no documentation linking deaths of killer whales to contact with oil; nor is there a known pathway for oil to be harmful to whales. Further, there is no way to attribute whale mortality to oil exposure when factors such as interactions with fishing fleets and natural mortality are ignored. Food source distribution should also be taken into account. (ESC)

Response: Killer whale pods are repeatedly seen in certain areas of PWS at specific times of the year over many years. A trend has been documented in the arrival times of certain resident pods at feeding areas in southwestern PWS and other locations. These areas and times were documented prior to the spill and are sufficiently established to make meaningful comparisons to post-spill distribution and movement patterns, at least for certain pods. At least five different killer whales pods were seen swimming through oil; no cetacean, including killer whales, has ever been documented to avoid oil in the water. There is no reason to assume that killer whales did not encounter and swim into oiled areas. Other mortality factors, such as those attributable to interactions to fishing vessels is not ignored. The timing and distribution of fishing vessels with various gear types has and will be reviewed to ascertain the possible level of mortality to killer whales by commercial fisheries. To date there are no fisheries that were likely contributors to killer whale mortality during the EVOS year. Natural mortality rates are too low to account for the high number whales missing from PWS pods. Food source distribution is too difficult to tract since the prey eaten by killer whales cannot reasonably be sampled.

Comment: It is not possible to evaluate the study plan without a clear definition in Objective B of the term "adjacent waters". Killer whales move in and out of PWS and "adjacent waters" so it is impossible to quantify what is "similar to that reported for prior years." (ESC)

Response: The term "and adjacent waters" should be deleted from the study plan. Conducting study activities outside PWS was deleted.

Comment: Since pod integrity and structure are not defined, the hypothesis of Objective C, i.e., that the parameters have remained constant, is not valid. Even if it could be tested, this hypothesis cannot be either accepted or rejected based on the information gained two years after the spill. (ESC)

Response: Pod integrity and structure are defined and accepted terms amongst killer whale biologist world-wide, and were discussed in-depth in previous study plans and the published literature. Killer whale pods are known to be matriarchal in structure with most individuals remaining in the same pod throughout their lives. Absence of whales from a pod for one year is adequate to assume mortality; absence for two years is stronger evidence of mortality. The hypothesis in Objective C is a valid test and data can reasonably be collected for its rejection or acceptance.

Comment: Without considering environmental factors other than the occurrence of the spill, it does not make sense to relate differences in whale natality and mortality to oil exposure since these parameters vary naturally. (ESC)

Response: Killer whale natality and mortality rates are low throughout their range. Mortality rates calculated for PWS, based on animals missing from pods since EVOS, are abnormally high. The marine environment in which killer whales exist is a relatively stable environment and variation in water temperature, salinity, and other properties is minimal. Since the EVOS there have been no extreme environmental perturbations (such as an El Niño event) in the eastern North Pacific Ocean or Gulf of Alaska that could reasonably account for the absence of seven killer whales during the EVOS and six whales the following year.

Comment: The Plan does not provide adequate detail regarding methodologies, sampling locations, survey design, and data compilation. Examples of this include: the description of sampling locations as those areas "known for whale concentrations"; a lack of reference to data other than photographs that will be used on the survey form; a lack of detail regarding the sampling methods and their statistical sufficiency; a lack of quantification of search effort to allow the evaluator to assess whether cross-year comparisons of abundance and distribution will be valid; and the potential bias inherent in the disturbance and harassment of whales caused by the field activities. (ESC)

Response: The objective of the 1991 Plan was to provide adequate information for reviewers to understand the scope and methods of the assessment. The Trustees believe the information provided is sufficient for this purpose.

Comment: Objectives A, B, and D appear to depend on a constant probability of whale sighting over the survey route when in reality this probability is highly variable. It is dependent on such factors as prey densities and bathymetry. This problem will be compounded by the addition of the sighting network. (ESC)

Response: The objectives do not depend on a constant probability of whale sighting. It is true that sightings are variable, but the locations of sightings are not. Past studies have shown that all killer whale pods occurring in PWS during the study period consistently pass through certain areas in southwestern PWS. These areas are part of the study survey route. Thus, any killer whale pod occurring in PWS during the study period will likely be sighted. Once sighted data are collected that will satisfy Objectives A,B, and D (as well as C and E).

Comment: The study description implies that the investigators will assume that an individual killer whale that is not found in Prince William Sound has died. The high mobility of this species makes this an indefensible conclusion. (ESC)

Response: As mentioned, individual killer whales remain in the same pod for life. There are no documented occurrences of killer whales leaving one pod and becoming members of another. If a pod is sighted, all the members of that pod will be present and accountable. The probability of sighting a particular pod is high since they regularly occur in PWS at certain times of the year. The species is not have a particularly large home range, when compared to other cetaceans and some pinniped species.

Comment: Reported injuries will not be valid because the baseline data are insufficient. In particular, pre-spill natality and mortality data are insufficient to allow "accurate, precise, complete or representative comparisons" required by the NRDA regulations. Nor does data sufficient exist to allow a meaningful definition of "normal" whale pattern distributions for comparison to post-spill data. (ESC)

Response: As mentioned above, the historical data base is adequate for comparative purposes to establish the presence or absence of individual whales within their respective pods. Pre-spill data are adequate to meet the objectives of the study plan. Intense killer whale studies began in PWS in 1984 that collected similar data to that proposed in the study plan and that were collected during the first two years of the oil-related research. The pre-spill data are sufficient in detail and quantity to make meaningful comparisons. The assertion that insufficient data exists for these comparisons is wrong.

Marine Mammals Study No. 5 - Harbor Seals

Comment: It is questionable whether the aerial surveys in Marine Mammals Study No. 5 are equivalent to previous aerial studies conducted in 1984, 1986, 1989 and 1990. Harbor seals can only be counted during molting and pupping periods. (API 12)

Response: Techniques, including survey route, aircraft type, air speed and altitude, and data collection and analysis, were the same for all surveys. The same observers were used throughout, specifically to eliminate the problem of observer variability. Historical data and multiple year surveys will allow valid statistical comparisons. Surveys were made during pupping and molting periods.

Comment: The term "normal year" (on page 16) with respect to aerial survey data concerning harbor seals is unclear in light of the fact that this species was declining in the five years prior to EVOS. Further, this reference cannot be reconciled with the Trustees' statement on page 17 that "a single year of post-spill data from 1990 is not sufficient to establish what is normal in a non-oil spill year." (NWF)

Response: "Normal year" refers to a non-oil-spill year. The statement regarding "a single year of data is not sufficient" is meant to point out the need for additional survey data in 1991. Because there are no historical data during the pupping period, we are required to use data collected in the years following the spill and to compare those data to data collected the year of the spill. Without 1991 data, we can only state that 1989 and 1990 were different. The 1991 data set will allow comparison of three years of data. From this comparison we will be able to conclude if the number of harbor seals counted the year of the oil spill was statistically different in regards to harbor seal abundance and distribution in subsequent years. Ideally an historical data set would have aided the statistical comparisons. However, since we do not have those data, we must either ignore pupping completely, or try to compare post-spill years to the spill year.

Comment: Populations of harbor seals have been declining over the last several decades. This study will not permit the Trustees to segregate the effects of the oil spill from the natural factors that have affected this species. (ESC)

Response: Design of the study will allow for detection of differences between oiled and unoiled areas that can be attributed to EVOS. Pre-spill data indicate that oiled and unoiled areas both demonstrated a decline of similar magnitude prior to the spill. Following the spill, the rate of decline was significantly higher at the oiled sites.

Comment: There is no clear cause-and-effect relationship between petroleum hydrocarbon exposure, tissue burdens and pathologic effects, so the cause of death in harbor seals will not be traceable. (ESC)

Response: The exposure pathway included seals lying and rolling in both fresh and weathered oil for, in some cases, the entire summer following the spill; seals swimming in and through oil on the water; seals breathing at the surface and inhaling fumes from the oil; and possibly seals eating contaminated prey. All of these are indicated in the study plan.

Comment: Objectives C and D are really just ongoing research efforts aimed at determining the cause of the decline in harbor seal populations in the northern Gulf of Alaska. The monies expended for this research are not compensable under the NRDA regulations. (ESC)

Response: The harbor seal project is not part of a long-term research or management project. Previous data were available, at 4-year intervals, but there was no plan to conduct annual surveys or do a study of this type prior to the spill. This study was designed directly in response to the spill, to take the best advantage of historical data.

Comment: The field methods will not be capable of separating changes in distribution from changes in abundance because of the lack of understanding of seal distribution dynamics. (ESC)

Response: Although the dynamics of harbor seal distribution are not well known in PWS, we do know that harbor seals demonstrate strong site fidelity. Radio-tagging studies from different parts of their range support this. Satellite-tagging studies ongoing in PWS will provide additional information directly relevant to PWS. Following the spill when seals were coated in black oil which served as a marker, there was little or no observed movement of oiled seals into unoiled areas or vice versa. Furthermore, a reduction in numbers at oiled sites was not accompanied by a concurrent increase at other sites.

Comment: QA/QC issues are not addressed in this study. (ESC)

Response: Standard, scientifically accepted procedures are followed.

Comment: There is no description of the locations where "impacted" and "control" seals were taken. Thus, the reader cannot assess the validity of the analytical methods of this study. If control animals were taken from Southeast Alaska, they are not a valid reference since they likely have different genetic characteristics and different habitat and food supplies that affect their well-being. (ESC)

Response: The selection of oiled and control seals was very straight forward. In 1989, "oiled" seals were physically oiled seals (blackened by oil) collected in areas that had oil on the haulouts. Seals collected in 1990 were taken in areas that had been oiled. Selection of seals from Southeast does provide a valid reference. They give an indication of levels of contaminants in an area far removed from the spill. Genetic differences are not considered in the study. We did not propose to collect substantial numbers of seals in unoiled areas. Instead we focused on documenting contaminant levels in seals within oiled areas. Simple comparisons were made between seals collected in heavily oiled areas of PWS to seals from more lightly oiled areas of PWS, seals collected one year later, and 2 seals from Southeast.

Comment: The analytical strategy incorrectly assumes that pathologic findings correlate to tissue residue data and that oiling levels two years ago in sample collection locations represent exposure of the collected seals to hydrocarbons in their home range. (ESC)

Response: Pathological conditions are not assumed to correlate with measurable residue data. Determining that harmful pathological conditions resulted does not require that residue levels be elevated. Pathological changes may or may not be associated with elevated residues depending on what residues are tested, time and duration of exposure to oil, length of time after exposure that samples were taken, etc. Pathological conditions may have been caused by volatile substances that were gone by the time the seals were collected.

Comment: It will not be possible to tell whether a statistically significant effect found between oiled and unoiled areas or pre-and post-spill comparisons is due to oil or other factors such as survey techniques, quality of observers, food supply or habitat differences. (ESC)

Response: Comparison of unoiled and oiled and pre- and post-spill data sets will be statistically straight-forward. Survey techniques were the same for all surveys. The same observers were used throughout, specifically to eliminate the problem of observer variability. Historical data and multiple year surveys will allow valid statistical comparisons. There are pre-spill data indicating that trends in abundance were the same in oiled and unoiled areas, despite any inherent differences in habitat or food.

Comment: There is no description of the types of tissues collected, methods for toxicological analyses, or techniques for fingerprinting of hydrocarbons. (ESC)

Response: Toxicological analysis of tissues has been done according to standard QA/QC procedures developed by an analytical chemistry working group of experts. The procedures were also reviewed and approved by an expert group of marine mammal veterinarians, the Marine Mammal Commission and its Committee of Scientific Advisors. Harbor seal samples were submitted through the NOAA/NMFS Oil Spill Damage Assessment Office to ensure that qualified laboratories and procedures were used.

Comment: Statistical procedures are too vaguely defined and sample sizes for the exposure/pathway work are inadequate. The level of effect being tested and the effort needed to detect that effect are not given. The sampling effort is not appropriate to the objective of the study: the probabilities of Type I and II errors are not given. (ESC)

Response: Sample sizes are considered appropriate and statistical methodology is clearly stated. It is also clear that the level of statistical significance is 0.05, an acceptable level in biological studies.

Comment: The 40% decline in abundance that was observed in the trend counts is insufficient for establishing any meaningful baseline, trend or natural variation because it was based on only two years worth of data. Since the cause of the decline in harbor seals is not known, it is unlikely that any impact of the spill on this species will be detected by this study. (ESC)

Response: Historical data in combination with data collected at the control sites will provide a basis for evaluating the ongoing population decline and any natural variation in the population. It is not necessary to know the cause of the ongoing decline in order to determine injury from EVOS.

Marine Mammal Study No. 6 - Sea Otters

Comment: MM6 is unwarranted in light of the fact that 1990 observations found large numbers of adults and pups in previously oiled areas feeding and behaving normally. Natural reproduction will overcome the losses suffered by this species as a result of the oil spill as there is a large population reservoir in the affected portions of Prince William Sound and the Gulf of Alaska. (ESC)

Response: Results from 1990 sea otter studies do not confirm that feeding and behavior of sea otters in oiled areas is normal. There is evidence of continuing injury to the population, and the injury does not appear to be limited to those sea otters that suffered acute exposure to the oil immediately following the spill. Oil persists in some areas of western PWS, and potential exposure of the sea otters continues. Study MM6 involves eight components which will be collectively interpreted to provide a comprehensive look at the status of sea otter populations in PWS.

Marine Mammal Study No. 6A - Boat Surveys

Comment: Study 6A's objective of estimating winter 1991 offshore densities in oiled and unoiled areas to enable the Trustees to estimate otter density values at the time of the spill does not address the need for confirmation of exposure to oil of otters that might have been present during the spill. (API)

Response: This study has the potential to determine if there are differential trends in the otter population between oiled and unoiled areas (i.e. a continuing decline in the oiled area with a stable trend in the unoiled area may support the hypothesis of continued oil-related injuries).

Comment: Eastern PWS is not a valid control area for Objective A because it supported higher densities of sea otters before the spill owing to its higher quality habitat. (ESC)

Response: The variations in habitat between eastern and western PWS are being considered, as appropriate, during data analysis and synthesis.

Comment: The assumption of Objective B that sea otter populations are stable in the absence of oil is wrong; there are many factors that could cause differences between years. (ESC)

Response: That changes in population cannot be automatically attributed to oil has been a consideration throughout the entire NRDA process: how to validate injury above and beyond the number of recovered carcasses. Although no single NRDA study will be adequate to determine additional injury to the sea otter population, in combination the studies should provide the needed information.

Comment: Any difference between pre- and post-spill otter populations found in carrying out Objective C could be the result of variation in distribution rather than abundance. (ESC)

Response: Since the study area encompasses PWS as a whole, we are able to detect if a decline within the oiled area is accompanied by an increase in the unoiled area (a change in distribution, perhaps due to avoidance). If the reviewer is suggesting that an overall decline within the study area could be due to emigration, that may also constitute an injury to the PWS population.

Comment: Objective D will create more of an index than a quantitative estimate of the post-spill population of otters in PWS because of the problems inherent in censusing otters. (ESC)

Response: As noted, the results of this study are actually a population index, rather than a population estimate. Sightability during surveys is also being considered. It is certainly quantitative not qualitative, and comparable over time. This study provides a random sample of both shoreline and offshore habitats, which produces an estimate with confidence levels for the sea otter population.

Comment: Sea otter populations are not constant in PWS from year to year, so using densities during the winter of 1991 to estimate densities during March of 1989 makes Objective E invalid. (ESC)

Response: Post-spill surveys may provide useful insight on what the population was like at the time of the spill and may help support the use of summer pre-spill data for comparative purposes.

Comment: Pre- and post-spill densities of otters are not comparable because of the variance among methods and transects in years 1984, 1985, 1990 and 1991. (ESC)

Response: This statement is in error. Considerable thought was given to the issue of comparability of surveys. The methods used in post-spill surveys are identical to those of Irons et al., 1988. Irons assisted in the design and implementation of this survey, and has also participated in the field effort. Paragraph 2 of the methods section clearly states the procedures followed to insure that the methodology is consistent from survey to survey. The statement that transect location is different every year is false. Post-spill surveys use the same shoreline transect design used in the pre-spill survey. This point is clearly stated in paragraph 5 of the methods section. The randomly selected sample is a subset of the pre-spill sample (which was itself, almost a complete count of all shoreline habitat within the Sound). While the actual sample size of transects may vary slightly, most of the same transects are surveyed with each replication. Regardless, since the set of transects was selected as a random sample, it is a simple matter to calculate a consistent population estimate or index with which to determine trends.

Comment: There is no documentation of an exposure pathway that will link any changes in distribution and abundance in 1991 to EVOS. (ESC)

Response: The determination of an exposure pathway is the purpose of other components of Marine Mammal study 6.

Comment: This study does not follow conventional scientific methods: there are no testable hypotheses or statistical assumptions given. Comparing third year post-spill surveys to pre-spill estimates will not produce an injury determination. (ESC)

Response: In an attempt to streamline the study plan for the current document, certain sections were deemed to be redundant, having already been presented in earlier study plans (significance levels, statistical assumptions, etc.). The focus of this study has remained essentially the same throughout.

The March 1991 survey documented a record low number of sea otters in the PWS area. This study is beginning to produce a picture of the population trend since the spill, a link in assessing damages.

Comment: The statement that "differences in sea otter densities will be tested using two sample t-tests and/or ANOVA, dependent upon post-stratification of oil condition" needs to be clarified. (ESC)

Response: Standard statistical conventions will be used.

Marine Mammal Study No. 6B - Intersection Model

Comment: Study 6B will provide little useful information since the lack of available information precludes testing the accuracy of the model or the underlying data. (API)

Response: The model is intended to synthesize available information and to provide an alternative estimate of exposure of sea otters to oil.

Comment: The model to be used for estimating sea otter mortality is not a widely accepted technique. It misuses the NOAA model of oil movement which was developed for response purposes and is not sufficiently sensitive for long-term modeling of oil trajectories. Because the mathematical model to be employed in this study relies on such uncertain data and invalid assumptions, it will not provide any useful information for damage assessment purposes. Its use is therefore contrary to the NRDA regulations. (ESC)

Response: The use of the NOAA model extends only for about 30 days following the spill, while it was still being used in response efforts. Trajectories are not projected beyond the model provided by NOAA. The NOAA model is used to estimate potential exposure. Mortality is estimated directly from data collected at the time of the spill.

Comment: The exposure region for each group of otters is too large. There is no basis for assuming that California otter movement patterns will be valid for estimating PWS otter movement regions; the food base distribution and colony sizes are different in Alaska and California. Also, using the whole otter region as an exposed area will result in an overstatement of numbers of otters potentially exposed. (ESC)

Response: The exposure region is a relative measure as compared to absolute. Under the definitions of the model, it cannot overestimate potential exposure.

Comment: The measure of exposure of a particular location to oil does not take into account the changing characteristics of oil from slick to mousse. (ESC)

Response: The model does account for exposure.

Comment: The assumption that all mortality in rehabilitation centers that occurred within thirty days of the spill is spill-related is unreasonable. All otters that died did so within 34 days; 28 of these deaths were of unoiled otters and clearly not spill-related. (ESC)

Response: There is no basis for the statement that the deaths of 28 "unoiled" sea otters were clearly not spill-related. Their deaths resulted from EVOS or associated activities.

Comment: The mortality model will lack precision because it does not account for the entire range of oiling levels. (ESC)

Response: The resolution of the model will reflect the resolution of the data. This is not an issue of precision.

Comment: The method of relating degree of oiling to exposure is not described sufficiently. There were significant changes in physical and chemical properties of oil in different geographical areas and over time. The degree-of-oiling categories are subjective and the cut-off points for classifying captured otters based on the quantity of oil on pelage are arbitrary. Without basing these classifications on pathological factors, mortality rates for this study will be mere guesses. (ESC)

Response: The mortality data associated with the model was collected beginning about 7 days into the weathering process. The categories are ordinal and reflect the relative extent of oiling and are therefore meaningful. Mortality estimates are derived directly from animals collected during the spill.

Comment: The statement that values defining high, moderate and low exposure will be defined for each study area needs clarification. There is no justification for this classification scheme and it appears from the study description that the data will be modified until they fit the preconceived model output. (ESC)

Response: Site selection was based on visual observations of sea otter oiling which provided a ranking of high and low levels of oiling.

Comment: The model for this study will produce only a coarse estimation of sea otter mortality and will not permit an estimation of confidence intervals. (ESC)

Response: The model is intended to provide an approximate estimate of mortality and will be used with other components of MM6 including data on actual carcass recovery and other studies to provide scientifically reliable information.

Comment: There has not been an adequate demonstration of exposure of otters to EVOS oil and the model does not account for the weathering of oil. Thus, the model will overestimate mortality. (ESC)

Response: The collection of hundreds of oiled sea otter carcasses unequivocally demonstrates exposure to oil. Not all sea otters exposed are represented in this sample. (See previous comment regarding changing properties of oil with respect to weathering.)

Marine Mammal Study 6C - Radiotelemetry

Comment: Two years of study are adequate to meet the stated objectives of Study 6C. The description of this study does not contain an adequate rationale for its continuation. (API)

Response: There has not been two full years of study on the sea otters being monitored in this study. To date, adults have been monitored for periods from about 1 to 1.5 years; weanlings have been monitored less than 1 year. Valuable information on movements, reproduction and survival can be gained by additional monitoring of the instrumented sea otters.

Comment: This study ignores the fact that translocation will play a larger role in otter survival than exposure to oil from EVOS. In addition, the objectives of this study will be compromised by the use of higher quality habitat of Eastern PWS as a control area. (ESC)

Response: Translocation was a necessary part of the rehabilitation process. There is no basis, however, for the statement that translocation will play a larger role in survival than oil exposure. Habitat in Eastern and Western PWS was judged to be sufficiently similar in quality to warrant using eastern PWS as a control.

Comment: Objectives A for the weanlings study and Objectives A through C for the adult females study cannot be achieved because there is no reliable baseline survival or age structure data available for PWS and because sample sizes will be far too small to assess survival at various age classes. (ESC)

Response: The hypotheses on survival can be tested using control (eastern PWS) and treatment (western PWS) groups. For the weanling sea otters, survival at different age intervals is being examined, which does not imply a comparison of different age classes. Sample sizes are adequate to test the stated hypotheses.

Comment: Objectives B of the weanlings study and Objective D of the adult females study cannot be tested by documenting movement in 1991 and comparing it to areas affected by oil in 1989 because this incorrectly assumes that differences in movements are attributable only to oil. (ESC)

Response: Objectives B and D involve documentation of movements of sea otters relative to areas affected by EVOS. Movements of sea otters in a control area are also being recorded. Testing for a relationship between movement of the otters and oiling of specific areas does not necessarily imply an assumption that differences in movements are attributable only to oil.

Comment: Comparisons to be made as part of Objectives A through C regarding rehabilitated otters' survival, movement and reproduction as between eastern and western PWS will not be valid owing to the differences in pre-spill habitat between those two areas. (ESC)

Response: Comparisons, with respect to rehabilitated sea otters' survival and reproduction, are being made between otters that underwent oiling, cleaning, treatment, and release and otters that did not undergo these processes. Because some rehabilitated otters have remained in eastern PWS after release differences in pre-spill habitat between eastern PWS and western PWS will not have significant bearing. However, habitat in eastern PWS and western PWS is sufficiently similar to justify using the east as a control area.

Comment: The Plan does not describe the field methods with sufficient specificity: there is no frequency of relocation of instrumented otters given; there is no method given for distinguishing between female and male otters during population counts; and there is no method for classifying oiled and unoiled areas. (ESC)

Response: Field methods were described in greater detail in Study Plans for previous years; less detail was supplied here in interests of brevity as radiotracking methods have not changed. Population counts in which male and female sea otters need to be distinguished are not a component of Study 6C. Generally, it is assumed that eastern PWS was unoiled and western PWS was oiled.

Comment: A sample size of 45 rehabilitated otters is too small to detect differences that could be extrapolated to the entire rehabilitated otter population. (ESC)

Response: A sample size of 45 instrumented sea otters, which represents approximately 25 percent of the total number released, is sufficient to measure effects that can be extrapolated to the rehabilitated sea otter population.

Comment: The assumption that sea otters captured in treated areas have been exposed to EVOS is not valid; nor is the assumption that otters from unoiled areas of PWS are healthy because of the habitat differences between eastern and western PWS. (ESC)

Response: Given the knowledge of sea otter movements, it is valid to assume that sea otters captured in and around oiled areas were exposed to oil, and sea otters captured in non-oiled areas were not exposed to oil. Further, the health status of sea otters in eastern PWS and western PWS would otherwise have been similar. Examination of blood and tissue samples will provide information regarding oil exposure.

Comment: The objectives of this study are compromised by the fact that otters were captured, maintained in captivity, stressed and translocated. Oil cannot be segregated from the other factors affecting rehabilitated otters. (ESC)

Response: It is recognized that various factors, including oiling, cleaning and captivity, may have influenced the fate of the sea otters following release. Records were kept on the degree of oiling at arrival and the clinical history of the sea otters while at the centers, and this will be taken into account when interpreting the data.

Comment: There is no documentation of current exposure pathway for all rehabilitated or untreated otters and no discussion of how this information will be utilized in either the selection or the implementation of rehabilitation. (ESC)

Response: Potential pathways of exposure to hydrocarbons are being considered; some testing (see study 6D) is ongoing, and results from other NRDA studies will be evaluated for information relevant to exposure pathways for sea otters.

Marine Mammal Study No. 6D - Prey Selection and Foraging

Comment: Given the limited purposes of Study 6D, a third year of this study is not necessary. (API)

Response: This is the first year that Study 6D has been implemented. It will provide specific information valuable in assessing EVOS induced injuries to sea otters.

Comment: This is not a study with testable hypotheses because description, estimations and collections are not scientific objectives and there are neither baseline nor comparative data by which to judge the results of this study. (ESC)

Response: This is a descriptive study. Sea otter prey species will be described as frequency of occurrence within each study area. Forage success can be tested among areas and over time to baseline data for 2 of the 3 study areas.

Comment: There are no methods for separating spill effects on foraging ecology from the effects of observer quality, natural variability in prey abundance and type, and differences in study areas. (ESC)

Response: All observers were trained in the field identification of sea otter prey species prior to data collection; observers will remain constant throughout the field study. The study design accounts for the natural, patchy distribution of sea otter prey species by sampling an area rather than a specific point. Effects of the spill will be measured in terms of the hydrocarbon assays of the sea otter prey for species occurring in all study areas.

Comment: There is no discussion of sample sizes or replication. (ESC)

Response: The study design stated a minimum sample of 500 identified sea otter prey items at each study area to describe the frequency of occurrence of specific prey. The study design is comparable to historic data available for 2 of the 3 study areas, which may serve as a replicate.

Comment: Site selections do not include control sites. No pre-spill data are available for Knight Island. Nor is there any control apparent over changes in prey populations among the study sites. (ESC)

Response: Toxicology of sea otter prey species will be tested along a gradient of shoreline oiling as described by the study areas, and this gradient will provide a basis for statistical testing of the data. Although pre-spill data are not available for the Knight Island area for forage success and frequency of occurrence of species in sea otter diet, this is not expected to be an impediment to interpretation of the results.

Comment: There is no strategy mentioned for listing prey by species, which is probably impossible if done with binoculars. (ESC)

Response: Sea otter prey species will be identified to the lowest taxon possible. All observers are trained in the identification of sea otter prey species prior to data collection. High resolution scopes will be used for all forage observations in the field. Under good viewing conditions, trained observers are capable of identifying prey by species.

Comment: There is insufficient description of toxicological analyses of prey item tissues and no mention of the compounds to be analyzed. (ESC)

Response: Toxicological analyses standardized for all damage assessment studies (see Technical Services Study Number 1) will be used for the prey items.

Comment: This study will not quantify injury to sea otter populations in PWS. Nor is there a justification for undertaking this study for restoration purposes. Therefore it is not a compensable study. (ESC)

Response: This study, in conjunction with other components of MM6 examining toxicology of sea otter tissues, reproduction and survival, will further the understanding of potential pathways of exposure to hydrocarbon contaminants persisting in the environment. Data acquired from study 6D will aid in the prediction of recovery of the sea otter populations in PWS and will be useful in planning appropriate restoration measures.

Marine Mammal Study No. 6E - Sea Otter Mortality

Comment: Study 6E does not appear to take into account the parameters unrelated to the spill that may be affecting otter mortality. The data collected in 1974 and 1975 may no longer be useful as baseline information. (API)

Response: Parameters unrelated to the oil spill may affect sea otter mortality and this should be reflected in variation among the ten years of baseline data to which post-spill data will be compared. All existing data is considered and applied as appropriate.

Comment: There are not adequate baseline data for making definitive comparisons of the number of deaths among prime age and female otters in the pre- and post-spill eras. In particular, there are no age structure data available for Knight and Naked Islands. Any differences found could be due to disease and/or meteorological conditions. (ESC)

Response: The ten years of baseline data provides a very good estimate of the number of deaths of prime age and female sea otters in an unoiled environment. There is little pre-spill information on age at death in the Knight and Naked Island areas, but these should be comparable to other areas in western PWS where baseline data are available. Information from other components of MM6, examining toxicology of tissue samples, and survival, reproduction and movements of sea otters in these areas, will be interpreted in coordination with results from Study 6E.

Comment: Objectives B and C fail to take into account the migration patterns and differences in natural mortality factors, search efforts, search dates, and wind and tide conditions. (ESC)

Response: Information on movements of sea otters will be forthcoming from Study 6C. Examination of recovered carcasses will provide insight into natural mortality factors. Physical factors such as wind and tide were recognized in the study plan as potential sources of variability. The 10 years of baseline data will provide an estimate of variation among years when oil was not a factor.

Comment: There is no information regarding the comparability of test and control sites. (ESC)

Response: The test and control sites were not described in detail in the study plan, but a reference was provided to earlier work in which the methods for baseline data collection were presented. Each of the sites should be comparable over time, and it is the across year comparisons that are central to the study.

Comment: Methods to be employed by the study do not distinguish between population distribution and population abundance effects. (ESC)

Response: Information gained in other components of MM6 (specifically, in MM6A and MM6C) will clarify differences in population distribution and abundance that may be pertinent to interpretation of this study.

Comment: The Plan is unclear as to the statistical procedures that will be used for this study: neither the level of effect to be tested nor the effort needed to detect an effect was given; sample sizes and replication are probably inadequate for valid statistical testing; and analyses assumes incorrectly that there was a stable pre-spill age distribution. (ESC)

Response: The sample sizes cannot be presented in the study plan as it is not possible to determine beforehand the number of carcasses that will be recovered. Chi-square contingency tables and t-tests were identified for the statistical analysis. A relatively stable pre-spill age distribution was observed and this information will be presented in the final report of the study.

Comment: Toxicological analyses of tissues to be performed in conjunction with this study are not sufficiently defined in light of the breadth of analyses described under Technical Services, and hydrocarbon analysis of decaying tissue will not provide results that can be interpreted. (ESC)

Response: The toxicological analyses that will be performed are standard analyses as described in Technical Services Study Number 1. It is recognized that some recovered carcasses are too decayed to allow comparisons of tissue sample analyses with analyses on fresh samples. However, results from analysis will be worthwhile in determining presence or absence and location of hydrocarbons.

Comment: Rates of carcass deposition are influenced by current patterns, wind fields, beach morphology and wave activity, but there is no indication that this study will take these factors into account. (ESC)

Response: Rates of carcass deposition may vary over years due to physical factors and with varying population densities--this was stated in the study plan. This will be considered when evaluating patterns of mortality over time.

Comment: There are differences in prime age between eastern and western PWS otters that create a natural bias in this study's data from control and oiled sites. This factor has not been considered in designing this study. (ESC)

Response: Comparisons between pre- and post-spill data are within eastern PWS or western PWS and so account for any relevant natural discrepancy.

Marine Mammal Study No. 6F - Bioindicators

Comment: Study 6F should not continue. There is too little known concerning baseline conditions and normal variability to reach any conclusions. (API)

Response: Extensive information on sea otter blood samples has been accumulated in previous years from California and PWS. Samples collected in southeast Alaska will complement the existing data. Furthermore, comprehensive information on normal variation and pathological changes in blood values in other mammalian species can be utilized as needed. It is not valid to state that too little is known concerning baseline conditions and normal variability to draw meaningful conclusions.

Comment: There is no explanation for the absence of funding for salaries in Marine Mammals Study # 6F. (NWF)

Response: Personnel to conduct Study 6F have been drawn from other parts of MM6; their salaries are identified in other components of the overall study.

Comment: Blood sample analyses taken for Objective A will depend on habitat, food availability and diet, thereby making otters from southeast Alaska an improper set of control animals. (ESC)

Response: Data analysis for Study 6F will be conducted with the participation of a highly qualified clinical pathologist with knowledge of the variation that may be expected from such factors. Blood samples collected from sea otters in southeast Alaska will be valuable for control purposes.

Comment: Objective B will create additional and unwarranted harassment of otters from rescue centers since blood analyses of otters indicate that conditions returned to normal in a short time. This objective also will invalidate the results of Study 6C. (ESC)

Response: Capture and collection of a blood sample are not expected to significantly affect the survival, movements, or reproductive capabilities of sea otters. Although the comment states that "conditions returned to normal," changes in kidney and liver function resulting from oil exposure may develop over time and be detected in blood values. Therefore current (and perhaps future) samples are potentially valuable as bioindicators of the effects of oil exposure.

Comment: Measurements of pre-weaning growth rates has no meaning since there are insufficient background data for comparison and interpretation and since growth rates are subject to a number of ecological variables that this study does not consider. (ESC)

Response: The component of Study 6F (Objective C) that was examining pre-weaning growth rates will not be conducted this year.

Comment: Objective D is research; it has no mechanism for relating oil exposure to EVOS. (ESC)

Response: Physical examinations are a standard routine in veterinary practice, and it is logical that all sea otters handled as part of this study should be examined. Any abnormalities that may be noted will be evaluated in terms of oil exposure.

Comment: Comparisons of study data to unpublished and undocumented pre-spill growth rate data will not provide valid scientific conclusions. (ESC)

Response: Comparison of data to unpublished work is an acceptable scientific approach, as unpublished does not connote unsubstantiated. Pre-spill data of significance to results will be presented as appropriate.

Comment: Comparison of otter baseline data to "mapped data on shorelines and offshore areas affected by oil" is not clearly described. There is no definition of the exposure index or any indication that an exposure pathway can or will be identified for use with the blood/urine samples collected in 1991. (ESC)

Response: The mapped data on shorelines and offshore areas affected by oil is being provided by Technical Services Study Number 3. We will work with them in conjunction with a biostatistician to determine valid methods for comparison of baseline data collected on the sea otters to oiling of an area. Results from the different components of MM6 will be interpreted in conjunction to evaluate extent of exposure and potential continuing injury to the sea otter population.

Marine Mammal Study No. 6G - Toxicity

Comment: The Trustees should be careful not to make Study 6G so broad a research project that it cannot be used specifically to rehabilitate otters in Prince William Sound. (API)

Response: Evaluating success of a rehabilitation effort will require an understanding of pathological changes induced by oil exposure. The scope of work under MM6G will provide information on rehabilitated and wild populations of sea otters in PWS.

Comment: It is unlikely that a pathway for exposure of sea otter to oil can be found in MM6F and MM6G since the waters of Prince William Sound and the Gulf of Alaska have returned to background levels of hydrocarbons and there is no evidence of substantive contamination of fish or other food on which otters might prey. (ESC)

Response: Hydrocarbon levels of waters in PWS and the GOA, and hydrocarbon levels of prey species will be evaluated in concurrent NRDA studies and results considered in interpretation of potential pathways of exposure for sea otters.

Comment: This study is duplicative of efforts being undertaken in MM6D and 6E and contains no testable hypotheses. (ESC)

Response: This study supports MM6D and MM6E and is complementary, not duplicative. Specific testable hypotheses are not stated as they will depend on numbers of carcasses and samples available in the different categories.

Comment: Objective A constitutes wasteful spending since there is already a publication containing information regarding the efficacy of medical treatment and rehabilitation of otters during the spill. (ESC)

Response: The current effort will further integrate the available data and provide additional detailed information on rehabilitation, acute and chronic injuries.

Comment: There is no exposure pathway that would justify evaluation of chronic effects of residual oil on otters. (ESC)

Response: Potential exposure pathways are being examined in this study. Chronic effects could come from an initial exposure or from longer term continued exposure to hydrocarbons persisting in the environment, or from a combination of both.

Comment: This study is pure research. It fails to indicate the type of model to be used to assess toxic effects and pathological processes. Descriptions of methods for examining recovered carcasses is too scant for meaningful comment. This study is unnecessary since necropsies and pathology studies have already been done. (ESC)

Response: This study is intended to develop a model to assess toxic effects and pathological processes resulting from exposure to oil. Important information not yet interpreted or summarized can be gathered from additional carcasses now being recovered as well as carcasses that were recovered in the summer of 1989 and 1990, and necropsied in the summer of 1990. Methods employed were not described in detail because they are standard veterinary pathology techniques of necropsy.

Comment: There is no discussion of methods or techniques of the histopathology, toxicology and hematology studies to be performed. (ESC)

Response: Histological and hematological methods and techniques utilized will be standard methods; pathologists doing the work are Board Certified. Toxicological techniques used are described in Technical Services Study Number 1.

Comment: There is no discussion of the manner in which date and duration of exposure and changing composition of oil will be determined. (ESC)

Response: These factors are recognized to be of potential importance and will be examined as part of the study where appropriate.

Comment: It is unreasonable to expect that the recovery of carcasses in 1991 will provide valuable clues to the factors surrounding the death of the animals thought to have died from exposure to EVOS two years ago. (ESC)

Response: There may be relationships between the death of animals in 1991 and their exposure to oil. This study may provide evidence of continuing damage from acute and chronic oil exposure, as well as information that relates to death of oiled sea otters in the rehabilitation centers.

Comment: To the extent that this study aims to further the understanding of pathology processes, it is basic research and not compensable under the NRDA regulations. (ESC)

Response: Pathological changes resulting from exposure to oil may continue to affect the health and recovery of sea otter populations in oiled areas. An understanding of these processes is a critical component of the overall sea otter study.

Comment: The following are not discussed in the study plan: statistical methods for testing a scientific hypothesis, methods for relating pathology to geographic locations of carcasses, and testing and validation of toxicity modeling effort. (ESC)

Response: Analysis of data and development of statistical tests will be done in coordination with a biostatistician. Geographic locations of carcasses will be combined with oiling data provided by other studies; pathologies in areas of different degrees of oiling will be compared. The toxicity modeling effort will be developed as a part of study MM6G.

Marine Mammal Study No. 6H - Database Management

Comment: The cost of this study is excessive given the limited amount of data generated by the sea otters studies; individual principal investigators should be able to manage their own data sets without creating a new database system. Further justification is needed for the employment of three full-time scientists devoted to this task. (ESC)

Response: A large amount of data already have been generated by the sea otter studies, and additional information is being collected and added to the data base. The scientists with direct involvement in the study are based in six different locations and coordination and distribution of data among them is required. The individuals assigned to this task full-time are one scientist and two biotechnicians, not three full-time scientists. All three individuals have been involved in supporting other aspects of Marine Mammal Study Number 6, and if their salaries were not identified under Study 6H they would be identified under Studies 6A-G as they are providing assistance to those studies.

Comment: The database management system (MM6H) is beyond the scope of NRDA and duplicates funding for MM6A, 6B, 6C, 6E, 6F, and 6G. (ESC)

Response: The database management system is required to coordinate data collected under the different substudies for MM6. If funding for the database support had not been identified in MM6H, an increased cost for personnel would have been incorporated into the other MM6 studies.

Comments on Terrestrial Mammals Studies - General

Comment: There is no justification for continuing the terrestrial mammals studies in 1991 because no continuing pathway for exposure to oil has been identified and no significant effects of oil from EVOS on these populations has been demonstrated. In fact, NOAA has observed that shoreline conditions are such that there is no potential threat to terrestrial mammals as a result of oiled biota in the intertidal zones. And there was no indication in the Summary of Injuries that these populations have been affected. (ESC)

Response: Only brown bear and river otter studies were continued in 1991. Both these species use intertidal habitats that are still contaminated by hydrocarbons. Therefore, a continuing pathway does exist. Brown bear are a relatively long-lived species with a low reproductive potential which will require long-term study in order to fully assess injury to populations. The Summary of Injuries clearly stated that there are indications of injury to river otter. In oiled habitat, home ranges are larger, movements are more erratic, and body weights are lower. These indications are adequate justification to continue the study.

Comment: The terrestrial mammals studies do not recognize that many natural variables such as severe winters, predator/prey relationships, and disease affect life cycle events. Thus, it is unlikely that these studies will be able to link a significant portion of the biological variability to contamination from oil. (ESC)

Response: The studies were designed to account for significant natural variation that could influence results, and, therefore are expected to detect injury from oil contamination. Variability in a biological system is expected, however, the cause of much of this variability is identifiable through empirical field observations, laboratory testing of biological tissues, and most importantly through the use of control site study areas. It is unlikely that biological communities in oiled study areas and unoiled areas would respond differently to a natural perturbation that was not detected by biologists.

Terrestrial Mammal Study No. 3 - River Otters

Comment: There does not appear to be sufficient background information on river otters blood analyses to make the comparisons undertaken by TM3 meaningful. Thus, it is questionable whether the study should be continued. (API)

Response: All pertinent literature and background information was thoroughly reviewed in preparation for blood analyses. This information was determined to be adequate to make reasonable comparisons of differences in blood parameters. In addition, this is only a part of the information expected from this project. Continuation is easily justified when the study as a whole is evaluated.

Comment: The river otter study is not cost-effective in light of the fact that few, if any, fatalities of river otters stemming from EVOS occurred, and it can only study short-term impacts on otter density since this species matures rapidly and has relatively large litters. (ESC)

Response: It is highly likely that significant fatalities occurred among river otter due to EVOS because of this specie's reliance upon intertidal habitat that was heavily oiled. Carcasses were likely not found because river otter tend to seek out concealed dens when ill. Long-term injury is possible because of continuing contamination of food items.

Comment: There is no valid pre-spill population data for river otters so this study cannot determine whether EVOS had any measurable impacts on this species. This cannot be overcome by comparing total numbers and survivorship between oiled and unoiled areas over the 1989 - 1991 period. (ESC)

Response: Comparison of total numbers and survivorship between oiled and unoiled areas over several years will allow an assessment of injury to populations. Other information being collected on direct effects, food habits, and habitat use will be a valuable aid in interpreting population data.

Comment: There are inadequate references for the statistical procedures to be used in the TM3, and criteria for selecting impact and control sites were not provided in the Plan. Thus, it will be difficult to determine whether a statistically significant effect was the result of EVOS or natural factors. (ESC)

Response: The study plan provides sufficient detail to allow evaluation of the statistical procedures. Additional information can be found in referenced publications. Sites for oiled and nonoiled study areas were selected on the basis of their similarities in habitat and in populations of otter.

Terrestrial Mammal Study No. 4 - Brown Bear

Comment: There is no data presented in the Plan to support the need for continued study of brown bear populations and the observational approach is not likely to meet the objectives of Terrestrial Mammals Study No. 4. (ESC)

Response: The purpose of the Plan is to provide information on project plans not to report results. The approach will adequately meet objectives because it involves both observation of radiocollared bears and necropsy of any mortalities to determine the cause of death.

Comment: The brown bear study ignores the obvious health of this population evidenced by the fact that the huntable surplus of this species has not been altered and the lack of documentation of brown bear mortality stemming from EVOS. Further, brown bears metabolize petroleum hydrocarbons quickly so it is doubtful that tissue analyses of dead bears will be traceable to EVOS oil. (ESC)

Response: The presence of a huntable surplus does not mean that injury did not occur, although we have thus far been unable to conclusively document injury. The ability of brown bears to metabolize petroleum hydrocarbons is not conclusively known. However, petroleum hydrocarbons have been found in dead brown bears, and EVOS is the most likely source of these contaminants.

Comment: There was insufficient detail given in the plan regarding the Katmai National Park and Black Lake study locations for TM4 to enable the reader to evaluate the study. Further, the use of the Katmai National Park spill area as a site for assessing injury to brown bear is inappropriate. The age structure of the brown bear population there, where the species is protected, is different from that of the bear in the control area where hunting is permitted. Thus, it will be difficult to isolate the age structure differences from effects of EVOS on bear populations. (ESC)

Response: Sufficient detail on study areas is provided to allow evaluation of the work. Age structure difference between the study areas is recognized and is considered in the study design. We expect it will be possible in analysis of the data to isolate this variable and, therefore, avoid improperly assigning differences to impacts of EVOS.

Comment: Population density estimates of brown bear for 1989 and 1990 will not be a sufficient database from which to predict any trend or identify impacts from EVOS on that population on the Alaska Peninsula. (ESC)

Response: The only population estimate available is from 1990. This will not be a sufficient data base for prediction of any trends or identification of impacts from EVOS. Population estimation was eliminated from the study for 1991 because obtaining additional estimates was not justified given the absence of conclusive evidence of injury.

Comments on Bird Studies - General

Comment: The bald eagle and peregrine falcon studies were discontinued because "all data pertinent to gathering injuries had been collected." If this is the case, the data obtained should have been reported to enable the reader to assess whether discontinuation of the studies was appropriate. (NWF)

Response: The Trustees exercise discretion regarding the manner and timing by which data and results are released, whether the study is ongoing or discontinued.

Comment: Several of the bird studies discuss studying oiled and unoiled areas, but it is not clear whether the oiled areas referred to are areas that were affected by the spill or are areas that currently contain oil. (API)

Response: Oiled areas are generally defined as those areas which were contaminated by the EVOS any time since the spill.

Comment: The bird studies are unnecessary owing to the information contained in the literature indicating that restoration work will not be needed for these species. The mortality they suffered is comparable to that occasioned by natural events and chronic pollution which do not cause long-term adverse effects. (ESC)

Response: The bird studies were developed with full cognizance of information available in the current scientific literature. There is considerable information in that body of literature to indicate that bird populations do not always recover rapidly after an oil spill. The EVOS was unique in its size as was the biological richness of the area where it occurred. Studies are essential before any such conclusion can be drawn regarding the health, density and population of resident and migratory species.

Comment: The Trustees' Plan ignores the record of natural recovery on the part of seabirds and the abundance of fish on which they feed. (ESC)

Response: Natural recovery and natural occurrence of bird and fish populations are being considered in the damage assessment.

Comment: There is no evidence of a continuing pathway for exposure of birds to oil. And NOAA found no evidence of oil causing sublethal effects through progression up the food chain. (ESC)

Response: The Trustees, including NOAA, are considering this point. The pertinent data and corresponding conclusions being made by the Trustees and their scientists are not being released at this time.

Comment: The bird studies fail to identify and consider variables such as severe weather conditions, food supply, disease and commercial fishing activity that can significantly affect bird populations. Thus, it will not be possible to determine whether an observed change is the result of EVOS or some other factor. (ESC)

Response: By utilizing appropriate comparisons (e.g., oiled vs. unoiled, pre-spill vs. post-spill) it is possible to account for these other variables. It is highly unlikely that these variables would consistently affect bird populations in oiled areas and not in unoiled areas. If any of these other causes are influential, appropriate weight will be given that factor in the relevant study.

Comment: The use of boat and land-based surveys will provide different levels of disturbance among the colonies and decrease the reliability of making comparisons among survey methods. (ESC)

Response: Boat-based surveys are being compared to boat-based surveys and land-based are compared with land-based at particular sites, thereby coming up with consistent comparisons of relative indices. Standardized methods and enough replicate counts on different days will refine precision enough for either method to evaluate the large degree of change that is apparent at this time.

Comment: The bird survey studies (B2, B3 and B4) lack valid pre-spill data and suitable control sites for an assessment of injury from EVOS. (ESC)

Response: In cases where baseline data did not exist, treatment (oiled) and control (unoiled) data sets were gathered to make comparisons. Control areas are selected and non-spill related variables are evaluated.

Comment: The description of survey techniques and analyses to be used in B2, B3, B4 and B11 are not detailed enough to allow the reader to evaluate whether the accuracy objectives will be met. Sampling approaches are defined only generally. The description of the application of statistical analyses to the data likewise is vague. (ESC)

Response: Efforts were made to provide sufficient information in the 1991 Plan to enable the public to understand how studies were to be conducted and how data would be analyzed.

Comments on Bird Studies - Specific

Bird Study No. 1 - Beached Birds

Comment: The funding of Bird Study 1's re-examination and cataloguing of carcasses for distribution to universities and museums is clearly non-compensable and has no bearing on ascertainment of restoration options. (API, ESC)

Response: The Trustees believe that they have a responsibility to make the best use of the resources destroyed as a result of the EVOS. The dead birds will need to be responsibly disposed of in some manner. Various alternatives were considered including incineration consistent with the regulations pertinent to the disposal of biological hazardous wastes. All the alternatives considered were expensive and had various limitations This alternative was considered to be a reasonable solution to the problem. The Trustees believe that this action will be compensable.

Comment: Re-examining bird carcasses to refine numbers and identification to species level will not serve any quantification of injury purpose. This will duplicate information already collected. There is no specification of the number of carcasses needing further identification; most birds are already identified by species. (ESC)

Response: Re-examining carcasses to refine numbers will serve to further quantify injuries. A re-examination of the carcasses will allow a determination of the portion of the total number beachcast birds that were killed by the spill based upon condition of oiling rather than on the basis of temporal differences in the species composition.

Comment: Multiple bird carcasses within a single bag will have contaminated each other and therefore will invalidate the classification of amount and distribution of oil on each individual bird, resulting in a bias of the data. (ESC)

Response: Efforts will be made to account for carcasses that were secondarily oiled while in contact with oiled birds in bags.

Comment: Objective C of B1 is clearly outside the scope of NRDA. (ESC)

Response: Reorganization of the storage system would be taking place as a result of the re-identification and is a secondary benefit to the study.

Comment: Objectives D and E are unclear and do not appear to have any relevance to NRDA. Also, there is no identification of the protocols to be used to select certain birds for further study, the types of data to be gathered, or the uses to which this additional data will be put. (ESC)

Response: Updating the log sheets with the best available information is referring to oiling information based upon actual examination of carcasses and identification to species where possible. Objective E is referring to data that could be collected by the distribution of carcasses to the scientific community. Data which could pertain to other studies might include specific numbers of birds killed by oil and the age class structures of certain species.

Comment: Repeated thawing and refreezing will accelerate decomposition and prevent accurate determination of the time of each bird death. This process also will disperse oil over the carcasses, preventing an accurate depiction of the proportion and distribution of oil on the plumage. This factors will produce unrealistic interpretations of oil spill effects on birds. (ESC)

Response: Carcasses will not be repeatedly frozen and thawed. Care will be taken to prevent further oil dispersion on carcasses.

Comment: There is no mention of the type of analyses that will "focus on the number of carcasses, species and degree of oiling" or the techniques to be used to assess and quantify injury. (ESC)

Response: The analyses that will be undertaken are primarily descriptive.

Comment: This study does not present testable hypotheses or methods for interpreting or rejecting results. (ESC)

Response: This study is merely an inventory of the contents of the vans. No testable hypotheses are pertinent to this study.

Comment: The cost of B1 appears to be excessive given its potential for rendering information to the NRDA and restoration processes. (ESC)

Response: The Trustees have considered the cost effectiveness of this proposal.

Bird Study No. 2 - Censuses

Comment: Bird Study No. 2 is not likely to produce anything definitive given the number and magnitude of variables associated with the distribution and abundance of highly mobile birds occupying such a large area as Prince William Sound. (API)

Response: Many variables have been taken into account in the design and data analysis of this study.

Comment: Natural variation of migratory birds, dissimilar observation techniques and extrapolation from local surveys to regional populations will counter the damage assessment objectives of this study. (ESC)

Response: These factors will be taken into account, when appropriate, during review of the data and analysis of the results.

Comment: Determination of distribution and estimation of abundance of waterbirds in PWS makes Objective A of B2 mere research. (ESC)

Response: Abundance and distribution inside and outside the oiled areas can be compared, making this a valid pursuit for NRDA. In addition, comparisons can be made to pre-spill abundance estimates.

Comment: The Trustees will not be able to establish a causal relationship between any observed change in the relative abundance of seabirds in Objective B because of the lack of baseline data and control areas. (ESC)

Response: There exist baseline data and areas of PWS outside the oiled area which can be used as controls.

Comment: Objective C will not be accomplished because B2 does not take into account the natural variability in waterbird populations. (ESC)

Response: Natural variability in waterbird populations is included as appropriate.

Comment: There is no indication that the level of effort, observer experience, seasonal timing or other factors affecting survey accuracy will match that of earlier surveys. Nor is there any confirmation that the same protocols will be used among surveys. Use of 25-foot boats likely will disturb birds and compromise the validity of any observations. Survey locations are not clearly enough described to assure the reader that representative data will be obtained. (ESC)

Response: The Plan states (Vol. 1, p. 66) that similar methods were used in the pre-spill studies. The principal investigators of this study went to great lengths to determine and duplicate methods used in previous studies and to otherwise assure that useful, comparable data will result.

Comment: The study does not mention replicate counts or survey strategies that would indicate achievement of a 95% confidence limit for survey data. (ESC)

Response: The 95% confidence limit referred to is for Objective A on P. 64 of Vol. 1 of the Plan.

Comment: Comparisons of the data obtained in this study to unpublished USFWS reports does not allow for adequate review because earlier methodologies cannot be evaluated against the proposed methodologies nor can the reliability of the prior studies be assessed. (ESC)

Response: Reports from previous studies are public information and can be obtained from the originating agency.

Comment: The Plan does not identify how this study will identify the presence or absence of oil during the boat surveys or a means of linking oil observed to EVOS. Nor does it appear that other variables that affect bird distributions and abundances will be recorded. (ESC)

Response: Information on the presence of oil exists in many databases. If corroboration is necessary, the presence of oil will be determined visually. All variables recorded during surveys are listed in the Methods section at page 65 of the 1991 Plan.

Comment: It appears from this study that the Trustee Council is combining oiling information from three separate data sets. This will produce an internally inconsistent database. (ESC)

Response: Consistent application of oiling information data sets is being addressed.

Comment: B2 does not describe adequately the statistical procedures for data comparisons. It is unclear how the effects of EVOS will be estimated and tested, especially with respect to Objective C. (ESC)

Response: Pages 67-70 outline specific statistical procedures and formulas to be used in analysis.

Comment: The use of baseline data from the 1970's is inappropriate since environmental and other changes have affected the bird populations in the intervening time and these cannot be segregated from the effects of the spill. (ESC)

Response: When data from the 1970's is used in conjunction with data collected during the 1980's, pre-spill trends can be discerned, and may be used in support of other documentation of damage to a given species.

Comment: Pre- and post-spill surveys used different transects. Thus, population estimates will not be comparable. Even if changes in bird densities among the years is found, the surveys will not be able to link the changes to the spill. (ESC)

Response: If two surveys are done for an area using the same observation techniques and both using valid methods for estimating populations, those estimates are both valid and can therefore be compared.

Bird Study No. 3 - Seabird Colony Surveys

Comment: Mass mortalities of murres, together with nesting and reproductive losses, are not rare events even in nature. The Trustees should consider that the reproductive failure of murres and the loss of that population's breeding adults is attributable to some factor other than EVOS. (ESC)

Response: This is being considered, but it is equally important to consider what effect such a widespread oil spill and the subsequent mortality might have on these colonies.

Comment: Bird Study No. 3 does not appear to take into account the natural variability of bird populations. Absolute numbers cannot be calculated using the assumptions relied upon in this study. (API)

Response: Natural variability is being taken into account, using baseline historical data which is available for certain sites.

Comment: The survey of seabird populations at sites far beyond the spill area in B3 has no relevance to establishing baseline populations. (ESC)

Response: No sites have been censused or monitored that are not in the spill area or adjacent to it.

Comment: Use of the Semidi Islands as a control site for B3 is inappropriate because of the unique oceanographic conditions which influence their food supply and because of their unique habitat. (ESC)

Response: The Trustees disagree. The Semidis are right on the edge of the spill, and contain comparable large murre colonies. In addition, there have been feeding studies of diving alcids and the food they bring to their young (U.S.F.W.S., Research Center, Alaska, Hatch pers. comm.) which support this comparison.

Comment: The objective of B3 cannot be attained because the study design does not account for such factors as climate, weather, food supply and natural variability, which affect bird populations. Therefore the Trustees will not be able to demonstrate a causal link between any measured change in numbers of birds and EVOS. (ESC)

Response: If any of these other causes are influential, then they should affect species and sites within and outside of the oil spill area.

Comment: Baseline data for nesting productivity is grossly inadequate and control and test sites are not comparable. Therefore the Trustees will not be able to make valid comparisons of reproductive parameters between oiled and unoiled colony sites. (ESC)

Response: There is good baseline data for certain sites. Control and test sites are considered comparable if done appropriately.

Comment: Diurnal variability in nest attendance can be greater than 100%. It is unclear whether this study takes this factor into account. (ESC)

Response: The stated study hours are the standards used at this time in Alaska.

Comment: This study will produce unrealistic comparisons because of the different levels of reliability of boat- and land-based surveys. (ESC)

Response: Standardized methods and enough replicate counts on different days will refine precision enough for either method to evaluate the large degree of change that is apparent at this time.

Comment: There is no justification in the study description of the secondary emphasis on kittiwakes, cormorants and parakeet auklets or the method for determining baseline reproductive success of murres. (ESC)

Response: It is anticipated that the data on the secondary species may be obtained in the course of this study most efficiently.

Comment: Although Middleton Island is mentioned in the introduction as a control site, the body of the study description does not explain how it will be used to gather or interpret results. (ESC)

Response: The type of census work done in the past on Middleton Island is being repeated in a comparable fashion and will be assessed in connection with overall study.

Comment: Much of the historical data concerning the proposed colony sites is outdated and too poorly documented to enable the Trustees to measure recent changes for some populations. Thus, it will not be possible to link changes in population status to the spill. (ESC)

Response: The approach has been to look at many different sites and several different species with the idea that any effect caused by something other than the oil spill should show up at other sites and with other species in some consistent pattern.

Comment: The statistical models for B3 are vaguely defined, so it is unclear how effects of EVOS will be measured, especially in light of the natural variations owing to time and location. (ESC)

Response: This study has relied on the advice of professional statisticians. Fieldwork was conducted to refine precision of estimates with as many standardized replicates as field conditions allowed. The probabilities of error types was examined and this information will be included in reports and discussions rather than in study plans.

Bird Study No. 4 - Bald Eagles

Comment: The estimate of acute mortality to bald eagles that Bird

Study No. 4 is designed to improve will be highly speculative. How the number of birds killed but never found can be determined is not well supported. It is questionable whether such a determination can be made at all. (API)

Response: This portion of the study is designed to provide a reasonable estimate of the numbers of eagles that died in addition to those found on the beaches of the spill area. It is inconceivable that workers found 100% of the eagles that died. Our task is to put reasonable bounds on the estimated mortality.

Comment: Objective A of Bird Study No. 4, an estimate of the numbers of resident bald eagles, will be difficult given the large area encompassed by Prince William Sound. (API)

Response: The technique has been applied to numerous areas significantly greater in extent than Prince William Sound. The technique has proven to be reliable and repeatable.

Comment: Bird Study No. 4 should explain how the investigators will assess whether birds sampled from oiled and unoiled areas have had access to both such areas given their mobility. (API)

Response: It is anticipated that the eagles in close proximity to oiled beaches will have higher probability of contamination than eagles resident on beaches 40-50 miles from contaminated shores. The comparison is being made between these groups of eagles. If eagles from the "control" group are exposed to oil and contaminated, it may reduce the observable differences between the groups and add to the extent of the area affected by EVOS.

Comment: Contrary to their statement concerning Data Analysis in Bird Study No. 4, the Trustees must assume that factors other than major physical changes in habitat will have occurred between 1982 and the time of the spill and that these factors could have caused changes in the eagle population. (API)

Response: Such changes have not been documented and there is no reason to expect they exist. There have been no catastrophic changes in the spill area since 1982, other that the spill itself. If any such factor becomes apparent it will be assessed.

Comment: Results of bird studies indicating that all known eagle territories were occupied in 1990 should be factored into future decision making and data analyses. (API)

Response: The Trustees will be considering the results of the 1990 studies conducted under NRDA.

Comment: The population survey, radio-tracking and productivity survey efforts of B outside the spill area will not serve any NRDA purpose. These aspects of this study are simply research. (ESC)

Response: It is difficult to collect comparative data if data are collected from only impacted areas. In addition, effects of oil on an individual eagle may not be evident only when the eagle is in the immediate area of the spill.

Comment: Collection of blood samples from eagles is unnecessary because samples from the same eagle population in 1989 showed normal blood characteristics. (ESC)

Response: Certain blood tests were significantly different between eagles captured along oiled beaches and those captured along clean beaches. It is reasonable to continue the blood work to determine if these differences are still detectable.

Comment: The historical data for B4 are outdated. And there is no indication whether the 1991 data will be gathered in a manner comparable to that of the 1982 data. (ESC)

Response: There is no reason to expect that the number of eagles would have fluctuated wildly from the estimate for 1982. The same methodology has been used for population surveys in 1982, 1989, 1990 and 1991.

Comment: Use of Copper River Basin eagles is inappropriate because of the different feeding ecology and nesting habitat in that area. (ESC)

Response: Occupancy and productivity data from the Copper River is remarkably similar to data from saltwater habitats in southeast Alaska and not significantly different from data collected on eagles in clean habitats throughout Alaska. Because of the potential for this population of eagles to be impacted by the spill and their proven similarity to other populations in the state, it is entirely reasonable to include these eagles in the study.

Comment: Objective A of B4 cannot be achieved because of the lack of comparable baseline or control data and because the natural variability of eagle populations in the region remains unknown. (ESC)

Response: See previous responses.

Comment: The sample sizes to be used are too small to allow the testing of Objective B's hypotheses concerning survival rates. (ESC)

Response: Unless the reviewer has unique knowledge, not available to the scientific community, about the variability of bald eagle survival rates there is no way this statement can be construed as valid.

Comment: The effects of the radio telemeter on eagle behavior and the inadequate sample size will render accomplishment of Objective C impossible. (ESC)

Response: Radio-tagging of hundreds of bald eagles with transmitters similar in design and attachment to the ones used in this project, has been documented to have no detrimental effects on the birds.

Comment: The costs and capturing activities for Objective D are not warranted because of the small amounts of highly weathered oil in 1991 and the absence of any exposure pathway. (ESC)

Response: Significant results obtained from the previously conducted sampling warrant follow up observations.

Comment: The locations, and criteria for choosing, oiled and unoiled sampling areas are not described adequately, especially in light of 1991 shoreline conditions. (ESC)

Response: Areas are selected by the presence of an eagle. Random locations without eagles are rejected. Areas that were heavily oiled, according to ADEC maps, will be given priority for the collection of additional samples. The point of the sampling is to find out if there are continuing impacts to bald eagles, not necessarily if abundant oil remains on the beaches.

Comment: Use of Malaspina Glacier, which is well outside the spill zone, as a control area is not appropriate. Collection of data from this area is simply research. (ESC)

Response: The population surveys begun in the 1970's encompassed the northern edge of the Gulf of Alaska from Cape Spencer to Cape Elizabeth. For comparability, the same area was surveyed for the assessment. It is an elementary scientific approach to use results from areas beyond the range of suspected impacts as controls.

Comment: The radio-tagging program does not account for natural dispersal of immature eagles and could increase the risk of mortality to fledglings, thereby creating study bias. The samples are too small to ensure that random samples across the age structure of the population will be obtained. There also is no description of how radio tag failure will be overcome. (ESC)

Response: Radio-tagging has not been shown to cause mortality in bald eagles. The comparison is being made between radio-tagged eagles from oiled areas and radio-tagged eagles from unoiled areas making the effect of the transmitter of little consequence as it would be the same for either group. There is no reason to expect that the age structure of adult eagles is significantly different between the eastern and western sides of PWS. The Kaplan-Meier procedure, cited in the study plan, discusses how missing transmitters are "taken into account".

Comment: The Trustees failed to indicate how individual eagles will be selected for blood sampling. Nonrandom selection may bias results. Post-mortem changes may invalidate the results of hydrocarbon analyses on eagle carcasses recovered. The carcass recovery study will only demonstrate where telemetered birds die. The oiled and unoiled areas in that portion of B4 that is to assess toxic and sublethal effects of EVOS on eagles are neither described adequately nor distinguished from one another. (ESC)

Response: Blood samples were taken from adult eagles. Individuals were selected from widely dispersed areas in both eastern and western PWS. Eagles in western PWS were trapped from areas with oiled beaches. Eagles were not trapped at random locations because neither eagles nor oil are distributed randomly and it serves no purpose to trap at sites without eagles. Post-mortem changes in eagles from oiled and unoiled areas are unlikely to be different. Determination of causes of mortality are being made by highly qualified individuals who are eminently qualified to determine if the analyses performed provide reliable data.

Comment: The statistical analyses to be performed in B4 are not described sufficiently; study sites are not disclosed; and the probabilities of Type I and Type II errors are not given. (ESC)

Response: Statistical models mentioned in the plan are routine tests presented in standard statistical texts. See for example, Zar, J.H. 1984. Biostatistical analysis. Prentice-Hall, Englewood Cliffs, New Jersey. Study sites are discussed above.

Comment: B4 does not appear to take into account the fact that short-term reductions in productivity have little impact on eagle populations. (ESC)

Response: Productivity analyses are taking into account acute and chronic population effects, as relevant.

Comment: The Trustees' bald eagle study disregards the results of the Fish and Wildlife Service's study evidencing the 1990 breeding success of this species, the survival of its fledglings and its recolonization of spill-affected areas. (ESC)

Response: The analysis and synthesis of the bald eagle data will consider the results of all relevant available studies.

Bird Study No. 11 - Sea Ducks

Comment: It is questionable whether there remains any pathway for exposure of sea ducks to oil (since oil is no longer present at the water surface or in the water column below the surface). Thus, the objective of Bird Study No. 11 may not be met. Also, the mobility of these birds could complicate the comparison of populations in oiled and unoiled areas. (API)

Response: The purpose of this study is to assess whether there is continuing harm as indicated by earlier studies. All relevant factors will be considered in evaluating the data.

Comment: This study is unwarranted in light of the Trustees' continued permitting of waterfowl hunting in spill-affected areas and their intent to take more ducks in 1991 for this study. (ESC)

Response: The population of waterfowl and the effects of EVOS on the population are proper for consideration by the Trustees.

Comment: Use of a predictive analytical model is not a standard technique for determining injury and therefore is not in accordance with the DOI regulations. (ESC)

Response: Modelling is a standard scientific technique in studies of this type.

Comment: Development of a data base for food habits of six species of seaducks in PWS is not likely to produce any data useful to

either injury assessment or identification of restoration alternatives. (ESC)

Response: This study is necessary to assess the continuing and longterm effects of EVOS.

Comment: Samples, statistical assumptions and results of Objective F will not be valid because harlequin ducks fly between oiled and unoiled areas. (ESC)

Response: Comparison techniques allow for scientifically valid conclusions to be reached.

Comment: Given the scope and design of Objectives B-E, B11 will not be able to predict mortality and reproductive effects broadly by correlating hydrocarbon gut and tissue data and morbidity data. (ESC)

Response: In corporation of all relevant data will allow the investigator to draw necessary and supportable conclusions.

Comment: The study and control sites are not defined, and the methodology for selecting individual sea ducks to be collected at each site is not given. Sample sizes will likely be too small for the Trustees to draw valid scientific conclusions from their analysis of harlequin duck productivity and development. (ESC)

Response: The Trustees retain the best scientific investigators available in order to obtain reliable results.

Comment: The use of a control site in Southeast Alaska is inappropriate owing to the 500-mile separation between the site and the spill zone. (ESC)

Response: For comparison it is necessary to assess sites both within and without the spill area.

Comment: There is no description of the techniques to be used in collecting tissues, the analysis of petroleum residue to be performed, or the manner in which fat deposition is to be classified. Thus, the reader cannot assess whether the study results will be based on subjective interpretations that would invalidate conclusions. (ESC)

Response: All techniques and analyses are performed pursuant to scientifically valid methods.

Comment: Integration of data from other studies such as coastal habitat probably will not be possible because of the spatial variation between data sets. (ESC)

Response: The Trustees are mindful of the need to integrate studies where appropriate.

Comment: It is not clear how oiling differences will be segregated from natural variability in the interpretation of data. Any differences in histopathology results between western and southeastern PWS could be due to natural differences in the two bird populations. In addition, nesting habitat, wintering habitat and food base differences will affect tissue analysis. (ESC)

Response: The principle investigator and the Trustees will consider and weigh various factors in arriving at a supportable damage assessment.

Comments on Fish/Shellfish Studies - General

Comment: The Plan fails to include any reference to the results of the subsistence sampling program conducted by NOAA and ADF&G and Exxon which provides convincing evidence that fish from throughout the spill area do not contain hydrocarbons above normal background levels. (ESC)

Response: The subsistence tests focussed on hydrocarbons in edible fish tissues; however, fish (unlike clams) have physiological pathways by which they process hydrocarbons into forms soon unidentifiable as having originated from the EVOS (the fish themselves are largely composed of hydrocarbons). This does not mean that the fish have not been harmed by exposure to oil in either a short or a long term fashion nor that this harm cannot be assayed by means other than hydrocarbon analysis.

Comment: The use of mixed function oxidase levels in fish tissues as a means of assessing hydrocarbon contamination is research rather than a method for determining restoration needs. The use of MFO's and cytogenetics to demonstrate injury is unproven and can yield a good deal of variability among season, food sources and life stages. Nor do they have a restoration purpose. (ESC)

Response: It is well established in the toxicological literature that MFO's are produced in response to hydrocarbon exposure. MFO's, though a defensive mechanism, often convert hydrocarbons into more toxic substances than the original compounds and create ultimate carcinogens. Thus these hydrocarbons can have acute toxic and long term mutagenic effects. While MFO's do mediate compounds which cause injuries, they are not injuries in themselves. They do indicate hydrocarbon exposure and suggest the possibility of injury. Histopathology and other assays actually document the injuries if they occur. MFO production (and potential for harm) does vary by life stage, etc. which is why control samples at the same stage, etc. are taken.

Conversely, cytogenetics do not change with life stage, etc. unless an organism has been exposed to a mutagen such as petroleum. Changes in this case can much more justifiably be classified as injuries since a much greater proportion of these changes have a negative survival impact than a positive one on an organism.

Both MFO and cytogenetic analyses have restoration purposes in that they can monitor decline in the continuation of injury. If they do not decline, more active intervention may be necessary in order to accomplish restoration.

Comment: Biochemical measurements such as bile fluorescent aromatic hydrocarbon concentrations and enzyme level changes are nonspecific indicators of exposure; they are highly variable naturally; they cannot be linked directly or positively with EVOS;

and they have no use in correlating population level impacts. (ESC)

Response: The Trustees will compile a variety of oiling data bases to demonstrate that these nonspecific indicators of hydrocarbon exposure were a result of the EVOS. Both types of data are necessary, however, in order to show that these organisms were not only in the path of oil but also came into intimate contact requiring a metabolic response.

Comment: A review of salmon population dynamics in Prince William Sound reveals a high degree of variability between stocks. Since differences between wild and hatchery stocks are not clearly understood by the fisheries managers of the area, it is not plausible to expect that the studies described in the Plan (FS 2, FS 3, FS 4, FS 5, FS 11, FS 27) will be able to adequately describe the subtleties of historical population dynamics with sufficient precision to assess the incremental impact of extremely low hydrocarbon levels. (ESC)

Response: The Trustees have great confidence in the area fisheries managers and their understanding of the wild and hatchery stocks. We believe that the impact of the EVOS will be assessable and that our published plans demonstrate this to be the case. The Trustees would also like to note, however, that FS 27, the sockeye overescapement study, does not take place in Prince William Sound and that the study locations are identified in the published study plan.

Comment: Studies 2, 3, 5, 27 and 28 may provide information that will be useful to fisheries managers, but not information that will assess oil spill impacts. They therefore are not compensable. (ESC)

Response: These studies have components that will demonstrate exposure of fish and shellfish to oil (observations of oiling), bioavailability (hydrocarbon and mixed function oxidase analysis), or injury to individual organisms (histopathology) and populations (survival data). Taken together they are structured to determine damage to fish stocks. Damage due to the oil spill may require management actions that would otherwise not have been necessary and ancillary benefits improving the management of stocks in general may result from these studies as there are ancillary benefits for many kinds of scientific studies; however, that is not the reason for conducting these studies.

Comment: Fish/Shellfish studies 2, 5 and 13 are designed to detect differences between oiled and unoiled areas, but not to determine the reasons for those differences. It will be very difficult to demonstrate that fish have not migrated between oiled and unoiled areas and that selected control sites are ecologically similar to oiled sites. It will be difficult to determine whether statistically significant differences are due to EVOS rather than biological factors. (ESC)

Response: Fish/Shellfish study 2 examines eggs and pre-emergent fry which have no ability to migrate. Mark and recapture experiments have determined that Dolly Varden and cutthroat trout have not wandered significantly between oiled and unoiled areas (FS 5). Fish Shellfish study 13 examines clams which have the ability to migrate very insignificant distances relative to oiling. Pairing ecologically similar sites was a high priority in choosing sampling locations. The preponderance of oiling, exposure (MFO and hydrocarbon analyses), and injury (histopathology, growth and survival) data will establish the EVOS as the cause of the injuries, if there are any.

Comment: Recruitment to fish and shellfish populations is also highly variable from year-to-year, resulting in equally variable commercial catch statistics and escapement numbers. Most of the fishery studies do not adequately consider this high degree of variability or the lack of reliable baseline data. Detection of differences exclusively due to oiling will not be statistically possible. (ESC)

Response: Fish/Shellfish Study 4 relies on coded wire tag recovery to estimate fry to adult survival. This data is very good and is extensively used by fisheries managers along the entire Pacific coast of North America. Otherwise it does not appear that this comment is properly addressed to this study. The comment is certainly incorrectly applied to Fish/Shellfish Studies 5 (Dolly Varden/cutthroat trout) and 13 (Clams in PWS) because there are no commercial fisheries for these species in Prince William Sound.

Comment: Studies 2, 3, 4, 5, 11 and 27 do not take into account the natural variables which affect key life cycle events, and it is not clear that the sampling programs for these studies will aid in distinguishing the percentages of biological variability that are due to hydrocarbon contamination and those due to other, natural factors. (ESC)

Response: The Trustees believe that these factors have been taken into account and that EVOS-induced changes will be detectable, particularly given the thorough examination of each study's methods by peer reviewers.

Comment: Studies 1, 2, 3, 4, 5, 11, 27 and 28 employ sampling programs that cover a broad range of very low level hydrocarbon exposures within a given area. Given this variability, it is unlikely that the sampling designs will be able to relate observed biological responses to any particular hydrocarbon concentrations. (ESC)

Response: These studies are not intended to be carefully controlled laboratory experiments. They are not bioassays to estimate a given concentration of oil in water. There are other tests by which we are attempting to do that. The Fish/Shellfish studies were designed to determine the injury done to fish as a result of the EVOS. Fish/Shellfish Study 27, sockeye overescapement, is related to hydrocarbon exposure levels only in that a sufficient quantity was present to force the closure of fisheries thereby resulting in the overescapements.

Fish/Shellfish Study No. 1 - Salmon Spawning

Comment: Since mussels are filter feeders, the Trustees should conduct water column hydrocarbon analyses and correlate these to mussel tissue analytical results to determine the need for and scope of this year's F/S Study No. 1. (API)

Response: Mussel samples provide a qualitative indication that contamination could occur in living organisms in the intertidal zone at the selected sites. The samples also provide a rough quantitative estimate of the degree of contamination. Mussels are indicator species that are particularly appropriate, being filter feeders that continuously process the water column. They are repositories for contamination that would likely go undetected by anything but a continuous sampling program which is impractical. Sampling in 1991 is designed to measure injury, of course, but will also hopefully measure recovery now or in the future.

Comment: Any study of oil spill effects on pink salmon is not justified in light of the record catches of 1990. Despite the juveniles' high risk of exposure to oil in 1989, their strong returns as adults in 1990 show lack of injury for that year class. (ESC)

Response: The record catch was largely a hatchery phenomenon not necessarily parallelled by wild returns. Among other factors, hatcheries' net pens were shielded from the oil by booms or were outside the spill area and their fish were able to spend a month or longer in this protected saltwater environment before they were released. Wild fish did not have those options. PWS pink salmon are not a single population and, therefore, hatchery successes and failures are not the only criteria by which the EVOS effects are determined. Additionally, some damage to wild salmon populations may have been specific to stocks from streams where intertidal spawning sites were oil contaminated. Strong returns of stocks originating from unoiled areas could easily mask damage to stocks from unoiled areas. If total adult returns to the entire Prince William Sound (PWS) are the sole criteria used for damage assessment, no damages could be discerned. Furthermore, the greatest stock specific damages may have occurred in eggs laid in oiled intertidal spawning areas in 1989. Adult pink salmon returns from those eggs will not occur until the summer of 1991.

<u>Comment</u>: The criteria used to select streams for survey are subjective and unrelated to the spill. In addition, application of results to non-surveyed streams will be limited. (ESC)

<u>Response</u>: Survey stream selection is based on very clearly defined criteria. Selected streams represent the spatial and temporal distribution of pink salmon stocks in PWS and include a broad representation of stream types. The greatest sampling effort occurs in western PWS where oil impacts were greatest and oiled and unoiled streams share geographic proximity, run timing, and similar stream characteristics. Included in the treatment and control streams selected are those streams where wild stocks received coded wire tags (F/S Study 3).

<u>Comment</u>: Prior knowledge of the study design and streams could result in observer bias. (ESC)

<u>Response</u>: It is not clear how prior knowledge of the study design might bias aerial observers. These streams do not receive additional survey effort nor do aerial observers have access to the results of foot surveys and weir programs. It may be possible that foot survey observers may be more conscientious on designated study streams than on non-study streams. This could result in reduced observer variance but would not introduce bias into their observations. Foot survey observers are rotated through the study streams in order to negate any bias due to prior knowledge or differences in counting skills.

<u>Comment</u>: Recalculating escapement to 1961 bears no relevance to impact assessment for a 1989 spill. (ESC)

<u>Response</u>: Recalculating historical escapements is critical to reconstructing historical stock specific total returns. Stock specific total return statistics will be used to test for and quantify significant declines in returns of oiled stocks.

<u>Comment</u>: The methods described will provide an estimate of average wetted area under conditions that prevailed when the measurements were taken. The relationship between this variable and "area-available-for-spawning" is not known for the study streams. (ESC)

<u>Response</u>: The measurements described are for average wetted area under conditions at the time measurements were taken. If the measurements are repeated in subsequent years, they will be representative of those stream conditions and the mean of measurements from all years should provide a reasonable measure of wetted area. While wetted area does not directly translate to total available spawning area, it is a good relative index for comparisons of available spawning area between streams.

Comment: Methods of selecting sampling locations using aerial photographs are important for evaluating potential bias. (ESC)

Response: We do not use aerial photographs to select sampling locations. They are merely an aid to mapping streams.

Comment: The study does not discuss the potential for uncontrolled environmental variables and how these factors might affect statistical analyses and interpretation of results. It is not clear how the subjective choice of study streams will affect the application of assessment results to non-study streams. (ESC)

Response: All streams selected for this study must be included in the ADFG Aerial Survey program. Selected streams include all those in F/S Studies 2 and 3 in 1989, 1990 and 1991. The historic foot survey data base includes many, but not all of the selected streams. Among the streams selected there is approximately equal temporal representation of returns of pink salmon stocks. Selected streams also represent the entire range of stream types in PWS. The study includes all oiled streams in the aerial survey program. Oiled streams selected are paired with at least one, and usually more than one control stream that shares geographic proximity, similar stream characteristics, stock run timing and stock run size. Because the study streams are a representative subset of all streams in PWS, results from study streams can readily be applied to non-study streams.

Comment: Selection criteria for estimating fish life in the stream are not identified. To avoid an arbitrary selection, a standard technique for estimating fish life in the stream should be used. (ESC)

Response: Fish life, or stream life, employs three or more methods at each study stream. Results of each method will be compared using data from the weired systems where total escapement and total fish days are known. These comparisons are the basis for the stream life estimating procedures for unweired systems.

Comment: The criteria used for separation of streams based on their exposure to oil, i.e., visual inspection and levels of hydrocarbons in mussel tissue sampled near each stream, have weaknesses. Thus, basic categorization of streams for this study will be affected. (ESC)

Response: The Exxon Valdez Oil Spill was not a controlled laboratory experiment. Prior knowledge of the stocks, the streams and the area and visual observations were the only sources of information upon which stream categorizations could be made. However, the Trustees plan to compile a variety of sets of oiling data which should more clearly delineate the EVOS hydrocarbon exposure various stocks received and the injuries they incurred.

Comment: Log-linear models for contingency table analysis should not be used since the data will represent estimated (rather than absolute) counts, there is a lack of temporal independence between years, and there is a need to test effects based on streams treated alike and not multinominal sampling error. (ESC)

Response: We agree this approach may not provide strong evidence of oil impact by itself. This study is designed to provide stream oiling information, effects of oiling on adults which had incubated in oiled substrates as eggs and pre-emergent fry, and an estimate of adult escapement. These data will be used by the other salmon projects (Fish/Shellfish 2, 3, 4 & 28) to determine injury to the population.

Comment: Methods do not indicate that covariates for stream size and spawning area will be used to adjust for differences not randomized to strata. (ESC)

Response: This study is not intended to show statistically significant impacts due to oiling and therefore it is not important that covariates for stream size and spawning area be used. It is a source of supporting data for studies 2, 3, 4 & 28. The combination of these studies will determine the impacts.

Comment: Effects of oiling, location, and time are confounded. It will be hard to determine whether a certain effect was due to EVOS or natural variation due to time and location. (ESC)

Response: As noted above, oiled streams were paired with at least one other unoiled stream. This should reduce or remove confounding factors.

Comment: It is not clear that the sampling program will yield data showing that the change in escapement is a function of oil contamination rather than other factors. (ESC)

Response: The Trustees have not yet stated that this is the case; however, we believe that our methods will demonstrate this if it is the case.

Fish/Shellfish Study No. 2 - Egg/Fry

Comment: Overwinter mortality is the result of a calculation of the change in mean density estimates from eggs to alevins. Factors other than mortality may cause changes in density among tidal zones. (ESC)

Response: "Overwinter mortality" is not a statistic mentioned in the plan although overwinter survival is. Overwinter survival is the ratio of live fry densities in the spring fry dig to the density of eggs (dead and live) and fry (dead and live) present in the gravel in the fall. Factors other than overwintering mortality could change this ratio. When treatment and control streams are paired into groups by similarities of stream type, stream size, climatological regime, stock size and stock run timing, the effects of factors other than mortality will be minimized.

Comment: The use of MFO levels in eggs and alevins to assess hydrocarbon contamination is clearly research. The use of MFO to demonstrate injury is an unproven technique which shows a great deal of variability among life stages, seasonal factors and food sources, and other factors. (ESC)

Response: MFO's as indicators of hydrocarbon contamination are well documented for many vertebrate species including salmon and trout. It is also well known by pathologists in general and cancer researchers in particular that MFO's commonly alter hydrocarbon contaminants into ultimate carcinogens. Whether MFO's increase a hydrocarbon's acute toxicity, its mutagenicity or its carcinogenicity, its potential as a catalyst for injury is inarguable. Differences in MFO activity by life stage, seasonal factors and food sources are not relevant when samples are taken simultaneously from oiled and unoiled fish or eggs at the same life history stage. Our peer reviewers and experts in biochemistry, toxicology, and pathology have recommended proceeding with MFO analysis.

Comment: Criteria used to select streams are unrelated to the spill. Results will not be applicable to non-surveyed streams. (ESC)

Response: Criteria used to select study sites are not subjective. The distribution of spilled oil is the basis for selection. Oiled streams are from sites representing a range of contamination from heavy to light. Control streams are specifically paired with oiled sites with respect to geographic proximity, climatic regime, stream size, stream type and stock timing.

Comment: Hydrocarbon levels in mussels near the stream bed may not be directly related to exposure of the stream. These data should not be used to determine the amount of hydrocarbon impacting the stream. (ESC)

Response: Results of hydrocarbon testing of mussels will be used to document whether oil contamination of organisms in the intertidal stream mouth may have occurred, although, of course, no direct comparison may be made with that portion of the stream above the intertidal area. However, since 75% of PWS pink salmon spawn in the intertidal area, the use of mussels as indicator organisms is valid. Results from F/S Study 1 samples will be used in a matrix of hydrocarbon sample data collected as part of the Natural Resource Damage Assessment (NRDA) process. Data from other projects will be used to test the implicit assumption that contamination in mussels can be related to instream contamination in other organisms.

Comment: It is not clear that analysis of shoreline mussels can discriminate EVOS hydrocarbons from other natural background hydrocarbons. (ESC)

Response: Please see Technical Services Study Number 1. Where hydrocarbon analyses in this and other studies are unable to precisely identify contaminants as being derived from the EVOS, parallel oiling data bases, observations and analyses will be employed to make this determination.

Comment: Several variables should be used to trace egg injury to fry mortality in order to obtain sufficient data for an accurate assessment of oil effects. (ESC)

Response: Eliminating these variables is largely a measure of site selection and was considered at that time.

Fish/Shellfish Study No. 3 - Wire Tagging

Comment: The Plan states that FS3 is being "transitioned" to a restoration program, yet no injury has been identified. The Plan should specify what is being restored, and how the study will facilitate restoration. (ESC)

Response: Most of the NRDA studies, including this one, have restoration value in that continuing damage assessment also provides a measure of the recovery of the environment. Documenting recovery or continuing damage is important in that it allows us to actively intervene where necessary to restore the environment and to focus our limited resources. The means by which the portion of this study transitioning into the restoration program accomplishes this is described in that new study available through the Federal Register.

Comment: Field methods are not sufficiently detailed to evaluate the validity of success for this study. (ESC)

Response: The success of this study is intimately associated with that of FS 1, FS 2, FS 4, and FS 28. Review of all of these studies should provide sufficient detail to evaluate the likelihood of success.

Comment: It is not clear how estimates of the survival and harvest rate of wild and hatchery salmon will be used to evaluate effects of the spill. (ESC)

Response: Two tests for oiled effects are possible. Pre-spill survival rates (control) for hatchery stocks are well known. They can be compared to post-spill survival rates (treatment) for each facility. Because juveniles from each facility were subject to different levels of contamination due to geographical differences, survival rates for each facility also can be compared for differences within years. The same is true for wild juveniles. Identification of oiled effects could occur at the juvenile stage (F/S 4) or at the adult stage (F/S 3).

<u>Comment</u>: There is not enough data for historical comparison and no measurement of exposure to oil. Thus, any differences in survival rates related to the oil spill may not be detectable. (ESC)

<u>Response</u>: Pre-spill survival estimates are available for one stock in each category. Even if subtle damage effects may not be discernable, significant effects will be. It is not valid to assume that damage effects will necessarily be minor and undetectable. It is only necessary to determine that the observed injuries, if any, are due to the EVOS rather than to use the injuries as a means of estimating the quantity of oil to which fish were exposed.

<u>Comment</u>: The Plan does not even describe criteria the analysts will use to classify areas as oiled or unoiled. (ESC)

<u>Response</u>: The classification of systems as oiled and unoiled uses visual observations of oil which will be supported by water sample and sediment analyses, mussel tissue analyses and MFO analyses of fish tissues. The categorization of oiled and unoiled is important to the project but a detailed description of the categorization procedures is unnecessary for this operational plan.

<u>Comment</u>: The level of replication (pink salmon: 2 oiled and 3 controls; sockeye: 2 oiled and 1 control) can only be used for determining the more obvious effects. (ESC)

<u>Response</u>: In total, stocks of pink salmon from three oiled and three control streams were tagged. Survival estimates will be made at four life history stages for each of these stocks. Stocks were selected to minimize non-spill effects and tagging levels. Tag recovery rates will be adequate for very accurate estimates of stock-specific catch contribution rates. The catch contribution estimates will be combined with weir enumerations of escapement for total return estimates of sufficient precision to estimate significant oiling effects.

<u>Comment</u>: For species other than pink salmon, the tag rate is different among groups. The approach is apparently inconsistent. (ESC)

<u>Response</u>: Tag rates are held constant for each release group within a facility. This minimizes the effects of differential tag loss and tagging mortality when adjusting tag rates in hatchery

brood stock returns. Tag rate adjustments are hatchery-specific. Therefore, it is not necessary to maintain constant tagging rates between facilities.

<u>Comment</u>: Analysis of CWT data uses a modification of Clark and Bernard (1987) that estimates sampling error. There is no discussion on how this step leads to a test of impact that incorporates spatial/temporal variance. (ESC)

<u>Response</u>: Stratification by tag lot, time and processor allows for more precise estimates of fishery contributions for each tagged wild stock stream and hatchery facility. These contribution estimates will provide survival estimates for the tagged groups as well as an estimate of wild stock contribution to the catch. This information, in conjunction with information from studies 1, 2, & 4, will be used by F/S 28.

<u>Comment</u>: Interpretation of the variance formula is incorrect. The formula ignores the covariance between catches of strata within a single release, not "covariance between release groups." The formula should be an <u>estimate</u> of the variance and not the variance as denoted. (ESC)

<u>Response</u>: The sentence preceding the variance algorithm indicates the variance estimate is an approximation.

<u>Comment</u>: Sampling error is likely to vary among locations, fisheries, stocks, and times. It is not likely that any observed differences in survival among stocks could be attributed to the spill effect. (ESC)

<u>Response</u>: All catch contribution estimates are stratified by time and area. Each temporally and spatially stratified contribution estimate has an associated variance. Heterogeneous spatial and temporal entry patterns for tagged stocks may result in different variances for the catch contribution estimates for different tag groups. However, the results for each group will be comparable. Based on previous analyses, variances associated with catch contribution estimates based on coded-wire tag results are not so large as to preclude discerning survival differences between oiled and unoiled stocks.

Fish/Shellfish Study No. 4 - Early Marine Salmon

<u>Comment</u>: It is not possible, without the data collected in prior years, to evaluate the need to continue F/S Study No. 4. Further, there is no explanation given for analyzing stomach contents or for failing to conduct comparisons of hydrocarbon analyses of prey items in oiled and unoiled areas. (API)

Response: This study needs to be continued in order to compare current data to that from previous years. The stomach analysis will provide information on food abundance in oiled and unoiled areas. Hydrocarbon analysis of food items did not appear to be as useful to this portion of FS 4 as MFO analysis of the fish themselves. MFO analysis provides an ultimate measure of exposure and bioavailability.

Comment: The study will compare growth and migration of salmon fry between oiled and unoiled areas. The relationship between areas of capture and areas where the apparent growth occurred is unknown. (ESC)

Response: The relationship between the area of capture and the area where growth occurred will be strengthened by examining otolith growth for the period immediately before capture of the fry.

Comment: The use of MFO to demonstrate injury is a yet unproven method. It shows much variability among life stages, seasonal factors, and food sources. Thus, it may not yield reliable results. (ESC)

Response: MFOs as indicators of hydrocarbon contamination are well documented for many vertebrate species including salmon and trout. It is also well known by pathologists in general and cancer researchers in particular that MFO's commonly alter hydrocarbon contaminants into ultimate carcinogens. Whether MFO's increase a hydrocarbon's acute toxicity, its mutagenicity or its carcinogenicity, its potential as a catalyst for injury is inarguable. Differences in MFO activity by life stage, seasonal factors and food sources are not relevant when samples are taken simultaneously from oiled and unoiled fish at the same life history stage. Our peer reviewers and experts in biochemistry, toxicology, and pathology have recommended proceeding with MFO analysis.

Comment: The study does not discuss potential effects of hatchery operations and procedures on the study analyses and interpretation of results. (ESC)

Response: Each tag lot belongs to a specific treatment group at a hatchery. The effects of different hatchery practices on growth will be considered by including "tag code" as a variable in the statistical analyses.

Comment: The use of an untested model developed for a shallow, arctic lagoon does not cure the statistical problems in the sampling design and is not likely to help injury assessment or restoration in Prince William Sound. (ESC)

Response: Unless the problems to which you are referring are noted, they cannot be addressed. However, spatial differences in fry growth may be due to spatial differences in environmental conditions. The relative effects of water temperature, prey density, and prey composition on fry growth can only be examined with a bioenergetics model that accounts for the complex interactions among these variables.

Comment: There is insufficient description of the criteria for classifying areas as oiled or unoiled. The distribution of sampling effort in time and space must be known to determine whether the study design can achieve its goals. (ESC)

Response: Six broad geographic sampling areas are described in the study plans for F/S Study #4 in oil years 1 and 2. The same areas will be sampled again in 1991. Results from Alaska Department of Environmental Conservation (ADEC) beach and aerial surveys were used to classify these areas as oiled and unoiled.

Comment: Reliance on a bioenergetics model to estimate growth will have a subjective influence on the relation of spill impacts to fish growth. It is not clear how model validation and sensitivity analyses will be used to interpret results. (ESC)

Response: Bioenergetics model validation and sensitivity analyses will be used to estimate model precision and the relative effects of model inputs. These analyses are unrelated to statistical tests of growth differences in oiled and unoiled areas. The bioenergetics model will be used to examine whether the observed growth differences may have resulted from different environmental conditions in oiled and unoiled areas.

Comment: Chi-square tests are restricted to analysis of count data, not the proportions or continuous random variables. (ESC)

Response: Prey composition in the diet in 1989 will be examined using Chi square tests on counts of prey items in the stomachs of fry taken from oiled and unoiled areas. The analysis will test for differences ($p=.05$) in the amount of prey taken in each of four prey categories between oiled and unoiled areas.

Comment: There is no indication how differences caused by geographic effects will be separated from oiled vs. unoiled effects, where the primary definition of "oiled" and "unoiled" is based on geography. (ESC)

Response: Fry have been sampled at many sites in both oiled and non-oiled areas to minimize any bias resulting from local effects. However, it is recognized that geographic effects confound oil effects. The bioenergetics model, multiple regression techniques, and analyses of stomach fullness will be used to evaluate growth conditions in oiled and non-oiled areas. All available data on environmental conditions in oiled and non-oiled areas will be used in these analyses. Data bases which document exposure (e.g. MFO, mussel and sediment analyses) will be used. The Trustees believe that differences between geographic and oiling effects will be distinguishable.

Fish/Shellfish Study No. 5 - Dolly Varden Char and Cutthroat Trout

Comment: Survival and growth rates of Dolly Varden char and cutthroat trout could be caused by other factors than the oil spill. No analysis is included to test for cause and effect due to oiling versus natural variability or geographical differences. (ESC)

Response: It is important to point out that fish were sampled before any potential exposure to an oiled marine environment since the Dolly Varden and cutthroat trout were overwintering in freshwater when the oil spill occurred. Given this, the first sample from each stream (the emigration during 1989) provides the baseline data for stocks in control and oiled groups. These data indicate mean-length-at-age was similar among control and oiled groups which indicate that fish of the same size grow at the same rate regardless of their overwintering location. Since overwintering populations of Dolly Varden and cutthroat trout are composed of many genetic stocks and the ambient climates in the experimental areas of PWS are similar, differences in average growth rates were not expected. Therefore, large differences in average growth rates between control and oiled groups would be attributed to some external disturbance so long as initial size of fish is corrected for. That this external disturbance is, in fact, the Exxon Valdez Oil Spill, will be documented in the same manner as other studies using a compilation of various oiling data bases, tissue and sediment analyses.

We do not have a direct measurement of pre-spill survival rates among the treatment groups but since the mean-length-at-age were similar between control and oiled groups this would indicate that survival rates were probably similar. If one of the treatment groups had higher survival rates, a greater difference in the mean-length-at-age would be expected and in particular in the older age classes (age 4 and older). This was not the case.

The experimental design, which includes replicate sites in both treatment groups, does take into consideration both natural variability and geographical differences. The study tests for differences in growth and survival between treatment groups only with tagged fish. The analysis tests to see if the differences in growth and survival are greater between control and oiled groups than differences with each treatment group.

Comment: It is unlikely that "all migrating fish can be examined for marks," in which case, the simple estimate of population size ($S=M_2/R_1$) will not be appropriate. (ESC)

Response: The Trustees believe every fish can be examined.

Comment: The three-sample Jolly-Seber model will provide an estimate of survival for only the period 1989-1990, assuming the three capture samples in 1989, 1990, and 1991. Thus, with only post-spill sampling, comparisons of survival before and after the spill will not be possible. (ESC)

Response: The study design uses replicates as described in a response above. Since we were able to census all of the fish at each site in the spring of 1991, we did not have to use the Jolly-Seber Model.

Comment: Comparison of 95% confidence intervals is an invalid means of testing differences between oiled and unoiled conditions since such a comparison should be based on the variance among streams treated alike. (ESC)

Response: Comparisons of 95% confidence intervals are valid since the streams are treated alike.

Comment: There are likely to be differences in survival and growth because of natural differences between the studied populations. Data should be gathered to analyze for spill-related effects. (ESC)

Response: The first answer under comments for this study apply here. However, please note that three oiled and two control sites were used in this study. The reason for the replication was to account for natural variability or geographic differences.

Fish/Shellfish Study No. 11 - Herring

Comment: The necessity for conducting F/S Study No. 11 (Injury to Herring) is questionable given the record number of herring netted over the last two years and the extensive work already done on this species in the prior years of damage assessment. (API)

Response: Impacts to herring recruitment from the 1989 oil spill would not be observable before 1992 at the earliest, when the majority of the 1989 year class begins returning as 3-year olds in the spawning biomass. Even then, not all of that year class will return as 3-year-olds; some will not return until 1993 or even later. Sublethal effects to adults exposed to the EVOS could also affect recruitment, although this again would not necessarily be reflected in catch records until 1992. Since herring are multi-year spawners, a missing age class would result in significant negative survival value to the spawning biomass perhaps for as long as seven years; not to mention damage to the food chain. Please see the answer to the following question for further elaboration on possible injury to recruitment.

Comment: The herring studies are not warranted in light of the apparent good health of the resource. The studies from prior years do not show any significant concerns. (ESC)

Response: Most of the herring harvested in the 1990 and 1991 fisheries were 1984, 1985 and 1986 year classes and, very likely, well out to sea at the time of the oil spill. Studies have shown herring to be most susceptible to the effects of hydrocarbons and other toxins in their early life history stages (i.e., egg and larval stages). Obviously, the Exxon Valdez oil spill would have had the greatest impact on the eggs laid down and the larvae that hatched in 1989, the year of the spill. Herring do not start to recruit to the fisheries until age 3, and there is evidence that they may not fully recruit to the fishery until age 4 or even 5. The effects at the population level will not begin showing up before 1992. Consequently, should the success of the fishery decide the health of the stocks, we would be unable to evaluate that success until at least then.

Comment: The ability to measure the biomass to within +/-25% in future years will not provide the resolution necessary to measure possible EVOS injury. (ESC)

Response: The biomass estimate may be utilized to examine the effects of EVOS on a population level, and if this were the only tool available to determine impacts, the above statement would be true; natural variability may mask some subtle impacts. However, this is not the only tool being employed to measure impact and, as stated in previously released results, sublethal impacts have been observed in early life stages of herring.

Comment: The study description does not provide sufficient detail to determine whether an accurate representation of AWLS (Age, Weight, Length, and Size) will be achieved. (ESC)

Response: AWLS sampling is more than adequate to provide a true representation of the AWLS for the population. The sampling program conducts a test fishery that evaluates both the major sightings of herring in Prince William Sound and herring caught in the fisheries. This sampling design gives a true representation of the herring in the population and those caught in the fisheries.

Comment: Hydrocarbon burden does not necessarily produce tissue injury. Any tissue damage may have resulted from other chemical or natural exposures during the course of annual migrations of these animals. (ESC)

Response: We agree that hydrocarbon burden does not necessarily produce tissue injury. However, demonstration of MFO activity suggests that these hydrocarbons may be converted into metabolites of acute toxicity to the fish and form ultimate carcinogens. Subsequent histopathology would tend to link hydrocarbon burden and MFO activity to observed injury, but a compilation of many sets of oiling data bases and laboratory analyses will provide the links which need to be established, if there are links.

Comment: There are no studies which demonstrate population level impacts from sublethal effects at exposures of this magnitude. MFO and cytogenetics analyses are experimental and results vary with diet, season, spawning activity, etc. Experimental measurements are not an acceptable measure of injury under NRDA regulations. (ESC)

Response: Cytogenetic abnormalities and MFO activity certainly have been linked with injuries to fish and other vertebrates including humans. Cytogenetic analysis results do not vary with diet, season, or spawning activity as claimed by Exxon, though MFO results do. Differences in MFO activity by life stage, seasonal factors and food sources are not as relevant when samples are taken simultaneously from oiled and unoiled fish or eggs at the same life history stage. It is also well known by pathologists in general and cancer researchers in particular that MFO's commonly alter hydrocarbon contaminants into ultimate carcinogens. Whether MFO's increase a hydrocarbon's acute toxicity, its mutagenicity or its carcinogenicity, its potential as a catalyst for injury is inarguable. Our peer reviewers and experts in biochemistry, toxicology, and pathology have recommended proceeding with MFO and cytogenetic analysis. Sublethal effects such as these by their definition make an individual animal less fit and less likely to survive. Whether effects upon individuals will have an impact upon the population remains to be empirically determined when the 1989 year class enters the exploitable portion of this population in 1992.

Comment: Estimating egg loss due to wave action or predation is not related to EVOS damage assessment. (ESC)

Response: The estimate of egg loss will make the biomass estimates more reliable. Measuring egg loss is just one way to improve the precision of the biomass estimate. Biomass will be estimated from spawn deposition surveys. From the time the eggs are deposited on the shoreline and a survey conducted by divers, some eggs will be lost to wave action and/or predation. The egg loss study measures this loss from the time of egg deposition until completion of the survey.

Comment: The diver surveys for spawn estimation are based on an inadequate sample design. Kelp should be taken to a laboratory for adequate estimation of egg cover. The samples selected for diver calibration must be representative of the available plant type and egg cover to be acceptable in correcting the diver estimates. (ESC)

Response: Randomly selected samples of kelp have been taken to the laboratory for diver "calibration" and are representative of the available vegetative cover and egg cover. This process, used to estimate biomass, has proven to be more than adequate in assessing egg production and subsequently herring biomass. The process used in Prince William Sound is similar to that used by biologists in British Columbia and Southeast Alaska for years.

Comment: Measuring distance from MLLW perpendicular to the shoreline is necessary to calculate the size of the spawning beds. (ESC)

Response: The distance from MLLW perpendicular to the shoreline is measured during the spawn deposition survey and is used to calculate the size of the spawning beds. The measurements are accurate and the tide level is taken into account when the measurements made.

Comment: The 12-16 dives to assess survival are proposed to be included as a factor in the ANOVA indicated by model Eq. 15. In actuality, these constitute repeated measures on only a few replicate locations. The repeated measurements on successive dives are not independent and violate the assumption of independence in ANOVA. (ESC)

Response: The measurements are not repeated measures but a measure of egg survival over time. The measurements are independent and time is included as a covariate in the subsequent ANCOVA. In this analysis, the assumption of independence is not violated.

Comment: Egg loss will be measured in the field. Herring depend on density for survival and there are no means of identifying the degree to which this affects year-class production. (ESC)

Response: The statement concerning herring exhibiting density dependent survival and there being no apparent relationship between herring spawning biomass and subsequent recruitment are contradictory. It has to be one or the other. If herring exhibit density dependent survival then there should be a relationship between herring biomass and subsequent recruitment. Studies on other fish species show such a relationship when considering certain factors, i.e., water temperature, salinity, size of other fish species. We have observed no such relationship for herring in our study.

Comment: The egg survival studies are being conducted at three locations which limits the investigation. Thus, the scope of the study to resolve effects throughout the impacted region will be limited. (ESC)

Response: There are only five significant spawning areas in Prince William Sound, one of them a small one. We conducted the egg survival study in the four major areas.

Comment: The biomass which will be estimated in 1991 will not include the fish which are the product of 1989 egg production. There were no significant 1989 adult mortalities. Thus, this study seems more geared to herring resource management than EVOS impact. (ESC)

Response: The 1991 biomass estimate is a continuance of baseline information that will be employed in a model that will predict affects. The increase in accuracy over the last three years will go toward improving that model. Impact studies on eggs and larvae were continued in 1991 for the following reasons:

1. When the effects from oil have disappeared, we would expect to see a return to baseline levels of abnormalities and natural variation due only to environmental factors outside the spill effects.

2. If adults continue to metabolize oil, potentially affecting egg production and reproduction, we would expect to measure the impact with samples collected and tests conducted in 1991 and possibly 1992.

Comment: There is no description for the oil exposure study (e.g. Is fresh or weathered oil used?) and it may not be representative of field conditions. (ESC)

Response: The exposure study will provide data on effects of oil on larval abnormalities, MFO levels, cytogenetics, and histopathology in relation to known levels of oiling. If effects are similar to our findings in the field, damage can be inferred. In addition, larvae will be sampled that have been reared at field sites but without being exposed to oil to test for and separate site effects from oiling effects. Two oiling mechanisms are being employed; one is a flow through system with particular levels of WST maintained in the water supply (standard dose-response with petroleum); the second is a "dip" or one time exposure method in whole fraction, which imitates what may have happened in nature; both methods will include a variety of dosages, all sublethal. Therefore, we believe this will be comparable to field conditions.

Comment: The test of the effects on fecundity based on comparison among five areas of sampling bears no relationship on EVOS exposure. This test selects individuals of a specific length range near the mean size. This sampling will produce a fecundity-weight relationship that will not be representative. (ESC)

Response: The literature suggests that herring egg atresia (therefore affecting fecundity) occurs following exposure to petroleum. Our range of sampling sizes around the mean represents 80% of the returning stock which, we believe, is sufficiently representative.

Fish/Shellfish Study No. 13 - Clam Injury

Comment: While the stated objectives do consider the available scientific literature on effects of oil on intertidal clam populations, the study design greatly underestimates the natural variability in all the biological and chemical parameters that will be measured. (ESC)

Response: Incremental growth data (both pre- and post-spill) will be available for comparison of the growth rate by site and this should clearly delineate oil spill effects if there are any.

Comment: Sediment samples for hydrocarbon analysis and clam samples for growth from all three positions at a given tide level are composited into single samples, obscuring any gradients of chemical and biological response at different levels on the shore. (ESC)

Response: Due to the need to take samples in triplicate it was deemed cost-prohibitive to take triplicate sediment samples at each tide level sampled; nevertheless, we believe this will not hamper our efforts to document damage if it has occurred.

Comment: It will be difficult to distinguish differences due to natural causes from those due to the presence of oil in the sediments or the clam tissues. (ESC)

Response: The compilation and comparison of oiling data bases, sediment and tissue analyses should allow this distinction to be made in this case as in other studies.

Comment: The sample size for estimating clam growth is reduced from 150 to 3 study sites because of pseudoreplication. (ESC)

Response: The sample size for estimating clam growth is unchanged from last year for this study. The reviewer is confusing this study with Coastal Habitat Study 1. The two studies are and have been independently investigated.

Comment: The growth measurements are not adjusted for clam territories. The study does not describe how the most appropriate growth model will be chosen. (ESC)

Response: We assume that "territories" refer to clam densities or plots, both of which will be considered in our analyses. Schnute's

Generalized Growth Model, which incorporates the classic growth models such as von Bertlanffy and Gompertz, will be used to select the most appropriate model.

Comment: The parameters being measured are quite variable over small temporal and spatial scales. As a result, it will be hard to assess the baseline condition. (ESC)

Response: Characterization of the baseline growth rate in clams is accomplished by measuring annuli which are retained.

Comment: Relationships between observed histopathology and oil-related effects on survival potential of natural mollusk populations have not been accurately established. Thus, the significance of any observed effects is questionable. (ESC)

Response: Various toxic components of petroleum have produced histopathologically documented lesions in mollusks and whole petroleum has been shown to kill populations of natural and cultured mollusks. Demonstrating that oil-induced histopathology has a negative survival impact on populations of mollusks should not be difficult though quantification may be. As well as mortalities; however, changes in growth rates could also be considered injuries. Histopathology results will be compared with data on the level of tissue and sediment hydrocarbons, growth rates prior to the spill and growth rates after the spill as well as a variety of other oiling data bases.

Fish/Shellfish Study No. 28 - Run Reconstruction

Comment: F/S Study No. 28 is unwarranted in light of the record salmon catches and the failure of the Trustees to demonstrate an injury to this resource that would require fishery restoration strategies. (API)

Response: The Trustees disagree. This study integrates data from F/S Studies 1 to 10, which includes, in addition to pink salmon, all of the other species of salmon. Adults of these other species will not return for some years yet so we really cannot claim record returns. Record pink salmon returns are largely a hatchery phenomenon, though even hatchery returns may have been greater in the absence of a spill. Wild pink salmon did not have the protective devices which somewhat shielded hatchery fish from the EVOS. The Trustees are concerned with stock specific injuries which cannot be directly inferred from the magnitude of returns of mixed stocks to a large area.

Comment: Historical data will be analyzed to develop estimates of model parameters. Other historical studies (FS1-FS10) focus on the correction of historical values based upon the results of recent data collections. These data are being collected at a time when the wild stocks are in recovery from over fishing and in transition, therefore, they are not representative. (ESC)

Response: Corrections are based on understanding the relationships between historical assessments and the more complete and comprehensive assessments done under the Natural Resource Damage Assessment (NRDA) studies. Key measurements of stream life are consistent with historical values and valid to apply to historical data.

Comment: The wild fish which made up 100% of the annual catch ten years ago have been reduced to less than 15% of the annual catch in recent years. Under these circumstances, it is difficult to determine the status quo. (ESC)

Response: Current wild pink salmon runs and escapements are in the range of historical levels. NRDA studies focused on separating hatchery and wild stocks and therefore can assess the changes in wild stock runs due to EVOS damages.

Comment: The anticipated performance on the life history modeling and run construction approaches are not discussed. An evaluation of the anticipated power of the methods to assess effects needs to be discussed in light of Peterman and Bradford (1987) and Peterman (1989) who indicate extremely low statistical power using stock assessment techniques. (ESC)

Response: We are aware of the possibility of low statistical power using these methods. Presently, we are awaiting additional data which will enable us to assess the power of these and other methods as well.

Comment: The study description does not include a plan for a model verification or sensitivity analysis in interpreting the presence or absence of effects. Errors in parameter estimates and model simplifications need to be measured and contrasted with estimation of any perceived effects. (ESC)

Response: On the contrary, these models can be effective in environmental assessment and decision making. The models require an enormous data base source and a comprehensive understanding of the dynamics of the phenomenon to be modeled. This modeling effort will use publications of this past decade for its mathematical foundation. It also will use the thirty years of catch, fishing effort, escapement, and tag recovery data that is available.

Fish/Shellfish Study No. 30 - Salmon Database Management

Comment: The expenditure of funds for F/S Study No. 30 should be limited to better organizing those data from projects directly related to the determination of potential injuries to resources in

Prince William Sound. The State of Alaska is contributing funds to this study to cover other uses of the data. (API)

Response: The organization of data from projects directly related to the determination of potential injuries to resources in PWS is exactly what this study does. The objective is to develop a biological database necessary for the analysis of data collected in the field studies. It is scheduled to terminate within one year after completion of field data collection and completion of laboratory analysis.

Comments on Coastal Habitat Studies

Coastal Habitat Intertidal Study 1A

Comment: The coastal habitat program is grossly disproportionate to restoration costs. Studies of shoreline recovery and restoration indicate that there are no practical approaches to restoration that will enable these habitats to recover more quickly than they will naturally. Thus, further intensive study is not justified. (ESC)

Response: This study has been reviewed extensively by appropriate experts for design and cost-effectiveness and, where appropriate, has been revised accordingly. Further, it has been coordinated with other studies to ensure integration of collection methods and study results. Our data do not support the conclusion that there are no practical approaches to restoring intertidal habitats, and do indicate a need to continue the study. Thus, the budget reflects the most cost-effective means to determine the extent of injury to coastal habitats resulting from the EVOS and is not disproportionate to the costs of restoration.

Comment: The coastal habitat studies and the restoration feasibility study concerning theses resources appear to be independent of one another with neither providing the justification necessary for actual restoration. Nor do they provide the method of identifying and selecting restoration options. (ESC)

Response: The coastal habitat damage assessment and restoration studies are being conducted by the same principal investigator and thus are fully coordinated. The comprehensive study provides the data needed to identify and test restoration options.

Comment: The coastal habitat studies do not describe how EVOS hydrocarbons will be distinguished from other natural and/or anthropogenic hydrocarbon sources. (ESC)

Response: Hydrocarbon samples collected by the Coastal Habitat project will be analyzed in Technical Services study #1. The analysis will measure concentrations of petroleum hydrocarbons specific to the EVOS.

Comment: The list of methods does not include the number to tide levels sampled at each site, the methods for sampling and analysis of biota and sediments, or the tests of biological conditions and community function. Thus, it is not possible to assess whether all the types of biological and chemical analyses were performed on samples from all sites. (ESC)

Response: The objective of the 1991 Plan was to provide summary information on individual studies, adequate for reviewers to understand the scope of the study. The Trustees believe there is sufficient information provided in the Plan for this type of review. The specific methods utilized during the study may produce results used in litigation and therefore constitute confidential information.

Comment: It is not clear whether the studies of hydrocarbon concentrations mentioned in both CH1 and CH2 are duplicative of one another or whether they will be used to address different components of injury determination. (ESC)

Response: A chemical analysis group was established to direct and monitor sample collection, coordination, and priorities. Sampling sites for all studies including CH1 and CH2 have been mapped for reference and coordination by field investigators to prevent duplication.

Comment: NOAA's remarks about the resiliency of the flora and fauna of intertidal communities belie the need to continue the Coastal Habitat study. NOAA's Net Environmental Benefit Analysis recognized that shoreline conditions do not pose any significant threat to wildlife, but studies continue in spite of this fact. (ESC)

Response: We have reviewed the findings of the Net Environmental Benefit Analysis and have incorporated any applicable findings into the study design. Our data to date do not support the conclusion that intertidal communities are free from contamination or that shoreline conditions pose no threat to wildlife.

Comment: The methods for random site selection are not adequately described. The criteria for selecting control sites may not have been rigorous enough to ensure that they will be comparable to oiled sites. (ESC)

Response: The site selection process is detailed in the August 1989 and 1990 State/Federal Natural Resource Damage Assessment and Restoration Plans. As explained in the 1990 plan, the additional 1990 control and experimental sampling sites were deductively selected to provide additional spatial and habitat distribution, thus providing a paired comparison that maintains the statistical validity of the design. Statisticians have been consulted during the development of the 1989, 1990 and 1991 study plans to ensure that appropriate statistical designs are met.

Comment: The Plan indicates that the Trustees did not place individual sites in oiling categories properly because they did not know oiling levels. (ESC)

Response: As stated on pages 11-12 of the 1990 plan, the potential study sites were visited by coastal habitat personnel verifying the sites physical, biological and oil classifications to ensure matched pairs with respect to oiled and control sites. Cumulative oiling data collected as part of the response actions were used to provide oiling data.

Comment: Shoreline treatment procedures were not considered in site selection, so "responses to varying degrees of oiling and subsequent clean-up procedures" really cannot be measured. (ESC)

Response: Shoreline treatment procedures have been incorporated to the extent possible into the restoration portion of the Coastal Habitat study. In addition, experimental techniques have been employed to further measure rates of recovery.

Comment: The Plan does not detail the total number of sites sampled, their distribution between control and oiled sites, their geographic location, or their shoreline type., Nor does it indicate whether individual sites were sampled more than once in 1990 or whether they were sampled in both 1989 and 1990. (ESC)

Response: Page 10 of the 1990 plan identifies that there were 102 sites to be studied in 1990. This number has been reduced to 57 sites for 1991. These sites are located throughout the spill area, with 26 sites in PWS, 18 in CIK and 13 in KAP. The sites are equally distributed between control and oiled sites and represent the five previously identified habitat types. As in 1990, all sites will be sampled twice.

Comment: There is no justification offered in Coastal Habitat Intertidal Study 1A for reducing the number of sampling stations from 97 in 1989-90 to 57 in 1991. Given the reduced field season in 1991, it is difficult to understand how this reduced sampling will permit the Trustees to detect injuries and extrapolate from them. (NWF)

Response: Coastal habitat data collection was scheduled to be conducted over a three-year period that began in 1989. Several samplings per year were collected to assess potential injuries and recolonization rates for intertidal flora and fauna. Sampling was reduced to allow for the timely processing of 1990 and 1991 samples, while still providing the necessary data to complete injury extrapolation.

Comment: It still is not possible to determine whether a statistically valid site selection strategy was developed to achieve Objective 1. (ESC)

Response: As with the 1989 and 1990 plans, the objective of the 1991 Plan was to provide summary information on individual studies, adequate for reviewers to understand the scope of the study. Biometricians have been consulted during the development of the study to ensure that appropriate statistical designs are followed that will allow for the accomplishment of Objective 1.

Comment: There are no criteria given to enable the reader to understand how individual sites were "ground-truthed" so as to meet Objective 2. Nor are the criteria given for selection of sites for each of the three years of study. (ESC)

Response: Study sites were selected and ground-truthed during Phase I of the Coastal Habitat study, which is described on pages 11-12 of the 1990 Plan. The potential study sites were visited by coastal habitat personnel examining the sites' physical and biological attributes to verify their appropriateness as a matched pair to respective oiled and control sites. Phase I of the study concluded in 1990.

Comment: The methods for injury determination that will be used for Objectives A and B are not provided. (ESC)

Response: The specific methods used in the coastal habitat study may produce results used in litigation and therefore constitute confidential information unavailable during the study process. A less detailed version is provided in the Plan to allow reviewers to understand the scope of the study and inter-relationships with other studies.

Comment: None of the Trustees' Plans to date have considered shoreline treatment in site selection for the stratified random study. (ESC)

Response: The random study design is based upon oiling category and habitat type and not upon such factors as, for example, shoreline treatment or berm relocations. However, such factors may be integrated as part of the coastal habitat restoration work.

Comment: It will not be possible to extrapolate biological and chemical responses observed at two levels of oiling to all oiled areas of PWS in order to achieve Objective C. By eliminating very lightly and lightly oiled sites from the study in 1990 and 1991, the Trustees have skewed the study toward the worst-case scenario. Any differences in biological or chemical parameters found among sites should apply only to moderately and heavily oiled sites. (ESC)

Response: Detailed hydrocarbon analysis is being performed on samples from each location and will provide a range of precise levels of contamination. This range of data will provide the means for extrapolating injury to a wide range of hydrocarbon levels, thus meeting study objectives.

Comment: It is not clear how the Trustees plan to meet Objective F since there is no discussion of linkages to other studies. (ESC)

Response: Inherent in the injury determination is a synthesis process that will integrate injuries from many studies in an ecosystem approach. Such factors as critical nesting habitat, food availability and contamination, and others will be considered.

Comment: It will not be possible to extrapolate impacts to the entire spill area because all control sites may not have been randomly selected. (ESC)

Response: As explained on page 11 of the 1990 Plan, the additional 1990 sampling sites were deductively selected to provide additional spatial and habitat distribution. This process provides for a paired comparison that maintains the statistical validity of the design. Statisticians were consulted during the development of the study plans to ensure that appropriate statistical designs were achieved.

Comment: It is not clear from Objective E how natural seasonal changes will be factored into estimating impact/recovery or what parameters will be used to predict recovery rates and their potential for restoration. (ESC)

Response: Coastal habitat data collection is a three year study that began in 1989. Several samplings per year are being collected to determine potential injuries and recolonization (recovery) rates of intertidal flora and fauna. In 1990, restoration feasibility studies were initiated designed to compare the rates of faunal recovery in rocky intertidal communities, and to demonstrate the feasibility of restoring these communities by enhancing recolonization rates of key species. Parameters examined include the presence or absence of common intertidal species on impacted and reference sites, population dynamics of several species of invertebrates, larval settlement on oiled versus non-oiled surfaces, and differences in algal grazing by limpets between oiled and non-oiled sites.

Comment: Insufficient information is provided to determine whether analytical methods of this study are based on standard and widely accepted techniques. The study description does not address QA/QC of biological samples, field methods or taxonomy. (ESC).

Response: The design of the study has been reviewed extensively by appropriate experts to ensure that it is based on standard and widely accepted techniques. A detailed study plan of data analysis, collection techniques, and QA/QC standards is not necessary for reviewers to understand the general scope of the study, and its inter-relationship with other damage assessment studies.

Comment: The study description does not indicate how the Trustees plan to address varying oiling levels, treatment/cleanup effects and physical environmental factors that affect the results. (ESC)

Response: The objective of the 1991 plan was to provide summary information on individual studies adequate for reviewers to understand the scope of the study, inter-relationships among studies, and the scope of the overall damage assessment program. A description of factors that may affect results used in litigation constitute confidential information unavailable during the study process.

Comment: The Plan does not address the extrapolation from specific stratified random sample sites to the universe of sites in each category or the statistical methods used to determine injury. (ESC)

Response: As noted above, the objective of the 1991 plan was to provide summary information on individual studies adequate for reviewers to understand the scope of the study, inter-relationships among studies, and the scope of the overall damage assessment program. A description of factors that may affect results used in litigation constitute confidential information unavailable during the study process.

Coastal Habitat Intertidal Study 1B

Comment: Reduction of sampling in Study 1B is unwarranted given the extensive baseline data available and the opportunity for obtaining valuable data that this presents. It is not clear whether this study is related to Fish/Shellfish # 13 and, if so, how. (NWF)

Response: The peer reviewers concurred that this study could meet its stated objectives at a reduced level. Subsequent information justified a second sampling effort under Restoration Science projects to monitor natural recovery at these sites. Fish/Shellfish #13 - "Effects of Hydrocarbons on Bivalves" - is studying clams at selected sites in the lower intertidal. Data from mussels and sediments may be useful to interpretation of their results, but the sampling sites and habitats are different.

Comment: According to Appendix D, "'Sites were selected before any oil reached them and prior to shoreline treatment'". Thus, it will not be possible to establish the response of biological and chemical parameters to varying degrees of oiling and subsequent clean-up procedures. (ESC)

Response: The response of biological and chemical parameters will be measured over a multi-year time series that will be influenced by degree of initial oiling, subsequent re-oiling, clean-up activities, natural weathering processes, and biological depuration. It is the sum of these responses that will determined and of most interest to identifying long-term contamination and injury.

Comment: The laboratory methods for analyzing tissue and sediment are missing. (ESC)

Response: Laboratory methods follow accepted standard practices and were approved in the QA/QC procedures. It was felt that detailed methodology was not necessary to present here, as it is the same methodology that is applied to all studies that take sediment or tissue samples for hydrocarbon analysis, and use TS#1 approved laboratories for these analyses.

Comment: There is no information given to determine whether the methods used for collection of the 1977-1981 data are the same as those used in 1989-1990. (ESC)

Response: Data collection methods are the same.

Comment: The Trustees fail to address how differences measure over time can be attributed to EVOS rather than natural or anthropogenic changes. (ESC)

Response: The presence of detectable Prudhoe Bay crude oil in sediments and mussels in Prince William Sound would not reasonably be considered to result from natural or anthropogenic sources other than the EVOS.

Comment: It will not be possible to extrapolate from nonrandomly selected sites to the universe of sites. (ESC)

Response: Nor would the Trustees attempt to do so.

Comment: The ten historical sites used in the coastal habitat program to assess sediment and mussel contamination are atypical of most oiled sites in PWS, which are in areas of high energy. Therefore differences observed between oiled and control sites cannot be used to extrapolate effects to the entire spill area.

Response: Most of the historical sites are moderately sheltered. Data obtained will be comparable among this subset of sites, many of which were also oiled by EVOS.

Comment: Presence of petroleum hydrocarbons in mussel tissues alone cannot be considered EVOS-related injury. The tissue residues must be found to have caused biological injury before pathway exposure is sought. (ESC)

Response: Pathways of exposure are not being sought. The presence of hydrocarbons in mussels and/or sediments is evidence of exposure itself. Evidence of exposure is necessary to establish linkages to injury.

Comment: There is no information regarding whether any of the ten nonrandomly selected sites are in areas affected by the spill. No site selection criteria were provided for those sites selected after the spill.

Response: Although not presented in the study description, there is substantial evidence on the degree of oiling of each site. Some sites were not oiled and serve as control sites, others were oiled and are maintained as study sites. The sites selected after the spill were done so rapidly, as soon as the path of the oil slick was apparent. These new sites were initially sampled before oil impact.

Comment: It does not appear that the transect selection, mussel sample collection or the photo-documentation is random. (ESC)

Response: Transects were selected according to the appropriate tide level for sampling. Along each 30-m transect, mussel, sediment, and photo-documentation are taken at random locations.

Comment: The Plan does not address QA/QC of biological samples or field methods or the statistical methods for determining injury. (ESC)

Response: QA/QC procedures are established for all NRDA studies (see Technical Services #1). This study complies with these QA/QC procedures. Appropriate statistical tests will be used depending upon the type of data to be analyzed.

Comments on Subtidal Studies - General

Comment: Subtidal studies 5, 6, and 7 ignore the highly successful salmon and herring fisheries of 1990 and 1991 and the positive findings of the subsistence sampling program indicating that fish throughout the spill area do not contain above-normal levels of hydrocarbons. (ESC)

Response: Although an apparent immediate impact on some fisheries may not have been observed (*e.g.* herring and salmon), our laboratory has found evidence suggesting continuing exposure of pollock and other fish species to oil. Since reproductive impairment and some histological changes may require longer times to manifest themselves, investigation of these biological effects is warranted. It is also important to note that the subsistence program is not focussing on benthic fish and is limited to specific areas near fishing villages. There is greater evidence of oil exposure to bottom-feeding fishes than fishes that reside primarily in the water column.

Comment: Subtidal sediment studies 1, 2 and 3 will not achieve their objective of extrapolating results to the entire spill area because the number of sites remains too small and the sites chosen for study were selected based on their potential for detecting impact rather than on a random basis. (ESC)

Response: Extrapolation of the results to the entire spill area was not an objective of these studies. Proper stratification of Prince William Sound would have been necessary to accomplish that objective. The process of stratification would have been far too costly and time-consuming. We chose, instead, to compare paired (oiled vs. unoiled) sites in a statistical design where sites are fixed rather than random. This precluded the delays associated with stratification allowing us to begin sampling soon after the spill thereby providing a complete record of the temporal changes in the hydrocarbon contamination of subtidal sediments.

Comment: The methods for detecting PAH metabolites in tissues from Subtidal Studies 6 and 7 are too imprecise to establish a conclusive link to EVOS oil in subtidal sediments. (ESC)

Response: The HPLC/florescence method for detecting metabolites of PAH in bile is a screening method that can identify fish that have been exposed to aromatic compounds. Using GC/MS to analyze for individual metabolites of aromatic compounds present in bile, a link between the source of aromatic compounds and the compounds present in the organism can be made. The analytical method that screens for the fluorescent aromatic compounds (FAC) in bile has been validated. In addition, a series of marker compounds identified by GC/MS, the dibenzothiophenols, provide a link to the source of the oil.

Subtidal Study No. 2 - Injury to Benthic Communities

Comment: Inclusion in the 1991 mass balance calculations of data from sites sampled in 1989 and 1990 is not valid because the temporal changes that have occurred in the nearshore subtidal zone where waves and currents are most active. (ESC)

Response: A valid comment if the 1991 mass balance calculations are to be considered a discrete entity to be viewed in isolation. Data from Air/Water Study No. 2 would then be useful for documenting shifts in the bathymetric distribution of those hydrocarbons included in the earlier mass balance calculations.

Comment: The microbial hydrocarbon oxidation potential will not establish a causal relationship to spill oil except in heavily oiled samples because it reacts to total available hydrocarbons and does not distinguish spill oil from background hydrocarbons that are present. (ESC)

Response: Microbial populations at a given site could show high activities to hydrocarbons due to acclimation to hydrocarbon inputs from sources other than the EVOS. However, the use of control sites and information from other studies will be used to help interpret the results of this study. This study is not being done in a vacuum.

Comment: The number of 1991 PWS study sites is not adequate to calculate the amount of oil remaining from the spill that could be present in subtidal sediments for mass balance models or to map "'the geographic and bathymetric distribution of hydrocarbon contamination of sediments in PWS and northeastern GOA'". (ESC)

Response: The goal of Air/Water Study No. 2 was to document the bathymetric distribution of oil at selected sites at various distances from the spill site. Oiled sites were chosen so that a range of levels of contamination of intertidal sediments would be included in the study design. Reference sites were paired with oiled sites by sediment type, aspect and exposure to wave action whenever possible. The 1991 sites are a subset of the original set of sites sampled in 1989-90. The 1991 sites were selected chiefly to document shifts in the subtidal distribution of petroleum hydrocarbons and to measure the persistence of oil in subtidal sediments.

Comment: Sampling sites were not selected randomly, so the results cannot be extrapolated to the entire spill region. (ESC)

Response: Correct. See responses above.

Comment: The mathematical methods for estimating maximum potential for in situ biodegradation and for distinguishing effects due to oiling from other factors are not provided. (ESC)

Response: In situ biodegradation will not be measured in this study nor will it be estimated from the data. Potential rates of biodegradation will be measured. These rates give an indication of the ability of the microbial populations at a given site to utilize certain hydrocarbon fractions. If a population can immediately utilize a given fraction the implication is that the population is acclimated to use of that hydrocarbon.

Comment: This study does not identify injury, its cause or its significance. The study does not mention the link between the microbial assay results, chemical analyses of the extracted hydrocarbon fraction, EVOS oil present in that fraction, and changes noted in subtidal infaunal communities associated with eelgrass and Laminaria beds from Subtidal Study No. 2. (ESC)

Response: This comment relates more directly to Subtidal Study No. 1 than Subtidal Study No. 2. Subtidal Study No. 1 is not intended to identify injury. Instead, the intent of the study is to determine the amount of oil that contaminated subtidal sediments and its chemical fate. By following the persistence of petroleum hydrocarbons in time, Subtidal Study No. 1 continues to estimate exposure for affected subtidal communities and, in this sense, supports other studies designed to more directly assess injury. This study is linked to Subtidal Study No. 2, however, and provides for both hydrocarbon and microbiological analyses of sediments associated with infaunal collections from eelgrass and *Laminaria* habitats.

Comment: The faunal composition of subtidal soft-bottom benthic communities varies dramatically even at very small spatial scales and year-to-year recruitment of the species represented in this zone is very high. Accordingly, variances within this survey will be high and the possibility of detecting changes due to EVOS is very small. None of the descriptors of community composition identified in the study description acts in a precise manner when responding to pollution, so it will not be possible to link oil pollution and observed changes in the composition and abundance of macro-infauna. (ESC)

Response: We recognize the complexity of soft-bottom benthic communities and the dramatic variation of faunal composition spatially and temporally. We are also aware of the problems of great variance in grab data. We expect, based upon previous studies by our investigators and others, to successfully apply the univariate and multivariate techniques outlined to demonstrate pollution effects from EVOS.

Comment: Volume of freshwater input is more important in site selection than proximity of a site to sources of fresh water. And the paired sites, e.g., Bay of Isles and Drier Bay and Herring Bay and Lower Herring Bay, do not meet the design criteria because their physical characteristics are so different. This makes the stratified random sampling design for the sites meaningless. (ESC)

Response: We are well aware of the differences in hydrology and oceanography between the bays selected. In most cases, sea grass beds at the heads of bays were chosen as the common denominator that is expected to have an important influence on the benthic environment of all sites. A sea grass system can be expected to flux a sizable and annually reliable amount of organic carbon to the subtidal environment. Similar benthic faunal components responding in a roughly similar manner would then be expected in the sites selected.

Comment: Continuation of this study for five years indicates that it is research, and not NRDA, oriented. (ESC)

Response: Comparison of data over several years is expected to make a significant contribution to injury assessment.

Comment: The procedure for calculating "'approximate carbon values for all wet-weights'" of the various taxonomic groups is not given and Appendix C does not contain the "'methodologies, rationale, and problems with the use of diversity indices, K-dominance curves, and geometric abundance as measures of pollution-induced disturbance.'" (ESC)

Response: Details concerning calculating approximate carbon values are not included because they are not considered essential for evaluating the study. Appendix C was inadvertently omitted from the published plan. However, details on the analysis techniques can be found in the referenced publications.

Comment: The Trustees will not be able to attribute changes in benthic communities to the presence of EVOS oil with any reasonable degree of confidence because: (1) the number of sites relative to the degree of freedom is small; (2) the control sites were not selected according to the design criteria; and (3) there is no baseline benthic community data for the study sites. (ESC)

Response: The experimental design is a reasonable approach to determination of injury from EVOS. For the shallow benthic work, the stratified random sampling design does have the minimum number of sites considered necessary. Addition of more sites is logistically impossible. Control sites were selected randomly within each strata, according to design criteria. For the deep benthic portion of the study, sampling is conducted in a paired design (treatment/control pairs of sites). The number of pairs was limited by the number of adequate control sites. The deep benthic study is not designed to extrapolate sampling results to the entire region. This requires a random stratification approach and a sampling effort that is cost prohibitive. The lack of baseline benthic data does not mean injury cannot be determined. Comparison of oiled and unoiled areas over time is expected to provide useful information.

Comment: The methods of SS2 refer to the fact that taxonomic identifications of shallow and deep benthos will only be taken to the family level or higher. This will preclude the Trustees from understanding the impacts of the oil spill on individual species and biological diversity which occurs at that level. It is possible then that there could be significant reduction in species diversity, a typical scenario in environments stressed by oil spills, without detection by the Trustees. If species identification is undertaken, it should not be limited to those taxa that are particularly abundant. (NRDC)

Response: Identifications to the family level will not allow understanding of impacts of EVOS on individual species. However, it will be useful for describing injury at the community level, which is expected to be adequate. It has been shown that the overall diversity of a community is comprised of hierarchial components which include family, genus and species, and thus the concept can be applied to families.

Comment: The Trustees should carry out deep benthic biological sampling at depths between 40 and 100 meters as well as at those two levels. (NRDC)

Response: It would be useful to have a continuum of sampling stations between 40 and 100 meters. However, time and funding constraints did not permit additional sampling.

Subtidal Study No. 3 - Bio-Availability & Transport of Hydrocarbons

Comment: Use of sediment traps for Objective C duplicates the direct sampling of subtidal sediments of Subtidal Study No. 1. They are inappropriate for determining particulate transport of hydrocarbons in shallow water because of the few sites sampled, the highly variable circulation patterns. The Trustees should simply sample the subtidal sediments if their aim is to demonstrate the presence or absence of absorbed hydrocarbons. (ESC)

Response: Objective C is "Determine if sediments settling out of the water column in nearshore subtidal environments contain adsorbed hydrocarbons." The sediment trap study does not duplicate the direct sampling of subtidal sediments by SS1, but instead compliments that work. The sediment traps will help determine how long after the spill oil remains mobile in the environment. The sediment trap study is not intended to determine particulate transport for all of Prince William Sound, but instead to determine if hydrocarbons are continuing to expose or re-expose subtidal areas at selected sites.

Comment: The mussel cages to be deployed at ten sites will not yield a representative picture of bio-availability in the spill area; the temporal trends noted will be site-specific and not suitable to extrapolation. (ESC)

Response: Determination of "...a representative picture of bio-availability in the spill area;" is not among the stated objectives of this study. Accomplishment of such an objective would require a sampling effort that is on the order of 100 times more expensive, and is not deemed cost-effective by the principal investigators. The proposed sampling effort is adequate to demonstrate oil transport mechanisms within the seawater column at heavily impacted sites.

Comment: There are no procedures mentioned that would differentiate EVOS oil from other sources of adsorbed hydrocarbons in mussels and sediments. Methods of analyzing bottom core samples and relation that data to data obtained from sediment traps are not included in the Plan. (ESC)

Response: Such procedures are discussed within the context of Technical Services Study No. 1.

Comment: The trustees do not explain the significance for damage assessment purposes of suspended cage mussel uptake or suspended sediment sorption of hydrocarbons. (ESC)

Response: Oil has caused damage to sub-surface organisms, but the mechanism of oil transport to various sub-surface habitats and organisms is not immediately obvious as it is with the surface habitats and organisms. Sampling caged mussels and trapping sediments is an attempt to complement the direct water sampling for hydrocarbons and to determine the availability of hydrocarbons to sub-surface habitats and organisms. These measurements have the advantage of integrating low level hydrocarbons for long periods of time.

Subtidal Study No. 4 - Fate and Toxicity of Spilled Oil

Comment: The study of oxidation products in SS4 is research and not compensable. Nothing in the literature quantitatively relates oxidation products/metabolites to parent hydrocarbon compounds, and GC/MS analysis may be inappropriate because many of the oxidation products are thermally unstable. (ESC)

Response: The study of oxidation products focuses on the sources of the toxicity associated with EXXON VALDEZ oil. The study is designed to determine whether, and to what extent, oxidation products contribute to the measurable toxicity of oiled sediment samples. Oxidation products are not routinely included in chemical analyses performed in oilspill assessments, and their omission could conceivably lead to an underestimate of overall potential effects, based on measurements of hydrocarbons alone.

Comment: It does not appear that this study will be used in the quantification of injury to natural resources. The study objectives include documentation of exposure and identification of aspects of damage, but there is no indication that injury will be assessed beyond the testing of statistical significance of observed differences. (ESC)

Response: As noted in the previous response, Subtidal Study No. 4 focuses on the mechanisms of oilspill toxicity. Toxicity bioassays provide information on the potential toxicity of the oil still residing in the Prince William Sound subtidal environment and on the threshold concentrations of oil required to elicit toxicity responses in test organisms. Separation of polar oxidation products was included to determine whether, and to what extent, oxidation products of oil may contribute to the measurable toxicity of oiled sediment samples. Used in conjunction with analytical data on the spatial distribution and chemical composition of petroleum residues in the environment, this information will be useful in assessing the potential biological impact of the spill.

Subtidal Study No. 5 - Spot Shrimp

Comment: There is an inconsistency between Objective D and Appendix D regarding whether the Trustees will attempt to make a determination of the oiling at study sites. (ESC)

Response: This apparent inconsistency is due to an unintentionally poor phrasing of Objective D. Hydrocarbon analysis of eggs and tissues could produce results anywhere in a continuous range from no contamination to a maximally heavy, quantifiable level. Thus there is potentially an infinite range of possible contamination levels in the tissue. The levels of oiling in the study area sites are considered to be either oiled or unoiled. Thus the sites have only two potential levels of oiling which are qualitative, not quantitative. This study therefore attempts to compare the quantitative levels of hydrocarbons in the tissues with the qualitative levels of oiling at the sites.

Comment: There are no methods given for documenting injury to tissues and comparing differences between oiled and unoiled sites. (ESC)

Response: Injury to tissue will be documented by necropsy and histopathology. The "Methods" section of this study plan notes that Chi-Square analysis will be used to compare differences. See Appendix B for histopathology procedures.

Comment: The Trustees should not use southwest PWS and northwest PWS as their oiled and control sites because of the differences between these two areas. (ESC)

Response: Data have been collected which allow comparisons of environmental conditions at each site. These data indicate that these sites are similar with regard to salinity, temperature, and dissolved oxygen content. There is no evidence to suggest that growth rates are different between sites. The selection of study sites was constrained both by the path the oil was known to have travelled and the distribution of the study animals.

Comment: There is no weight given to the fact that there was a marked decline in spot shrimp stocks prior to the spill in statistical areas 201-00 and 201-02, which cover three of the four oiled test sites. There is no information indicating that the Trustees have selected control sites that are similar to test sites in terms of baseline production of shrimp. (ESC)

Response: Declines in the spot shrimp stocks in these areas were due to over fishing and addressed via closures in 1988. Given the stock conditions, efforts to locate study sites in these areas focused on their ability to provide spot shrimp to the study. With no commercial effort since 1988 and if there were no oil spill effect, expectations would be for improvement in the stock's condition.

Comment: The study description does not consider seasonal migration of shrimp from shallow to deep water. Larval mobility into and out of potentially injured areas will not be documented in this study. (ESC)

Response: Seasonal migration of shrimp from shallow to deep water is not an issue because the field portion of this study takes place at the same time each year. Furthermore, with fishing depths of 20 to 120 fathoms, vertical migration should be bracketed within the sampling zone. Little is known of larval mobility within PWS.

Comment: The oiled test sites, Chenega Island, Herring Bay, Elrington Passage and Green Island, were affected by oil in varying degrees. The Trustees have provided insufficient information regarding the selection of control and impact sites and how the oiling at these sites will be documented. Appendix D indicates that sites are classified as oiled or unoiled based only on observations of surface oil. This will produce a quantification of injury based upon a spectrum of exposure levels in both time and space. (ESC)

Response: The shrimp study does not attempt to relate injury to particular quantitative levels of oiling but simply to the qualitative presence of oil. Oiling at study areas was documented via ADEC overflights as well as by ADF&G personnel. The EVOS was not a controlled laboratory experiment. Visual observations and knowledge of the stocks were the only means of making early decisions as to where and how sampling should take place. Testing tissues for hydrocarbons will provide one means of documenting the presence of oil in these areas. But the Trustees do plan to compile all oiling data bases and make these available to the study principal investigators.

Comment: Use of the commercial shrimp pots will not aid in the determination of whether the 1989 year class suffered a high mortality rate in heavily oiled areas relative to other year classes because the pots are designed to catch adult shrimp of marketable size. In 1991, the 1989 year class will still be juveniles and a statistically significant proportion of them will not be captured by the gear. (ESC)

Response: The gear used in this study is known to be able to capture both juveniles and shrimp of a non-marketable size. At 2.5 years of age, some of the 1989 year class should recruit to the fishing gear this year and give an indication of the class presence or absence. The survey to be conducted in the Fall of 1992 will further substantiate this.

Comment: Use of sampling pot strings of 11 pots per station is not random. Subsequent analysis of catch data seems to assume that all pots are independent. This has questionable validity. (ESC)

Response: Pot spacing was adjusted in 1990 to remove any effective overlap. Efforts will be made to determine whether the current interval accomplishes this.

Comment: There is no information given as to how EVOS hydrocarbons will be distinguished from other hydrocarbons in analysis of shrimp tissue and egg samples. Without environmental exposure data, the Trustees cannot document a pathway and causal link between EVOS and differences in abundance, size, distribution and fecundity. (ESC)

Response: See Technical Services Study Number 1 for further information on the analysis of hydrocarbon tissue samples. The Trustees will use a compilation of oiling data bases, including but not limited to those gathered in this study, to demonstrate environmental exposure.

Comment: By focusing on the 1989 year class, the Trustees have precluded documentation of pre-spill baseline conditions for pot shrimp captured by gear and therefore will not be able to distinguish spill effects from natural differences between the test areas. (ESC)

Response: The multiple age classes of spot shrimp captured in 1989 and 1990 will indicate pre-spill conditions such as recruitment and age structure.

Comment: Owing to the pre-spill bias between oiled and control areas which will influence the test results, this study really focuses on resource management and not injury assessment. It therefore is not compensable. (ESC)

Response: A stock subject to a high level of exploitation may be even more vulnerable than one exploited at a lower level. This study collects data not only on relative abundance but fecundity, growth and recruitment as well. With the possibility of a pre-spill bias, the spot shrimp stocks in oiled areas are more, not less, deserving of post-spill monitoring and study. Injuries which force resource management changes are certainly compensable.

Subtidal Study No. 6 - Rockfish and Shallow Reef Habitats

Comment: The use of otolith microstructure to evaluate depressed growth stemming from oil contamination is an experimental technique. (ESC)

Response: The need to evaluate depressed growth was indicated. The use of otolith microstructure to show environmental stress is a proven technique and was selected as the best means to meet this objective.

Comment: Sampling of reefs in shallow water biases the outcome because of the accessibility of these waters to divers. (ESC)

Response: The same sampling techniques are used at all sampling locations. This allows us to compare differences between sites and does not bias results. While the sampling depths are accessible to project divers, the sampling locations are essentially unexploited by sports divers because of the distances between the sites and area ports.

Comment: The Trustees cannot determine the presence or absence of EVOS hydrocarbons in demersal rockfish by analyzing bile. This is non-specific to hydrocarbon source and may be subject to interference by other compounds. (ESC)

Response: The hydrocarbon analysis may be non-specific; however, the presence of hydrocarbons in bile, in concert with other results, may lead to the conclusion of contamination by the EVOS.

Comment: Identification of EVOS hydrocarbons by tissue analysis is questionable because of the efficient, and perhaps selective, metabolic functions in fish as well as the possible occurrence of non-Evos hydrocarbons. (ESC)

Response: Other assays and observations will be used in association with the bile hydrocarbon results to establish damage due to the EVOS if it has occurred.

Comment: It is unclear how otolith descriptions will be interpreted, specifically otolith-derived age composition and mean length-at-age data. (ESC)

Response: Examination of age structures (otoliths) and comparison with length data are standard techniques commonly used in many fisheries studies. This enables the researcher to better define the population being examined and to observe changes in growth rates.

Comment: It does not appear that this study will be used in the quantification of injury to natural resources. The study objectives include documentation of exposure and identification of aspects of damage, but there is no indication that injury will be assessed beyond the testing of statistical significance of observed differences. (ESC)

Response: Results are intended to be qualitative, not quantitative. Although the sampling sites will not be representative of all depths due to the nature of the sampling techniques, there will not be a bias between oiled and unoiled sites.

Subtidal Study No. 7 - Measurement of Hydrocarbons & Metabolites

Comment: The discussion of the reduction in scope of Subtidal Study No. 7 raises questions about the previous year's findings and whether the likelihood of the deleted portions of the study to document injury stems from the study design. (NWF)

Response: The narrowing of focus of the 1991 study is aimed at continuing only those aspects which are most likely to assist in documentation of injury or damage.

Comment: The fish bile metabolite analysis methods provided in Subtidal Study No. 7 are not source-specific. (ESC)

Response: See above response regarding methods for detecting PAH metabolites.

Comment: This study ignores the apparent good health of fish populations in PWS and focuses on biochemical indicators that will not draw links to EVOS or to actual resource injury. (ESC)

Response: The potential long-term effects of oil exposure of fish populations are not known, therefore we are assessing such biological effects as reproductive impairment, as well as biochemical indicators. The biochemical indicators will be used to link long-term effects to exposure.

Comment: The techniques described in Objective B cannot distinguish between metabolites stemming from EVOS and non-EVOS hydrocarbons in the large and diverse area of study. Analysis of enzyme induction is subject to these same problems. (ESC)

Response: See above response regarding methods for detecting PAH metabolites.

Comment: The lack of baseline data in the literature for pathological incidence, mortality and fecundity for the species in the study area casts doubt on the validity of any input data used in a simulation model. (ESC)

Response: There is some literature on flathead sole and we have information on many species from reference areas.

Comment: Some of the species to be sampled and analyzed are highly mobile and exhibit low fidelity to the collection site. It is not explained how their geographic range can be accounted for in assessing the significance of apparent exposure. (ESC)

Response: The study will assess both the exposure to oil and the resulting biological effects on individual fishes using a number of chemical, biochemical and biological methods. Models will be tested which are based on results of analyses of individual fish and which, thus, are not site-dependent.

Comment: The analytical methods described are not specific to the source of hydrocarbons that may be metabolized. AHH activity in liver and measurement of cytochrome P-450IA1 are not specific to hydrocarbons. Thus, a causal link to EVOS cannot be established. (ESC)

Response: See above response regarding methods for detecting PAH metabolites.

Comment: The Trustees have not accounted for the variability of concentrations of metabolites in bile with recent feeding behavior of fish. (ESC)

Response: The bile results are corrected for protein content which does reduce variability. The bile method is a screening technique which detects exposure of fish to oil, it does not attempt to precisely quantitate the level of exposure and thus variability in actual levels of FACs due to feeding behavior or other factors is not as important as the ability to detect and document exposure.

Comment: The time lag inherent in detection of metabolites in bile and enzymatic activity in liver will frustrate any attempt to correlate exposure and effect. (ESC)

Response: The time lag is very short (several hours to a few days) between exposure to oil and appearance of metabolites in bile or changes in enzyme levels or activity.

Comment: Analysis of stomach contents and sediments for hydrocarbons is of questionable value in documenting exposure in more mobile species. (ESC)

Response: Measurement of hydrocarbons in sediments documents the contamination of a particular site. Analysis of stomach contents is important because diet is a potentially important route of exposure of fish to hydrocarbons. These analyses, along with the measurement of bile FAC, liver AHH, reproductive function and histolopathological effects in individual fish help document exposure and resultant biological effects of petroleum hydrocarbons.

Comment: The use of pollock and yellowfin sole to assess reproductive impairment is questionable because there is no evidence that these species represent the total finfish population or are the dominant species in that resource. (ESC)

Response: Pollock is a commercially important species that had shown evidence of oil exposure in the previous years analyses. Yellowfin sole is a species that matures during the time of sampling and is thus appropriate for studies of reproductive impairment. In addition, yellowfin sole is a benthic fish. Benthic fishes have tended to show evidence of continuing oil exposure more than fish like Dolly Varden, which are not bottom-feeding.

Comments on Technical Services Studies

Technical Services Study No. 1 - Hydrocarbon Analysis

Comment: TS1 (and Appendix A) still does not provide sufficient detail to evaluate the analytical methods or the adequacy of the numbers of samples analyzed. (ESC)

Response: Appendix A includes general information on standard operating procedures for collecting and handling samples for hydrocarbon analysis. The study plan for the 1991 studies includes more specific information on procedures to be used in the collection of study-specific samples.

Comment: There is insufficient detail for the reader to determine whether the analytical models for measuring hydrocarbons are capable of distinguishing between low levels of EVOS hydrocarbons and other natural and/or man-made sources. (ESC)

Response: The list of hydrocarbon compounds for which analyses are being conducted was carefully chosen to ensure that distinction could be made between EVOS hydrocarbons and other natural and/or man-made sources.

Comment: The description of the program for measuring hydrocarbon metabolites in bile lacks standards and reference materials. (ESC)

Response: Laboratories measuring bile metabolites commonly use naphthalene and phenanthrene standards. In addition, bile from a bile pool reference material (control material) are being analyzed.

Comment: The quality assurance plan for chemical analyses in TS1 and Appendix A indicates that intercalibration of data will occur after samples have been analyzed by a laboratory. This could result in the discarding of relevant data and ultimately a bias in results. All data should be reported with necessary qualifications rather than discarded. The Plan should be revised to make clear whether data that do not meet the Trustees' standards will be discarded or archived. (ESC)

Response: Laboratories analyzing samples for the EVOS Natural Resource Damage Assessment (NRDA) are required to analyze an accuracy based material within +/-15% of the value of each analyte or measurement parameter. If a laboratory failed to meet this standard, they were not allowed to analyze EVOS samples. Intercalibration exercises are used to insure that participating laboratories are maintaining proficiency in the analyses of the samples. If a laboratory fails to analyze a set of intercalibration samples correctly, data from that laboratory produced during the time period covered by the intercalibration samples are flagged. They are not destroyed.

Comment: The analytical methods of Objective A of TS1 cannot be evaluated because of the lack of detail in the Plan. The Trustees should include the full list of compounds that will be collected for alkane analysis. (ESC)

Response: The alkanes from C_{10} through C_{34} are currently being reported by each of the laboratories analyzing samples for the EVOS NRDA.

Comment: The Plan should include the detailed procedures used by field personnel in collecting samples, identifying and shipping them, and maintaining the chain of custody.

Response: The Plan gives the general procedures that must be followed to meet the standards. Each project is responsible for providing specific guidance for field personnel. Training was provided for principal investigators and field personnel to ensure that samples were taken correctly. Specific guidance is given on chain of custody and shipping of samples.

Comment: The proposed audits of field and laboratory procedures are inadequately detailed, and there is no mention of auditing sample analysis, biological observations, database input, chain-of-custody procedures or mapping. (ESC)

Response: The audits proposed meet applicable Federal standards, i.e., refer to the Toxic Substances Control Act, part 792, Good Laboratory Practices Standards.

Comment: It is not clear how the proposed method of labelling samples will produce a unique set of sample numbers. (ESC)

Response: A sample identification is given to each sample as it is received from the field. Therefore, the sample identification is unique to that sample.

Comment: Analytical techniques and biased sampling programs will make the production of a material balance on the fate of spilled oil virtually impossible. (ESC)

Response: The analytical techniques being used are adequate to characterize the oil and its fate. The methods used in constructing a material balance on the oil are well represented in the literature, for example, see Boehm, McKay, or Payne.

Technical Services Study No. 3 - Mapping

Comment: Proposed mapping efforts lack appropriate detail regarding the types of maps and analytical products for the reader to determine whether this study will aid in monitoring geographic distributions of data pertinent to assessing injury from EVOS. Nor is there mention of the types of databases to be developed or the organization of those databases. (ESC)

Response: Map types and analytical products are varied as required to support the range of NRDA studies. The geographic information system (GIS) is one of several tools used by investigators to assess injury from EVOS. The types of databases to be developed in the GIS are relational using geographic and other components. The organization of the databases is determined by the state-of-the-art computer operating systems, application, software, and client needs.

Comment: There is not sufficient information in the Plan regarding the quality control on data input to the mapping process to determine whether it will be adequate. (ESC)

Response: Data processing standards and procedures are implemented to ensure adequate quality control on data input.

Comment: No information is given in statistical treatments used to average data values for input to the mapping process. (ESC)

Response: Real data will be input to the mapping process. The source data will be used to verify database input and output, and inputted as appropriate.

Comment: It is not possible to determine from the information provided: (1) whether the mapping work will contribute to the objective quantification of injury to resources; or (2) whether "multi-thematic atlases of pre-spill data" exist on the scale needed for comparison with post-spill data; or (3) whether the mapping effort will be cost-effective. (ESC)

Response: (1) Technical Services #3 (TS3) mapping group provides support to NRDA studies. TS3 has been well utilized by investigators in their assessment studies. (2) Multi-thematic atlases of pre-spill data exist and are central to the objectives of TS3. (3) TS3 supports several NRDA studies and has been determined to be cost effective on a study by study basis. Also TS3 provides consolidated services for cost effectiveness. TS3 is designed to provide support to the entire NRDA process. It provides consolidated services to facilitate the management and presentation of information and avoid duplication of effort.

Technical Services No. 3 - Geographic Information System

Comment: Proposed mapping efforts lack appropriate detail regarding the types of maps and analytical products for the reader to determine whether this study will aid in monitoring geographic distributions of data pertinent to assessing injury from EVOS. Nor is there mention of the types of databases to be developed or the organization of those databases. (ESC)

Response: Map types and analytical products are litigation sensitive; however, accepted mapping science methods will be used, recognizing all data limitations. Development of databases will include a geographic component that will provide for commonality of data types.

Comment: There is not sufficient information in the Plan regarding the quality control on data input to the mapping process to determine whether it will be adequate. (ESC)

Response: Technical Services 3 adheres to accepted mapping methods using state-of-the-art technology that includes quality assurance steps that compare data input with source information and with subsequent iterations of database development.

Comment: No information is given on statistical treatments used to average data values for input to the mapping process. (ESC)

Response: Real data will be inputted to the mapping process. Source data will be used to verify database input and output.

Comment: It is not possible to determine from the information provided: (1) whether the mapping work will contribute to the objective quantification of injury to resources; or (2) whether "multi-thematic atlases of pre-spill data" exist of the scale needed for comparison with post-spill data; or (3) whether the mapping effort will be cost-effective. (ESC)

Response: Sufficient detail is given to allow assessment of whether this work will contribute to quantification of injury. Objective "multi-thematic" atlases of pre-spill data exist and are central to the objectives of this project. The work will be conducted in an efficient cost-effective manner.

Comments on Cultural Resources

Comment: Because cultural resources are not a natural resource within the meaning of the NRDA regulations, this study should not be funded by the NRDA process. (ESC, APSC)

Response: A valuation of the committed use of the cultural attributes of natural resources, as well as the natural components of cultural sites, is properly within the CERCLA/Clean Water Act damage assessment process. While other statutes may address injuries to archaeological resources, they do not preclude activities undertaken pursuant to the CERCLA/Clean Water Act.

Comment: The information given in this study plan does not explain its objectives or methodologies sufficiently. (ESC)

Response: The objective of this study is clearly stated to be the assessment of injuries to archaeological resources as a result of the EVOS. The study methodology adopted is to use sample sites and statistically project injury estimates.

Comment: The survey work proposed to be undertaken in this study has already been accomplished as part of Exxon's clean-up efforts. Thus the survey and site selection portions of the cultural resources program are duplicative of existing information. (ESC)

Response: The principle purpose of EXXON's beach survey work was to identify sites for cleanup. Archaeological investigations of the sites were limited. However, the data gathered by Exxon in its cleanup effort contributed to the development of a list of archaeological resource sites that were injured, from which selected study sites were chosen.

Comment: It is not clear why investigations of sites in unoiled areas will be made. Potential site injury is a function of shoreline type, stratigraphy, location, degree of oiling, impacts from cleanup techniques, and the artifacts present. Given the unique nature of each site, the range of distribution and the diversity of time span, it is inappropriate for the Trustees to extrapolate control sites to oiled areas. (ESC)

Response: Archaeological sites are individually unique. As a result, the cost of investigating archaeological sites is high and the funds available to assess injuries are limited. Therefore, archaeological sites will be defined by site types and injuries will be determined from a statistically derived sample. In order to describe the population of sites most accurately and to give a basis for statistical treatment, a sample of study sites located in the general spill area was selected rather than biasing the study by only looking at oiled sites.

Comment: The cost associated with this study seems excessive given the small number of documented disturbances to cultural and archeological resources. (ESC)

Response: Archaeological investigations are labor intensive and involve complicated and expensive laboratory analyses. Tests necessary to identify the presence of oil are costly. Additionally, the geographic area of study is extremely remote. This factor causes very high logistical costs both for access and safety reasons. The use of a government contract to perform the study allows for a reduction in costs and the successful achievement of the goals of the study.

Comment: The study description does not indicate whether the methods employed will meet the standards and guidelines for archeology and historic preservation. (ESC)

Response: This study conforms to all appropriate standards and guidelines.

Comment: The Plan fails to provide adequate information to evaluate how the significance of historical properties, topologies, site investigations, interview impacts, soil characteristics, radiocarbon dating and erosion rates will be determined. (ESC)

Response: The significance of historic and prehistoric properties will be determined using processes outlined in existing Federal regulations. The issue of site significance was addressed under the Memorandum of Agreement signed by EXXON, Federal agencies, the State Historic Preservation Officer, and Native corporations. The validity of topologies, adequacy of site investigations, and effects of archaeological investigations will also be addressed following existing federal procedures and normal scientific archaeological standards. For example, the degradation of spill-affected historic properties may be compared with properties that have not suffered oil spill related injuries to arrive at rates of degradation.

Comment: Interviews of response workers and government employees may result in biased information. No description is given of the manner in which results of these interviews will be used to quantify injury. (ESC)

Response: Information received from interviews will be evaluated for bias and verified. One of the aims of the study is to document injury to sites both quantitatively and qualitatively. Once the types of injury are estimated, those injuries can be projected statistically to the total body of archaeological data in the study area.

Comments on Economic Studies - General

Comment: The reliability of using contingent valuation to measure alleged non-use losses is questionable. (API)

Response: The Federal Trustees believe that the contingent valuation method can provide an accurate estimate of the existence (non-use) value losses that occurred in this incident.

Comment: The 1991 economic studies bear no relevance to CWA standards for assessing damages based on restoration costs. As such, they do not serve their purpose: determining cost of restoration vs. value of the injured resource, or identifying most cost-effective restoration alternative. (ESC)

Response: The Clean Water Act does not establish restoration costs as the sole measure of recoverable natural resource damages. In addition to funds necessary to restore injured natural resources, the Trustees are entitled to recover interim lost use value. The economic studies are designed to measure that value.

Comment: The 1991 Plan still does not include state studies, contrary to the agreement between federal and state trustees announced on January 14, 1991. This is an indicator of lack of coordination and questionable quality of study methods. (ESC)

Response: The fact that the State and federal studies were not conducted jointly in no way suggest that the study methods were inadequate.

Comment: Insufficient description of study objectives and methodologies points to Trustee Council's lack of intention to elicit meaningful review and comments on those studies. (ESC)

Response: The descriptions of the economic studies are intended to provide the public with general information about studies that are planned or ongoing. The Trustees believe that the quantity of information provided is sufficient to serve that purpose.

Comment: Most of the 1991 studies assess alleged damages that are noncompensable under the laws and regulations governing natural resource damage assessment. (ESC)

Response: The Trustees disagree. The studies are designed to value natural resource damages that are recoverable under controlling law.

Comment: The 1991 studies include several cases of double counting of damages: non-use losses of natives in three separate studies; changes in property values which include separately measured use value effects; separate estimates of losses in sport fishing and charterboat operations; inclusion of duplicate non-use values.

(ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resource damages are not double-counted.

Comment: The 1991 studies are defective due to the use of contingent valuation as methodology, the lack of integration with studies of injury determination and state studies, and the inclusion of unnecessary data collection. (ESC)

Response: The contingent valuation method is not defective; all economic damage studies are fully integrated with the injury studies, no unnecessary data will be collected for the natural resource damage assessment.

Comments on Economic Studies - Specific

Economics Study No. 1 - Commercial Fisheries

Comment: Economic Study No. 1 is really geared toward determining whether consumers perceive problems with seafood as a result of the spill, but how this will be determined is unclear and the multitude of factors that influence the seafood market and the existence of alternate seafood resources will make such a determination very complex. (API)

Response: The purpose of this plan is to provide public notice of the types of economic studies contemplated by the Federal Trustees. It is not intended to provide detailed descriptions of the specific methods being used owing to the litigation sensitive nature of the study.

Comment: If any losses were incurred by fishermen, processors, wholesalers, retailers, and consumers, such losses are private not public. (ESC)

Response: The Trustees agree that losses experienced by fishermen, processors, wholesalers and retailers are private. However, general losses to consumers through supply and price changes may be considered a public loss for which the Trustees may recover.

Comment: Any such losses are negligible. Salmon supply increased in 1989 and prices dropped due to factors unrelated to the spill. In fact, ADF&G has cited surplus salmon inventories in Tokyo, increased Japanese hatchery production of chum salmon, and increased international sales as reasons for commercial fishery losses. (ESC)

Response: The Trustees do not expect to claim any losses that were not caused by the oil spill.

Comment: From 1988 to 1989, salmon quantity increased in Alaska by 37% and worldwide by 23%. Specifically, Alaska's major markets are in fresh/frozen red salmon and canned pink salmon. Worldwide production of fresh/frozen red salmon increased 39% from 1988 to 1989 and that of canned pink salmon increased 100%. Thus, salmon production was not affected by the spill. (ESC)

Response: See above response.

Comment: Claims for any losses incurred by consumers would constitute double-counting of private claims already made by individuals, businesses, and classes. (ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resource damages are not double-counted.

Comment: There appears to be no relationship between ECON1 and the other fish injury assessment studies contained in the Plan. Some data regarding any commercial fisheries losses are available from state and federal sources, e.g., Savikko, Herman, and Tim Page, "1989 Preliminary Alaska Commercial Fisheries Harvests and Values". Therefore, more data collection is not necessary. (ESC)

Response: This damage study will use information provided through the injury studies where applicable. Furthermore, it will make use of any accurate data and information available through other sources, where appropriate.

Economics Study No. 4 - Public Land Value

Comment: Any reduction in land value is not compensable as a natural resource damage. Recourse for alleged damage should be through private claims. Public lands affected by oil are not identified. (ESC)

Response: The Trustees do not intend to present claims for property value decreases experienced by private landowners.

Comment: Spill effects are hard to assess by comparing pre-spill and post-spill prices. Other factors, such as interest rates, use restrictions, low population density, access problems, and severe weather influence land values. (ESC)

Response: This study will take into account all relevant factors appropriate for estimating damages.

Comment: ECON4 will lead to double counting of damages because damages for some uses of public lands are covered by other studies. For example, the value of land directly reflects the services provided by the land, such as recreation, and ECON5 covers estimated recreational use damages. (ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure the estimates of natural resource damages do not include double-counting.

Comment: Hypothetical values are not compensable. For depressed values to be compensable, actual transactions must take place. Most of the allegedly affected area consists of state and federal lands and is rarely subject to sale. In addition, there is a vast supply of near substitutes for almost any parcel of land in Alaska. Thus, any compensable damages to land values will be very low. (ESC)

Response: Property values in the region affected by the EVOS may have been damaged regardless of whether the losses were actually realized through transactions. The concept of substitutes will be taken into account as appropriate in this study.

Comment: No accounting is provided for recovery in land value as a result of cleanup and restoration. (ESC)

Response: All damages to land values consistent with appropriate economic and legal theories will be estimated.

Economics Study No. 5 - Recreation

Comment: The Trustees should avoid underestimation of damages that could result from placing recreation users in a single category. Many kayakers also fish and camp and use charter boat services. The models do not clearly reflect this phenomenon. (NWF)

Response: The Federal Trustees will try to avoid underestimation of damages wherever possible. The fact that recreationists engage in multiple activities on a single trip will be taken into consideration in the estimation of damages.

Comment: The study aims to assess any damages to recreational users who had to choose substitutes or derived less enjoyment. The study ignores the fact that popular recreational resources such as the College Fjords and Columbia Glacier areas were unaffected by the spill. In addition, closure of commercial salmon fisheries resulted in increased escapement which most likely led to increased sport fishing. (ESC)

Response: All relevant facts will be taken into consideration for the estimation of recreation damages, including availability of substitute recreation sites and changes in sport fishing catch rates.

Comment: Contingent valuation is an unproven methodology for assessing losses incurred by sea kayakers. (ESC)

Response: The Federal Trustees believe that contingent valuation can be an appropriate method for estimating damages to sea kayakers under certain circumstances.

Comment: Any damages to commercial services, such as equipment rental businesses, charter boat services, tour boats and guides, should not be estimated. Compensation is available to public trustees only for foregone use of publicly owned natural resources. (ESC)

Response: The Trustees may recover for consumer surplus losses experienced by individuals that were prevented from enjoying natural resources because of the spill, even though their access would ordinarily be through commercial services.

Comment: Any recreational losses could be double counted, for example, recreational fishing and boat charters for sport fishing; sea kayaking and boat charters for kayak transportation. (ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resource damages are not double-counted.

Comment: Much of the data sought in this study is available from other sources, i.e., cruise ship bookings, cruise line capacities, visitor rates, hotel occupancy rates, sport fishing catch rates, rail passengers. Thus, additional collection effort is not required. (ESC)

Response: The Federal Trustees will use the most cost effective sources they can identify to obtain data necessary for accurate estimation of economic damages.

Economics Study No. 6 - Subsistence

Comment: Economic Study No. 6 addresses losses incurred by private individuals and is therefore beyond the scope of the Trustees' authority to study damages. There must be a public use of the resource identified and a means for discounting private uses to avoid double-counting. (API)

Response: The subsistence study will measure a loss associated with the use of natural resources. The Trustees do not intend to double count losses.

Comment: Double counting of losses is likely, including claims by native groups. Any losses of non-use values by subsistence communities are also counted in ECON7 and ECON9. (ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resource damages are not double-counted.

Comment: There is still no discussion of the goods or amenities to be analyzed by either market or non-market methods. Contingent valuation should not be used as a method in this situation. (ESC)

Response: The economic study plans are intended to provide general notice of the types of economic studies that are being carried out or are contemplated. The Federal Trustees believe that the descriptions of the studies are adequate for that purpose. Further, they believe that the contingent valuation method can be appropriate for estimating damages to subsistence households.

Comment: Mitigation efforts or income effects that offset losses are not considered. The oil spill resulted in increased employment opportunities provided by the cleanup. (ESC)

Response: The Federal Trustees will take into account all relevant factors appropriate for accurately measuring economic damages.

Economics Study No. 7 - Total Value of Natural Resources

Comment: It is not possible to tell from the description of Economic Study No. 7 whether it could permit double-counting from valuation estimates derived from other studies such as recreation uses. (API)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resource damages are not double-counted.

Comment: This study aims to estimate the total value of natural resources affected by the spill by summing up the intrinsic and use values. The term "intrinsic value" covers existence value, option value, and bequest value. Intrinsic value should represent only inherent worth of natural objects, independent of any values held or imposed by man. No legal basis exists for damages based on intrinsic value as defined by the Trustees. (ESC)

Response: The Ohio decision and the DOI natural resource damage assessment regulations both authorize recovery for all components of the intrinsic value of natural resources.

Comment: Crude oil is naturally degradable. After bulk oil removal, natural resources will be fully restored within a short period. Thus, there cannot be losses of existence or bequest values for temporary injuries to natural resources. (ESC)

Response: Existence, bequest and option values may have been reduced by the EVOS because complete restoration of the injured natural resources may not occur and public perception of the value of the injured natural resources may be altered for an extensive period of time.

Comment: Option values represent the expected discounted value of future use. Future use is not expected to be adversely affected by the spill. Therefore, option value losses must be confined to temporary effects. (ESC)

Response: Existence, bequest and option values may have been reduced by the EVOS because complete restoration of the injured natural resources may not occur and public perception of the value of the injured natural resources may be altered for an extensive period of time.

Comment: Non-use value losses are permanent irreversible damage to unique resources. These cannot be applied to resources temporarily injured and for which there exist substitutes. (ESC)

Response: There may have been permanent and irreversible injury to natural resources affected by the EVOS.

Comment: Contingent valuation is an untested method of assessing damages. There has been no evidence presented that contingent valuation can be used to assess lost non-use values or the total values of injured resources, and there was no explanation given for changing the scope of this study to include the measurement of use values. (ESC)

Response: The Federal Trustees believe that the peer-reviewed literature and the opinions of known experts in the field are sufficient to establish the validity of the contingent valuation method for purpose of estimating certain natural resource damages in this case.

Comment: Use of willingness-to-pay measures should be applied in contingent valuation, rather than use of willingness-to-accept measures. (ESC)

Response: The Federal Trustees do not intend to discuss litigation sensitive information in this plan.

Comment: Estimating total value will result in double-counting. There is no description of the methods to compare estimates from other studies and to determine which is the most accurate assessment. (ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resources damages are not double-counted.

Comment: This study will use contingent valuation to estimate the total value of natural resource losses stemming from EVOS without distinguishing between use value and non-use value. Use value could be estimated through other means such as travel cost and hedonic pricing methods. (ESC)

Response: Direct use values can be estimated via a number of market and non-market based economic methodologies. Contingent valuation is an accurate method for estimating both direct use and indirect use (existence values) that may have been lost in this incident.

Comment: Using contingent valuation to estimate non-use value amounts to attempting to determine intrinsic value. Thus, if contingent valuation were used to determine use value and non-use value, then accuracy of study would be doubtful. (ESC)

Response: The Federal Trustees believe that the contingent valuation method is an accurate way to estimate both use and non-use (existence, option, etc.) values that may have occurred as a result of the EVOS.

Comment: Any damages are a fraction of the total value of natural resources. It is not clear how damages will be assessed from attempts to estimate total value. (ESC)

Response: The total value of the injury to natural resources as a result of the EVOS will be estimated.

Comment: Revision of ECON7 to estimate total value would result in double-counting the value estimated in ECON5 and other studies. (ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resource damages are not double-counted.

Economics Study No. 8 - Affected Research Programs

Comment: Losses to research programs are not appropriate subjects for damage assessment; they should be asserted by the private parties who were conducting them. Whether any of the programs would have culminated in useful information is speculative. (API)

Response: The Trustees may recover for losses to the public associated with decreased ability to gather scientific knowledge.

Comment: Researchers and research institutions are the proper parties to assert claims for any such losses. Losses of any reduction in knowledge available to mankind are hypothetical and noncompensable. (ESC)

Response: The Trustees believe that these losses are not hypothetical.

Comment: No credit is given to spill-related research which generated large increases in knowledge. (ESC)

Response: Trustees are not required to give "credit" for spill-related research knowledge gained as a result of combating the effects and measuring the damages of an oil spill.

Economics Study No. 9 - Archaeological Resources

Comment: Archaeological damages should not be included in the definition of natural resources. (ESC)

Response: The Trustees believe a valuation of the committed use of the cultural attributes of natural resources, as well as the natural components of cultural sites, is properly included in the natural resources damage assessment.

Comment: Losses will be double counted. For example, alleged loss of value of archaeological resources as tourist attractions is also counted in ECON5 and archeological science values are also included in ECON8. (ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resource damages are not double-counted.

Comment: There should be a method to divide "intrinsic" values held by native groups into subparts, e.g., existence values for archeological resources and existence values for cultural heritage, in order to avoid double or triple counting. (ESC)

Response: The Federal Trustees have taken, and will continue to take, all steps necessary to ensure that the estimates of natural resource damages are not double-counted.

Economics Study No. 10 - Petroleum Products Price Impacts

Comment: Petroleum price increases are not caused by the injury to natural resources. There are many variables which affect the price of oil. (ESC)

Response: The Federal Trustees will take into consideration all relevant factors appropriate for accurately measuring economic damages.

Comment: Any economic effects on private individuals are secondary and indirect. Therefore, the proper claimants should be the consumers and/or distributors. (ESC)

Response: The Trustees may legally recover the losses experienced by consumers of petroleum products if price increases were caused by the oil spill.

Comment: The study that purports to measure the possible impact of EVOS on the price of petroleum products on the West Coast fails to describe a resource that has been injured. Thus the study is beyond the authority of the Trustees, especially given the Department of the Interior's position with respect to the scope of compensable value taken in its proposed revisions to the damage assessment regulations. (API)

Response: The Trustees are entitled to recover for losses to services that would have been provided by natural resources but for the oil spill. Transportation is one of those services that is provided by Prince William Sound. Closure of the Sound to tanker traffic for a period after the spill may have caused the gasoline price increase that occurred on the West Coast shortly after the spill. If the spill did cause the increase in prices, the Trustees may recover the associated consumer surplus losses.

Comment: Economic Study No. 10 cites no "natural resource" as its subject of study. Consequently, there is no legal authority for conducting this study. (API, APSC)

Response: See above response.

Comments on Restoration Planning

Comment: Because the principal means of restoring Prince William Sound is likely to be through natural recovery and some selected measures designed to foster this process, the Trustees' focus on finding statistical differences in resources that they may not be able to rehabilitate is inconsistent with the restoration intent of the damage assessment process. (API)

Response: A thorough examination of injury to natural resources from the spill is necessary to determine whether the rate of natural recovery to pre-spill condition, if indeed natural recovery will occur, is acceptable. If it is determined that natural recovery will not be acceptable, other restoration alternatives will be considered. In any case, complete examination and understanding of the effects of the spill on natural resources will enable more informed decision-making for restoration. Statistical analysis is an essential component to scientific investigation and will continue to be a part of all scientific studies conducted by the Trustees.

Comment: The Trustees have not focused on the need for restoration and cost-effective means for achieving it. The acquisition of land should be a choice of last resort. (API)

Response: The Trustees have proposed that only projects that are directly linked to injured natural resources and are necessary to restore these resources are implemented in 1991. Cost-effectiveness is one of several criteria the Trustees are employing in evaluating potential restoration alternatives. If other restoration measures will restore the injured natural resources and services they provided to their pre-spill conditions more effectively and less expensively than through acquisitions, the Trustees may choose those other measures as the alternative, provided that other evaluation criteria do not contradict this decision.

Comment: The Draft Restoration Work Plan lacks information necessary for the public to understand and evaluate the proposed restoration activities. This includes sound technical and scientific information concerning the nature and extent of injuries to the natural resources; an estimate of the amount of the resources that have been impacted or the service level reduction; a description of alternative restoration measures, including natural recovery; and the cost-effectiveness and time associated with each restoration project. This information is crucial to determining whether the proposed restoration measures are reasonable and necessary, regardless of whether the Trustees follow the DOI regulations. The Plan's lack of information concerning the nature and extent of injuries uncovered as a result of the trustees' studies impedes the public's ability to comment or suggest restoration alternatives. (ESC, NWF, API, ESC)

Response: The Trustees believe there is sufficient information to proceed with a limited and modest restoration program in 1991. The majority of the 1991 science studies address information necessary to assess restoration alternatives and to develop restoration projects. Cost-effectiveness is a consideration in determining projects to be implemented in 1991. Detailed restoration study work plans are available to the public.

Comment: Information regarding the extent of the results obtained to date from the studies that were the subject of the 1990 technical support project #3, the status of further study proposals and time frames for future activities is very sketchy. (NWF)

Response: A summary of the effects of the oil spill on natural resources was filed with the Federal District Court in Alaska and made available to the public on April 8, 1991. Until there is a judicially approved settlement or the litigation process concludes, the Trustees have determined that litigation sensitive material will not be released if it might compromise the Trustees' ability to pursue their natural resources damage claims.

Comment: The Draft Work Plan does not assess the cost-effectiveness of a range of restoration options, only the option proposed for implementation. It also fails to take into account a cost-benefit analysis of the proposed restoration measures. The Trustees should not simply consider the cost-effectiveness of restoration alternatives, but they should choose the most cost-effective alternative. (API, ESC)

Response: Cost-effectiveness is a consideration in determining projects to be implemented in 1991 and is one of several factors the Trustees are employing in evaluating potential restoration alternatives. It would be inappropriate to select restoration alternatives based only on cost-effectiveness without regard to ecological and other factors.

Comment: One of the goals of the Draft Work Plan is to "identify life history requirements, limiting factors and environmental processes that are especially sensitive or that may be enhanced." This appears to go beyond the identification of cost-effective restoration measures that would return injured resources to conditions that would have existed but for the spill. (API, ESC)

Response: Life history requirements, limiting factors and environmental processes that are especially sensitive or that may be enhanced are critical components which need to be understood in the development of any restoration plan. Without this information it is impossible to determine if an activity will be effective in restoring a resource. Focusing only on the mechanism of injury may not be as effective or successful for restoration as dealing with other limiting factors. As stated above, cost-effectiveness is one of several criteria the Trustees are employing in evaluating potential restoration alternatives.

<u>Comment</u>: The Trustees' 1990 restoration feasibility studies and those proposed for 1991 appear to be simply basic scientific research projects rather than necessary restoration work. It is premature and inappropriate to undertake these studies prior to documenting injuries. The Trustees should limit their restoration planning activities to those necessary to restore injured resources to conditions that would exist but for the spill. (API, ESC)

<u>Response</u>: Although the quantification of injury to some resources is still being conducted, the Trustees believe there is sufficient information to proceed with a limited and modest restoration program in 1991. Waiting for a complete documentation of all injuries before proceeding with feasibility studies would unnecessarily delay the start of restoration.

<u>Comment</u>: The proposed Protection of Strategic Fish and Wildlife Habitats and Recreation Sites project aims to protect resources not impacted by the spill since it appears to cover non-spill territory. The Plan does not explain why such acquisitions represent the best means of restoring affected resources. This may not be cost-effective compared to other options. This method of protecting these resources may enhance the recovery of injured resources, but land acquisition should be employed as a restoration measure only if it is the sole viable alternative. The Trustees should consider other restoration alternatives in lieu of this project, including natural recovery, the enforcement of Alaska Statute 41.17.010 - 41.17.950 to prevent harvesting of timber in those areas where protection is required, and more direct restoration measures. (API, ESC)

<u>Response</u>: There is an ecological link between the marine and intertidal habitats injured by the oil spill and adjacent uplands. For injured species that use the uplands as well as marine habitats, protecting the upland habitats may facilitate their recovery. Restoring injured resources within the oil spill area is the preferred alternative of the Trustees. If that is not feasible or sufficient, resources in other areas will be considered for replacement restoration.

<u>Comment</u>: There is no justification in the Draft Work Plan for choosing as the preferred restoration alternatives those activities that are proposed. (API)

<u>Response</u>: The Trustees are proposing to conduct restoration activities in 1991 that are linked to injured resources and have a demonstrated ability to restore or improve the habitat for the selected species.

<u>Comment</u>: The areas of injured rye grass communities should be identified and there should be a discussion of the results expected

from natural recovery vis-a-vis transplanting and fertilization. (API, ESC)

Response: This project was dropped from the 1991 program after the spring shoreline assessments failed to identify sites requiring rye grass restoration.

Comment: The Public Information and Education project should be limited to the distribution of information apprising the public of ways to avoid disturbing injured resources. (API, ESC)

Response: Though a variety of media may be used in this project, the main focus is on reducing human impacts to injured resources. Materials will be directed toward specific "user" groups.

Comment: The Salmonid Stock and Habitat Restoration project, and in particular its construction of fish ladders and spawning channels to overcome hydrological barriers, goes beyond restoring the injured resource to its pre-spill condition. It appears to modify pre-existing ecosystem conditions rather than to redress a demonstrable spill induced injury. These measures also are out of character with the wilderness quality of the area for which they are proposed. Given no demonstrated injury to the salmon resource, it is debatable whether this restoration project is even necessary. (API, ESC)

Response: The Summary of Effects of Exxon Valdez Oil Spill in Natural Resources, filed with the U.S. District Court, District of Alaska on April 8, 1991, describes the injury to salmonid stock. The activities proposed in this project work toward restoring species injured by the oil spill. In some cases this will involve enhancing fish populations in streams not injured by the oil spill as a replacement for injured populations. Neither fish habitat enhancement projects, nor other restoration activities will be conducted where they conflict with existing land management direction.

Comment: In order for the public to be able to assess the propriety and cost-effectiveness of the restoration activities, the Final Plan should include: a description of the natural resource sought to be restored; its baseline; the injury it has suffered, including the pathway and the amount of the resource impacted; the locations of the injured resources; an estimate of the foregone benefit or service level reduction caused by the injury and the valuation thereof; an explanation of the manner in which the proposed project will act to restore the injured resource and the amount of time needed to achieve complete restoration; a listing of alternative restoration measures and estimate of time for each to achieve its purpose; and a cost-effectiveness analysis of the restoration alternatives. (ESC)

Response: A final restoration plan will be developed when funds are received from the responsible parties. The final plan may contain the information identified.

Comment: The Trustees should not simply consider the cost-effectiveness of restoration alternatives, but they should choose the most cost-effective alternative. (ESC)

Response: Cost effectiveness is one of many factors the Trustees will use in evaluating restoration alternatives. It is not anticipated that restoration options analysis will use only one of these factors.

Comment: There is no budget outlined in the Plan for restoration implementation projects or any other indication of how these projects will be funded. (NRDC)

Response: Until responsible parties supply resources for restoration projects, funds will be provided by the sponsoring agencies. A projected budget for the implementation projects was published in the March 1, 1991 Federal Register (56 FR 8898) identifying restoration projects.

Comment: The Clean Water Act permits recovery for only those damages stemming from the costs actually incurred in restoration or replacement of damaged natural resources. The Trustees cannot recover lost use and non-use values. (APSC)

Response: In Ohio v. Department of the Interior, 880 F.2d 432 (D.C. Cir. 1989), the court indicated that lost use values may serve as a measure of damages under Section 311 of the Clean Water Act.

Comment: The 1991 plan disregards the restoration implementation project designed to protect strategic fish and wildlife habitats and recreation sites. Acquisition and protection of critical habitats demands immediate action so that restoration options are not foreclosed. (NWF)

Response: The 1991 plan includes an acquisition program as identified in the March 1, 1991 Federal Register (56 FR 8898).

Comment: Objective D's reference to "support of the overall natural resource damage assessment process" is unclear. (NWF)

Response: The ultimate objective of the natural resource damage assessment process is to restore the resources injured by the oil spill. Identifying the costs associated with implementing restoration actions is one aspect of that overall process.

Comment: The descriptions of the results of field studies to date are too cursory to be of use in evaluating the feasibility of individual restoration techniques. (NWF)

Response: The information on the field studies has been provided to give the public an understanding of the kinds of restoration projects the Trustees may pursue. The release of further information regarding the studies may compromise the Trustees' ability to recover damages for injuries to natural resources. (See Response No. 3)

Comment: The 1991 Plan states that "restoration approaches" will be "further evaluated' and that "further implementation activities may be recommended." These remarks are puzzling since no Restoration implementation activities had been undertaken at the time of the Plan's publication. (NWF)

Response: Four restoration implementation projects were identified in the March 1, 1991 Federal Register (56 FR 8898). Portions of the implementation projects, except the beach wild rye grass rehabilitation project, are being implemented this year.

Comment: It is unclear from the 1991 Plan's reference to the August 1990 Progress Report what the Trustees are doing to assess the feasibility of the other restoration options suggested in the matrices of that report. (NWF)

Response: The Trustees are continuing to evaluate all reasonable restoration options, including those identified in the August 1991 Progress Report.

Comment: It is not clear why monitoring should not be implemented prior to resolution of the damage claims. (NWF)

Response: The Trustees are implementing several monitoring studies in 1991, including concentrations of hydrocarbons in mussels and sediments, harbor seals, killer whales, sea otters, harlequin ducks, black oystercatcher, pink salmon and coastal (intertidal) habitats.

Comment: The budgetary information included in the 1991 Plan is puzzling. It is not clear what "restoration science studies" are referred to or how they could cost $4 million since some of them are only being considered in 1991. And the Trustees' statement on page 280 that implementation projects are being considered in 1991 contradicts the fact that no funds are allocated for implementation projects. (NWF)

Response: The restoration planning work group estimated the restoration science studies would cost $3.875 million in 1991. Since that time the cost figures have been revised based on completed study plans. The availability of those study plans was published in the Federal Register on July 31, 1991. The Trustees have made some funds available to conduct direct restoration projects in 1991.

Comment: The scope of the restoration feasibility studies conducted thus far is too narrow. For example, Objective D of F/S 13 is to identify potential alternative methods and strategies for restoration, lost use, populations, or habitat where injury is identified. Yet restoration or acquisition of equivalent resources is required for all injured resources, so this study should not be singled out. (NWF)

Response: The ultimate goal of all damage assessment studies is restoration of injured resources. Not all NRDA studies have reached the stage where development of restoration options is possible. As information concerning injury becomes available the restoration plan will include an evaluation of restoration options for all injured resources to determine the best way to restore them to their baseline level.

Comment: The Trustees should not prioritize restoration needs based on an assumption that restoration funds will not meet those needs because the potentially responsible parties are responsible for the entire liability. Restoration needs must be determined on the basis of damage assessment and economic studies. (NWF)

Response: Until the responsible parties provide funds to restore the injured resources, the Trustees will prioritize restoration needs based on resource injury, information needs, and the availability of funds.

COMMENTS AND RESPONSES CONCERNING THE DRAFT 1991 RESTORATION WORK PLAN

The Trustees received 20 comments on the March 1, 1991 Federal Register notice requesting comments on the draft 1991 Restoration Work Plan. Comments were received from industry, environmental, native and archaeological groups and individuals. This section provides a synthesis of the comments and their respective responses. Comments and responses are organized into two categories, general comments on the 1991 Restoration Work Plan and comments on specific restoration projects.

General Comments on the Work Plan

Comment: No NRDA studies are available to the public so that alternative activities or measures could be suggested.

Response: A summary of the 1991 NRDA studies is provided in the 1991 State/Federal Natural Resource Damage Assessment and Restoration Plan for the Exxon Valdez Oil Spill published April 1991. Additionally, a summary of the effects of the oil spill on natural resources was lodged with the Federal District Court and made available to the public on April 8, 1991.

Comment: Due to lack of data, we cannot understand what has happened or make informed and pertinent comments. Without information on technical and science studies it is impossible to determine if proposed activities are necessary, reasonable, or cost effective.

Response: A summary of the effects of the oil spill on natural resources was lodged with the Federal District Court and made available to the public on April 8, 1991. Detailed study plans and work plans for 1991 science studies and implementation projects were made available to the public on July 31, 1991 (56 Fed. Reg 36150).

Comment: Due to the lack of data available to the public it is, in many cases, impossible to advise the Trustees regarding the optimum restoration approaches. This is a violation of the legal requirements to provide opportunity for public participation in the restoration planning process pursuant to the Administrative Procedures Act, the National Environmental Policy Act, and the Clean Water Act.

Response: The Trustees recognize that due to remaining litigation concerns, the release of natural resource injury data has been restrained. However, as noted in the previous response, a significant amount of information regarding injury has been released to the public. The Trustees recognized the need for meaningful public participation in the restoration planning process in the Memorandum of Agreement between the State and Federal government and intend to comply with all applicable laws.

Comment: Requests for comments must be made early enough so that comments can meaningfully affect the design and conduct of studies. The delay in release of the Draft 1991 Restoration Plan cripples public efforts to comment on the Work Plan and the Trustees' efforts to carry out critical restoration duties.

Response: The Draft 1991 Restoration Work Plan was released to the public with sufficient time to provide meaningful comment on the overall scope of the program. To the extent possible, the Trustees have incorporated public comments into development of the work plan. The Trustees continue to strive toward providing sufficient time for public review so that substantive comments may be incorporated into the design and conduct of the proposed projects and studies.

Comment: Technical workshops discussed in Federal Register notice must be open to scientists and public representatives.

Response: The technical workshops discussed in the Federal Register notice reviewed information from the damage assessment process that is litigation sensitive and therefore the workshops could not be open to the public. However, these workshops were attended by several "outside" experts, competent in the disciplines being discussed. This peer review assured scientific review of any proposed projects.

Comment: Release more data in light of pending settlement.

Response: Additional information on the nature and extent of the effects of the oil spill on natural resources has been made available. Until all litigation concerns are resolved, the Trustees must proceed under the assumption that litigation sensitive material should not be released.

Comment: The draft plan lacks documentation of extent of injuries or cost effectiveness of proposed alternative restoration measures.

Response: Though the full extent of the injuries to natural resources is still being assessed under the Natural Resources Damage Assessment, there is sufficient information to proceed with certain restoration measures in 1991. The detailed study and work plans provide additional information on the costs of the proposed projects.

Comment: Cost of a project can only be chargeable to the potentially responsible party under the NRDA framework if the project constitutes necessary restoration work.

Response: The Trustees have approved only those projects that are directly linked to injured resources and are necessary to restoring the resources.

Comment: The DOI regulations require complete description of the nature and extent of injury, estimate of the amount of resource which has been impacted or service level reduction, valuation of the loss attributable to the injury, description of alternative restoration measures, including natural recovery, and costs and time associated with each restoration alternative.

Response: The DOI regulations are discretionary and the Trustees believe it is inappropriate to disclose fully the value or extent of injury at this time. Alternative restoration measures were evaluated before selecting any restoration activity.

Comment: The DOI regulations require selection of the cost-effective restoration alternative.

Response: Though the Trustees are not required to follow the DOI regulations, cost-effectiveness was a consideration in determining projects to be implemented in 1991.

Comment: DOI regulations provide the standards under which proposed restoration activities must be evaluated. Regulations require that the work plan be judged by its ability to identify the necessity for, and reasonable costs of, restoration of injured resources. The final plan must follow procedures in 43 CFR 11.81 and 11.82. To comply with the DOI regulations and to allow for meaningful review, the final plan must provide specific information.

Response: As stated above for the implementation projects, the Trustees are not required to follow the NRDA regulations. However, the Trustees believe that the selection process for the implementation projects is broadly consistent with the NRDA regulations.

Comment: The restoration studies have been or are being undertaken before there has been any determination or quantification of injury to the resource in question. It is premature to conduct restoration feasibility studies before the injury is first quantified and understood.

Response: Though the formal quantification of injury to some resources is still being conducted, the studies proposed under the restoration program in 1991 have been reviewed to ensure linkage to the effects of the oil spill. Feasibility studies serve to determine the effectiveness of a restoration method that may be applied later.

Comment: What is the relationship between the restoration process described in this notice and the organizational structure and process to be employed under the Memorandum of Agreement governing the use of the settlement money? How will the settlement affect EPA's role in the restoration planning process?

<u>Response</u>: The organizational structure that will implement any settlement has not been developed. Until an organizational structure is agreed to by the Trustees it is premature to speculate on the relationship.

<u>Comment</u>: The prospect that the settlement may provide money to finance restoration activities should not short-circuit or distort the essential program of scientific studies of the on-going damage to the Prince William Sound caused by the oil spill.

<u>Response</u>: Though restoration is the ultimate goal of the NRDA process, the identification and quantification of injury will proceed to a logical conclusion. Continuing to monitor injuries may be an appropriate component of a restoration program.

<u>Comment</u>: More money is required for needed restoration. The proposed settlement may sound like it provides a lot of money for Prince William Sound, as much as $1.1 billion, and the terms specifying uses for the money appear to limit the spending to needed restoration projects. However, after closer review a very different picture emerges.

<u>Response</u>: The 1991 Restoration Work Plan has been developed separately from any proposed settlement and work on it will continue. Trustee agencies funded the restoration activities proposed in the work plan.

<u>Comment</u>: We generally support the criteria for evaluating restoration alternatives. However, we urge that those criteria be amended to provide that when acquisitions are an alternative they be subjected to an additional criterion such as, "the degree to which the acquisition addresses conservation of lands that are important for a multiple set of habitat and use and nonuse values, where those habitats or values face a clearly identifiable near or long term risk."

<u>Response</u>: Not all of the criteria for identifying habitats appropriate and suitable for acquisition have been developed. If areas meet the initial evaluation factors for restoration, additional criteria will be applied to identify and prioritize suitable sites. The suggested criterion will be evaluated for inclusion into the selection process.

<u>Comment</u>: We believe that the restoration planning process should not just consider the cost effectiveness of the restoration alternative but require selection, as do the DOI regulations, of the cost-effective alternative. Furthermore, the reasonableness of the cost of a restoration project must be evaluated through a cost-

benefit analysis.

Response: Cost-effectiveness is one of seven factors the Trustees will employ in evaluating potential restoration alternatives. A cost benefit analysis has been conducted on restoration implementation projects proposed for 1991 that involve market resources.

Comment: The Draft Plan states that a "key goal of the restoration planning activities is to identify life history requirements, limiting factors, and environmental processes that are especially sensitive or that may be enhanced." These goals seem to go beyond identifying cost-effective restoration measures which will return the injured resources to their baseline.

Response: Life history requirements, limiting factors and environmental processes that are especially sensitive or that may be enhanced are critical components which need to be understood in the development of a restoration plan. Without this information it is difficult to determine if an activity may be effective in restoring injured resources.

Comment: We are concerned about use of the sixth criterion for evaluating restoration projects, i.e. the "reasonableness of cost of the restoration project in light of the value or ecological significance of the resource." Comparing restoration costs with benefits is difficult, and not authorized under the recent Ohio decision, which required restoration costs to be recovered unless they were "grossly disproportionate" to the value of the resource lost.

Response: The wording of the sixth criterion is not inconsistent with the Ohio decision. The Trustees intent is to provide some reasonable measure of the cost of restoration options relative to resource values that would help determine if a restoration option is grossly disproportionate to the value of the resource lost.

Comment: The restoration planning process proposed in the Draft Work Plan fails to require selection of the cost-effective restoration alternative and limit restoration projects to measures required to restore the injured resources to the conditions which would exist absent a spill.

Response: Section II.A.1. of the March 1, 1991 Federal Register notice identifies cost effectiveness as one of the factors the Trustees intend to use in evaluating potential restoration alternatives. The intent of the restoration plan, and any alternative restoration options chosen, is to return the injured resources to their baseline condition.

Comment: Though a project may be desirable from the viewpoint of environmental conservation or protection, the cost of a project can only be chargeable to the potentially responsible party under the NRDA framework if the project constitutes necessary restoration work.

Response: The Trustees will only implement projects considered to be restoration work necessary to return the injured resources toward their baseline condition.

Comment: Alaska Trustees want to dismantle the science program. According to recent press reports, the Alaska trustees are seeking to end the damage assessment and restoration studies so that more funds will be available to pay for restoration implementation. The science program must guide restoration planning. It is impossible to restore the ecosystem unless there is knowledge about the nature and extent of injuries.

Response: The Trustees intend to continue the damage assessment studies until they are satisfied the extent and nature of injury is fully documented and understood. Their overall objective is to restore the injured resources and toward that end will continue to emphasize attaining the information necessary to achieve restoration as the damage assessment portion of the process winds down.

Comment: Additional projects that would benefit the Chugach Region should be looked at for funding out of the restoration process include a shellfish mariculture test program in Tatitlek, Chenega Bay and Eyak; the English Bay sockeye salmon enhancement project; the Port Graham pink salmon hatchery and a small fish hatchery located in the Seward Lagoon.

Response: These projects, in addition to other projects proposed by Trustee Agencies or members of the public, will be evaluated as part of a continuing restoration program, provided that injuries are documented.

Comment: I would like to propose that the restoration program fund an $80,000 investigation of third and fourth year recovery of beach and intertidal ecosystems at Green Island RNA.

Response: See response above.

Comment: Remove introduced predators (foxes, rats, etc.) from islands where they have severely reduced or destroyed seabird colonies would be a good form of mitigation.

Response: This proposal will be evaluated as part of a continued restoration program. See response above.

Comment: I suggest that you consider measures that would restrict visitation around certain seabird colonies where reproductive rates have not returned to normal by 1990.

Response: The Public Information and Education project identified in section III B of the Federal Register notice works toward encouraging voluntary compliance with this proposal. The Trustees will evaluate the need for additional management measures to restrict human interference as part of a continuing restoration program.

Comment: I suggest that the work plan describe measures to restore murre populations. I am particularly interested in your decision to fund feasibility studies for restoration on murrelets and harlequins, but not on murres. Your work plan should clearly identify the process you used to fund certain feasibility studies, but not others.

Response: Alternative restoration measures for murres have not been fully identified or evaluated. Restoration measures identified for 1991 are those where sufficient information is available to determine whether restoration projects or science studies are appropriate. In 1991 murres will continue to be studied as part of the damage assessment program.

Comment: We urge the Trustees to devote their energies to developing restoration and acquisition programs to address the significant injuries to sea and river otters, harbor seals, sea lions, murres, intertidal and subtidal habitats.

Response: These species are the subject of continued damage assessment studies or restoration science studies. The end point for these studies is the identification of restoration options. The sea lion damage assessment study for 1991 is funded only for the completion of data analysis and final report preparation.

Comment: The Bird Treatment and Learning Center has recently established a trust fund and is eligible and well qualified to receive funds to accomplish, as appropriate, objectives of the Exxon Oil Spill settlement.

Response: Contracting with organizations or individuals outside of Trustee Agencies may be an appropriate method of achieving restoration objectives and will be considered as part of an ongoing restoration program.

Comment: There were projects started by many villages during the year 1989 and because of the spill were not able to either continue these projects or apply for continued funding. I would like to see those projects completed and funding made available to apply for and finish incomplete projects such as community halls, youth shelters, etc.

Response: Restoration funds can only be used to restore injured natural resources or their services.

Comment: We have several product lines that should be considered in the Valdez cleanup project. All of our chemical products are nonflammable, biodegradable, nonfuming, noncorrosive, noncaustic, and contain no hazardous products.

Response: These chemicals appear to be more appropriate for the response activities than for restoration. Though the Trustees do not foresee the need for further cleanup as part of the restoration process, should there be need for these types of chemicals, they would be evaluated by the appropriate response personnel.

Comment: I believe that it is important and would be very useful to restoration goals to initiate a much more comprehensive and explicitly integrated long-term monitoring program on the condition (health) of the interacting marine, intertidal, and shoreline resources of Prince William Sound and southcoastal Alaska.

Response: A comprehensive long-term monitoring program may be developed as part of a final restoration plan.

Comment: I strongly encourage immediate implementation of as broad a range of monitoring studies as possible. As soon as possible, all pertinent data must be shared throughout the scientific community.

Response: Monitoring activities are proposed as part of the 1991 science program. A comprehensive monitoring program also may be developed as part of a final restoration plan. Data will only be released if they do not jeopardize the Trustees' ability to pursue damage claims in a judicial forum.

Comment: We urge the Trustees to limit consideration of natural recovery as one of the routine factors used to determine restoration options. Any use of natural recovery in analyzing restoration alternatives should place a heavy emphasis on the burden of proving, through strong scientific evidence, that natural recovery would occur subsequent to the spill. Uncertainties about future recovery of the ecosystem should be resolved in favor of active restoration programs.

Response: Natural recovery will be analyzed in the same context as any other restoration option and the rate of natural recovery will be considered in making decisions regarding restoration alternatives and priorities.

Comment: It would be beneficial to see continued subsistence foods testing and monitoring, restoration of natural resources like fish, clams, mussels, sea urchins, herring roe, and/or enhancement of these and other natural resources.

Response: Food testing of subsistence resources is continuing during 1991 as part of the Oil Spill Health Task Force program. In addition, monitoring studies have been initiated for other resources used for subsistence purposes to determine their recovery. As restoration options for these resources are identified they will be evaluated as part of a continuing restoration program.

Comment: At the present time, there is no emphasis being placed on the dependence of communities on damaged subsistence resources. When determining priorities for project sites to be funded, consideration should be given to he proximity of such projects to communities where there are subsistence uses.

Response: Resource uses, such as for subsistence harvest, will be a consideration in determining which restoration projects will be included in a final restoration plan.

Comment: There is a need for continuing testing of subsistence foods and an information program to disseminate the information. Data on the toxicity of subsistence foods as well as the long term health risks associated with consumption of contaminated foods is necessary.

Response: The Oil Spill Health Task Force program is conducting studies on the toxicity of subsistence foods and disseminating the information.

Comment: The draft 1991 Restoration Plan indicates that no restoration feasibility studies on cultural resources were conducted during 1990. Nor does the draft plan identify cultural resources as part of the restoration study plans contemplated for 1991. It is important that future restoration plans include appropriate restoration planning activities for cultural resources.

Response: Impacts to cultural resources are being studied under the current damage assessment process. As information on the extent and nature of injury to cultural resources becomes available, restoration options will be evaluated.

Comment: Restoration planning activities that should be considered to restore cultural resources damaged by the oil spill include studies focusing on the feasibility of techniques for removing oil from contaminated organic materials to permit radiocarbon dating, stabilization of sites damaged from erosion or pedestrian traffic, enhanced public education or law enforcement and continued inventory of areas for cultural sites.

Response: The Trustees will consider these suggested activities once the nature and extent of damages to cultural resources is known.

Comment: Removal and relocation of some cultural artifacts with appropriate documentation may be necessary on some sites. These activities must be coordinated closely with the Alaska State Historic Preservation Officer, Alaska Native Corporations and the appropriate land managers.

Response: The Alaska State Historic Preservation Officer and land managers will be involved in any activities that may affect cultural resources. Whenever appropriate, Alaska Native Corporations and appropriate land managers will also be consulted.

Comment: We remain concerned about the lack of assessment and restoration of cultural/archeological resources and compliance with Federal Historic Preservation Laws. We urge the funding of planning and projects to include these natural resources.

Response: A major archeological resource study is being conducted this year under the damage assessment process. Restoration options for cultural and archeological resources will be evaluated and carried out as funds become available.

Comment: The Restoration Plan sometimes includes and sometimes erroneously excludes the value of services provided by natural resources. Section IIA.1.a. should be rewritten as "the nature and extent of natural resources and services injured, lost or destroyed. "Services" should be incorporated into the objective and identification of areas to be protected in Restoration Project No. 4.

Response: The Trustees agree that the services provided by a natural resource are a component of their value.

Comment: We support the approach in the plan that restoration activities should benefit "multiple rather than single species or resources", but suggest that this be reworded as "multiple species, resources, and services, rather than single species, resources or services."

Response: The Trustees intend to take an ecosystem approach to restoring the oil spill area and select projects that benefit multiple resources and their services whenever possible.

Comment: Overall the plan seems to be very heavily directed toward office activities. The bulk of the 1991 plan is the Planning Process (II A), Restoration Feasibility Studies (II B), Technical Support Projects (II C), and Restoration Planning Activities (III A) which are all similar in the exclusive inclusion of state and federal personnel and their assessment and analysis of information that has not been made public.

Response: The majority of the 1990 and 1991 Restoration Feasibility Studies, Technical Support Studies and Restoration Implementation Activities are field projects.

Comment: In section III A there is a reference to "applying knowledge or toxicological effects derived from the oil spill literature." Is that the published literature, unpublished literature or both?

Response: Both the published literature and unpublished literature will be reviewed in determining restoration options.

Comment: The restoration work plan does not identify where restoration would occur. You should not be swayed into placing all resources in Prince William Sound. Although the area was hard hit, much if not most of the wildlife damage occurred beyond Prince William Sound. You should recognize that most of the seabirds were killed along the Kenai Peninsula and Kodiak Island. I suggest that restoration efforts for seabirds be focused on areas outside Prince William Sound.

Response: The entire oil spill area is being evaluated in determining restoration options.

Comment: Major parts of the proposed restoration projects appear to be directed toward habitats not affected by the spill.

Response: The Trustees disagree. The 1991 restoration program was developed with a direct link between injured resources and proposed restoration activities.

Comment: It appears that the Trustees failed to analyze what measure of restoration is necessary; instead they are tailoring the restoration program to the small amount of funds projected to become available in the short term from the settlement. Instead of attempting to decide the extent of restoration and acquisition that is possible with the funds recovered through settlement, the Trustees are under an obligation to determine the costs of restoration, replacement, and acquisition necessary to return the ecosystem to full productivity and diversity, plus the lost value of the resources. Then, the next step is to ensure that funds are sought to fulfill these obligations.

Response: It is not possible, based on present information, to develop a comprehensive restoration program. In addition, until funds are provided by the responsible parties the Trustees are carrying out the restoration program with agency funds. The normal budgeting appropriation process determines the amount of funds available in any year. The restoration planning process will continue to identify a suite of restoration options, and associated costs, necessary to restore the ecosystem to pre-spill condition.

Comments Relating to Specific Restoration Projects

Restoration Project No. 4 - Protection of Strategic Fish and Wildlife Habitats and Recreation Sites

Comment: Restoration project number 4 should focus on fish and wildlife habitats and recreation areas, rather than fish and wildlife habitats and recreation sites.

Response: Recreation sites will probably vary in size and will be determined on a case-by-case basis.

Comment: The Restoration Planning Working Group should initiate a project to determine if landowners of land specifically or generally identified by the public are interested in receiving financial benefits in return for conservation of their lands.

Response: As part of the planning toward restoration, areas identified by the public may be evaluated to determine their potential for possible acquisition. The willingness of the landowner to participate in an acquisition program will play a critical role in the process.

Comment: The geographic scope of the acquisitions project should not be limited to the oil spill area. A better criterion would be "to acquire or conserve lands that are important for a multiple set of habitat, use or nonuse value services where those habitats or values face a clearly identifiable near or long term risk."

Response: Restoring resources injured within the oil spill is the first priority of the restoration program. Areas outside the spill zone that are important for injured resources and services will also be considered.

Comment: Acquisition of land for federal management should only be developed if, in the judgment of the agency acting as trustee, it constitutes the only viable method of obtaining the lost services.

Response: The cost effectiveness criterion identified in II. 1. a. in the Federal Register will be applied to this project as well as all others. If other restoration measures restore the lost services or resources more effectively and less expensively than acquisitions they will generally be used.

Comment: No information is given to explain the need to protect habitats or recreation sites outside the area impacted by the oil spill in order to address injuries related to the oil spill.

Response: Effort will be made to protect habitats and recreation sites within the oil spill area before replacement or equivalent sites are considered.

Comment: There is serious concern as to whether this activity can be justified as cost effective compared to natural recovery or other more direct restoration measures.

Response: Cost effectiveness is a criterion that will be applied to this project.

Comment: The project appears to be focused primarily on protecting resources (e.g., uplands) that were not impacted by the oil spill. This is evidenced by the fact that the project's scope appears not to be limited to the oil spill area. Acquisition of land for federal management should only be considered if it is the sole viable restoration alternative.

Response: There is a clear and important ecological link between the marine and intertidal habitats injured by the oil spill and adjacent uplands. For injured species that use the uplands as well as marine habitats, protecting the upland habitats may facilitate their recovery. Restoring injured resources within the oil spill area is the preferred alternative of the Trustees.

Comment: Studies 4 & 5 from 1990 should be expanded to expedite the identification of critical habitats as targets for acquisition and land use management changes. These studies should be expanded to include all species that were damaged by the spill, with priority given to those species identified as being most severely impaired.

Response: As more information from the damage assessment studies becomes available, it will be used to expand, as needed, any ongoing studies or identify new restoration activities.

Comment: Proposed changes in land use status should include changes in designations of existing federal and state lands.

Response: The Trustees are establishing a process to evaluate existing federal and state land management plans and status and identify possible changes to facilitate restoration of injured resources.

Comment: Where important lands have already been identified for acquisition, such acquisition should begin this summer. Any funds available from the settlement should be devoted to these uses on a priority basis. Federal and state funds should be used for such acquisition subject to later reimbursement if funds from a settlement are not immediately available.

Response: The Trustees have been utilizing appropriated funds to carry out the damage assessment and restoration programs and insufficient funds were appropriated to acquire upland resources in 1991. In addition, the Trustees must first focus on identification and evaluation of acquisition options.

Comment: Acquisition should not be limited to a "willing seller" basis. Eminent domain, where consistent with applicable federal and state law, should be used to acquire critical resources in private lands where the existing owner is not willing to sell.

Response: The Trustees do not anticipate a need to use eminent domain to extinguish private property rights under the restoration program.

Comment: We are concerned with the "no action" option where it is most appropriate to allow "natural" recovery to proceed. If direct restoration or replacement is not feasible or appropriate, then acquisition becomes the preferred option.

Response: All options, including natural recovery, will be evaluated on a case-by-case basis.

Comment: I encourage you to consider purchase of critical wildlife property from the private sector and place it [in] protective status in the public domain. Examples are: Purchase Gull Island in Kachemak Bay; purchase inholdings and timber rights in Kachemak Bay State park; purchase or cause to be set aside the intertidal and supratidal lands at the base of the Homer Spit, including portions of Mud Bay.

Response: These examples, as well as others identified by the public or agencies, will be evaluated as part of any acquisitions program.

Comment: Purchase inholdings in Kachemak Bay State Park.

Response: See comment above.

Comment: Purchase old growth forest habitat in PWS and the GOA oil spill area. These areas are important nesting habitat for the Marbled Murrelets.

Response: See comment above.

Comment: Purchase privately owned seabird colonies. Thirty Three seabird colonies are recommended (listed) for purchase.

Response: See comment above.

Comment: Villages that have expressed an interest in the purchase of equivalent resources would need to be approached individually and dealt with on a case-by-case basis.

Response: The Trustees agree and intend to discuss potential acquisitions individually with private landowners should the decision be made to seek acquisition of private lands.

Comment: Implementation project 4, acquisition of habitat, warrants the highest priority and immediate action.

Response: The priority for implementation projects is determined on a case-by-case basis. At this time the Trustees have not determined priorities for these or other science studies.

Restoration Project No. 1 - Beach Wildrye

Comment: The specific locations of the injured rye grass communities should be identified in the Final Plan, and a comparison of the results expected from natural recovery and transplanting/fertilizing should be provided.

Response: After further investigation and assessment, it was determined that implementation of this project was not necessary for restoration of injured rye grass in the spill area.

Comment: Use of fertilizer to promote beach grass restoration should be done with caution, so that excess nutrients are not a problem on a localized water quality basis. Consideration should be given to the use of organic fertilizers, where nutrients are less soluble, thus less likely to run off into receiving waters, and more likely to be retained for long-term benefit to the plants being restored.

Response: Though implementation of this project was determined not to be necessary at this time, this comment will be taken into consideration in the design of any future projects that involve fertilizers.

Restoration Project No. 3 - Salmonid Stocks and Habitat Restoration

Comment: I would urge you to include a longer cycling salmon, such as the chum salmon, into the studies and restoration plans.

Response: Chum salmon are included in the fish habitat improvement project.

Comment: Section III B (3.) describes projects that are incompatible with the existing management schemes of the Kenai Fjord National Park and the Kachemak Bay State Wilderness Park. Am I correct in assuming that these areas will then be precluded from these recovery remedies?

Response: Fish habitat enhancement projects and other restoration activities will be reviewed to ensure compliance with laws and management plans before they are implemented. In some cases, changes in the management plans may be recommended.

Comment: Section III B (3.) has a funding level that is grossly insufficient to effect recovery for the valuable subsistence, commercial and recreational fisheries that were damaged by the oil spill. The loss of resource is different from the loss of income derived from the resource.

Response: The funding identified in the Federal Register notice is an estimate of the funds necessary to carry out a program in 1991 only and does not reflect fish restoration projects that may take place in the future.

Comment: It appears that this project contemplates activities which go beyond restoration of an injured resource to its baseline levels. Additionally, these measures are not consistent with the wilderness character of the area.

Response: The activities proposed in this project will work toward restoring species injured by the oil spill. In some cases this may involve enhancing fish populations in streams not injured by the oil spill as a replacement for injured populations. Activities will be carried out consistent with land management plans and policies, including wilderness.

Restoration Project No. 2 - Public Information and Education for Recovery and Protection of Alaska's Marine and Coastal Resources

Comment: The project should be limited to distributing information on how to avoid disturbing the injured resources.

Response: The primary purpose of the project is to reduce human impacts on injured resources. The Trustees believe that through public education people can better understand the effects of their actions on injured wildlife.

Comment: This project could be expanded to include cultural/archeological resources. The Needs and Objectives should be amended to read "The Exxon Valdez oil spill caused direct and indirect injury to the marine birds, mammals and archeological sites of southcentral Alaska. The purpose of this project is to make users of the area aware of the changes to the ecosystem resulting from the oil spill and to lessen the potential for additional harmful human disturbances". The Methods section should then be expanded to include cultural/archeological resources.

Response: Although the extent of injury to cultural/archeological resources is still being determined by the NRDA process, the Trustees are interested in fully informing the public about ways to reduce impacts to injured resources. Consideration will be given to including the suggestion in the project.