Draft Environmental Impact Statement

for the *Exxon Valdez* Oil Spill Restoration Plan

Prepared by:

***Exxon Valdez* Oil Spill Trustee Council**

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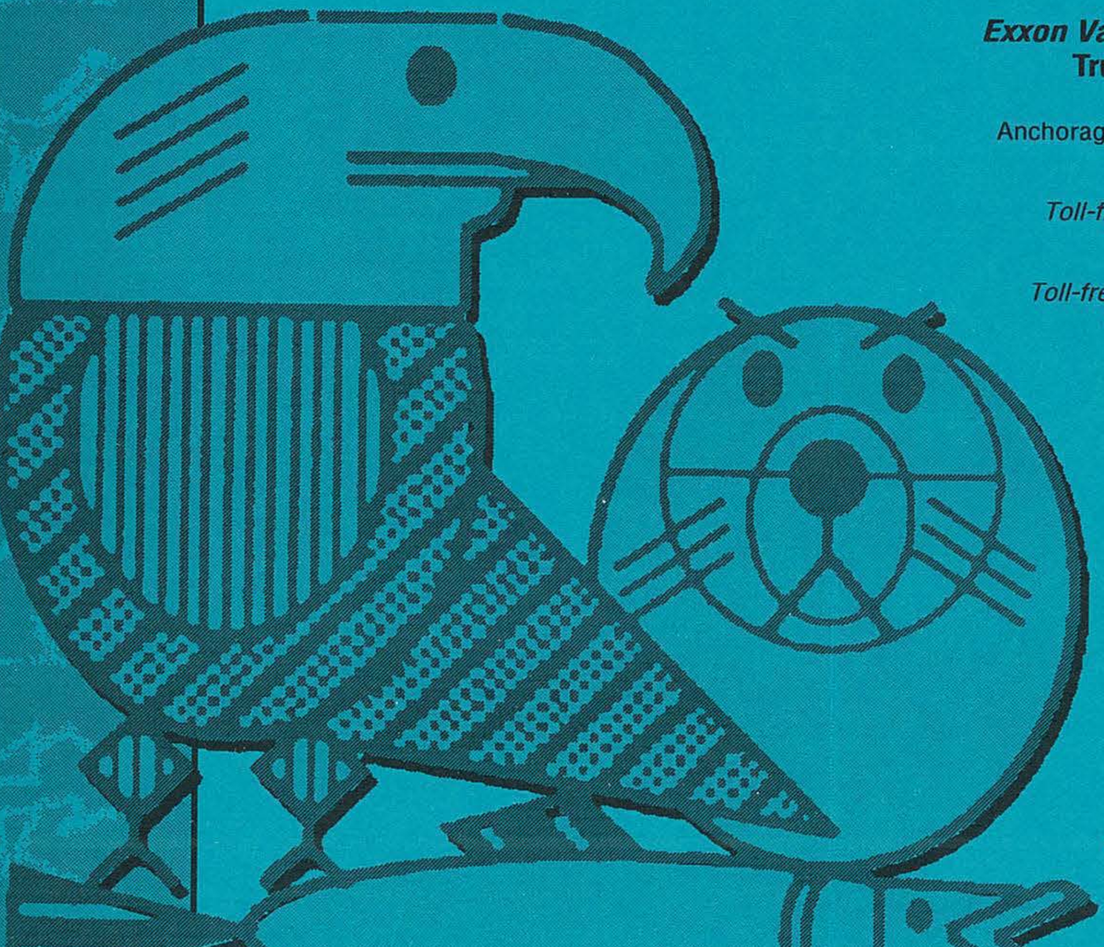


June 1994

Exxon Valdez Oil Spill Trustee Council

Restoration Office

645 G Street, Suite 401, Anchorage, Alaska 99501-3451

Phone: (907) 278-8012 Fax: (907) 276-7178

June 1994

Dear Interested Citizen:

We are soliciting your review and comments on this *Draft Environmental Impact Statement* for the *Exxon Valdez Oil Spill Restoration Plan.* The comment period will extend for 45 days during June and July. Open House meetings to take public comments are scheduled as follows:

Date	Community	Time	Address
June 27, 1994	Anchorage	4:00-8:00 PM	EVOS Trustee Council Restoration Office 645 G Street, Suite 100
June 29, 1994	Seward	4:00-8:00 PM	Kenai Fjords National Park Visitor's Center 1212 4th Ave., Small Boat Harbor
July 1, 1994	Homer	4:00-8:00 PM	City Council Chambers 491 E Pioneer Ave.
July 5, 1994	Kodiak	4:00-8:00 PM	Alaska Dept. of Fish and Game Conference Room 211 Mission Rd.
July 7, 1994	Cordova	4:00-8:00 PM	U.S. Forest Service Third Floor Conference Room 612 Second Street
July 19, 1994	Valdez	4:00-8:00 PM	City Council Chambers 212 Chenega Ave.

Please send written comments to:

> *ExxonValdez* Oil Spill Trustee Council
> Attn: EIS Comments
> 645 G Street, Suite 401
> Anchorage, AK 99501-3451

To conserve paper and save on postage costs, this document is also available on computer diskette. Contact the Oil Spill Public Information Center at the above address or by calling 907/278-8012, toll-free within Alaska at 1-800-478-7745, from outside Alaska at 1-800-283-7745 to request a diskette.

This is an important opportunity for you to comment on the restoration approaches the Trustee Council will be using. We look forward to receiving your comments.

Sincerely yours,

Exxon Valdez Oil Spill Trustee Council

Draft Environmental Impact Statement

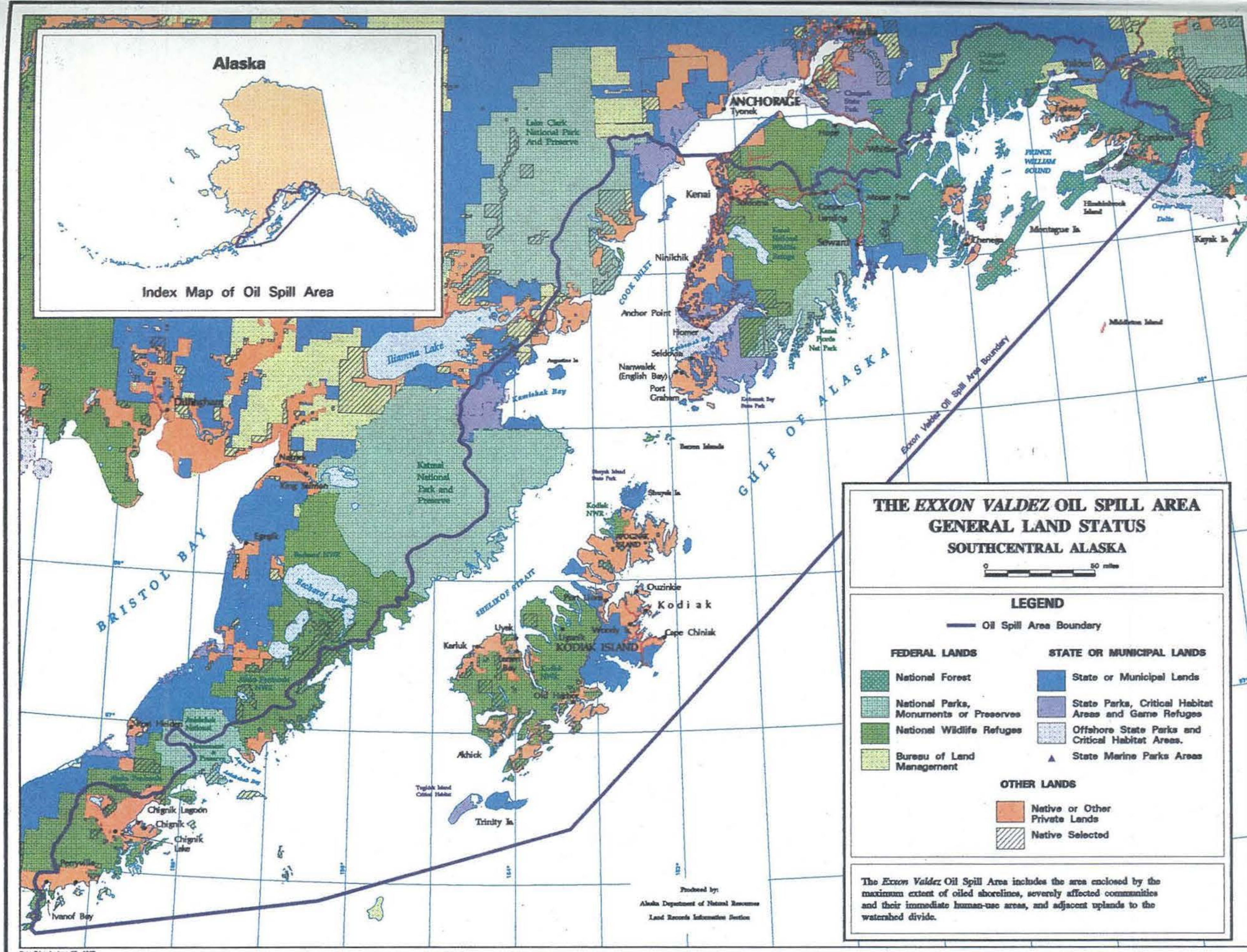
Exxon Valdez Resroration Plan

Lead Agency	U.S.D.A. Forest Service Alaska Region
Responsible Officials	The Secretary of Agriculture The Secretary of Commerce The Secretary of the Interior
For Further Information	Rod Kuhn EIS Project Manager *Exxon Valdez* Restoration Office 645 G Street, Suite 401 Anchorage, AK 99501-3451 907 278-8012

Abstract

The *Exxon Valdez* Trustee Council issued a draft Restoration Plan in November of 1993. The draft Restoration Plan provides long-term guidance for restoring the resources and services injured by the *Exxon Valdez* Oil Spill of March 24, 1989. This draft Environmental Impact Statement (DEIS) analyzes the potential environmental impacts of the draft Restoration Plan as the Proposed Action - Alternative 5, and four other alternatives that provide different policies and emphasis than the proposed action. The alternatives are: (1) No Action, normal agency management would occur, but no restoration actions would be funded from by the Trustees; (2) Habitat Protection, habitat acquisition and protection actions would be the only restoration actions pursued; (3) Limited Restoration, a mix of habitat protection, monitoring and research, and general restoration actions would be implemented for the most severely injured resources and services; (4) Moderate Restoration, habitat protection, monitoring and research, and general restoration would be used to restore all injured resources and services; (5) the Proposed Action (Draft Restoration Plan), uses all three restoration categories to restore the injured resources and services, but places a greater emphasis on monitoring and research than any other alternative, while still emphasizing habitat protection; general restoration actions would be used primarily for resources and services that are still not recovering.

Reviewers should provide the Trustees with their comments during the review period of the draft environmental impact statement. This will enable the Trustees to analyze and respond to the comments at one time and to use information acquired in the preparation of the final environmental impact statement, thus avoiding undue delay in the decisionmaking process. Reviewers have an obligation to structure their participation in the National Environmental Policy Act process so that it is meaningful and alerts the agency to the reviewers' position and contentions. Vermont Yankee Nuclear Power Corp. v. NRDC. 435 U.S. 519, 553 (1978). Environmental objections that could have been raised at the draft stage may be waived if not raised until after completion of the final environmental impact statement. City of Angoon v. Hodel (9th Circuit, 1986) and Wisconsin Heritage, Inc. v. Harris, 490 F. Supp. 1334, 1338 (E.D. Wis. 1980). Comments on the draft environmental impact statement should be specific and should address the adequacy of the statement and the merits of the alternatives discussed (40 CFR 1503.3).



THE EXXON VALDEZ OIL SPILL AREA
GENERAL LAND STATUS
SOUTHCENTRAL ALASKA
0
50 miles
LEGEND
Oil Spill Area Boundary
FEDERAL LANDS
National Forest
National Parks, Monuments or Preserves
National Wildlife Refuges
Bureau of Land Management
STATE OR MUNICIPAL LANDS
State or Municipal Lands
State Parks, Critical Habitat Areas and Game Refuges
Offshore State Parks and Critical Habitat Areas.
State Marine Parks Areas
OTHER LANDS
Native or Other Private Lands
Native Selected
The Exxon Valdez Oil Spill Area includes the area enclosed by the maximum extent of oiled shorelines, severely affected communities and their immediate human-use areas, and adjacent uplands to the watershed divide.
Alaska
Index Map of Oil Spill Area
ANCHORAGE
Tyonek
Kenai
Ninilchik
Anchor Point
Homer
Seldovia
Nanwalek
(English Bay)
Port
Graham
Seward
Chenega
Montague Is.
Hinchinbrook Island
Kayak Is.
Middleton Island
PRINCE WILLIAM SOUND
COOK INLET
GULF OF ALASKA
Exxon Valdez Oil Spill Area Boundary
Iliamna Lake
Kamishak Bay
Augustine Is.
Barren Islands
Lake Clark National Park And Preserve
Katmai National Park and Preserve
Dillingham
Naknek
King Salmon
Egegik
Becharof Lake
BRISTOL BAY
SHELIKOF STRAIT
Shuyak Is.
Kodiak NWR
Ouzinkie
Kodiak
Cape Chiniak
Uyak
Karluk
KODIAK ISLAND
Old Harbor
Akhiok
Trinity Is.
Port Heiden
Chignik Lagoon
Chignik
Chignik Lake
Perryville
Ivanof Bay
Produced by:
Alaska Department of Natural Resources
Land Records Information Section

Summary

Summary

Exxon Valdez Oil Spill Restoration Plan Draft Environmental Impact Statement

Background of the Proposed Action

The *Exxon Valdez* Oil Spill

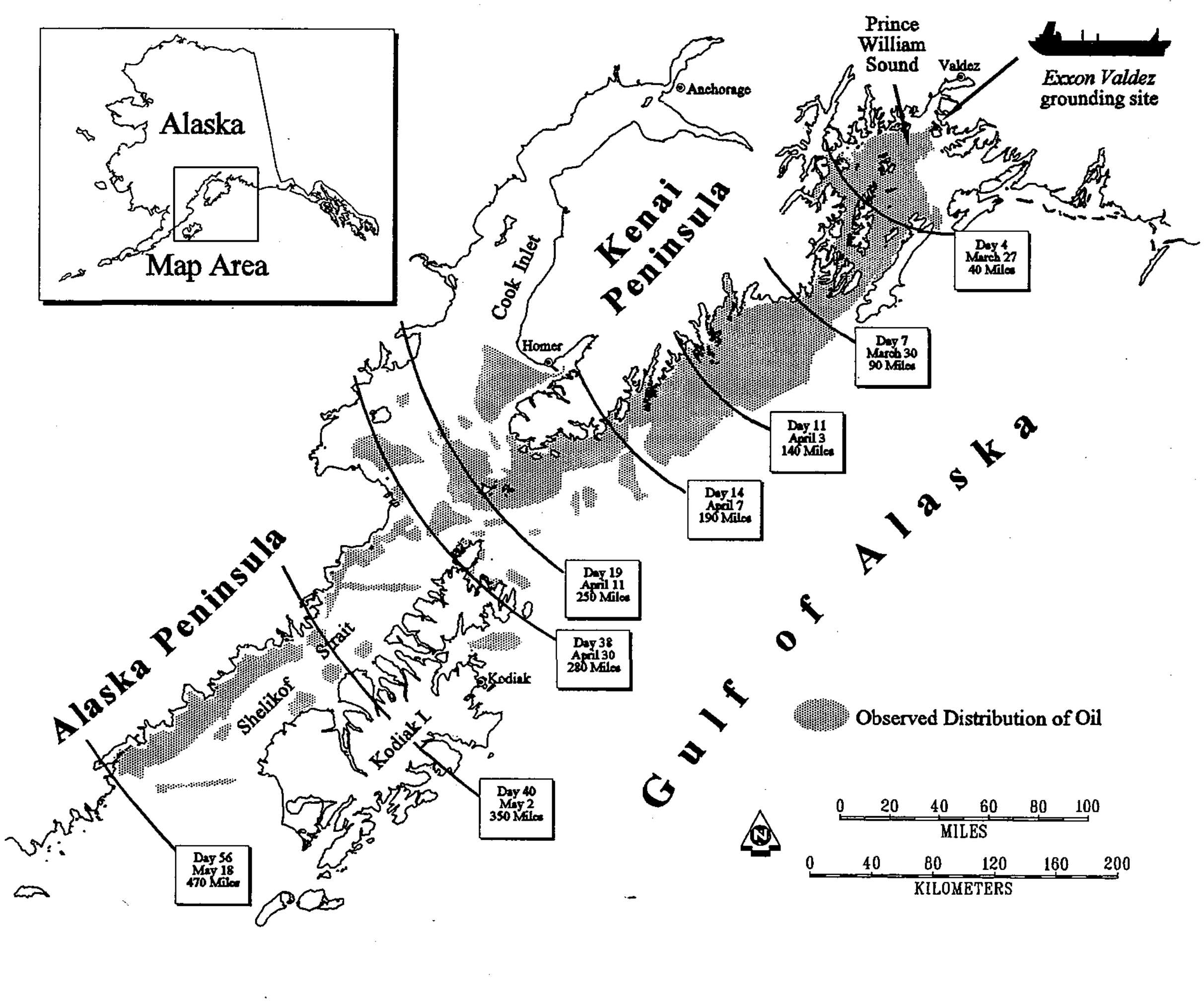
On March 24, 1989, the tanker *Exxon Valdez* ran aground on Bligh Reef in Prince William Sound, Alaska, causing the largest tanker oil spill in U.S. history. Approximately 11 million gallons of North Slope crude oil subsequently moved through southwestern Prince William Sound and along the western coast of the Gulf of Alaska, causing injury to both natural resources and services (human uses) in the area. Figure S-1 shows the extent of surface oiling as recorded by satellite imagery and aerial observation at the time of the spill.

Because the weather for the first 3 days following the spill was calm, the oil did not move from the immediate area, although the slick expanded during that time. On the fourth day, however, a major storm moved oil through Prince William Sound to the southwest, where it reached beaches on Little Smith, Naked, and Knight Islands. Within 6 days of the spill, oil had reached the Gulf of Alaska. The leading edge of the oil slick reached the Chiswell Islands and the Kenai Peninsula by April 2 and the Barren Islands by April 11. By the middle of May 1989, some 470 miles of shoreline had been oiled, including parts of Prince William Sound, the Kenai Peninsula, the Kodiak Archipelago, and the Alaska Peninsula. During the summer of 1989, oil from the spill was found as far as 600 miles from Bligh Reef, the site of the grounding.

Immediately following the spill, efforts to clean the oiled beaches and to assess the extent of the damage began. Federal agencies, the State of Alaska, private citizens, and the Exxon Corporation and its contractors mobilized treatment efforts on the oiled shorelines. In the water, containment booms were used to corral the oil. On the beaches, high-pressure hot-water washing, manual rock washing, and bioremediation techniques were among the methods used to remove oil from the shoreline.

Scientists initiated studies during the summer of 1989 to determine the nature and extent of injury to area plants and animals. Although studies began as soon as possible following the spill, some opportunities to gather data were lost; the shortage of resources and the difficulty of the work made immediate response impossible. In 1989, 72 studies were carried out in 10 categories of natural resources and related services. The number of studies in progress has decreased steadily since 1989, but research is continuing on the effects of residual oil in the ecosystem and on the natural recovery process.

Figure S-1



Purpose of the Proposed Action

The purpose of the proposed action analyzed in this draft environmental impact statement (DEIS) is to restore, in so far as possible, the injured natural resources and thereby the services they provide affected by the *Exxon Valdez* oil spill (EVOS). The purpose of this document is to analyze the effects of proposed uses of the remaining funds (approximately $620 million as of February 1994, after final reimbursements) in accomplishing the mission of the Trustee Council. The Trustee Council previously completed project-specific National Environmental Policy Act (NEPA) documentation on the time-critical restoration projects undertaken in the 1992 through 1994 Annual Work Plans. This DEIS will analyze the 1995 through 2002 program under which the Annual Work Plans will be developed.

The Draft Restoration Plan issued by the EVOS Trustee Council in November 1993 is one of five general approaches to restoration analyzed in this DEIS. The final restoration approach--which will be published in the Final Restoration Plan--will be decided by the Trustee Council. The impact analysis in this draft environmental impact statement (DEIS) will be considered in their decision. The Final Restoration Plan will provide broad, long-term guidance for implementation of restoration activities to restore resources and the services they provide that were injured during the EVOS in the area shown in the *Exxon Valdez* Oil Spill Area map preceding the first page of this document. (The EVOS area includes the area enclosed by the maximum extent of oiled shorelines, severely affected communities and their immediate human-use areas, and uplands adjacent to the watershed divide.)

Planning Process

Alternatives for the Draft Restoration Plan were prepared for public review and comment in the publication, Draft *Exxon Valdez* Restoration Plan Summary of Alternatives for Public Comment, EVOS Trustee Council, April 1993. The brochure described five alternative courses of action, including the no action alternative; explained the evaluation criteria used; and outlined the differences among each of the alternatives. It also discussed an approach to implementing the alternatives; and it covered administration, funding allocation guidelines and mechanisms, monitoring, and public participation.

This DEIS was written to inform public officials and citizens of potential environmental effects that could result from implementation of the Restoration Plan. This will allow decisions about the Restoration Plan to be based on an understanding of the environmental consequences. Because decisions made in the restoration process may authorize the use occupancy, or disposition of Federal public lands, the Draft Restoration Plan is also subject to evaluation with respect to its impact on subsistence uses in accordance with §810 of the Alaska National Interest Lands Conservation Act (ANILCA).

The DEIS is a requirement under Federal law (NEPA, 1969) for the Federal actions that will take place under the Restoration Plan. The State of Alaska is cooperating in this DEIS because the Trustee Council will implement actions that are jointly funded.

As a programmatic DEIS, this document does not address site-specific situations, proposals, or regulations. Such matters will be dealt with in subsequent Annual Work Plans issued by the Trustee Council. Such individual matters may also be subject to further review under NEPA as well as §810 of ANILCA.

Summary

A brief discussion of the environmental impact statement (EIS) process follows.

Notice of Intent

On April 10, 1992, a Notice of Intent to prepare an EIS for the development of a restoration plan following the March 24, 1989, *Exxon Valdez* oil spill was published in the Federal Register (57 FR 12473). This notice stated that public meetings would be held throughout the EVOS area to solicit comments on the Restoration Plan and possible effects on resources and services.

On January 14, 1994, a Revised Notice of Intent to prepare an EIS was published in the Federal Register (59 FR 2352). An opportunity to submit additional comments was opened through February 1994, and a public meeting was held in Anchorage on January 27, 1994.

Scoping

The Council on Environmental Quality defines scoping as "an early and open process for determining the scope of issues to be addressed in an EIS and for identifying the significant issues related to a proposed action" (40 CFR 1501.7). It is a means for early identification of important issues deserving analysis in an EIS. The scoping process for this EIS is discussed in greater detail later in this summary.

Preparation of the Draft Environmental Impact Statement (DEIS)

The DEIS has several parts. It describes the proposed action and alternatives and the potentially affected physical, biological, and human environments; provides an analysis of potential adverse effects; describes mitigating measures to reduce adverse effects; and presents a record of consultation and coordination with others during the DEIS preparation. The DEIS is filed with the Environmental Protection Agency (EPA), and its availability is announced in the Federal Register.

Public Comment Period

A 45-day public comment period follows the release of the DEIS. During this period, public meetings and at least one hearing are held, and oral and written comments are requested from the public. Specific dates and locations for the public meetings and hearing(s) will be announced.

Preparation of the Final EIS (FEIS)

Oral and written comments on the DEIS are addressed in the FEIS. Any needed revisions are made to the FEIS before it is filed with EPA and made available to the public by announcement in the Federal Register.

Record of Decision (ROD)

Oral and written comments on the DEIS are addressed in the FEIS. Any needed revisions are made to the FEIS before it is filed with EPA and made available to the public by announcement in the Federal Register.

Implementation

The selected alternative for the Final Restoration Plan are implemented after a final ROD has been signed.

Major Issues Addressed

The interdisciplinary team (IDT) assigned to write the DEIS reviewed and analyzed the concerns and ideas expressed in the public involvement and interagency scoping. The following issue statements describe those concerns and ideas in general terms. The issue statements were evaluated to decide which issues were significant and should be addressed in the DEIS.

The public, agencies, community leaders, and other knowledgeable individuals and organizations raised many issues during the scoping process. The agencies identified the significant issues based on "reviews of similar actions, knowledge of the area or areas involved, discussions with community leaders, and/or consultations with experts and other agencies familiar with such actions and their effects" (Forest Service Handbook 1909.15 [11.5]). These issues are addressed in this document.

Issues Addressed in the EIS

Five of the issues raised during scoping were determined to be relevant to the environmental impact analysis and will be used to evaluate each alternative. Brief explanations of these issues are presented below.

Issue 1: How would restoration activities contribute to restoring injured resources and services?

This issue is central to the analysis performed in the EIS and the evaluation of restoration option effectiveness presented in the Draft Restoration Plan. In particular, the public is interested in how the rate of recovery of the resources affected by the spill will be affected by implementation of the restoration activities. The rate and degree of recovery could be measured by changes in population or distribution of species, the time required for recovery, or other factors. Besides changes in population and diversity, habitat conditions, and acreage or sites protected from development or other physical encroachment, changes in human use or management or changes in aesthetic quality also could affect the rate and degree of recovery.

Issue 2: How would activities directed at injured resources and services affect other resources and services?

Each of the proposed restoration options aims to aid injured resources and services; however, the potential exists for other resources and services to be affected as well. Although an action could be designed to improve recovery of a specific resource, the same action also could indirectly affect other resources and services. Potential impacts include changes in the number or structure of other species populations as a result of restoration-associated changes in the amount or quality of available habitat or food sources.

There would be no adverse impacts to these other resources from any of the alternatives under consideration in this DEIS other than those shown in the economic analysis. The benefits to these other resources would be in the nature of restoring or protecting their habitat and/or increasing their food supply as secondary benefits of restoring or protecting the habitat of an injured resource.

Issue 3: What ecological change would occur in the spill area as a result of restoration activities?

Ecological recovery in the spill area is the intent of the proposed restoration activities. The anticipated result of the combined restoration efforts is recovery of the ecosystem to prespill conditions and overall biodiversity levels.

Issue 4: How would restoration activities affect land uses, local economies, and communities?

Some proposed restoration activities may result in the creation or elimination of jobs; and the number and kinds of new jobs, as well as the income associated with them, are of interest to the public. A concern is that employment could be reduced in some resource development industries that may be adversely affected by some restoration options. The effect of increased or decreased employment on the economy and services of the local communities also concerns the public, as well as government agencies and private industry.

For example, the public has anticipated that changes in land use could result from land acquisition for protection of habitat. Ownership of some land could move from the private sector to the public sector. Increased protection of lands already under public management may be considered. Some changes in existing land management strategies could decrease opportunity for such activities as logging and mining; others could increase access to recreation sites and maintain opportunities for commercial tourism. The economic and infrastructure implications of these changes are considered in this document.

Issue 5: What changes to subsistence uses would occur as a result of restoration activities?

Some of the proposed restoration options are directed at restoring subsistence uses of resources in the spill area. Subsistence use was affected by contamination of resources used for subsistence and by users' perception of contamination. Subsistence users also report declines in the abundance of many subsistence resources. Restoration activities may focus on increasing the abundance of natural resources in the area used for subsistence. Subsistence use also may be affected by the implementation of options that are not intended to specifically address subsistence use; this potential for secondary impact is considered in the analysis of the alternatives.

There are continuing human health and safety concerns that certain resources used for subsistence may have been contaminated. Eating oil-contaminated food is harmful to humans, as is direct physical contact with crude oil. To avoid injury to humans, fisheries were closed and harvesting of affected species was discouraged immediately after the spill occurred. Some of the restoration activities aim to decrease the levels of harmful hydrocarbons in resources used for subsistence. Others focus on obtaining information to determine the level of persistent contamination, if any, in harvested resources.

Impact Topics

The IDT considered the various proposed alternatives and the issues raised in public comment and selected the following impact topics to cover these issues analytically. Some of the key factors that were considered included: whether any actions are proposed that are likely to have an environmental impact; and, the issues and concerns raised by the public during scoping. This information along with the public comment, and the recovery status of the resources and services is the basis for the decision to analyze the impacts to the following resources and services:

Fish

Pink Salmon	Sockeye Salmon
Pacific Herring	

Intertidal Resources (Such as Clams, *Fucus*, Mussels, Limpets, etc.)

Marine Mammals

Harbor Seals	Sea Otters

Birds

Common Murres	Harlequin Duck
Marbled Murrelet	Pigeon Guillemot

Other Resources

Designated Wilderness Areas	Archaeology

Services

Commercial Fishing	Sport Fishing
Recreation	Tourism
Subsistence	

In addition to the resources and services analyzed in this DEIS, the restoration program may include other resources with injuries related to the spill. These resources include killer whales, river otters, bald eagles, black oystercatchers, rockfish, and subtidal organisms. At this time, actions that have been identified for these resources are primarily monitoring and research activities, or management based actions. These types of actions are outside the scope of analysis in this DEIS.

The NEPA requires an analysis of impacts on the human environment. Some topics required to be studied by NEPA are not affected by the proposed action. These include land use plans and coastal zone management plans.

Alternatives

This summary describes the array of management alternatives considered in the development of the *Exxon Valdez* Restoration Plan. It covers the five alternatives for restoration, including the "no action" alternative. For more detailed information about the alternatives, please refer to the Draft *Exxon Valdez* Oil Spill Restoration Plan Summary of Alternatives for Public Comment (EVOS Trustee Council, April 1993; hereafter referred to as the brochure) and the Draft *Exxon Valdez* Oil Spill Restoration Plan (EVOS Trustee Council, November 1993).

Each of the alternatives addresses policies for selecting possible restoration activities. Each of the alternatives is made up of variations of four basic categories of activities: (1) Habitat Protection and Acquisition; (2) General Restoration of resources and services; (3) Monitoring and Research; and (4) Administration and Public Information. The General Restoration category contains general types of actions designed to achieve a particular objective in relation to an injured resource. ("Actions" is the term used to refer to site-specific projects to be implemented to achieve the goals of the alternative.) The analysis in this draft environmental impact statement (DEIS) pertains to the alternatives and the their associated action patterns but does not consider individual actions. Appropriate site-specific environmental analysis will be conducted by the appropriate agencies for all future actions.

Alternative 5 contains an element not present in the other alternatives. In response to public comments that a fund should be set aside for long-term restoration and research activities, the proposed action includes the establishment of a Restoration Reserve.

Alternative 1: No Action

The "no action" alternative required by the NEPA consists entirely of normal agency management activities. If this alternative were implemented, current management would continue, no new activities or programs would be instituted as a result of the oil spill, and the scope of present activities and programs would not change. Agency monitoring of natural recovery would remain at present levels, and agency responsibilities would remain unchanged. None of the remaining funds from the civil settlement would be spent if this alternative were implemented.

Alternative 2: Habitat Protection

The goal of Alternative 2 is to provide maximum protection of strategic lands and habitats important to the long-term recovery of injured resources and the services they provide. Monitoring and Research and Habitat Protection and Acquisition are the only restoration actions included in this alternative. The primary means of protection in this alternative is the acquisition of private land interests or changes in the management of currently held public lands. Monitoring and Research would be conducted to evaluate the effectiveness of protection measures and to track the recovery of damaged resources and services. Actions that may be undertaken under this alternative would be confined to the area affected by the oil spill.

Policies

- Habitat of injured resources and the services they provide within the spill area will be protected from degradation or disturbance.
- Restoration actions will address all injured resources and the services they provide.
- Restoration actions for recovered resources will continue even after a resource has recovered.
- The location of restoration actions will be limited to the spill area.
- Habitat Protection will be used to protect or increase existing human use of the spill area.

Alternative 3: Limited Restoration

Alternative 3 focuses on accelerating recovery of the resources and services most severely injured by the oil spill. This alternative targets resources whose populations declined as a result of the spill and that have not yet recovered. Only actions determined to be most likely to produce significant improvements over unaided natural recovery are included in this alternative. All restoration actions included in Alternative 3 will be confined to the spill area.

Habitat Protection is a major part of this alternative; none of the proposed actions would substantially increase human use within the spill area. Monitoring and Research are also included in Alternative 3.

Policies

The most effective actions will be taken within the spill area to protect and restore all injured resources and thereby the services they provide except those biological resources whose populations did not measurably decline . The existing character of the spill area will be maintained.

- Restoration actions would address all resources ***except*** those biological resources whose populations did not measurably decline.
- Restoration actions for recovered resources will cease once a resource has recovered.
- Restoration actions will be conducted that provide substantial improvement over natural recovery.
- The location of restoration actions will be limited to the spill area.
- Restoration actions will be used to restore injured resources and thereby protect existing human use of the spill area.

Alternative 4: Moderate Restoration

This alternative is broader than Alternative 3 in that it aims to aid recovery of all injured resources and the services they provide; not just those with population level injuries. Restoration actions included in Alternative 4 address only those resources and services that have not yet recovered from the oil spill. It is also broader than Alternative 3 in terms of the resources addressed; in Alternative 4, measures would be taken to aid recovery of resources that sustained sublethal injuries. Actions that are judged to provide substantial improvements over unaided recovery would be implemented. The actions in this alternative would be confined to Alaska but could extend beyond the spill area. Habitat Protection is included in this alternative, but to a lesser extent than in Alternatives 2 and 3. This alternative may increase opportunities for human use to a limited extent. Monitoring and Research may be conducted.

Policies

- The most effective actions to protect and restore all injured resources and thereby the services they provide will be taken. Opportunities for human use of the spill area will be increased to a limited extent.
- Restoration actions will address all injured resources.
- Restoration actions for recovering resources will cease once a resource has recovered.
- Restoration actions will be conducted that provide substantial improvement over natural recovery.

- Restoration actions could occur anywhere there is a link to injured resources.

- Restoration actions would be used to restore injured resources and thereby protect or increase existing human use of the spill area.

Alternative 5: The Proposed Action Comprehensive Restoration

This represents a modification of the Alternative 5 shown in the Draft *Exxon Valdez* Restoration Plan Summary of Alternatives for Public Comment (EVOS Trustee Council, April 1993). Alternative 5 is the broadest in scope of the proposed alternatives. This alternative will help all injured resources and the services they provide within the spill area and, under specific circumstances, in other parts of Alaska. Unlike Alternatives 3 and 4, this alternative will allow actions to aid resources that have already recovered, as well as those that have not. Actions likely to produce some improvement over unaided recovery will be allowable under this alternative. Habitat Protection is the largest part of this alternative. Alternative 5 also allows for expansion of current human use and allows for appropriate new uses through the restoration of natural resources. Monitoring and Research will be at the highest levels in this alternative.

Alternative 5 contains an element not present in the other alternatives. In response to public comments that a fund should be set aside for long-term restoration and research activities, the proposed action includes the establishment of a Restoration Reserve.

Policies

- Restoration activities may be considered for any injured resource.

- Restoration activities will occur primarily within the spill area. Limited restoration activities outside the spill area, but within Alaska, may be considered under the following conditions:
  1) when the most effective restoration actions for an injured migratory population are in a part of that population's range outside the spill area, or
  2) when the information acquired from research and monitoring activities outside the spill area will be significant for restoration or understanding injuries within the spill area.

- Restoration activities will emphasize resources that have not recovered.

- Resources may be enhanced, as appropriate, to promote restoration. Restoration projects may not adversely affect the ecosystem.

- Projects designed to restore or enhance an injured service:
  1) must benefit the same user group that was injured, and
  2) should be compatible with the character and public uses of the area.

Comparison of Alternatives

The essential variation among the alternatives has to do with the balance between Monitoring and Research, Habitat Protection, and General Restoration activities. Alternative 2 principally consists of Habitat Protection with no restoration activities. Alternative 4 places the greatest emphasis on General Restoration activities. Alternative 5 proposes a greater emphasis on Monitoring and Research than the other alternatives while still emphasizing Habitat Protection.

Alternatives 3, 4, and 5 vary in terms of the scope of restoration activities proposed. Restoration in Alternative 3 would be limited to actions that would significantly aid natural recovery of the most injured resources; all actions would be taken only in the spill area.

Alternative 4 envisions actions that would aid recovery of all injured resources and services, not just the most injured. These actions could take place within or outside the spill area; none would occur outside the State of Alaska. Alternative 5 is the most comprehensive in its approach in that all injured resources and services could be aided, regardless of the degree of initial injury or recovery status. As in Alternative 4, actions could take place within the spill area or elsewhere in the State of Alaska. Under the Alternative 5 approach, not only would assistance to recovery of injured resources occur, but also actions to expand current uses and to encourage new uses would be taken.

Environmental Consequences

This section contains the analysis of the environmental consequences that could result from implementing the five alternatives described. In many EIS's the analysis focuses on the numbers or degree of loss to various resources. It is an important distinction of this EIS that with few exceptions, the impacts estimated to occur under the various alternatives are increases in populations or services from some existing injured level.

The analysis of impacts is based in large part upon what has been learned from studies carried on since the EVOS. Much of this research has focused on the area of Prince William Sound. As a result, most of the estimated impacts from actions in the alternatives are based on what we have learned from the Prince William Sound studies and extrapolated for analysis in the other areas of the EVOS.

The current situation provides the basis for comparing the effects of the action alternatives. In this programmatic document, it should be noted that the No Action Alternative consists of normal agency management activities and the assumptions that (1) natural recovery will be the only restoring agent at work and (2) private land owners will harvest their commercial timber lands in the long term.

If the No Action Alternative were implemented, current management would continue, no new activities or programs would be instituted as a result of the oil spill, and the scope of present activities and programs would not change. Agency monitoring of natural recovery would remain at present levels, and their responsibilities would remain unchanged. None of the remaining funds from the civil settlement would be spent at this time on restoration activities if this alternative were implemented.

Monitoring and research, as actions, generally do not impact resources and services and therefore are analyzed only for their economic impacts. It is recognized that the general restoration category also includes such actions as data gathering, surveys, and analysis that would not impact the resources--thus these activities would not be included in the EIS analysis except for the impacts on the economy.

"Recovery"

The definition of the term recovery has a significant bearing on the discussion of the various alternatives described in this summary. The settlement funds may be used for the purpose 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 goal of restoration is recovery of all injured resources and services. For some resources, little is known about their injury and recovery, so it is difficult to define recovery or develop restoration strategies.

In the analysis of impacts to the various resources in the EIS, it may be that an action will accelerate the rate of recovery and not measurably impact the number of individuals in the population for several years. This is still viewed as having a significant beneficial impact on the resource analyzed.

In general, resources and services will have recovered when they return to conditions that would have existed had the spill not occurred. Because it is difficult to predict conditions that would have existed in the absence of the spill, recovery is often defined as a return to prespill conditions. For resources that were in decline before the spill, such as marbled murrelets, recovery may consist of stabilizing the population at a lower level than before the spill.

Alternative 1: No Action

Biological Resources

Intertidal Zone. With the exception of certain habitats and specific organisms, the intertidal zone has largely recovered from the effects of EVOS. *Fucus* and the organisms associated with the rockweed, still have not recovered in the upper intertidal zone, and many mussel beds are still contaminated with oil. With no intervention, it may take over a decade before the algal based communities resemble the prespill condition. The oil that is trapped beneath mussels is likely to remain unweathered for many years. The consequences of the presence of these sources of relatively fresh oil is unknown, but they may have negative impacts on other organisms that rely on mussels for prey.

Marine Mammals

Harbor Seals. At this time, there is too little information available to predict when the populations within the EVOS area will recover. Recovery is unknown for all regions of the spill area.

Sea Otters. Assuming moderate growth rates, a low immigration rate, and that the subsistence level remains negligible, sea otters in Prince William Sound could recover in 7 to 35 years after the population begins to increase. For other regions in the EVOS area, the populations should return to their prespill levels in less time.

Birds

Harlequin Duck In the short term through 1995, populations likely will remain at 1990 - 1993 levels in both oiled and nonoiled areas. However, if reproductive failure continues in harlequin ducks in the oiled area, natural mortality would cause the population to decrease. No measures to restore the injured harlequin duck population would be taken, nor would the status of the injured population be known. The long-term effects of this alternative would possibly be a loss of critical nesting habitat in forested riparian habitat and subsequent reduction of reproduction capacity in the EVOS area.

Murres. Over the long term, this alternative could take the Barren Islands population 20 to 80 years to recover fully. However, recent insight on population recovery of common murre populations, based on 20 years of data from the Bering Sea, suggests that the population at the Barren Islands may recover within 20 years (Roseneau, oral comm., 1994).

Pigeon Guillemot. The short-term effects of this alternative on the injured pigeon guillemot population in Prince William Sound through 1995 are expected to be negligible. Expected effects outside of Prince William Sound are unknown. The local population at Naked Island may continue to decrease slowly on the short term, but on the long term through 2001, the guillemot population for all of Prince William Sound should stabilize or slowly increase. This alternative would have a low-negative overall effect on recovery of the pigeon guillemot population.

Marbled Murrelet Projected logging with the accompanying loss of nesting habitat, on the long term, may have a low-to-moderate negative effect on recovery of the injured murrelet population.

Fish

Pink Salmon. No changes are expected within one life cycle, however, long-term recovery of the injured pink salmon resource is expected to require approximately 20 years (10 generations), however, the recovery of wild stocks may never recover to 100 per cent of the prespill population (EVOS Trustee Council, April 1993). Because of inheritable changes in egg survival, it is likely that there may also be a 10-percent reduction of the population of pink salmon within Prince William Sound (Spies, 1994). Fortunately, this reduction is not expected throughout the entire EVOS area. Wherever spawning habitat may become reduced as a result of developmental activities, however, pink salmon populations may be further affected.

Sockeye Salmon. No recovery can be expected to accrue in one life cycle, but a long-term recovery may be expected within 10 to 50 years and it is reasonable to expect that the injured populations may recover to prespill conditions (EVOS Trustee Council, April 1993). However, there also is a moderate risk that the zooplankton populations and populations of sockeye salmon fry may never achieve the same balance of prespill conditions or that some habitat degradation may occur because of developmental activities.

Pacific Herring. No improvements are expected to accrue within one life cycle. The long-term recovery of Pacific herring is unknown because, although there is evidence to suggest that the EVOS had an effect on Pacific herring reproduction, it is not possible to blame their population declines solely on the oil spill (Spies, 1994). Ultimately, however, some spawning groups may not recover to prespill conditions and some can be expected recover sooner than others.

Social and Economic Impacts

Archaeological Resources. Under this alternative, cultural resources in the spill area would not be protected, enhanced, or understood better than at present. Over the short term, the impacts of this alternative would be negligible since it is expected that any changes would be gradual. Over the long term, this would constitute a low negative impact to archaeological and historical sites and to the understanding and appreciation of cultural resource values as they apply to the spill area.

Subsistence. In the No Action Alternative, the existing trends in subsistence harvest species populations and subsistence use are likely to continue over the long term, though changes are expected to occur gradually. The continued hiatus in subsistence activities would have negligible short-term and potentially high, potentially permanent, long-term negative effects on the perpetuation of cultural values and subsistence uses within some of the villages in the spill area.

Recreation and Tourism. The short-term impacts of the No Action Alternative on recreation and tourism would be negligible since all changes are expected to be gradual. The long-term effects would be low level negative impacts to tourism and moderate negative impacts to recreation, these effects stemming from continued damage to the resources on which these service depend.

Wilderness. The short-term negative impact to Designated Wilderness and Wilderness Study Areas, and to the wilderness character of other lands, would be negligible because of the slow rate at which changes are expected to accrue. The long-term negative impact to Wilderness Areas and Wilderness Study Areas would be moderate, resulting from persistence of oil and of public perceptions of recovery of designated Wilderness Areas and Wilderness Study Areas, and a lack of protection for wilderness qualities in de facto wilderness.

Commercial Fishing. No observable improvements are expected within one life cycle of the commercially-important species, Pacific herring and pink and sockeye salmon. Long-term recovery can be expected through the natural process although some areas or commercial fisheries may never recover to pre-spill conditions and some populations may recover sooner than others.

Sport Fishing. No improvements are expected within one life cycle of the sport fish species. Long-term recovery to at or near prespill levels can be expected although some resources and some populations will recover sooner than others, and some resources or populations may never recover to pre-spill levels. Confidence in the rates of recovery will be low without monitoring. Real or perceived recovery of the injured resources and services may require 10 or more years (EVOS Trustee Council, April 1993).

Economy. Short-term impacts are anticipated to be negligible. For long-term impacts, qualitative analysis indicates that Alternative 1 will result in moderate negative effects in commercial fisheries and recreation. Quantitative analysis reflects effects resulting in several sectors from investment but not effects on commercial fishing or recreation. Quantitative analysis indicates that Alternative 1 results in annual averages in output for a 10-year period in increases of $1.6 million for the finance, insurance, and real estate sector; $0.76 million in the services sector; and $3 million for all other sectors. Employment increases jobs by 21 in the finance, insurance, and real estate sector; 15 in services; and 47 total.

Alternative 2: Habitat Protection

Biological Resources

Intertidal Zone. The short-term effects would be negligible. A change in ownership would not necessarily translate into a change in current activities.

The long-term effects would be moderately beneficial. The protection can span a large portion of the intertidal zone, but the potential for reducing disturbance or preventing additional injury would vary substantially between parcels.

Marine Mammals

Harbor Seals. The short-term effects would be negligible. Compared to the existing condition of the habitat, the protection of upland parcels is not expected to produce any notable change in the disturbance to harbor seals.

The long-term effects would have low to moderate benefits. Of the 81 parcels included in this analysis, over half include haulout sites near or on the parcels. Although the type of use at these haulout sites is not known, many of them may be used during pupping and molting.

Sea Otters. The short-term effects would be negligible. Compared to the existing condition of the habitat, the protection of upland parcels is not expected to produce any notable change in disturbance or in the health of the injured sea otter population.

The long-term effects would have low benefits to the sea otter populations throughout the EVOS area. Assuming that adverse effects of disturbance are likely to be most notable when large-scale disturbances are near concentrations of females and pups the benefits of habitat protection would be low. Of the 81 parcels included in this analysis, 25 percent are near known pupping concentrations. Of these, several are in areas where there is less risk of large-scale disturbances. However, because the effects of disturbance are unknown, the benefits may be greater than anticipated here.

Birds

Harlequin Duck. The short-term effects through 1995 of land acquisition on harlequin duck recovery are likely to be negligible, and populations would remain at levels observed during 1990 to 1993 surveys.

The highly beneficial long-term effects of this alternative would provide maximum protection of existing reproductive potential of harlequin ducks, therefore guarding against possible future loss of nesting habitat through development.

Murres. All large colonies of murres, and most smaller ones, are already protected, so the short-term effects of habitat protection to murres would be negligible.

The long-term effects of this alternative on murre populations throughout the EVOS area would be low. However, acquisition of Gull Island in Kachemak Bay would ensure protection of this colony, and thus may have a moderate long-term local benefit to murres.

Pigeon Guillemot. Habitat acquisition would have a negligible effect on pigeon guillemot population recovery on the short term, because there appears to be no development slated for private land with known colonies.

On the long term, protecting habitat where two of the largest colonies in Prince William Sound are located would be moderately beneficial in allowing population recovery and in preventing further inroads to the injured population through habitat degradation.

Marbled Murrelet. Depending on the potential for imminent logging on land parcels that contain prime habitat, the short-term effect of protecting habitat under this alternative could have high benefits.

The long-term effects would have very high benefits. On the long term, acquisition of old-growth forest habitat would have the highest possible benefit for ensuring murrelet population recovery.

Fish

Pink Salmon. The short-term effects would be negligible. No benefits from habitat protection would be accrued within one life cycle.

The long-term effects would have moderate benefits. Habitat protection and acquisition actions would have a long-term benefit to pink salmon stocks in the EVOS area by helping to ensure maintenance of wild-stock production. More than half of the parcels that may be purchased have moderate or high value for pink salmon.

Sockeye Salmon. The short-term effects would be negligible. No benefits from habitat protection can be expected within one life cycle.

The long-term effects would have moderate benefits. Habitat protection and acquisition actions would benefit sockeye salmon stocks in the EVOS area by helping to ensure maintenance of wild-stock production; however, fewer than one-fourth of the individual parcels that may be purchased are rated as moderate or high value for sockeye salmon.

Pacific Herring. The short-term effects would be negligible. No benefits would be accrued within one life cycle.

The long-term effects would have moderate benefits. Habitat protection and acquisition actions would benefit Pacific herring stocks in the EVOS area by helping to ensure maintenance of production. Over half of the parcels that may be purchased have moderate or high value for Pacific herring.

Social and Economic Impacts

Archaeological Resources. The short-term direct benefit of habitat protection and acquisition on cultural resources would be low. Long term, this alternative would provide moderate benefit to the protection of archaeological and historical resources on acquired parcels.

Subsistence. Short-term impacts to subsistence-harvest species and subsistence users would be negligible because of no change in subsistence regulations, activities, or locations. Changes in subsistence uses are expected to occur gradually. Long term, the level of parcel acquisition possible in this alternative may allow for localized increases of populations of fish, wildlife, and intertidal resources important for the perpetuation of subsistence activities and their associated lifestyle in the spill area. This would be a long-term low to moderate benefit to subsistence.

Recreation and Tourism. Short-term benefits to recreation and tourism would be negligible because any changes are expected to take a considerable amount of time. Long-term benefits are likely to be low to moderate in terms of both direct effects on maintaining the quality of the landscape and indirect effects on maintaining stable ecosystems on which recreation and tourism depend in the spill area.

Wilderness. Short-term and long-term benefits to designated Wilderness would be negligible both in terms of restoring Wilderness pristine appearance and public perception of damage. Long-term moderate benefits are likely to result from greater protection of the wilderness-like setting of acquired lands and natural reduction of residual oil in designated Wilderness.

Commercial Fishing. The short-term effects would be negligible. No benefits will be accrued within one life cycle of the protected species.

The long-term effects would have moderate benefits. Habitat protection and acquisition actions may have a long-term benefit to salmon and Pacific herring stocks in the EVOS area by helping to ensure maintenance of wild-stock production to support the commercial fishing industry.

Sport Fishing. The short-term effects would be negligible. No benefits will be accrued for sport fishing opportunities immediately upon a purchase.

The long-term effects would have moderate benefits. Habitat protection and acquisition actions may have a long-term benefit to sport fish species in the EVOS area by helping to ensure maintenance of fish production and access for the sport-fishing activities.

Economy. Short-term impacts are anticipated to be negligible.

In long-term impacts, qualitative analysis indicates that Alternative 2 will result in moderate economic benefits in commercial fisheries and recreation and moderate negative effects in forestry. Quantitative analysis reflects effects resulting from habitat acquisition on forestry and other sectors but not effects on commercial fishing and recreation. Quantitative analysis indicates that Alternative 2 results, in annual averages for a 10-year period, in a loss of approximately $38 million in forestry industry output, an increase of $7 million in construction industry output, and $3 million in services. The corresponding changes in employment are a loss of 440 jobs in forestry, an increase of 65 in construction, and an increase of 959 in services.

Alternative 3: Limited Restoration

Biological Resources

Intertidal Zone. The short-term effects of the restoration actions would be negligible. All of the proposed actions would require some time before changes could be expected.

The combined long-term effects on intertidal organisms are unknown. For direct restoration actions, effects are unknown because both of the actions analyzed are still being tested. The long-term effects of the Habitat Protection actions for reducing disturbance or preventing additional injury to intertidal organisms are moderately beneficial and will vary substantially between parcels.

Marine Mammals

Harbor Seals. The short-term effects on harbor seals would be negligible. All of the proposed actions require some time after implementation before any changes could be expected.

The combined long-term effects would be moderately beneficial. The proposed actions could reduce negative impacts on harbor seals and may result in increased recovery rates in local areas.

Sea Otters. The short-term effects would be negligible. All of the proposed actions will take time before any results could be expected.

The combined long-term effects would be moderately beneficial. The proposed actions improve the habitat quality for sea otters through reducing the risk of exposure to oil, the potential for disturbance, and the impacts from subsistence harvest. These effects may produce a change in abundance of sea otters in some areas but are not likely to produce a notable increase on a regional scale.

Birds

Harlequin Duck. The short-term effects through 1995 of land acquisition on harlequin duck population recovery are expected to be negligible, and populations are expected to remain at 1990-1993 levels.

The long-term effects of this alternative would have a high benefit for maintaining, protecting, and increasing the reproductive potential of harlequin ducks. Cleaning oiled mussel beds would eliminate the source of hydrocarbon contamination of body tissues, and also enhance the food base of local populations.

Murres. All large colonies of murres, and most smaller ones, are already protected, so the benefit of habitat protection to murres would be negligible in the short-term.

The long-term effects of this alternative on murre populations throughout the EVOS area would be low. However, acquisition of Gull Island in Kachemak Bay would ensure protection of this colony, and thus may have a moderate long-term local benefit to murres.

Pigeon Guillemot. Because there appears to be no development planned on private lands with known colonies of pigeon guillemot, the short-term effects of this alternative on population recovery would be negligible.

The long-term effects would have moderate benefits. In the long term, acquiring habitat where two of the largest colonies in Prince William Sound are located would moderately benefit population recovery and prevent further inroads to the injured population through habitat degradation.

Marbled Murrelet. Depending on the potential for imminent logging on individual land parcels that contain prime murrelet nesting habitat (i.e., old growth coniferous forest), the short-term effects of land acquisition could be of high benefit.

In the long term, acquisition of old growth forest habitat would have the highest possible benefit for ensuring murrelet population recovery.

Fish

Pink Salmon. The short-term effects would be negligible. No benefits from habitat protection would accrue within one life cycle.

The long-term effects would have moderate benefits. Habitat protection and acquisition actions would assist the recovery of the injured wild stocks of pink salmon by protecting important habitats.

Sockeye Salmon. The short-term effects would be low. Some benefits in some drainages may accrue within one life cycle.

The long-term effects would have high benefits. These actions will assist the recovery of the injured wild sockeye salmon stocks, however, some of these actions may be more beneficial in certain portions of the EVOS area and some other populations may not become restored.

Pacific Herring. The short-term effects would be negligible. No benefits will accrue within one life cycle.

The long-term effects would have moderate benefits. Habitat protection and acquisition actions may have a long-term value to Pacific herring stocks in the EVOS area by helping to assure maintenance of reproductive potential.

Social and Economic Impacts

Archaeological Resources. Short-term effects of the proposed actions range from low to high benefit, or moderate benefit overall, stemming from habitat acquisition, site monitoring and stewardship, site monitoring, and salvage excavations. Long-term benefits are likely to be moderate because high benefits are expected locally.

Subsistence. Short-term benefits to populations of harvestable subsistence resources, and thus to subsistence users, would be low.

The proposed actions may help locally to reduce the negative impacts on species important to subsistence use, as well as improve subsistence user's confidence in determining the healthfulness of subsistence foods, which would be a long-term moderate benefit to subsistence uses.

Recreation and Tourism. The short-term benefits of both habitat protection and acquisition and general restoration actions would be low changes in numbers of visitors or locations of recreation/tourism activities .

The long-term benefits of habitat protection and acquisition would be moderate protection for lands against extractive activities. The long-term benefits of general restoration actions would be moderate stabilization of existing recreational opportunities.

Wilderness. Short-term effects on designated Wilderness would be negligible both in terms of restoring Wilderness pristine appearance and public perception of damage, though low benefit to non-Wilderness lands may be derived from greater protection against extractive activities. Long-term moderate benefits are likely to result from greater protection of the wilderness-like setting of acquired lands and natural reduction of residual oil in designated Wilderness.

Commercial Fishing. The short-term effects would be negligible. New runs probably cannot be established within one life cycle to support new commercial fisheries to replace opportunities lost because of fishing closures or reduced harvests.

The long-term effects would have moderate benefits. These actions would assist the replacement of lost commercial fishing opportunities; however, some portions of the EVOS area would obtain greater benefits than others.

Sport Fishing. The short-term effects would be negligible. New sport fisheries probably cannot be established within one life cycle of sport fish species to replace lost sport fishing opportunities.

The long-term effects would have high benefits. After salmon and trout production is expanded, newly established sport fisheries can be expected to provide substantial recreational benefits.

Economy. Short-term impacts are anticipated to be negligible.

For long-term impacts, qualitative analysis indicates that Alternative 3 will result in moderate economic benefits in commercial fisheries and recreation and moderate negative effects in forestry. Quantitative analysis reflects effects resulting from habitat acquisition on forestry and other sectors but not effects on commercial fishing and recreation. Quantitative analysis indicates that Alternative 3 results, in annual averages for a 10-year period, in a loss of approximately $32 million in forestry industry output, an increase of $8 million in construction industry output, and $3 million in services. The corresponding changes in employment are a loss of 330 jobs in forestry, an increase of 70 in construction, and an increase of 766 in services.

Alternative 4: Moderate Restoration

Biological Resources

Intertidal Zone. The short-term effects of the restoration actions would be negligible. All of the proposed actions would require some time before changes could be expected.

The combined long-term effects on intertidal organisms are unknown. For direct restoration actions, effects are unknown because both of the actions analyzed are still being tested. The long-term effects of the Habitat Protection actions for reducing disturbance or preventing additional injury to intertidal organisms are moderately beneficial and will vary substantially between parcels.

Marine Mammals

Harbor Seals. The short-term effects would be negligible. All of the proposed actions require some time after implementation before any changes could be expected.

The long-term effects would be moderately beneficial. The proposed actions could reduce negative impacts on harbor seals and may result in increased recovery rates in local areas.

Sea Otters. The short-term effects would be negligible. All of the proposed actions will take time before any results could be expected.

The combined long-term effects would be moderately beneficial. The proposed actions improve the habitat quality for sea otters through reducing the risk of exposure to oil, the potential for disturbance, and the impacts from subsistence harvest. These effects may produce a change in abundance of sea otters in some areas but are not likely to produce a notable increase on a regional scale.

Birds

Harlequin Duck. The short-term effects through 1995 of this alternative on harlequin duck population recovery are expected to be negligible, and populations should remain at 1990-1993 levels.

The long-term effects of this alternative would have a high benefit for maintaining, protecting, and increasing the reproductive potential of harlequin ducks. Cleaning oiled mussel beds would eliminate the source of hydrocarbon contamination of body tissues, and also enhance the food base of local populations.

Murres. There would be a negligible short-term effect to the injured murre population from this action within the EVOS area.

Predator control outside of the EVOS area, and acquisition of carefully selected parcels would provide a low overall long-term benefit to murre populations.

Pigeon Guillemot. This alternative would likely have negligible short-term effects for pigeon guillemots through 1996.

In the long term, acquiring habitat where two of the largest colonies in Prince William Sound are located, one of which is included in the high-priority-acquisition package, would have a moderate effect on allowing population recovery and in preventing further inroads to the injured population through habitat degradation.

Marbled Murrelet. The short-term effects of land acquisition for the injured marbled murrelet population could have a high benefit if logging is imminent.

The long-term effects would have very high benefits. In the long term, land acquisition is the highest possible benefit to the injured murrelet population.

Fish

Pink Salmon. The short-term effects would be low. Although some benefits may be accrued quickly, it is not reasonable to expect substantial results within one life cycle.

The long-term effects would have moderate benefits. It can be expected that these actions may assist the recovery of the injured wild stocks of pink salmon. Long-term benefits, however, may be accrued in only portions of the EVOS area.

Sockeye Salmon. The short-term effects would be low. Some benefits in some drainages may be accrued within one life cycle.

The long-term effects would have high benefits. It can be expected that these actions would assist the recovery of the injured wild stocks of sockeye salmon. Certain actions, however, may be useful in only portions of the EVOS area, and not all populations may be totally restored.

Pacific Herring. The short-term effects would be negligible. No benefits would be accrued within one life cycle.

The long-term effects would have moderate benefits. Habitat protection and acquisition actions can be expected to have a long-term value to Pacific herring stocks in the EVOS area by helping to assure maintenance of production potential.

Social and Economic Impacts

Archaeological Resources. The proposed actions would increase the level of protection for archaeological resources, and improve the understanding or appreciation of cultural resource values in the short-term. Since the degree of change is expected to increase gradually, the effect is estimated to be moderate benefits to archaeological resources in the short-term.

In the long-term, the proposed actions may increase protection for archaeological resources and substantially improve the understanding or appreciation of cultural resource values, creating moderate to high benefits.

Subsistence. The proposed actions require some time after implementation before any changes could be expected, so the short-term benefits to subsistence uses are expected to be low.

Moderate to high benefits to subsistence use is expected in the long-term. The proposed actions are expected to moderately increase populations of subsistence harvest species negatively affected by the EVOS and substantially increase the confidence of subsistence users in determining the healthfulness of subsistence foods.

Recreation and Tourism. The proposed actions may increase numbers of visitors, types of recreation opportunities available, and quality of experiences, but this is expected to occur gradually, accruing low benefits over the short-term.

Moderate to high benefits are expected over the long term because the proposed actions may increase recreational use levels, types, and opportunities. This is expected to occur locally in some cases and throughout the spill area in other cases.

Wilderness. Short-term effects on designated Wilderness and the wilderness character of non-designated wildlands would be low benefit from greater protection and removal of traces of residual oil. Long-term moderate benefits are likely to result from greater protection of the wilderness-like setting of acquired lands, reduction of residual oil, increased populations of wildlife, and increased public awareness of the level of recovery in designated Wilderness and wilderness-like areas.

Commercial Fishing. The short-term effects would be negligible. New runs of salmon probably cannot be established within one life cycle to support new commercial fisheries that would replace opportunities lost because of fishing closures or reduced harvests.

The long-term effects would have moderate benefits. These actions would assist the replacement of lost commercial-fishing opportunities; however, some portions of the EVOS area would obtain greater benefits than in other portions.

Sport Fishing. The short-term effects would be negligible. New sport fisheries to replace lost sport fishing opportunities probably cannot be established within one life cycle of sport fish species.

The long-term effects would have high benefits. After salmon and trout production is expanded, and newly-established sport fisheries can be expected to provide substantial recreational benefits.

Economy. Short-term impacts are anticipated to be negligible.

For the long-term impacts, qualitative analysis indicates that Alternative 4 would result in moderate economic benefits in commercial fisheries and recreation and moderate negative effects in forestry. Quantitative analysis reflects there would be effects resulting from habitat acquisition on forestry and other sectors but not on commercial fishing and recreation. Quantitative analysis indicates that Alternative 4 would result, in annual averages for a 10-year period, in a loss of approximately $23 million in forestry industry output, an increase of $11 million in construction industry output, and $2 million in government. The corresponding changes in employment would be a loss of 143 jobs in forestry, an increase of 96 in construction, an increase of 306 in services, and an increase of 45 in government.

The Proposed Action Alternative 5: Comprehensive Restoration

Biological Resources

Intertidal Zone. The short-term effects of the restoration actions would be negligible. All of the proposed actions would require some time before changes could be expected.

The combined long-term effects on intertidal organisms are Unknown. For direct restoration actions, effects are unknown because both of the actions analyzed are still being tested. The long-term effects of the Habitat Protection actions for reducing disturbance or preventing additional injury to intertidal organisms are moderately beneficial and will vary substantially between parcels.

Marine Mammals

Harbor Seals. The short-term effects would be negligible. All of the proposed actions require some time after implementation before any changes could be expected.

The long-term effects would be moderately beneficial. The proposed actions could reduce negative impacts on harbor seals and may result in increased recovery rates in local areas.

Sea Otters. The short-term effects would be negligible. All of the proposed actions will take time before any results could be expected.

The combined long-term effects would be moderately beneficial. The proposed actions improve the habitat quality for sea otters through reducing the risk of exposure to oil, the potential for disturbance, and the impacts from subsistence harvest. These effects may produce a change in abundance of sea otters in some areas but are not likely to produce a notable increase on a regional scale.

Birds

Harlequin Duck. The short-term effects through 1996 of the proposal on harlequin duck recovery would be negligible and populations would likely remain at 1990 to 1993 levels in both oiled and nonoiled areas.

The long-term effects of this alternative would have a high benefit to help maintain, protect the reproductive potential of harlequin ducks. Acquisition of the high priority package of land parcels would maximize the recovery potential of the injured harlequin duck population by guarding against loss of feeding and nesting habitat. Cleaning oiled mussel beds would eliminate the source of hydrocarbon contamination of body tissues that may be interfering with reproduction, and also enhance the food base of local populations.

Murres. There would be a negligible short-term benefit to the injured murre population from this action within the EVOS area.

Reducing disturbance that causes additional mortality at the Barren Islands would allow population recovery to proceed at a faster rate than otherwise possible, resulting in a low long-term overall benefit to the injured murre population.

Pigeon Guillemot. This alternative likely would have negligible short-term effects for pigeon guillemots through 1996.

On the long term, acquiring habitat where two of the largest colonies in Prince William Sound are located--one of which is included in the high priority acquisition package--would have a moderately beneficial effect on population recovery and in preventing further inroads to the injured population through habitat degradation.

Marbled Murrelet. The short-term effects of land acquisition for the injured marbled murrelet population could have a high benefit if logging is imminent.

On the long term, land acquisition is the highest possible benefit to the injured murrelet population.

Fish

Pink Salmon. The short-term effects would be low. Although some benefits may be accrued, it is not reasonable to expect substantial results within one life cycle.

The long-term effects would have high benefits. It is expected that these actions would assist the recovery of the injured wild stocks of pink salmon. The long-term effects of some or all of these actions may be realized in 6 to 10 years (3 to 5 generations of pink salmon). Certain actions, however, may be useful only in portions of the EVOS area, and not all populations may be totally restored.

Sockeye Salmon. The short-term effects would be low. Some benefits in some drainages may be accrued within one life cycle.

The long-term effects would have high benefits. It can be expected that these actions will assist the recovery of the injured wild stocks of sockeye salmon. Long-term effects of some or all of these actions may be realized in 10 to 50 years (2 to 10 generations of sockeye salmon). Certain actions, however, may be useful in only portions of the EVOS area, and all populations may not be totally restored.

Pacific Herring. The short-term effects would be negligible. No benefits will be accrued within one life cycle.

The long-term effects would have moderate benefits. Habitat protection and acquisition actions will have a long-term value to Pacific herring stocks in the EVOS area by helping to ensure maintenance of production. Over half of the parcels that may be purchased have moderate or high value for Pacific herring.

Social and Economic Impacts

Archaeological Resources. The proposed actions would increase the level of protection for archaeological resources, and improve the understanding or appreciation of cultural resource values in the short-term. Since the degree of change is expected to increase gradually, the effect is estimated to be moderate benefits to archaeological resources in the short-term.

In the long-term, the proposed actions may increase protection for archaeological resources and substantially improve the understanding or appreciation of cultural resource values, creating moderate to high benefits.

Subsistence. Short-term increases in populations of harvestable subsistence resources, and thus benefits to subsistence uses, would be low benefit.

The proposed actions may help locally to reduce the negative impacts on species important to subsistence use, as well as improve subsistence user's confidence in determining the healthfulness of subsistence foods, which would be a long-term moderate benefit to subsistence uses.

Recreation and Tourism. The proposed actions may increase numbers of visitors, types of recreation opportunities available, and quality of experiences, but this is expected to occur gradually, accruing low benefits over the short-term.

Moderate to high benefits are expected over the long-term because the proposed actions may increase recreational use levels, types, and opportunities. This is expected to occur locally in some cases and throughout the spill area in other cases.

Wilderness. Short-term effects on designated Wilderness and the wilderness character of non-designated wildlands would be low benefit from greater protection and removal of traces of residual oil. Long-term moderate to high benefits are likely to result from greater protection of the wilderness-like setting of acquired lands, reduction of residual oil, increased populations of wildlife, and increased public awareness of the level of recovery in designated Wilderness and wilderness-like areas.

Commercial Fishing. The short-term effects would be negligible. New runs to support new commercial fisheries probably cannot be established within one life cycle of salmon to replace opportunities lost because of fishing closures or reduced harvests.

The long-term effects would have moderate benefits. These actions would assist the replacement of lost commercial fishing opportunities. However, some portions of the EVOS area would obtain greater benefits than other portions.

Sport Fishing. The short-term effects would be negligible. New sport fisheries to replace lost sport fishing opportunities probably cannot be established within one life cycle.

The long-term effects would have high benefits. After salmon and trout production is expanded, newly-established sport fisheries can be expected to provide substantial recreational benefits.

Economy. Short-term impacts are anticipated to be negligible.

In long-term impacts, qualitative analysis indicates that Alternative 5 would result in moderate economic benefits in commercial fisheries and recreation and moderate negative effects in forestry. Quantitative analysis reflects there would be effects resulting from habitat acquisition on forestry and other sectors but not on commercial fishing and recreation. Quantitative analysis indicates that Alternative 5 would result, in annual averages for a 10-year period, in a loss of approximately $28 million in forestry industry output, an increase of $6 million in construction industry output, and $2 million in services. The corresponding changes in employment would be a loss of 279 jobs in forestry, an increase of 55 in construction, and an increase of 320 in services.

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Chapter 1

Purpose and Need

The Proposed Action

The *Exxon Valdez* Oil Spill (EVOS) Trustee Council has the joint responsibility under a Memorandum of Agreement for the restoration of natural resources and services injured by the EVOS of 1989. The proposed action is to restore the injured natural resources and services through implementation of a Restoration Plan. The Draft Restoration Plan that is Alternative 5 in this draft environmental impact statement (DEIS) is the proposed action. This represents a modification of the Alternative 5 shown in the Draft *Exxon Valdez* Restoration Plan Summary of Alternatives for Public Comment, EVOS Trustee Council, April 1993 (later referred to as the brochure). The Draft Restoration Plan was issued in November 1993, and is also being made available concurrently with this DEIS.

Purpose of and Need for the Proposed Action

Purpose of the Proposed Action

The purpose of the proposed action analyzed in this DEIS is to restore, in so far as possible, the injured natural resources and thereby the services they provide affected by the EVOS. The purpose of this document is to analyze the effects of proposed uses of the remaining funds (approximately $620 million as of February 1994, after final reimbursements) in accomplishing the mission of the Trustee Council. The Trustee Council previously completed project-specific National Environmental Policy Act (NEPA) documentation on the time-critical restoration projects undertaken in the 1992 through 1994 Annual Work Plans. This DEIS will analyze the 1995 through 2002 program under which the Annual Work Plans will be developed. (See the following section on "Litigation and Settlement" for a more complete discussion of the terms of this settlement.)

The Draft Restoration Plan issued by the EVOS Trustee Council in November 1993 is one of five general approaches to restoration analyzed in this DEIS. The final restoration approach--which will be published in the Final Restoration Plan--will be decided by the Trustee Council. The impact analysis in this draft environmental impact statement (DEIS) will be considered in their decision. The Final Restoration Plan will provide broad, long-term guidance for implementation of restoration activities to restore resources and the services they provide that were injured during the EVOS in the area shown in the *Exxon Valdez* Oil Spill Area map preceding the first page of the Summary of this document. (The EVOS area includes the area enclosed by the maximum extent of oiled shorelines, severely affected communities and their immediate human-use areas, and uplands adjacent to the watershed divide.)

Need for the Proposed Action

The Federal and State governments, acting as Trustees for natural resources are responsible for taking actions necessary to restore resources and the services they provide that were injured by the EVOS. The Federal Water Pollution Control Act (Clean Water Act) (33 U.S.C. § 1321[f]) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. § 9607[f]) provide the legal basis for these responsibilities.

The EVOS contaminated approximately 1,500 miles of Alaska's coastline. In 1991, Exxon agreed to pay the United States and the State of Alaska $900 million in civil settlement funds to restore the resources injured by the spill and the reduced or lost services (human uses) they provide. Of that amount, approximately $620 million remains available to fund restoration activities as of February 1994.

The EVOS Restoration Plan will provide long-term guidance to the Trustee Council for using these funds in restoring the resources and services injured by the oil spill.

Litigation and Settlement

After the spill, President George Bush and Alaska Governor Steve Cowper both declared their intent to restore the affected ecosystem as well as the local economy. Both the United States and the State of Alaska filed civil complaints against the Exxon Corporation and other parties; separate criminal complaints also were filed.

A settlement between the Exxon companies and the United States and the State of Alaska were approved by the Federal District Court in Civil Actions A91-082 (*United States v. Exxon Corp.*) and A91-083 (*State of Alaska v. Exxon Corp.*) on October 9, 1991. As part of this settlement, the Exxon companies agreed to pay the United States and the State of Alaska $900 million over a period of 10 years. Generally, these payments are deposited in the registry of the U.S. District Court for Alaska where they are invested through the Federal Court Registry Investment System. As funding needs for restoration projects are identified, the Trustee Council, through the Alaska Department of Law and the U.S. Department of Justice, applies to the court for disbursement of funds from the Registry.

Civil Action A91-081 (*United States v. State of Alaska*) resolved the claims the United States and the State of Alaska had against each other as a result of the spill. Under the Memorandum of Agreement and Consent Decree, the United States and the State act as co-trustees in the collection and joint use of the restoration funds. Under the Memorandum of Agreement (MOA), the governments may use these funds for the 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 MOA also provides for the reimbursement of certain spill-related expenses such as litigation costs, cleanup, and damage assessment. Such amounts are not deposited in the Court Registry, but are paid directly by Exxon to the respective government.

The MOA provides that the six Trustees are responsible for making all decisions regarding funding, injury assessment, and restoration. Six individuals have been designated to serve as Trustees; three represent the State of Alaska and three represent the Federal Government. The individuals serving in this capacity are the Commissioner of the Alaska Department of Environmental Conservation (ADEC), the Commissioner of the Alaska Department of Fish and Game (ADF&G), the State Attorney General, the Secretary of the U.S. Department of the Interior (USDOI), the Secretary of the U.S. Department of Agriculture (USDA), and the Administrator of the National Oceanic and Atmospheric Administration (NOAA). In accordance with a subsequent Memorandum of Understanding (MOU) executed by the six Trustees, the Alaska-based EVOS Trustee Council was formed to coordinate and oversee the development and implementation of the restoration program. The State Trustees serve as members of the Trustee Council. Each of the Federal Trustees appointed a representative to the Trustee Council. The Regional Forester of the Forest Service represents USDA, the Assistant Secretary for Fish and Wildlife and Parks represents USDOI, and the Regional Director of the National Marine Fisheries Service (NMFS) represents NOAA. The planning, evaluation, and implementation of restoration activities require the unanimous agreement of the Trustee Council.

In addition to the civil claims described above, the United States and the State of Alaska also filed criminal claims against the Exxon Corporation and Exxon Shipping Company. These claims were settled on October 8, 1991, along with the civil claims. Exxon Corporation and Exxon Shipping entered guilty pleas, admitting that they had violated several environmental laws. A fine of $150 million dollars was imposed, of which $125 million was remitted because the Exxon companies had cooperated with the Government during the cleanup, already had paid many private claims, and had tightened their environmental controls after the spill. Of the remaining $25 million, $12 million was deposited into the North American Wetlands Conservation Fund, and $13 million was deposited into the Victims of Crime Account. These funds are not controlled by the Trustee Council and the expenditure of these sums therefore are not considered in the Restoration Plan.

Under the criminal settlement, the companies also agreed to pay $100 million as restitution. Half of this money was paid to the United States and half was paid to the State of Alaska. By agreement of the governments, these funds are managed separately by the United States and by the State of Alaska. Although these funds are to be used exclusively for restoration projects within the State of Alaska relating to the *Exxon Valdez* oil spill, they are outside the scope of the Restoration Plan and this DEIS because they are managed by each government.

Decision to be Made

Following public review and comment on the Draft Restoration Plan and the DEIS, the Trustees will decide which of the five alternatives will be adopted as the Final Restoration Plan. During implementation, the Restoration Plan may be amended as needed to respond to new information about injuries and recovery, to make use of new technology, or to respond to other changing conditions. Public participation will be sought before any changes would be made to the Restoration Plan.

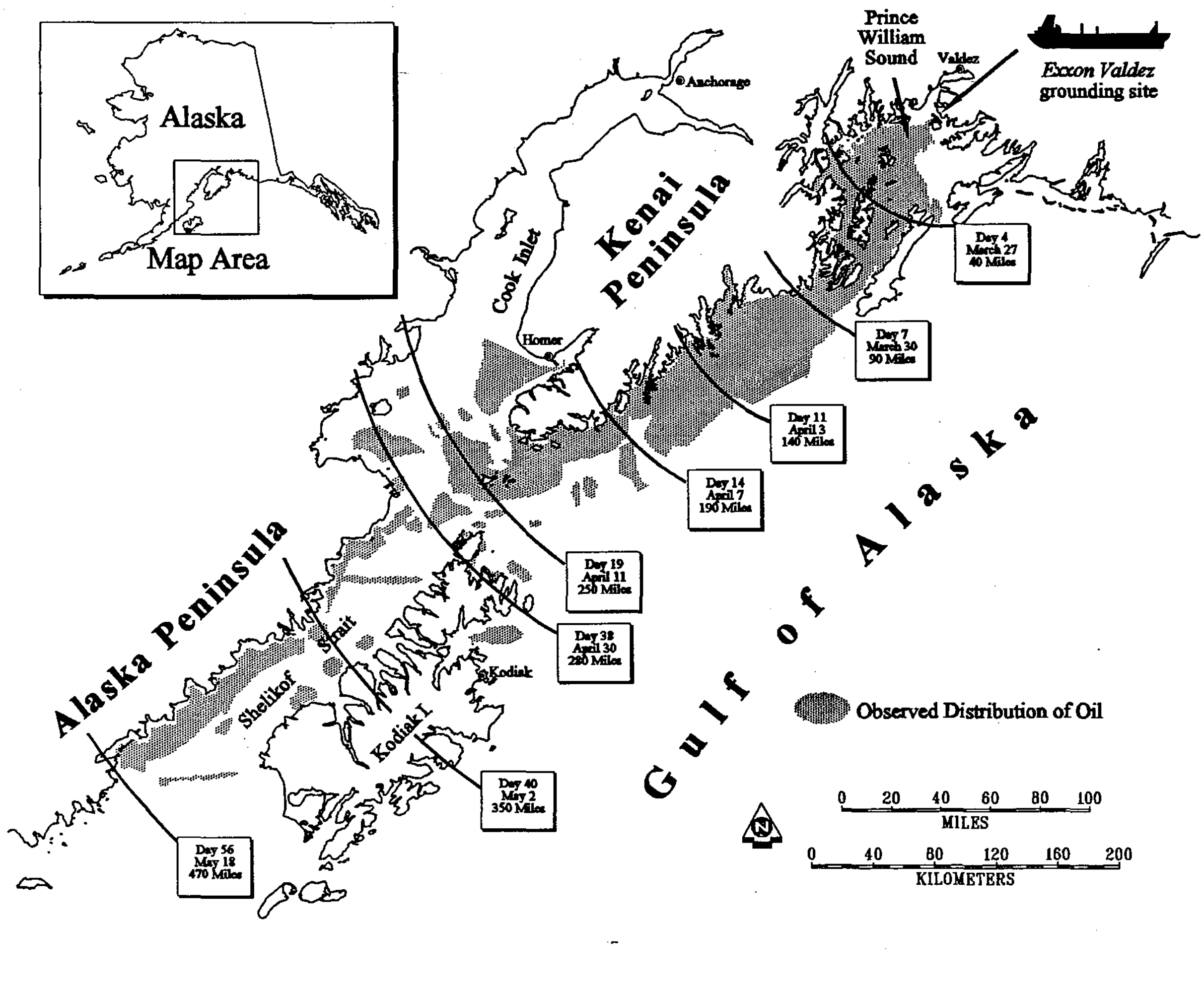
1 Purpose and Need

Background of the Proposed Action

The *Exxon Valdez* Oil Spill

On March 24, 1989, the tanker *Exxon Valdez* ran aground on Bligh Reef in Prince William Sound, Alaska, causing the largest tanker oil spill in U.S. history. Approximately 11 million gallons of North Slope crude oil subsequently moved through southwestern Prince William Sound and along the western coast of the Gulf of Alaska, causing injury to both natural resources and services (human uses) in the area. Figure 1-1 shows the extent of surface oiling as recorded by satellite imagery and aerial observation at the time of the spill.

Figure 1-1



Because the weather for the first 3 days following the spill was calm, the oil did not move from the immediate area, although the slick expanded during that time. On the fourth day, however, a major storm moved oil through Prince William Sound to the southwest, where it reached beaches on Little Smith, Naked, and Knight Islands. Within 6 days of the spill, oil had reached the Gulf of Alaska. The leading edge of the oil slick reached the Chiswell Islands and the Kenai Peninsula by April 2 and the Barren Islands by April 11. By the middle of May 1989, some 470 miles of shoreline had been oiled, including parts of Prince William Sound, the Kenai Peninsula, the Kodiak Archipelago, and the Alaska Peninsula. During the summer of 1989, oil from the spill was found as far as 600 miles from Bligh Reef, the site of the grounding.

Immediately following the spill, efforts to clean the oiled beaches and to assess the extent of the damage began. Federal agencies, the State of Alaska, private citizens, and the Exxon Corporation and its contractors mobilized treatment efforts on the oiled shorelines. In the water, containment booms were used to corral the oil. On the beaches, high-pressure hot-water washing, manual rock washing, and bioremediation techniques were among the methods used to remove oil from the shoreline.

Scientists initiated studies during the summer of 1989 to determine the nature and extent of injury to area plants and animals. Although studies began as soon as possible following the spill, some opportunities to gather data were lost; the shortage of resources and the difficulty of the work made immediate response impossible. In 1989, 72 studies were carried out in 10 categories of natural resources and related services. The number of studies in progress has decreased steadily since 1989, but research is continuing on the effects of residual oil in the ecosystem and on the natural recovery process.

The Trustee Council began developing a restoration plan in 1990. Most of the effort at that time was focused on identifying and developing possible restoration techniques. Following the October 9, 1991 settlement between the Exxon companies, the United States, and the State of Alaska, the Trustee Council decided to continue development of a restoration plan and to provide for meaningful public participation therein. Following public review and comment on the brochure in April 1993, the Trustee Council developed the Draft Restoration Plan in November 1993 as the proposed action for this DEIS. The Final Restoration Plan will assist the decisionmaking process by establishing management direction for identifying and selecting activities to restore injured resources and services. Program-level guidelines will assist in evaluating and implementing future proposed restoration activities. These activities will be developed as part of the Trustee Council's Annual Work Program and will be evaluated by the policies set forth in the Restoration Plan. Each Annual Work Program will contain descriptions of the restoration activities to be funded that year, based on the policies and spending guidelines of the Restoration Plan, public comments, and changing restoration needs.

Alternatives for the Draft Restoration Plan were prepared for public review and comment in the publication, Draft *Exxon Valdez* Restoration Plan Summary of Alternatives for Public Comment, EVOS Trustee Council, April 1993. The brochure described five alternative courses of action, including the no action alternative; explained the evaluation criteria used; and outlined the differences among each of the alternatives. It also discussed an approach to implementing the alternatives; and it covered administration, funding allocation guidelines and mechanisms, monitoring, and public participation.

Based on public comment on the alternatives presented in the brochure, the Trustee Council has modified and designated Alternative 5 as the proposed action for this DEIS and has published this modified alternative as the Draft Restoration Plan. This DEIS is intended to assist decisionmakers and the public in assessing the merits of the various alternatives and determining which of the possible alternatives should be selected as the Final Restoration Plan.

As stated above, each restoration alternative is made up of four types of activities, and each alternative places different emphasis on each category. These activities are as follows:

- Habitat protection and acquisition.

  This activity is designed to limit further injury to species and services within the spill area by protecting habitats. Habitat protection options include acquiring privately held land, obtaining less than fee simple acquisition of rights to privately held land, or changing the management of publicly held land.

- General restoration.

  General Restoration includes a wide variety of restoration activities. Some General Restoration activities will improve the rate of natural recovery by directly manipulating the environment. Other activities protect natural recovery by managing human uses or reducing marine pollution. A few general restoration activities may involve facilities. Facilities may direct human use away from sensitive areas, support other restoration activities, or replace facilities needed for access and damaged by the spill.

- Monitoring and research.

  Monitoring and Research includes gathering information about how resources and services are recovering, whether restoration activities are successful, and what continuing problems exist in the general health of the affected ecosystems. It provides important information to help direct the restoration program. In addition, it will provide useful information to resource managers and the scientific community that will help restore the injured resources and services.

- Administration and public information.

  Funding levels for administration and public information activities depend on the number and scope of the other activities. As more projects and programs are implemented, the percentage of funds allocated to management and administration decreases. These activities also include providing information to the public about restoration activities and the progress of recovery.

Description of the Process

This DEIS was written to inform public officials and citizens of potential environmental effects that could result from implementation of the Restoration Plan. This will allow decisions about the Restoration Plan to be based on an understanding of the environmental consequences. Because decisions made in the restoration process may authorize the use occupancy, or disposition of Federal public lands, the Draft Restoration Plan is also subject to evaluation with respect to its impact on subsistence uses in accordance with §810 of the Alaska National Interest Lands Conservation Act (ANILCA).

Purpose and Need 1

The DEIS is a requirement under Federal law (NEPA, 1969) for the Federal actions that will take place under the Restoration Plan. The State of Alaska is cooperating in this DEIS because the Trustee Council will implement actions that are jointly funded.

As a programmatic DEIS, this document does not address site-specific situations, proposals, or regulations. Such matters will be dealt with in subsequent Annual Work Plans issued by the Trustee Council. Such individual matters may also be subject to further review under NEPA as well as §810 of ANILCA.

A brief discussion of the environmental impact statement (EIS) process follows.

Notice of Intent

On April 10, 1992, a Notice of Intent to prepare an EIS for the development of a restoration plan following the March 24, 1989, *Exxon Valdez* oil spill was published in the Federal Register (57 FR 12473). This notice stated that public meetings would be held throughout the EVOS area to solicit comments on the Restoration Plan and possible effects on resources and services.

On January 14, 1994, a Revised Notice of Intent to prepare an EIS was published in the Federal Register (59 FR 2352). An opportunity to submit additional comments was opened through February 1994, and a public meeting was held in Anchorage on January 27, 1994.

Scoping

The Council on Environmental Quality defines scoping as "an early and open process for determining the scope of issues to be addressed in an EIS and for identifying the significant issues related to a proposed action" (40 CFR 1501.7). It is a means for early identification of important issues deserving analysis in an EIS. The scoping process for this EIS is discussed in greater detail later in this chapter.

Preparation of the Draft Environmental Impact Statement (DEIS)

The DEIS has several parts. It describes the proposed action and alternatives and the potentially affected physical, biological, and human environments; provides an analysis of potential adverse effects; describes mitigating measures to reduce adverse effects; and presents a record of consultation and coordination with others during the DEIS preparation. The DEIS is filed with the Environmental Protection Agency (EPA), and its availability is announced in the Federal Register.

Public Comment Period

A 45-day public comment period follows the release of the DEIS. During this period, public meetings and at least one hearing are held, and oral and written comments are requested from the public. Specific dates and locations for the public meetings and hearing(s) will be announced.

Preparation of the Final EIS (FEIS)

Oral and written comments on the DEIS are addressed in the FEIS. Any needed revisions are made to the FEIS before it is filed with EPA and made available to the public by announcement in the Federal Register.

Record of Decision (ROD)

Following the release of the FEIS, there is a 30-day waiting period before any action can be taken on the proposal. Then, a ROD documenting the final decision is issued. The decisionmaking process on the Restoration Plan ends with a final decision by the Trustees regarding the Final Restoration Plan. The ROD is publicly released and announced in the Federal Register.

Implementation

The selected alternative for the Final Restoration Plan is implemented after a final ROD has been signed.

Scoping Process

Public Involvement

Roles of the Agencies

The Trustee Council selected the USDA Forest Service to act as the lead agency in developing the EIS for the Restoration Plan (see 40 CFR 1501.5–7, 1503.1, and 1508.16). The USDOI, the NMFS, the Alaska Department of Natural Resources (ADNR), the ADEC, and the ADF&G are acting as cooperative agencies with the Forest Service in preparing the EIS and scoping the action but are technically joint agencies in making the final decision.

The lead agency is responsible for coordinating the public scoping process, which is required by 40 CFR 1501.7. During the scoping process, the Forest Service coordinated with affected Federal, State, and local agencies and other interested parties, including the public; determined the scope and significance of issues to be analyzed in the DEIS; identified and eliminated issues that were not germane to the analysis; and oversaw development of the DEIS. As required by the Council on Environmental Quality (CEQ) regulations at 1506.6(f), the planning record for the Restoration Plan DEIS includes the data and information used in the analysis of the alternatives, scoping records, a chronology, and other relevant information. The planning record is available for public review on request.

Role of the Public

The MOA between the Federal and State governments requires meaningful public involvement in the decisionmaking process. Toward that end, virtually all decisions made by the Trustee Council have been made in an open public forum with opportunity for public comment. Public comments received on the Restoration Framework document also were used to identify significant issues related to implementing a restoration program. A *Summary of Alternatives for Public Comment on the Draft Restoration Plan* was released in April 1993. Public comments on the Summary of Alternatives, the Draft Restoration Plan, and the DEIS will be used to refine the Final Restoration Plan.

Since approval of the settlement, the Trustee Council has provided five different opportunities for formal public comments to be submitted. The first was in January and February 1992, to solicit input for the formation of a Public Advisory Group. The second occurred in May 1992, when the public was invited to comment on the Restoration Framework at meetings in Seldovia (teleconferenced to Port Graham), Homer, Kodiak, Juneau, Tatitlek, Valdez, Seward, Whittier, Chenega Bay, Anchorage, Cordova, and Fairbanks. These comments were used to identify issues related to implementing a restoration program. The third period for public comment was in November 1992, when agencies and individuals were invited to an "open house" held in Anchorage to discuss input for the DEIS. In the fourth period, a round of meetings was held in April 1993 to collect public comments on the Summary of Alternatives for Public Comment, released in April 1993. These meetings were held in Chignik Lagoon, Chignik Lake, Chenega Bay, Karluk, Kodiak, Port Graham, Ouzinkie, Port Lions, Seldovia, Larsen Bay, Homer, Akhiok, Old Harbor, Nanwalek (English Bay), Anchorage, Valdez, Seward, Tatitlek, Juneau, Cordova, Fairbanks, and Whittier. A fifth period for public comment was held in late January and early February 1994 after the publication of the Draft Restoration Plan and the Revised Notice of Intent to prepare an EIS. A public meeting was held in Anchorage at that time.

The DEIS and the Draft Restoration Plan will be available for public comment for 45 days. The comments received from the public will be used to create the final EIS.

In addition, a Public Advisory Group, formed in October 1992, was established to provide comment to the Trustee Council on all matters relating to planning, evaluating, and allocating funds, as well as planning, evaluating, and conducting injury assessments and restoration activities. This group is made up of 15 members who represent a cross-section of the interest groups and the public affected by and concerned about the spill. Additionally, there are two ex officio members representing the Alaska Legislature.

The Trustee Council has sought public comment on the following questions concerning the Draft Restoration Plan:

- Which resources and services should be targeted for restoration efforts?

  Should restoration actions address all injured resources and services, or should they address only those biological resources whose populations declined measurably as a result of the spill?

- How long should restoration actions last?

  Should they be undertaken until a resource or service has recovered, then stopped? Or should they continue beyond that determined point of restoration?

- Which restoration actions should be undertaken?

  Should the Restoration Plan include only those actions that are expected to produce substantial improvement over the rate of natural (unaided) recovery? Or should actions believed to produce at least some improvement over the rate of unaided recovery be included as well?

- In what geographic area should restoration actions be taken?

  Should actions be limited to the spill area, or should they be taken in any area where there is a link to injured resources or services?

- To what extent, if any, should restoration actions create opportunities for human use?

  Should human use of, and access to, the spill area be decreased? Protected? Increased? Or should new opportunities for human use be considered?

1 Purpose and Need

Issues

The interdisciplinary team (IDT) assigned to write the DEIS reviewed and analyzed the concerns and ideas expressed in the public involvement and interagency scoping. The following issue statements describe those concerns and ideas in general terms. The issue statements were evaluated to decide which issues were significant and should be addressed in the DEIS.

The public, agencies, community leaders, and other knowledgeable individuals and organizations raised many issues during the scoping process. The agencies identified the significant issues based on "reviews of similar actions, knowledge of the area or areas involved, discussions with community leaders, and/or consultations with experts and other agencies familiar with such actions and their effects" (Forest Service Handbook 1909.15 [11.5]). These issues are addressed in this document.

Issues Addressed in the EIS

Five of the issues raised during scoping were determined to be relevant to the environmental impact analysis and will be used to evaluate each alternative. Brief explanations of these issues are presented below.

Issue 1: How would restoration activities contribute to restoring injured resources and services?

This issue is central to the analysis performed in the EIS and the evaluation of restoration option effectiveness presented in the Draft Restoration Plan. In particular, the public is interested in how the rate of recovery of the resources affected by the spill will be affected by implementation of the restoration activities. The rate and degree of recovery could be measured by changes in population or distribution of species, the time required for recovery, or other factors. Besides changes in population and diversity, habitat conditions, and acreage or sites protected from development or other physical encroachment, changes in human use or management or changes in aesthetic quality also could affect the rate and degree of recovery.

Issue 2: How would activities directed at injured resources and services affect other resources and services?

Each of the proposed restoration options aims to aid injured resources and services; however, the potential exists for other resources and services to be affected as well. Although an action could be designed to improve recovery of a specific resource, the same action also could indirectly affect other resources and services. Potential impacts include changes in the number or structure of other species populations as a result of restoration-associated changes in the amount or quality of available habitat or food sources.

There would be no adverse impacts to these other resources from any of the alternatives under consideration in this DEIS other than those shown in the economic analysis. The benefits to these other resources would be in the nature of restoring or protecting their habitat and/or increasing their food supply as secondary benefits of restoring or protecting the habitat of an injured resource.

Issue 3: What ecological change would occur in the spill area as a result of restoration activities?

Ecological recovery in the spill area is the intent of the proposed restoration activities. The anticipated result of the combined restoration efforts is recovery of the ecosystem to prespill conditions and overall biodiversity levels.

Issue 4: How would restoration activities affect land uses, local economies, and communities?

Some proposed restoration activities may result in the creation or elimination of jobs; and the number and kinds of new jobs, as well as the income associated with them, are of interest to the public. A concern is that employment could be reduced in some resource development industries that may be adversely affected by some restoration options. The effect of increased or decreased employment on the economy and services of the local communities also concerns the public, as well as government agencies and private industry.

For example, the public has anticipated that changes in land use could result from land acquisition for protection of habitat. Ownership of some land could move from the private sector to the public sector. Increased protection of lands already under public management may be considered. Some changes in existing land management strategies could decrease opportunity for such activities as logging and mining; others could increase access to recreation sites and maintain opportunities for commercial tourism. The economic and infrastructure implications of these changes are considered in this document.

Issue 5: What changes to subsistence uses would occur as a result of restoration activities?

Some of the proposed restoration options are directed at restoring subsistence uses of resources in the spill area. Subsistence use was affected by contamination of resources used for subsistence and by users' perception of contamination. Subsistence users also report declines in the abundance of many subsistence resources. Restoration activities may focus on increasing the abundance of natural resources in the area used for subsistence. Subsistence use also may be affected by the implementation of options that are not intended to specifically address subsistence use; this potential for secondary impact is considered in the analysis of the alternatives.

There are continuing human health and safety concerns that certain resources used for subsistence may have been contaminated. Eating oil-contaminated food is harmful to humans, as is direct physical contact with crude oil. To avoid injury to humans, fisheries were closed and harvesting of affected species was discouraged immediately after the spill occurred. Some of the restoration activities aim to decrease the levels of harmful hydrocarbons in resources used for subsistence. Others focus on obtaining information to determine the level of persistent contamination, if any, in harvested resources.

Issues Not Addressed in this EIS

The public raised many issues during the various public comment periods and public meetings that were relevant to developing the Draft Restoration Plan but are not relevant to analyzing the effects of the proposed action and alternatives. Those issues are identified in the Restoration Framework document published in April 1992 and in the Draft Restoration Plan (November 1993). Those issues relate to planning and were dealt with in those documents. They were determined to not address issues which would have a significant effect on the human environment.

Impact Topics Studied by the EIS

During the scoping process for the DEIS and the Draft Restoration Plan, many resources and services were named as having been injured or reduced as a result of the EVOS. Tables 1-1 and 1-2 show the resources and services that were identified at some point in the scoping. The injury status of these resources and the services they provide was evaluated in the development of the Draft Restoration Plan and was displayed in Appendix B, Tables B-4, B-5, and B-6 (pp. 35-55). Some resources identified in Table 1-1 showed no oil spill mortality. This was especially true of most of the terrestrial mammals. Several other resources showed mortality but no measured population decline because of spill injury. Other resources identified by the public are believed to be recovering. Table B-1, in Appendix B of the Draft Restoration Plan, shows the latest information on the status of the injured resources and services.

The brochure published in April 1993 listed the resources and the services they provide that were reduced or injured by the oil spill and categorized the natural resources by whether a population decline had occurred. In the Draft Restoration Plan released on November 28, 1993, Table B-1, the injured biological resources were grouped by recovery status, not by measured population decline. The other resources and human uses injured or reduced also were shown.

Table 1-1
Resources Identified in Scoping[1]

Mammals	Fish and Shellfish	Birds	Intertidal Organisms
Harbor Seal	Cutthroat Trout	Bald Eagle	Seaweed
Sea Otter	Dolly Varden	Black Oystercatcher	Snail
Killer Whale	Pacific Herring	Common Murre	Barnacle
River Otter	Pink Salmon	Harlequin Duck	Sea Urchin
Black Bear	Sockeye Salmon	Marbled Murrelet	
Mountain Goat	Rockfish	Pigeon Guillemot	
Deer	Tomcod	Eider Duck	
Mink	Silver Salmon	Other Ducks	
Dall Porpoise	Northern Smoothtongue	Swan	
Sea Lion		Brant	
	Chum Salmon	Canada Geese	
	King Salmon	Loon	
	Bottomfish	Cormorant	
	Candlefish	Grebe	
	King Crab	Bonaparte's Gull	
	Tanner Crab	Arctic Tern	
	Dungeness Crab	Black-Legged Kittiwake	
	Shrimp	Tufted Puffin	

[1]Note: Common names of species used in public comments.

Source: Summary of Public Comment on Alternatives, EVOS Trustee Council, September 1993.

Table 1-2
Services and Other Resources Identified in Scoping

Services	Other Resources
Commercial Fishing	Air, Water, and Sediments
Commercial Tourism	Archaeological Resources
Passive Use	Designated Wilderness Areas
Recreation Including Sport Fishing, Sport Hunting, And Other Recreation Use	
Subsistence	

Source: Summary of Public Comment on Alternatives, EVOS Trustee Council, September 1993.

Impact Topics

The IDT considered the various proposed alternatives and the issues raised in public comment and selected the following impact topics to cover these issues analytically. Some of the key factors that were considered included: whether any actions are proposed that are likely to have an environmental impact; and, the issues and concerns raised by the public during scoping. This information, along with the public comment, and the recovery status of the resources and services is the basis for the decision to analyze the impacts to the following resources and services:

Fish

Pink Salmon	Sockeye Salmon
Pacific Herring	

Intertidal Resources (Such as Clams, *Fucus*, Mussels, Limpets, etc.)

Marine Mammals

Harbor Seals	Sea Otters

Birds

Common Murres	Harlequin Duck
Marbled Murrelet	Pigeon Guillemot

Other Resources

Designated Wilderness Areas	Archaeology

Services

Commercial Fishing	Sport Fishing
Recreation	Tourism
Subsistence	

In addition to the resources and services analyzed in this DEIS, the restoration program may include other resources with injuries related to the spill. These resources include killer whales, river otters, bald eagles, black oystercatchers, rockfish, and subtidal organisms. At this time, actions that have been identified for these resources are primarily monitoring and research activities, or management based actions. These types of actions are outside the scope of analysis in this DEIS.

The NEPA requires an analysis of impacts on the human environment. Some topics required to be studied by NEPA are not affected by the proposed action. These include land use plans and coastal zone management plans and are discussed below.

Possible Conflicts Between the Proposed Action and Other Plans

A review of the Coastal Management Programs and other land management plans to identify any conflicts between them and the Draft Restoration Plan (the proposed action in the DEIS) was made in accordance with 40 CFR 1502.16(c).

The programs and plans that were reviewed include:

- The 1964 Chugach National Forest Land and Resource Management Plan, as amended.
- The Kodiak National Wildlife Refuge CCP.
- The Alaska Maritime National Wildlife Refuge CCP.
- The Kenai Fjords National Park General Management Plan (GMP) (1984)
- The Katmai National Park and Preserve GMP, Wilderness Suitability, and Land Protection Plan (LPP) (1986)
- The Kenai Fjords LPP (1988 as amended 1992)

- The Kenai Fjords Wilderness Recommendations FEIS (1988)
- The Katmai National Park and Preserve Wilderness Recommendations FEIS (1988)
- The Bureau of Indian Affairs (BIA) land use plans for restricted Native allotments
- Eyak Lake AMSA Cooperative Management Plan
- The 1986 Kenai River Comprehensive Management Plan.
- The 1988 Prince William Sound Area Plan for State Lands.
- The 1989 Alaska Coastal Management Program (ACMP) Statutes and Regulations.
- The 1989 City of Whittier Coastal Management Program.
- The Valdez Coastal Management Program, reprinted July 1992.
- The 1986 Cordova Coastal Management Program.
- The 1990 Kenai Peninsula Borough Coastal Management Program.
- The 1992 Port Graham/Nanwalek Area Which Merits Special Attention.
- The 1983 Kodiak Island Borough Coastal Management Program.
- The Regional Comprehensive Salmon Enhancement Plans for:
  Prince William Sound, 1983, 1986, and 1994;
  Cook Inlet, 1982; and,
  Kodiak, 1984 and 1992.

Findings

Chugach National Forest Land and Resource Management Plan. The Forest Planning Staff reviewed the relationship between the Chugach Forest Plan and EVOS activities and reached the following conclusions:

1. Current Forest Plan management direction allows for implementation of EVOS restoration activities identified in the Draft Restoration Plan.

2. Habitat protection and acquisition are compatible and consistent with Forest Plan direction. Much of the Chugach National Forest has a protective management prescription and is naturally protected because of remoteness or topography.

3. The Forest Plan does not need to be amended to achieve the goals of the Draft Restoration Plan.

4. Restoration activities approved to date are appropriate and consistent with the current Forest Plan management prescriptions section where appropriate management practices and activities are identified.

5. The goals and objectives of the proposed EVOS Monitoring and Research programs are fully compatible with those outlined in the Forest Plan.

6. If funded and implemented, many of the scheduled Chugach National Forest projects will provide incidental benefits toward reaching EVOS restoration objectives.

National Wildlife Refuge System Comprehensive Conservation Plans. The Fish and Wildlife Service has reviewed the relationship between the Kodiak National Wildlife Refuge CCP, and Alaska Maritime National Wildlife Refuge CCP, and the EVOS Draft Restoration Plan and reached the following conclusions:

> Habitat protection and acquisition are compatible and consistent with the Kodiak National Wildlife Refuge and Alaska Maritime National Wildlife Refuge CCP's.

- Acquisition of high value habitats and inholdings within the Kodiak National Wildlife Refuge and Alaska Maritime National Wildlife Refuge is supported by the CCP's. Also, the Kodiak National Wildlife Refuge Land Protection Plan describes and set priorities for all refuge inholdings for protection status.

- Certain specific actions that could be undertaken in implementing the Restoration Plan, such as developing new facilities or employing habitat manipulation techniques, could be in conflict with refuge plans. However, the Draft Restoration Plan does not identify where any actions will occur and requires that all actions be in compliance with Federal and State laws and regulations. There is no provision or direction in the Draft Restoration Plan to conduct activities on any Federal, State, or private lands when the land manager is not in agreement with the action.

National Park System Plans. The National Park Service has reviewed the relationship between the proposed action and the GMP's and LPP's for Kenai Fjords National Park and Katmai National Park and Preserve, and we reached the following conclusions:

- Habitat protection and acquisition are compatible and consistent with the GMP's and LPP's for Kenai Fjords National Park and Katmai National Park and Preserve.

- Acquisition of high value habitats and inholdings within Kenai Fjords National Park and Katmai National Park and Preserve is supported by the GMP's and LPP's.

- The National Park Service is not aware of any conflicts between the Draft Restoration Plan the Park GMP's and LPP's.

Bureau of Indian Affairs Restricted Native Allotments. The Bureau of Indian Affairs indicated that there are no conflicts between the proposed action and land use plans for restricted Native allotments managed by the Bureau. They also stated that they will continue to work with the affected tribes to ensure subsistence activities and resources are restored and protected.

Prince William Sound Area Plan for State Lands. The areawide land management policies outlined in Chapter 2 of the Area Plan consist of goals and management guidelines for coordination and public notice; fish and wildlife habitat and harvest areas; floating residential and commercial facilities; forestry; instream flow; mariculture; materials; public and private access; recreation, tourism, cultural and scenic resources; settlement; shoreline development; subsurface resources; and transportation and utilities. Many of the management guidelines presented in the Area Plan compliment restoration objectives outlined in the Draft Restoration Plan. While some of the activities that could be carried out on State land within Prince William Sound could conflict with restoration objectives, the Area Plan itself does not conflict with the Draft Restoration Plan.

Alaska Coastal Management Program Statutes and Regulations. The pertinent section of the ACMP is 6 AAC Chapter 80. This chapter details the standards used by State agencies in carrying out their responsibilities under the Alaska Coastal Management Act. Standards have been established for activities related to coastal development; geophysical hazard areas; recreation; energy facilities; transportation and utilities; fish and seafood processing; timber harvest and processing; subsistence; habitats; air, land, and water quality; historic, prehistoric, and archaeological resources; and areas that merit special attention.

All of the standards in the Alaska Coastal Management Act are designed to minimize conflicts between resource use and resource protection. The intent of the standards appears to be maintaining a healthy functioning ecosystem. Objectives of the ACMP, under which fall the coastal management programs of all borough, city, or Areas Meriting Special Attention (AMSA's) are outlined below.

- The use, management, restoration, and enhancement of the overall quality of the coastal environment;

- the development of industrial or commercial enterprises that are consistent with the social, cultural, historic, economic, and environmental interests of the people of the State;

- the orderly, balanced utilization and protection of the resources of the coastal area consistent with sound conservation and sustained yield principals;

- the management of coastal land and water uses in such a manner that, generally, those uses that are economically or physically dependent on a coastal location are given higher priority when compared to uses that do not economically or physically require a coastal location;

- the protection and management of historic, cultural, natural, and aesthetic values and natural systems or processes within the coastal area;

- the prevention of damage to or degradation of land and water reserved for their natural values as a result of inconsistent land or water usages adjacent to that land;

- the recognition of the need for a continued supply of energy to meet the requirements of the State and the contribution of a share of the State's resources to meet National energy needs; and,

- the full and fair evaluation of all demands on the land and water in the coastal area.

The ACMP policies, standards, and objectives are not in conflict with the goals and objectives of the Draft Restoration Plan. The Draft Restoration Plan is consistent with the ACMP to the maximum extent practicable.

Eyak Lake AMSA Cooperative Management Plan. The policies and guidelines of the Eyak Lake AMSA Cooperative Management Plan are designed to protect to the maximum extent possible resource values important to the community, and it does not appear there is any conflict between the Draft Restoration Plan and the Eyak Lake AMSA.

Kenai River Comprehensive Management Plan. The goals and objectives section is the pertinent section of the Kenai River Management Plan. The plan is designed to protect and perpetuate the fish and wildlife and their habitats along the Kenai River while protecting and enhancing public use and enjoyment of the river. These goals and objectives are in harmony with the Draft Restoration Plan goals and objectives, and there are no apparent conflicts between the two plans.

City of Whittier Coastal Management Program. The City of Whittier Coastal Management Program covers the western and southern portion of Passage Canal from the Anchorage Municipality boundary to about one mile east of Shotgun Cove. The goals and objectives outlined in the program revolve around a theme of providing for orderly development of the Whittier coastal management area while protecting other resource values to the extent possible. Improving access to Whittier and Shotgun Cove and developing Shotgun Cove for residential use and as a small boat harbor are examples of the plan goals. Two areas which merit special attention are identified in the plan, the Shotgun Cove/Emerald Bay Subdivision and the Whittier Port and Harbor.

The Whittier CMP policies are designed to minimize impacts to coastal resources while allowing appropriate development to occur within the coastal area. The goals, objectives, and policies of the Whittier CMP are not in conflict with the goals and objectives of the Draft Restoration Plan.

Valdez Coastal Management Program. This program covers the Valdez Municipal Boundary and roughly extends from the mouth of Valdez Narrows on the west to Keystone Canyon on the east. The goals of the program are designed to facilitate reasonable community expansion and development while meeting resource protection laws and regulations. The goals dealing with industrial, commercial, and residential development could be construed to be in conflict with the Draft Restoration Plan. However, this development is focused in areas already receiving high human use or on lands with low value as habitat for injured resources. Other coastal program goals are designed to protect coastal habitats and scenic beauty and therefore compliment the objectives of the Draft Restoration Plan.

Cordova Coastal Management Program. The Cordova Coastal Management Program covers the city limits of Cordova. The objectives outlined in the program are to be used in evaluating plans or permit applications for development within the program boundaries. They are designed to minimize impacts to the coastal zone while allowing for water-related or water-dependent uses. These objectives do not appear to conflict with the goals and objectives of the Draft Restoration Plan.

Port Graham/Nanwalek AMSA. This AMSA covers most of the Port Graham and Nanwalek Village Corporation lands to the west of Kachemak Bay State Wilderness Park. The AMSA includes Windy Bay, Port Chatham and the Chugach Islands. The area was designated as an AMSA to 1) protect traditional human subsistence needs; 2) maintain the high quality and productivity of important coastal habitats and resources; 3) minimize conflicts between uses of coastal resources and development activities; and 4) preserve unique cultural values, lifestyles, sites of historic and archaeological significance, and areas of outstanding scenic beauty. The goals for water quality, coastal erosion, fish and wildlife habitat, subsistence, commercial fishing, mariculture, cultural resources, transportation, recreation and tourism, navigation obstruction, timber harvest, fish and seafood processing, and oil spill emergency preparedness and response--and the enforceable policies developed to further those goals--go beyond the Kenai Peninsula Borough Coastal Management Program in providing protection to resources. There does not appear to be any conflict between the goals and policies of this program and the Draft Restoration Plan.

Kenai Peninsula Borough Coastal Management Program. The Kenai Peninsula Borough Coastal Management Program covers the entire Kenai Peninsula Borough up to the 1,000-ft contour. It is tiered off the ACMP and provides more specific direction on review of uses and activities requiring permits and approvals within the coastal zone. Broad goals, specific objectives, and enforceable policies are spelled out for coastal development; geophysical hazards; recreation and public access; energy and industrial development;

transportation and utilities; fishing and seafood processing; mariculture; timber management; mining and mineral processing; subsistence; fish and wildlife habitat; air, land, and water quality; and archaeological and historic resources.

The goals, objectives and policies are designed to allow for compatible development while maintaining a quality environment. There does not appear to be a conflict between the Kenai Peninsula Borough Coastal Management Program and the Draft Restoration Plan.

Kodiak Island Borough Coastal Management Program. The Kodiak Island Borough Coastal Management Program covers the entire Borough, from sea level to the tops of the mountains. The Borough boundary is the Kodiak Archipelago. Goals, objectives, and policies that address coastal development; recreation; energy facilities; transportation; utilities; fisheries; timber harvesting and processing; agriculture; and mining and mineral processing provide direction in reviewing and approving activities and uses of the coastal zone. These goals, objectives, and policies are tiered off of the ACMP. There does not appear to be any conflict between this coastal management program and the Draft Restoration Plan.

Regional Comprehensive Salmon Enhancement Plans. These documents provide comprehensive plans for the management, rehabilitation and enhancement of salmon resources according to State of Alaska Legislative mandate (Chapter 113 SLA 1971) that directed the Alaska Department of Fish and Game to "develop and continually maintain a comprehensive, coordinated long-range plan for the orderly present and long-range rehabilitation... of all aspects of the state's fishery." Projects that may be proposed and funded as a result of this programmatic EIS will be reviewed according to this established plan to assure that they will be consistent projects identified in that plan. The goals and objectives of the Restoration Plan are consistent with those of the Regional Comprehensive Salmon Enhancement Plans.

Impacts and Alternatives Considered But Not Analyzed in Detail in the EIS

The following are those impact topics and alternative elements considered but not analyzed in detail in the development of this DEIS. The topics and elements are briefly described and the reasons for not pursuing them further are given.

Impact Topics Not Analyzed

Resources and the services they provide that currently are recovering and are not the subject of proposed restoration actions under any of the proposed alternatives, except that monitoring and research may be done to ensure that the resources do recover fully. These resources are as follows:
- Bald eagle--recovering,
- black oystercatcher--recovering,
- intertidal organisms (other than clams, mussels, and *Fucus*)--no actions proposed,
- killer whale--recovering, and
- subtidal organisms--no actions proposed.

The status of recovery of the following resources and services is unknown at this time. Impacts on these resources and services will not be analyzed in the DEIS, except as noted.

They represent a minor portion of the various alternatives and thus would have few actions associated with them other than monitoring.

Biological Resources:
- Cutthroat trout--no actions proposed (except creating or enhancing runs for sport fishing, which is an injured service),
- Dolly Varden--no actions proposed (except creating or enhancing runs for sport fishing, which is an injured service),
- river otter--no actions proposed, and
- rockfish--no actions proposed.

Services:
- Sport hunting--Sport hunting is most directly affected by specific agency regulations of the ADF&G.
- Passive uses--Injuries to passive uses are tied to public perceptions of injured resources. Any restoration objective that aids recovery of injured resources, or prevents further injuries, will help recovery of passive-use values. Passive uses will have recovered when people perceive that aesthetic and intrinsic values associated with the natural resources injured by the spill area are no longer diminished.

Alternative Elements Not Considered in Detail

Agency Management Actions

The Trustee Council uses funds from the civil settlement for activities to restore injured resources and the services they provide. The Trustee Council *does not* manage fish and wildlife resources or manage land. Fish and game management decisions are made by fish and game boards, or by appropriate Federal or State agencies. The Trustee Council may fund research necessary for restoration. The analysis in the DEIS is limited to those actions funded by the Trustee Council that impact (positively or negatively) the resources identified as the subject of some action (impact topics).

Monitoring and Research

The alternatives analyzed in this DEIS consist of four categories of restoration activities: administration and public information, monitoring and research, general restoration, and habitat protection. Of the anticipated activities that may occur under each of these categories, only some activities in the general restoration and habitat protection categories have the potential to produce environmental effects to be analyzed in this DEIS. Other activities, especially monitoring and research, could result in projects that would be only informational in nature but extremely beneficial to the restoration of injured resources or the services they provide. These benefits either depend on the results of research that is not yet completed or require an agency management action that is outside the jurisdiction of the Trustee Council. Therefore, the impacts of these actions will not be analyzed in this DEIS.

For example, the restoration program may include research projects designed to determine if changes in the forage fish populations are contributing to the long-term decline or slow recovery of the injured marbled murrelet populations. The implementation of research projects is not likely to produce an environmental effect, although this will be determined during the project-specific NEPA assessment at the time the research is undertaken. In this example, there are at least two possible outcomes from the research:

1. Key forage fish populations are stable and readily available in important marbled murrelet foraging areas, or

2. Forage fish populations are lower than expected in important marbled murrelet foraging areas.

Either of these findings provide valuable information in the restoration effort to help marbled murrelets. In the first case, scientists and managers would know to focus their restoration efforts on other possible explanations, such as disease or habitat loss. In the second case, efforts could be made to improve the forage fish populations. Some of these activities, such as management changes to commercial fisheries, are outside the jurisdiction of the Trustee Council. In this example, the decision to implement management changes that could cause a change in the forage fish population and, subsequently, a change in the recovery of marbled murrelets may be made by the State Board of Fish and Game or appropriate federal agency and is outside the authority of the Trustee Council.

Because it is impossible to predict the outcome of potential research activities that may be a part of the restoration program alternatives, these activities are not included in the analysis of effects in this DEIS. Similarly, monitoring and general restoration projects that are designed to improve our ability to manage an injured resource but require action outside the authority of the Trustee Council is beyond the scope of this DEIS.

Chapter 2

Alternatives, Including The Proposed Action

Chapter 2

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Chapter 2

Alternatives, Including The Proposed Action

Introduction

This chapter describes the array of management alternatives considered in the development of the *Exxon Valdez* Restoration Plan. It covers the five alternatives for restoration, including the "no action" alternative. The injured resources and services (human uses) that would likely be affected by implementation of each of the alternatives are summarized below under the Comparison of Alternatives section. For more detailed information about the alternatives, please refer to the Draft *Exxon Valdez* Oil Spill Restoration Plan Summary of Alternatives for Public Comment (EVOS Trustee Council, April 1993; hereafter referred to as the brochure) and the Draft *Exxon Valdez* Oil Spill Restoration Plan (EVOS Trustee Council, November 1993).

Each of the alternatives addresses policies for selecting possible restoration activities. Each of the alternatives is made up of variations of four basic categories of activities: (1) Habitat Protection and Acquisition; (2) General Restoration of resources and services; (3) Monitoring and Research; and (4) Administration and Public Information. The General Restoration category contains general types of actions designed to achieve a particular objective in relation to an injured resource. ("Actions" is the term used to refer to site-specific projects to be implemented to achieve the goals of the alternative.) The analysis in this draft environmental impact statement (DEIS) pertains to the alternatives and the their associated action patterns but does not consider individual actions. Appropriate site-specific environmental analysis will be conducted by the appropriate agencies for all future actions.

Alternative 5 contains an element not present in the other alternatives. In response to public comments that a fund should be set aside for long-term restoration and research activities, the proposed action includes the establishment of a Restoration Reserve.

Program Elements Common to All Alternatives

There are several program elements that are common to all of the proposed alternatives. They are as follows:

- The restoration program will take an ecosystem approach.

  Recovery from the oil spill involves restoring the ecosystem as well as restoring individual resources. An ecosystem includes the entire community of organisms that interact with each other and their physical surroundings, including people and their relationship with other organisms. The ecosystem will have recovered when the population of flora and fauna are again present, healthy, and productive; there is a full complement of age classes; and people have the same opportunities for the use of public resources as they would have had if the oil spill had not occurred.

  For General Restoration activities, preference is given to projects that benefit multiple species rather than to those that benefit a single species. However, effective projects for restoring individual resources will also be considered. This approach will maximize benefits to ecosystems as well as injured resources and the services they provide.

  Habitat Protection and Acquisition emphasizes protection of multiple species, ecosystem areas, such as entire watersheds or areas around critical habitats. This approach will be more likely to ensure that the habitat supporting an injured resource or service is protected. In some cases, protection of a small area will benefit larger surrounding areas, or provide critical protection to a single resource or service.

  Monitoring and Research activities include an ecosystem monitoring and research program. The ecosystem monitoring and research program will provide an understanding of the physical and biological interactions that affect an injured resource or service. This understanding will facilitate restoration and management.

- Projects designed to restore or enhance an injured service must have a sufficient relationship to an injured resource.

  This policy requires that a project to restore or enhance an injured service must be sufficiently related to a natural resource. It can be related to a natural resource in various ways. It could directly restore a resource, provide an alternative resource, or restore access or people's use of the resource. The strength of the required relationship has not been defined by law, regulation, or the courts. However, a connection with an injured resource is necessary. In determining whether to fund a project to restore services, the strength of the project's relationship to injured resources will be considered.

- Competitive proposals for restoration projects will be encouraged.

  Most restoration projects have been undertaken by State or Federal agencies. However, the number of competitive contracts awarded to nongovernmental agencies has increased each year and is expected to continue to increase.

  This policy encourages active participation from individuals and groups in addition to the trustee agencies and may generate innovation and cost savings. This approach may be inappropriate for some restoration projects, but, where appropriate, competitive proposals will be sought for new project ideas and to implement the projects themselves.

- Restoration projects will be subject to open, independent scientific review before Trustee Council approval.

  This policy continues an already existing practice. Independent scientific review gives an objective evaluation of the scientific merits of the project. It also assures the public that scientific judgements are without bias.

- Meaningful public participation in restoration decisions will be actively solicited.

  Public participation has been an important part of the restoration process and a public concern since the spill occurred. This policy continues existing practices. Public review and user group participation will continue to play a key role in future Trustee Council activities, such as developing work plans, and will precede Trustee Council decisions.

- Government agencies will be funded only for restoration work that they do not normally conduct.

  Many public comments have expressed concern that restoration funds will support activities that government agencies would do anyway. This policy addresses that concern. It also affirms the practice that has been in effect since the beginning of the restoration process. To determine whether work is normally conducted by agencies, the Trustee Council will consider agency authority and the historic level of agency activities.

2 Alternatives

Alternative 1: No Action

The "no action" alternative required by the National Environmental Policy Act (NEPA) consists entirely of normal agency management activities, which are described below. If this alternative were implemented, current management would continue, no new activities or programs would be instituted as a result of the oil spill, and the scope of present activities and programs would not change. Agency monitoring of natural recovery would remain at present levels, and agency responsibilities would remain unchanged. None of the remaining funds from the civil settlement would be spent if this alternative were implemented.

The following text briefly summarizes the normal agency management activities that would apply to the EVOS area. The U.S. Forest Service manages the Prince William Sound portion of the Chugach National Forest with a primary management emphasis on recreation and fish and wildlife. No timber harvesting is planned within the Prince William Sound area at this time. Recreation management is primarily directed at providing marine-based recreation, cabins, and wilderness experience. Wildlife and fish management is directed at improving habitat for sport and commercial species and subsistence use and of maintaining wild stock habitat.

The National Oceanic and Atmospheric Administration's (NOAA) normal agency management activities for living marine resources in Alaska occur principally under three statutes: The Magnuson Fisheries Conservation and Management Act, which calls for NOAA to manage the commercial fisheries in Federal waters by developing and implementing Fishery Management Plans; the Endangered Species Act, which requires the protection of, and promotes the recovery of, endangered and threatened species; and the Marine Mammal Protection Act, which requires the conservation, protection, and management of species of whales, porpoises, and pinnipeds from adverse human activities. All of these management activities are implemented through regulation, enforcement, and research.

The U.S. Fish and Wildlife Service (USFWS) manages the national wildlife refuges to accomplish the following purposes:

- To conserve fish and wildlife populations and habitats in their natural diversity, including but not limited to marine mammals; marine birds and other migratory birds; the marine resources upon which they rely; and bears, caribou, and other mammals.

- To fulfill the international treaty obligations of the United States with respect to fish and wildlife and their habitats.

- To provide the opportunity for continued subsistence uses by local residents.

- To provide a program of national and international scientific research on marine resources.

- To ensure, to the maximum extent practicable, water quality and necessary water quantity within refuges under its management.

There are currently no plans to change any USFWS management activities in response to the oil spill.

The National Park Service (NPS) manages the National Park System and the National Historic Register to accomplish the following purposes:

- To conserve the scenery and the natural and historical objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

- To provide the opportunity for continued subsistence uses by local residents.

- To document and protect nationally significant archeologial and historic resources.

The Alaska Department of Environmental Conservation (ADEC) regulates activities that could directly affect resources because of pollution or other environmental injury. It formulates regulations limiting the amount, kind, and location or other restrictions necessary to protect the resources and environment. The ADEC is involved in education efforts and technology transfer directed at reducing pollution.

The Alaska Department of Natural Resources (ADNR) manages State land and resources and regulates timber harvest on private and State land under the Alaska Forest Practices Act. Through the State Office of History and Archaeology, ADNR is responsible for protection of archaeological resources statewide. In the spill area, the ADNR manages Shuyak State Park (Afognak Island), Kachemak Bay State Park (Kenai Peninsula), and several marine parks in Prince William Sound; conducts an active oil and gas leasing program in Cook Inlet; and authorizes use of public waters, for example, for hatcheries and glacier ice harvesting. Management of State-owned lands in the spill area also includes such actions as authorizing aquatic farming, timber transfer facilities, or shore fishery leases on tidelands; selling certain designated uplands; transferring uplands to municipalities to fulfill their entitlements; issuing rights-of-way across State lands; and entering into land exchanges or cooperative management agreements beneficial to the State.

The Alaska Department of Fish and Game (ADF&G) is charged with managing, protecting, and enhancing the fish, game, and aquatic plant resources of the State. Functions include managing harvests to ensure sustained yields of wild stocks of fish and game, granting permits for activities in anadromous fish streams, administering ADF&G Special Areas, overseeing and coordinating fisheries enhancement activities, and collecting data on subsistence harvest activities. In addition, the Department reviews and comments on a variety of permit applications and plans that potentially impact State-managed species and habitats. The ADF&G also makes management recommendations to the State Board of Fisheries and Game, which is responsible for determining fish and wildlife allocation issues and establishing harvest regulations. The ADF&G has the authority to order emergency harvest openings and closures.

2 Alternatives

Assumptions Used for Impact Assessment

One aspect of significance to the analysis of the alternatives in this EIS is the assumption that under Alternative 1 -- the No Action alternative -- the private lands in the EVOS area are subject to private use and as a result could be used for some purposes that could effect the habitat and possibly the resources that were injured by the spill itself. Because this is the case, it was assumed for purposes of analysis in this EIS that those lands would be put to such uses and would result in adverse impacts to the injured resources and services being analyzed.

The analysis of the impact of habitat protection is based on the 863,100 acres considered in the Comprehensive Habitat Protection Process; Large Parcel Evaluation and Ranking Volumes I and II (EVOS Restoration Team, 1993). These parcels are shown in Figures 2-1 through 2-3. Appendix A, Table A-1 shows the specific benefits associated with protecting each of these parcels.

The parcels evaluated in the large parcel process were drawn from parcels nominated by landowners and were limited to parcels greater than 1,000 acres. The pool of candidate lands will change as more landowners express interest in having their land considered and as smaller parcels are considered. However, the large parcels evaluated and ranked in 1993 are assumed to be indicative of the benefit that may result from habitat protection.

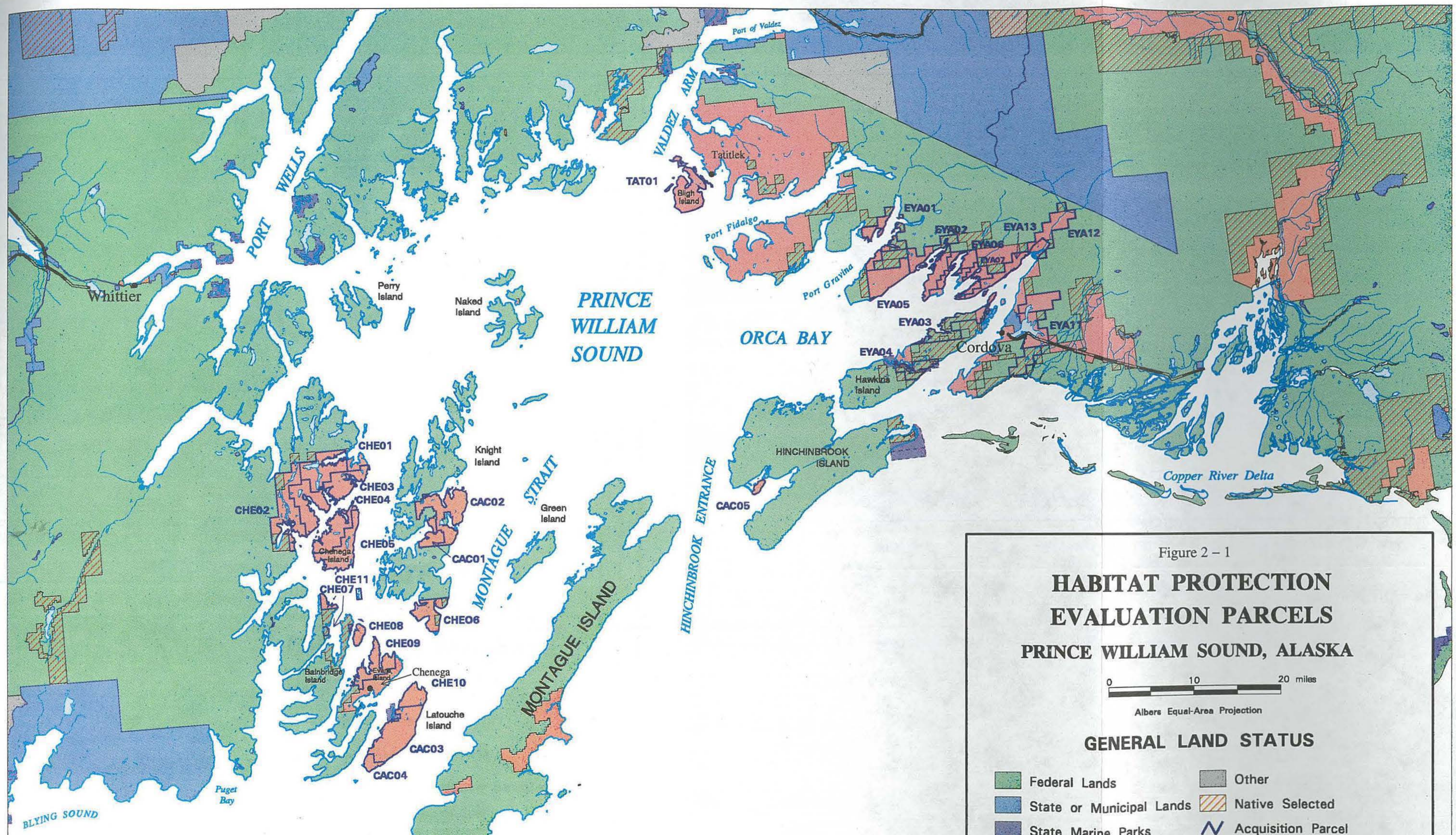

Figure 2 – 1

HABITAT PROTECTION EVALUATION PARCELS

PRINCE WILLIAM SOUND, ALASKA

0 10 20 miles

Albers Equal-Area Projection

GENERAL LAND STATUS

- Federal Lands
- State or Municipal Lands
- State Marine Parks
- Native or Other Private Lands
- Other
- Native Selected
- Acquisition Parcel Boundaries

SOURCES:
Land status provided by the US Forest Service, 1993, and the ADNR, Land Records Information Section (LRIS), 1993.

Parcel boundaries and related habitat information was extracted from 'Comprehensive Habitat Protection Process: Large Parcel Analysis,' prepared by the Exxon Valdez Restoration Team and the Habitat Protection Work Group, November 30, 1993.

Date Printed: May 19, 1994

Produced by: Alaska Department of Natural Resources, Land Records Information Section

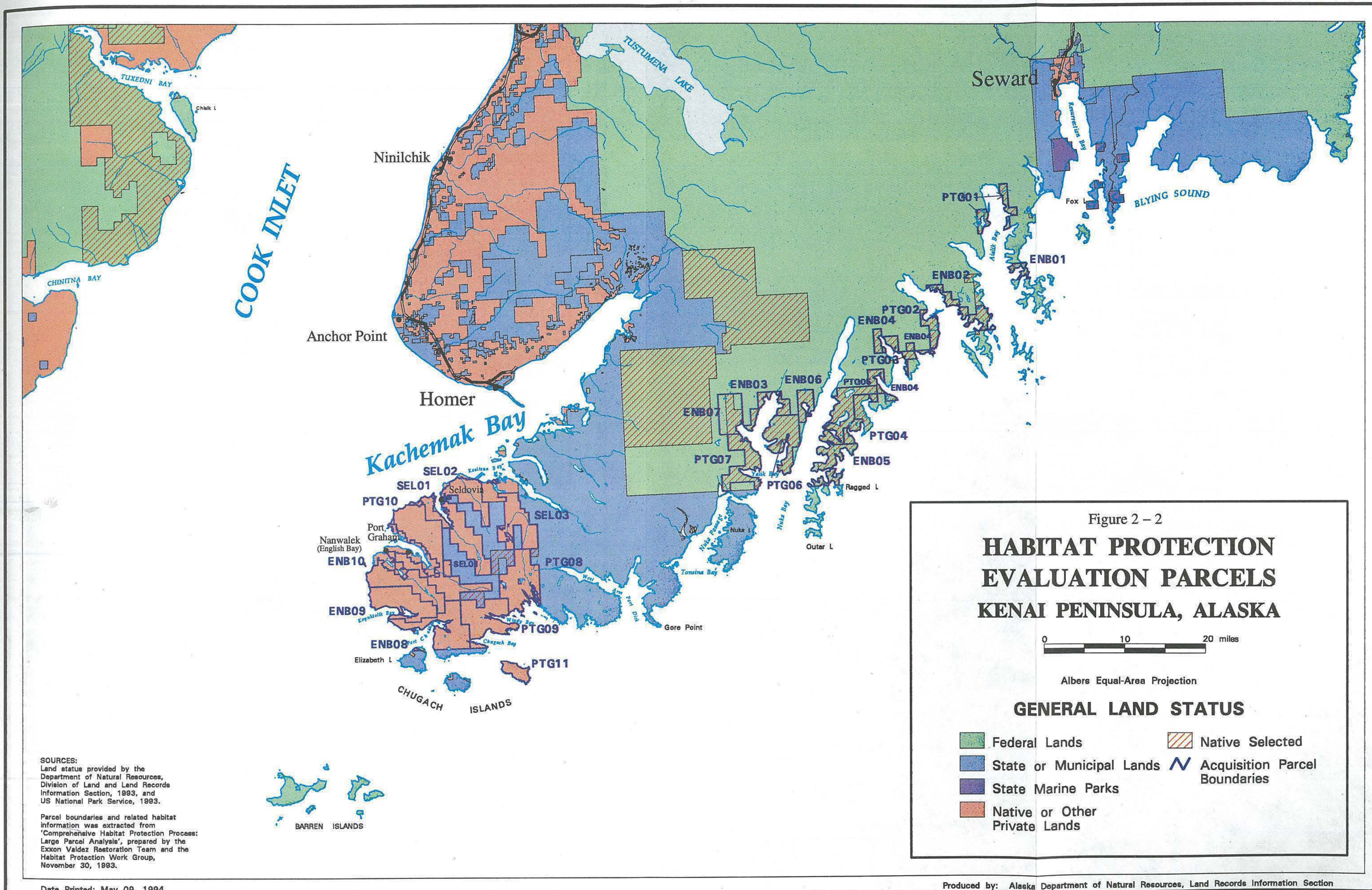

Figure 2 – 2

HABITAT PROTECTION EVALUATION PARCELS KENAI PENINSULA, ALASKA

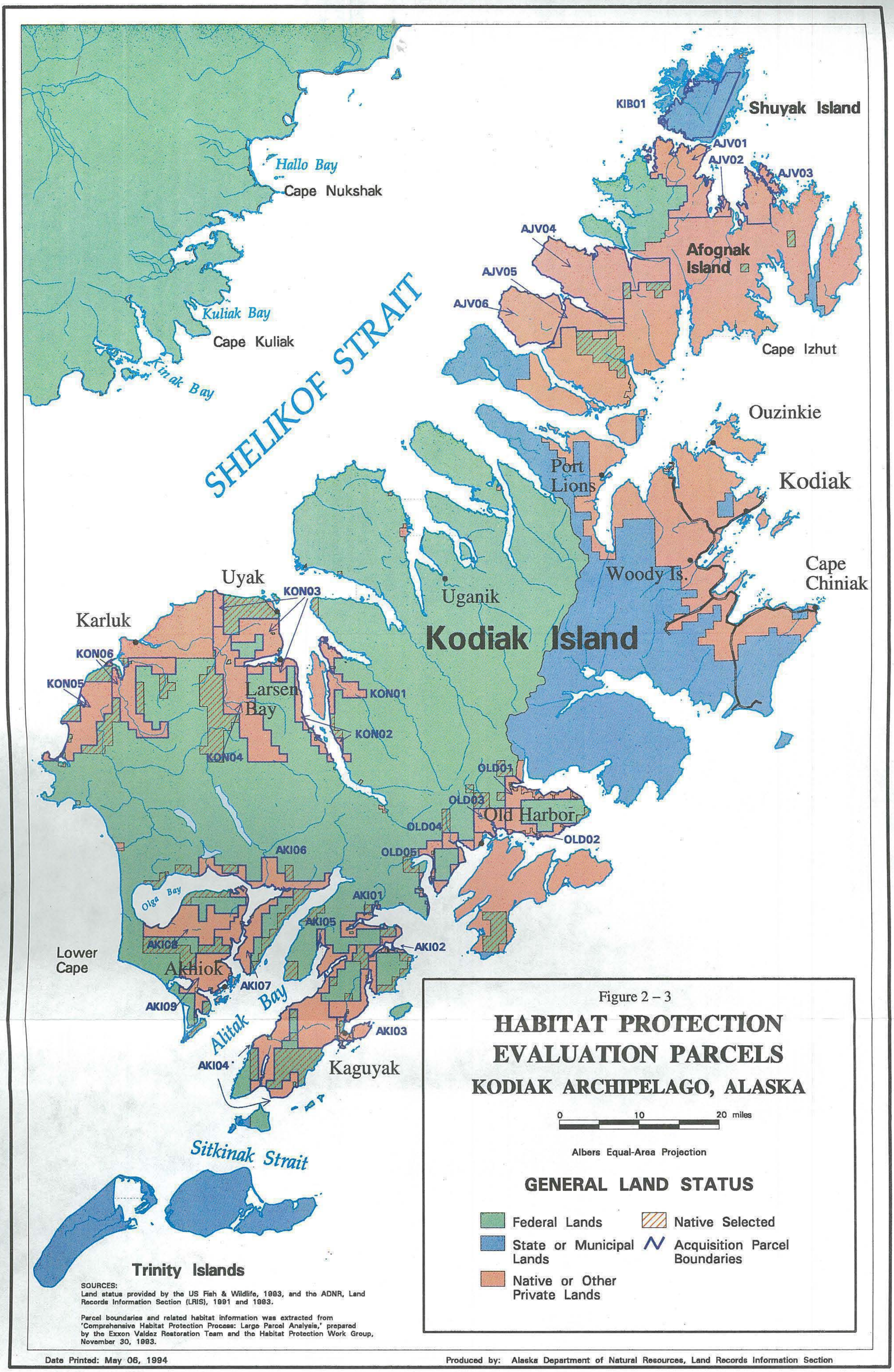

Figure 2 – 3

HABITAT PROTECTION EVALUATION PARCELS
KODIAK ARCHIPELAGO, ALASKA

Alternative 2: Habitat Protection

The goal of Alternative 2 is to provide maximum protection of strategic lands and habitats important to the long-term recovery of injured resources and the services they provide. Monitoring and Research and Habitat Protection and Acquisition are the only restoration actions included in this alternative. The primary means of protection in this alternative is the acquisition of private land interests or changes in the management of currently held public lands. Monitoring and Research would be conducted to evaluate the effectiveness of protection measures and to track the recovery of damaged resources and services. Actions that may be undertaken under this alternative would be confined to the area affected by the oil spill.

Policies

- Habitat of injured resources and the services they provide within the spill area will be protected from degradation or disturbance.
- Restoration actions will address all injured resources and the services they provide.
- Restoration actions for recovered resources will continue even after a resource has recovered.
- The location of restoration actions will be limited to the spill area.
- Habitat Protection will be used to protect or increase existing human use of the spill area.

Assumptions Used for Impact Assessment

Of the remaining balance of approximately $620 million, it is assumed for purposes of this analysis that approximately $564 million, would be used to acquire and/or otherwise protect lands within the spill area, $31 million would be spent on Monitoring and Research, and $25 million would be spent on Administration and Public Information. This does not represent a commitment of actual resources, but is illustrative only for purposes of analysis.

The implementation of this alternative means that most, if not all, of the remaining funds, apart from those spent on Administration and Public Information and Monitoring and Research, would be spent on Habitat Protection.

Habitat Protection and Acquisition may include purchase of private land or interests in land such as conservation easements, mineral rights, or timber rights. Different payment options are possible, including multi-year payment schedules to a landowner. Acquired lands or other rights would be managed to protect injured resources and the services they provide. In addition, cooperative agreements with private owners to provide increased Habitat Protection are also possible.

At this time, we do not know what the cost of various levels of protection will be at fair market value. For purposes of analysis in this alternative, we are assuming that all the parcels shown in Figures 2-1 through 2-3 would receive some level of protection. The specific benefit that would accrue for each resource and service for each parcel is shown in Table A-1, Appendix A.

Alternative 3: Limited Restoration

Alternative 3 focuses on accelerating recovery of the resources and services most severely injured by the oil spill. This alternative targets resources whose populations declined as a result of the spill and that have not yet recovered. Only actions determined to be most likely to produce significant improvements over unaided natural recovery are included in this alternative. All restoration actions included in Alternative 3 will be confined to the spill area. Habitat Protection is a major part of this alternative; none of the proposed actions would substantially increase human use within the spill area. Monitoring and Research are also included in Alternative 3.

Policies

The most effective actions will be taken within the spill area to protect and restore all injured resources and thereby the services they provide except those biological resources whose populations did not measurably decline . The existing character of the spill area will be maintained.

- Restoration actions would address all resources ***except*** those biological resources whose populations did not measurably decline.

- Restoration actions for recovered resources will cease once a resource has recovered.

- Restoration actions will be conducted that provide substantial improvement over natural recovery.

- The location of restoration actions will be limited to the spill area.

- Restoration actions will be used to restore injured resources and thereby protect existing human use of the spill area.

Assumptions Used for Impact Assessment

Although the majority of the funds will be used to acquire and/or otherwise protect lands within the spill area, this alternative also includes funding for General Restoration activities. Of the remaining balance of approximately $620 million, it is assumed for purposes of this analysis that approximately $465 million will be used for Habitat Protection and Acquisition, $75 million will be used for General Restoration, $43 million will be used for Monitoring and Research, and $37 million will be used for Administration and Public Information. This does not represent a commitment of actual resources, but is illustrative only for purposes of analysis.

Typical Actions Assumed Under Alternative 3

Habitat Protection and Acquisition

Habitat Protection and Acquisition may include purchase of private land or interests in land such as conservation easements, mineral rights, or timber rights. Different payment options are possible, including multi-year payment schedules to a landowner. Acquired lands or other actual rights would be managed to protect injured resources and the services they provide. In addition, cooperative agreements with private owners to provide increased Habitat Protection are also possible.

At this time, we do not know what the cost of various levels of protection will be at fair market value. For purposes of analysis in this alternative, we are assuming one end of the range of protection possibilities is that all parcels shown in Figures 2-1 through 2-3 would receive some level of protection. The other end of the range assumes that since fair market value and the actual rights negotiated will vary widely, not all parcels could be protected. This assumed smaller range of parcels is shown in Figure A-1, Appendix A. The specific benefit that would accrue for each resource and the services they provide for each parcel is shown in Table A-1, Appendix A.

General Restoration

Marine Mammals
Cooperative programs with subsistence users
Cooperative programs with fishermen

Subsistence Uses
Food testing

Fish
Salmon egg incubation boxes
Net pens
Hatchery rearing
Create new fisheries (sport and commercial)
Enhance or create replacement runs (sport and commercial)

Birds
Predator control
Clean mussel beds - 60 potential sites have been identified in Prince William Sound.

Recreation/Tourism
Stabilize existing recreation opportunities

Intertidal Resources
Transplant *Fucus* (seaweed)

Archaeology
Salvage sites - 24 sites have been identified as injured
Implement site stewardship program
Preserve sites (stabilize)

Alternative 4: Moderate Restoration

This alternative is broader than Alternative 3 in that it aims to aid recovery of all injured resources and the services they provide; not just those with population level injuries. Restoration actions included in Alternative 4 address only those resources and services that have not yet recovered from the oil spill. It is also broader than Alternative 3 in terms of the resources addressed; in Alternative 4, measures would be taken to aid recovery of resources that sustained sublethal injuries. Actions that are judged to provide substantial improvements over unaided recovery would be implemented. The actions in this alternative would be confined to Alaska but could extend beyond the spill area. Habitat Protection is included in this alternative, but to a lesser extent than in Alternatives 2 and 3. This alternative may increase opportunities for human use to a limited extent. Monitoring and Research may be conducted.

Policies

- The most effective actions to protect and restore all injured resources and thereby the services they provide will be taken. Opportunities for human use of the spill area will be increased to a limited extent.

- Restoration actions will address all injured resources.

- Restoration actions for recovering resources will cease once a resource has recovered.

- Restoration actions will be conducted that provide substantial improvement over natural recovery.

- Restoration actions could occur anywhere there is a link to injured resources.

- Restoration actions would be used to restore injured resources and thereby protect or increase existing human use of the spill area.

Assumptions Used for Impact Assessment

About half of the settlement funds would be used for Habitat Protection and Acquisition. A significant portion of funds would go to General Restoration; and monitoring and administration funds would be slightly increased over Alternative 3.

Of the remaining balance of approximately $620 million, it is assumed for purposes of this analysis that approximately $310 million will be used for Habitat Protection and Acquisition, $217 million will be used for General Restoration, $50 million will be used for Monitoring and Research, and $43 million will be used for Administration and Public Information. This does not represent a commitment of actual resources, but is illustrative only for purposes of analysis.

Typical Actions Assumed Under Alternative 4

Habitat Protection and Acquisition

Habitat Protection and Acquisition may include purchase of private land or interests in land such as conservation easements, mineral rights, or timber rights. Different payment options are possible, including multi-year payment schedules to a landowner. Acquired lands or other actual rights would be managed to protect injured resources and the services they provide. In addition, cooperative agreements with private owners to provide increased Habitat Protection are also possible.

At this time, we do not know what the cost of various levels of protection will be at fair market value. For purposes of analysis in this alternative, we are assuming one end of the range of protection possibilities is that all parcels shown in Figures 2-1 through 2-3 would receive some level of protection. The other end of the range assumes that since fair market value and the actual rights negotiated will vary widely, not all parcels could be protected. This assumed smaller range of parcels is shown in Figure A-1, Appendix A. The specific benefit that would accrue for each resource and the services they provide for each parcel is shown in Table A-1, Appendix A.

General Restoration

Marine Mammals

Cooperative programs with subsistence users
Cooperative programs with fishermen

Subsistence Uses

Food testing

Fish

Salmon egg incubation boxes
Net pens
Hatchery rearing
Nutrient enrichment
Create new fisheries (sport and commercial)
Enhance or create replacement runs (sport and commercial)
Enhance existing runs of uninjured pink and sockeye salmon
Relocate hatchery runs of pink salmon

Birds

Predator control - 18 islands have been identified.
Clean mussel beds - 60 potential sites have been identified in Prince William Sound.

Recreation/Tourism

Improve existing recreation opportunities
Stabilize existing recreation opportunities

Intertidal Resources

Transplant *Fucus* (seaweed)

Archaeology

Salvage sites - 24 sites have been identified as injured.
Implement site stewardship program
Preserve sites (stabilize)
Acquire replacement artifacts

The Proposed Action Modified Alternative 5: Comprehensive Restoration

This represents a modification of the Alternative 5 shown in the Draft *Exxon Valdez* Restoration Plan Summary of Alternatives for Public Comment (EVOS Trustee Council, April 1993). Alternative 5 is the broadest in scope of the proposed alternatives. This alternative will help all injured resources and the services they provide within the spill area and, under specific circumstances, in other parts of Alaska. Unlike Alternatives 3 and 4, this alternative will allow actions to aid resources that have already recovered, as well as those that have not. Actions likely to produce some improvement over unaided recovery will be allowable under this alternative. Habitat Protection is the largest part of this alternative. Alternative 5 also allows for expansion of current human use and allows for appropriate new uses through the restoration of natural resources. Monitoring and Research will be at the highest levels in this alternative.

Alternative 5 contains an element not present in the other alternatives. In response to public comments that a fund should be set aside for long-term restoration and research activities, the proposed action includes the establishment of a Restoration Reserve.

Policies

- Restoration activities may be considered for any injured resource.
- Restoration activities will occur primarily within the spill area. Limited restoration activities outside the spill area, but within Alaska, may be considered under the following conditions:
  1) when the most effective restoration actions for an injured migratory population are in a part of that population's range outside the spill area, or
  2) when the information acquired from research and monitoring activities outside the spill area will be significant for restoration or understanding injuries within the spill area.
- Restoration activities will emphasize resources that have not recovered.
- Resources may be enhanced, as appropriate, to promote restoration. Restoration projects may not adversely affect the ecosystem.
- Projects designed to restore or enhance an injured service:
  1) must benefit the same user group that was injured, and
  2) should be compatible with the character and public uses of the area.

Assumptions Used for Impact Assessment

Of the remaining balance of approximately $620 million, it is assumed for purposes of this analysis that approximately $295 to $325 million will be used for Habitat Protection and Acquisition, $65 to $100 million will be used for General Restoration, $130 to $165 million will be used for Monitoring and Research, $20 to $35 million will be used for Administration and Public Information, and $100 to $130 million will be placed in a Restoration Reserve account. This does not represent a commitment of actual resources, but is illustrative only for purposes of analysis.

Typical Actions Assumed Under Alternative 5

Habitat Protection and Acquisition

Habitat Protection and Acquisition may include purchase of private land or interests in land such as conservation easements, mineral rights, or timber rights. Different payment options are possible, including multi-year payment schedules to a landowner. Acquired lands or other actual rights would be managed to protect injured resources and the services they provide. In addition, cooperative agreements with private owners to provide increased Habitat Protection are also possible.

At this time, we do not know what the cost of various levels of protection will be at fair market value. For purposes of analysis in this alternative, we are assuming one end of the range of protection possibilities is that all parcels shown in Figures 2-1 through 2-3 would receive some level of protection. The other end of the range assumes that since fair market value and the actual rights negotiated will vary widely, not all parcels could be protected. This assumed smaller range of parcels is shown in Figure A-1, Appendix A. The specific benefit that would accrue for each resource and the services they provide for each parcel is shown in Table A-1, Appendix A.

General Restoration

Marine Mammals
Cooperative programs with subsistence users
Cooperative programs with fishermen
Reduce disturbance to harbor seals

Subsistence Uses
Food testing

Fish
Salmon egg incubation boxes
Net pens
Hatchery rearing
Nutrient enrichment
Fish migration corridor improvements (blockage removal and fish passes)
Habitat improvements (spawning channels, etc.)
Relocation of hatchery runs
Create new fisheries (sport, subsistence, and/or commercial)
Enhance or create replacement runs (sport, subsistence, and/or commercial)
Enhance existing runs of uninjured pink and sockeye salmon

Birds
Predator control - 2 islands have been identified
Clean mussel beds - 60 potential sites have been identified in Prince William Sound.

Reduce disturbance to common murres
Reduce disturbance to pigeon guillemots

Recreation/Tourism
Improve existing recreation opportunities
Stabilize existing recreation opportunities
Create new recreation opportunities
Promote public land recreation use

Intertidal Resources
Transplant *Fucus* (seaweed)
Mariculture clams

Archaeology
Salvage sites - 24 sites have been identified
Implement site stewardship program
Preserve sites (stabilize)
Acquire replacement artifacts

Restoration Reserve for future restoration needs

Other Alternatives Considered and Rejected

An alternative that consisted only of natural recovery monitoring was considered but rejected from detailed consideration. This alternative was similar to Alternative 1 except that some of the settlement funds would be spent on monitoring the recovery of the resources. This aspect of the alternative is contained in the other alternatives and did not require a new alternative.

Comparison of Alternatives

Table 2-1 identifies and compares how each of the proposed alternatives addresses the five restoration issues posed in Chapter 1. Alternative 1 is not included because it would have a very limited effect on these issues. The alternatives cannot be rank-ordered as to their relative effectiveness because this judgment is tied to the values assigned to the issues.

Each alternative in the Draft Restoration Plan is structured to give varying degrees of emphasis among four categories of activities: (1) Habitat Protection and Acquisition; (2) General Restoration; (3) Monitoring and Research; and (4) Administration and Public Information. The no action alternative (Alternative 1) does not contemplate any activities in the categories above and beyond normal agency management actions.

The comparative emphasis on categories of actions for Alternatives 2 through 5 as illustrated by the variations in budget emphasis is shown in Table 2-2. The essential variation among the alternatives has to do with the balance between Monitoring and Research, Habitat Protection, and General Restoration activities. Alternative 2 principally consists of Habitat Protection with no restoration activities. Alternative 4 places the greatest emphasis on

General Restoration activities. Alternative 5 proposes a greater emphasis on Monitoring and Research than the other alternatives while still emphasizing Habitat Protection.

Alternatives 3, 4, and 5 vary in terms of the scope of restoration activities proposed. Restoration in Alternative 3 would be limited to actions that would significantly aid natural recovery of the most injured resources; all actions would be taken only in the spill area.

Alternative 4 envisions actions that would aid recovery of all injured resources and services, not just the most injured. These actions could take place within or outside the spill area; none would occur outside the State of Alaska. Alternative 5 is the most comprehensive in its approach in that all injured resources and services could be aided, regardless of the degree of initial injury or recovery status. As in Alternative 4, actions could take place within the spill area or elsewhere in the State of Alaska. Under the Alternative 5 approach, not only would assistance to recovery of injured resources occur, but also actions to expand current uses and to encourage new uses would be taken.

Table 2-3 is a comparison of the impacts of the various alternatives on the impact topics analyzed in this DEIS. The complete discussion of these impacts is found in Chapter 4. Table 2-4 contains the definitions of the various levels of impact.

Table 2-1.

Issues Addressed by Alternatives

Issues	Alternatives			
	2	3	4	5
1. How would restoration activities contribute to restoring injured resources and services?	Largest percent of allocation for Habitat Protection of all alternatives, could enhance natural rate of recovery.	Second highest allocation of restoration funding for Habitat Protection. Only high rate of recovery options selected under this alternative.	Third highest allocation of restoration funding for Habitat Protection. Would include only those resources and services that have not recovered from *EVOS*.	Least amount allocated to Habitat Protection. Would include all injured resources and services. Largest amount allocated to Monitoring and Research.
2. How would activities directed at injured resources and services affect non-target resources and services?	Habitat Protection would greatly enhance ecosystem functioning and nontarget species.	Habitat Protection would greatly enhance ecosystem functioning and nontarget species.	Habitat Protection would moderately enhance ecosystem functioning and nontarget species.	Habitat Protection would moderately enhance ecosystem functioning and nontarget species.
3. What ecological change would occur in the spill area as a result of restoration activities?	Habitat Protection would enhance the ecological integrity of the *EVOS* area and therefore prevent adverse ecological change to the largest degree.	Habitat Protection would enhance the ecological integrity of the *EVOS* area to the second largest degree and General Restoration could enhance recovery of natural ecological conditions for selected species.	Habitat Protection would enhance the ecological integrity of the *EVOS* area and General Restoration could enhance recovery of natural ecological conditions for selected species.	Habitat Protection would enhance the ecological integrity of the *EVOS* area and General Restoration could enhance recovery of natural ecological conditions for selected species.

Table 2-1

Issues Addressed by Alternatives

Issues	Alternatives			
	2	3	4	5
4. How would restoration activities affect land uses, local economies, and communities?	Habitat Protection could preclude areas from resource extraction. Tourism and fishing economies may benefit.	Habitat Protection may preclude areas from resource extraction. Tourism and fishing economies could benefit. Short-term disruption of fishing.	Habitat Protection may preclude areas from resource extraction. Tourism and fishing economies could benefit. Short-term disruption of fishing.	Habitat Protection may preclude areas from resource extraction. Tourism and fishing economies may benefit. Short-term disruption of fishing.
5. What changes to subsistence uses would occur as a result of restoration activities?	Habitat Protection would preserve opportunities for subsistence uses on certain lands.	Habitat Protection would preserve opportunities for subsistence uses on certain lands. General Restoration could enhance opportunities for subsistence use.	Habitat Protection would preserve opportunities for subsistence uses on certain lands. General Restoration could substantially enhance opportunities for subsistence use.	Habitat Protection would preserve opportunities for subsistence uses on certain lands. General Restoration could moderately enhance opportunities for subsistence use.

2 Alternatives

Alternative 5 represents a modification from that shown in the Draft *Exxon Valdez* Restoration Plan Summary of Alternatives for Public Comment (EVOS Trustee Council, April 1993).

Table 2-2
Comparative Budget Emphasis of Restoration Categories by Alternative

	Projected Budget (in millions of dollars) Alternatives				
Category	**1**	**2**	**3**	**4**	**5**
Administration & Public Information	$0	$25	$37	$43	$20-35
Monitoring & Research	0	31	43	50	130-165
General Restoration	0	0	75	217	65-100
Habitat Protection	0	564	465	310	295-325
Restoration Reserve	0	0	0	0	100-130
Reimbursements	25-35	25-35	25-35	25-35	25-35

Note: Reimbursements are determined by the governments; not the Trustee Council and therefore are not part of this analysis.

This table does not reflect the interest earnings that will accrue to the various balances over the payment period and be available for Trustee Council expenditures.

The following Table 2-3 is a summary of the long-term impacts taken from the analysis contained in Chapter 4 of this DEIS. It should be noted here that with few exceptions the impacts are beneficial and not adverse to the resources.

Table 2-3
Comparison of the Impacts of the Alternatives From Chapter 4

Resource	2	3	4	5
Intertidal organisms	Moderate	Unknown (moderate protective)	Unknown (moderate protective)	Unknown (moderate protective)
Harbor Seals	Low-Moderate	Moderate	Moderate	Moderate
Sea Otters	Low	Moderate	Moderate	Moderate
Harlequin Duck	High	High	High	High
Common Murre	Low	Low	Low	Low
Pigeon Guillemot	Moderate	Moderate	Moderate	Moderate
Marbled Murrelet	High	High	High	High
Pink Salmon	Moderate	Moderate	Moderate	High
Sockeye Salmon	Moderate	High	High	High
Pacific Herring	Moderate	Moderate	Moderate	Moderate
Archaeological/ Cultural Resources	Moderate	Moderate	Moderate to High	Moderate to High
Subsistence	Low To Moderate	Moderate	Moderate to High	Moderate to High
Recreation /Tourism.	Moderate	Moderate	Moderate to High	Moderate to high
Wilderness	Low to Moderate	Moderate	Moderate	Moderate to High
Commercial Fishing	Moderate	Moderate	Moderate	Moderate
Sport Fishing	Moderate	High	High	High
Economy (Forestry)	Negative Moderate	Negative Moderate	Negative Moderate	Negative Moderate
Economy (Commercial Fishing)	Moderate	Moderate	Moderate	Moderate
Economy (recreation)	Moderate	Moderate	Moderate	Moderate

Note: Impacts are beneficial unless otherwise stated.

Table 2-4
Definitions of Impact Levels

Resource	NEGLIGIBLE	LOW	MODERATE	HIGH
Intertidal organisms	Little or no improvement in the resource's ability to recover, or in the quality of its habitat. Little or no reduction in impacts from human interactions.	Proposed restoration actions may reduce negative impacts from the spill or from some anticipated, or current, human activities. These reduced negative effects do not create an improvement in the ability of the injured population to recover either locally or regionally.	Proposed restoration actions have a high potential to reduce negative impacts from the spill or from anticipated, or current, human activities. These reduced negative effects could improve the ability of the injured population to recover more rapidly but measurable increases would only occur in localized areas.	Proposed restoration actions have a high potential to change the ability of the injured population to recover, so that the expected time period to reach recovery is reduced on a regional basis.
Marine Mammals	Little or no improvement in the resource's ability to recover, or in the quality of its habitat. Little or no reduction in impacts from human interactions.	Proposed restoration actions may reduce negative impacts from the spill or from some anticipated, or current, human activities. These reduced negative effects do not create an improvement in the ability of the injured population to recover either locally or regionally.	Proposed restoration actions have a high potential to reduce negative impacts from the spill or from anticipated, or current, human activities. These reduced negative effects could improve the ability of the injured population to recover more rapidly but measurable increases would only occur in localized areas.	Proposed restoration actions have a high potential to change the ability of the injured population to recover, so that the expected time period to reach recovery is reduced on a regional basis.
Birds	Little or no change expected in population level, productivity rate, or sub-lethal injury.	Unlikely to affect regional recovery of population level, productivity rate, or sub-lethal injury, but may enhance recovery of local segment of population.	Likely to enhance to a measurable degree the regional recovery of population level, productivity rate, or to reduce sub-lethal injury, and may substantially enhance recovery of local segment of population.	High probability of substantially enhancing population level, productivity rate, or for reducing sub-lethal injury throughout EVOS region.

Table 2-4 (cont.)

Definitions of Impact Levels

Resource	NEGLIGIBLE	LOW	MODERATE	HIGH
Fish	Little or no increase or recovery of the injured resource sooner than by natural recovery; or, little or no protection of the habitat from disturbance.	Unlikely or small increase or recovery of the injured resource sooner than by natural recovery; or, limited protection of the habitat from disturbance.	Moderate increase or partial recovery of the injured resource or service sooner than by natural recovery; or, high benefits in limited area(s); or, moderate protection of the habitat from disturbance.	Recovery of the injured resource sooner than by natural recovery; or, recovery of the injured resource to a greater than pre-spill amounts; or, substantial protection of the habitat from disturbance.
Cultural Resources	Little or no protection for achaeological or historic sites; or little or no improvement of the understanding or appreciation of cultural resource values within the EVOS area.	Small increase in protection for archaeological or historic sites; or small improvement of the understanding or appreciation or cultural resource values in limited locations within the EVOS area.	Moderate increase in protection for achaeological or historic sites; or moderate improvement of the understanding or appreciation of cultural resource values througout the EVOS area; or substantial improvement of the understanding or appreciation of cultural resource values in limited locations within the EVOS area.	Substantial increase in protection for archaeological or historic sites; or substantial improvement of the understanding or appreciation of cultural resource values throughout the EVOS area.
Subsistence	Little or no change in populations of subsistence harvest species injured by EVOS; or small increase in confidence by subsistence users that subsistence foods lack contamination.	Small increase in populations of subsistence harvest species injured by the EVOS; or small increase in confidence by subsistence users that subsistence foods lack contamination.. Increases may be localized or throughout the EVOS area.	Moderate increase in populations of subsistence harvest species negatively affected by EVOS; or moderate increase in confidence by subsistence users that subsistence foods lack contamination throughout the EVOS area; or substantial increases in populations or confidence levels in localized areas.	Substantial increase in populations of subsistence harvest species negatively affected by EVOS; or substantial increase in confidence by subsistence users that subsistence foods lack contamination throughout the EVOS area.

Table 2-4 (cont.)

Definitions of Impact Levels

Resource	NEGLIGIBLE	LOW	MODERATE	HIGH
Recreation & Tourism	Little or no change in numbers of users, or on the quality of their experience.	Small increase in numbers of users, or small increase in protection or improvement of recreation quality in localized areas within the EVOS area.	Moderate increase in numbers of users, or moderate increase in protection or improvement of recreation quality throughout the EVOS area; or substantial increase in numbers of users or substantial improvement of recreation quality in localized areas within the EVOS area.	Substantial increase in numbers of users, or substantial increase in protection or improvement of recreation quality throughout the EVOS area.
Wilderness	Little or no reduction of residual oil and materials left from clean-up activities, and no change in public perception of injury to Wilderness.	Small reduction of residual oil and materials left from clean-up activities, or small change in public perception of injury to Wilderness.	Moderate reduction of residual oil and materials left from spill clean-up activities, or moderage change in perception of injury to Wilderness.	Substantial reduction of residual oil spill and materials left from clean-up activities and substantial change in perception of injury to Wilderness.
Commercial Fishing & Sport Fishing	Little or no increase or recovery of the injured service sooner than by natural recovery; or, little or no protection of the habitat from disturbance.	Unlikely or small increase or recovery of the injured service sooner than by natural recovery; or, limited protection of the habitat from disturbance.	Moderate increase or partial recovery of the injured service sooner than by natural recovery; or, high benefits in limited area(s); or, moderate protection of the habitat from disturbance.	Recovery of the injured service sooner than by natural recovery; or, recovery of the injured resource to a greater than pre-spill amounts; or, substantial protection of the habitat from disturbance.
Economy	Barely measurable contribution to employment and economic output over a 10-year period or longer.	Less than a substantial contribution to employment and economic output over a 10-year period or longer.	Moderately substantial contribution to employment and economic output over a 10-year period or longer.	Very substantial contribution to employment and economic output over a 10-year period or longer.

Chapter 3

Affected Environment

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Chapter 3

Affected Environment

Introduction

This chapter describes the areas within the Gulf of Alaska from Prince William Sound to the Alaska Peninsula directly affected by the *Exxon Valdez* oil spill (EVOS). The first part of the chapter

- describes the physical and biological environment including the physical setting; marine, coastal, and terrestrial ecosystems; and individual biological resources; and
- summarizes injury to the birds including results of the natural resource damage-assessment studies.

The second part of the chapter

- describes the social and economical environment in the affected area before and after the spill and
- gives the historical background of the affected regions, as well as information about the socioeconomic and cultural impacts of the spill on affected communities.

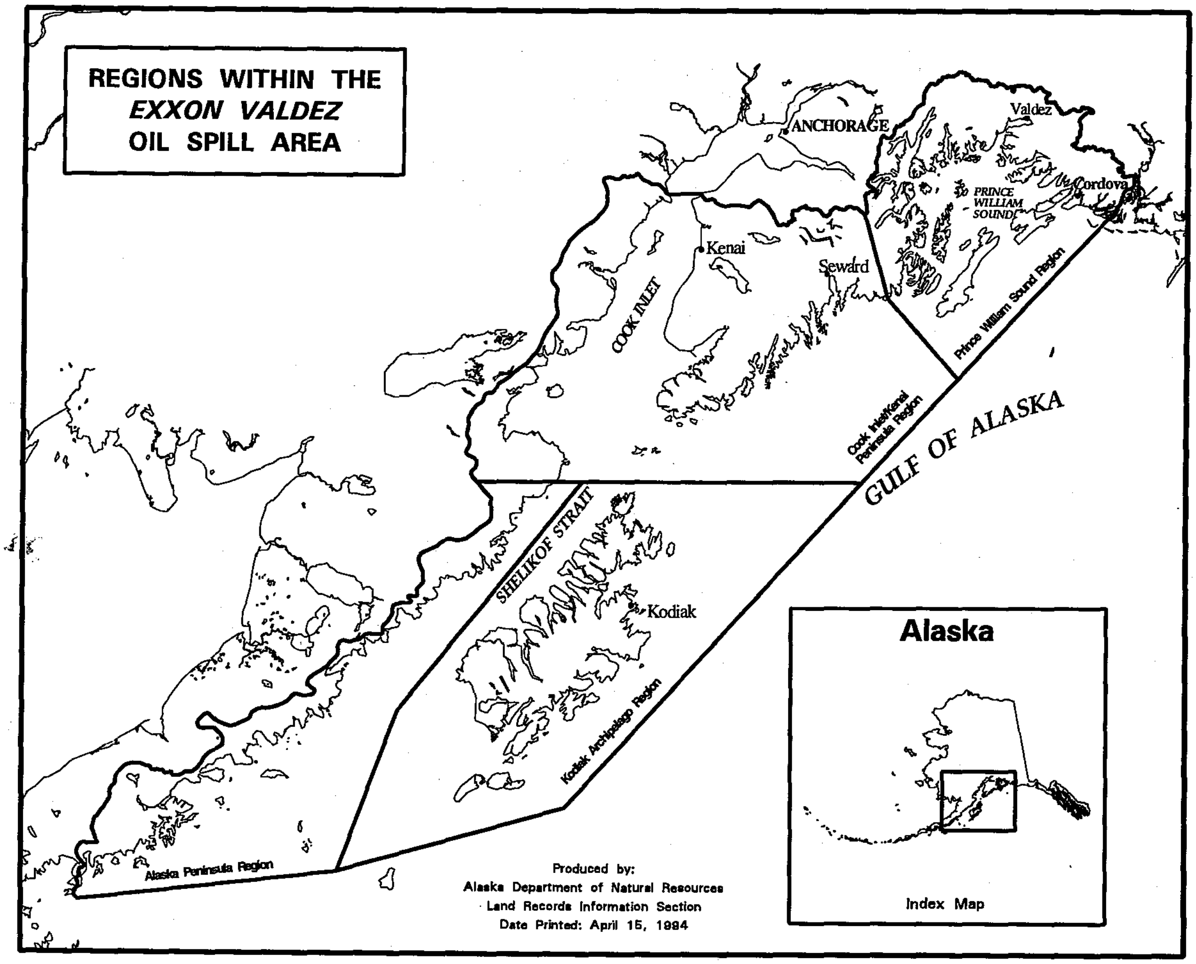
Physical Setting

The EVOS area is located in southcentral Alaska, including the northern and western portions of the Gulf of Alaska, and encompasses a surface area of approximately 75,000 square miles. The EVOS area is divided into 4 regions as shown in Figure 3-1. At the northeastern edge of the EVOS area is Prince William Sound, which is about the size of Maryland's Chesapeake Bay or Washington State's Puget Sound (Mickelson, 1989). Southwest of Prince William

3 Affected Environment

Sound are the Kenai Peninsula and Kodiak Island. South of the Kenai Peninsula is the Shelikof Strait, which lies between Kodiak Island and the Alaska Peninsula. The Alaska Peninsula narrows into the Aleutian islands. The EVOS area contains 15 major islands, 19 minor islands; and 150 lesser islands.

Figure 3-1



The geology of the region is young and relatively unstable; glaciers, earthquakes, and active volcanoes are common. In March 1964, an earthquake with an epicenter west of Columbia Glacier in Prince William Sound shook for approximately 5 minutes and destroyed the towns of Valdez, Kodiak, Seward, and Chenega. Winter winds in the Gulf of Alaska generally are easterly or southeasterly and interact with currents to push waters into Prince William Sound. This produces complex flow patterns that result in strong downwelling and an outflow of surface waters to the southwest. Most of the EVOS area has a maritime climate with heavy precipitation that averages 150 inches annually in Prince William Sound. Much of the area is snow covered in the winter, with up to 21 feet of snowfall per year in Valdez. In Prince William Sound, 15 percent of the total area, mostly in the mountains, is covered with permanent ice and snow (Mickelson, 1989).

Greater EVOS Ecosystem

The Draft EVOS Restoration Plan (November 1993) states that ecosystems include the entire community of organisms that interact with each other and their physical surroundings, including people and their relationship with other organisms. The greater EVOS ecosystem could be divided into numerous smaller ecosystems based on differing vegetative communities, amounts of rainfall, human activities, or countless other factors. For the purposes of this document, there are three primary ecosystem divisions within the oil spill area: the terrestrial (upland), the coastal (shoreline), and the marine (pelagic) ecosystems. In addition to describing these ecosystems, this chapter also describes the particular resources and services (human uses) that were most affected by the oil spill. Table 3-1 illustrates how these individual resources relate to the three ecosystem subdivisions. Appendix B shows the scientific names and common names of all species discussed in this DEIS.

Table 3-1
Distribution of Resources by Ecosystem Category

Resource	Terrestrial	Coastal	Marine
Natural Resources			
Harbor Seal	-	x	x
Sea Otter	-	x	-
Sockeye Salmon	x	x	x
Pacific Herring	-	x	x
Pink Salmon	x	x	x
Common Murre	-	x	x
Harlequin Duck	x	x	-
Marbled Murrelet	x	x	x
Pigeon Guillemot	-	x	x
Intertidal Organisms	-	x	-
Other Resources			
Archaeological Resources	x	-	-
Designated Wilderness	x	-	-

Marine Ecosystem

The marine ecosystem in the EVOS area is characterized by deep water (hundreds of meters) and cold temperatures. Most of the marine waters within the oil spill area are located above the continental shelf and are less than 200 m deep. The offshore waters of the Gulf of Alaska strongly influence the ecology of the shallower coastal waters. This deeper, open water region is not directly affected by wave action, terrestrial runoff, or other near-shore processes. In general, water flows throughout the Gulf of Alaska in a counterclockwise pattern. The Alaska Coastal Current dominates the shelf waters from Prince William Sound around the coast to the beginning of the Aleutian Islands (Reed and Schumacher, 1986). Waters in Prince William Sound and Cook Inlet have lower salinity than the rest of the Gulf due to meltwater from glaciers and snow covered mountains, outflow from numerous rivers, and from high rainfall in the summer (Reed and Schumacher, 1986). High winds and strong currents provide mixing of waters and the important plankton communities.

The EVOS area includes some of the most productive high-latitude shelf waters in the world (Sambrotto and Lorenzen, 1986). Phytoplankton blooms occur in the late spring and decline during the summer. Zooplankton follow the distribution of phytoplankton and peak 1 to 2 months later. Copepods, euphausiids, and other zooplankton are the major food source for many marine species, including whales and salmon (Cooney, 1986). Polychaete annelids and mollusks dominate a diverse benthic community of more than 200 species to depths of 200 m (O'Clair and Zimmerman, 1986).

Diverse and abundant communities of finfish and shellfish are present in the EVOS region, especially in Prince William Sound, Cook Inlet, and Shelikof Strait. Five species of Pacific salmon (chinook, coho, pink, chum, and sockeye) leave the open ocean to spawn in the intertidal zones and rivers of the region. Abundant saltwater finfish include halibut, sole, flounder, sablefish, pollock, and Pacific Ocean perch. King, Tanner, and Dungeness crabs are present in many areas within the EVOS region and, in summer months, move to shallower water for spawning. Shrimp, clams, and scallops also are important shellfish in the region (Alaska Department of Fish and Game [ADF&G], 1985).

Large populations of marine mammals are an important component of the marine ecosystem. The most abundant species are sea lions, harbor seals, sea otters, and whales. It is estimated that 100,000 individual marine mammals annually reside in or migrate through the Gulf of Alaska. Many areas within the oil spill region contain large concentrations of marine mammals, e.g., sea otters in Prince William Sound, sea lions on the Barren Islands, and seals throughout the bays and river deltas of the mainland and Kodiak Island.

Coastal Ecosystem

The coastal ecosystem is vital to the health of the greater EVOS area ecosystem. It connects the highly productive marine ecosystem to the rugged terrestrial ecosystem and provides food and shelter for marine and terrestrial organisms. Tectonic and glacial influences have produced an extremely irregular coast characterized by long beaches and dune ridges backed by high marine terraces. Short meltwater streams and large river deltas add to the diversity of the coastal topography. The coastal ecosystem includes the terrestrial and aquatic areas dominated by near-shore processes such as tidal movement, salt spray, intertidal and shoreline vegetation, marshes, and beach areas where salt and shoreline processes dominate, as well as shallower offshore waters that are greatly influenced by near-shore processes. It also includes narrow fjords and channels that occur in the spill area. The coastal ecosystem has two distinct zones: the subtidal and the intertidal.

The Subtidal Zone

The nearshore, shallow subtidal zone provides the transition area between the marine, deep-water environment and the intertidal zone. The subtidal zone extends from the low tide boundary of the intertidal zone into the open-water area. Because the nearshore subtidal community is similar in many respects to the intertidal community, it is considered separately from the marine ecosystem. Monitoring and research are the most likely restoration actions to focus on the subtidal communities. Because monitoring and research are not likely to produce environmental impacts (see the discussion on Monitoring and Research in Chapter 1, pg 19) organisms in the subtidal community are not analyzed in this DEIS. However, clams occur in both intertidal and subtidal zones and may be affected by some of the proposed actions. Therefore, the impacts on clams will be analyzed along with other intertidal organisms.

The Intertidal Zone

The intertidal zone is the environment located between the extent of high and low tides. Because of the rise and fall of the tides, the area is not always covered with water. The size of the intertidal area is determined by the slope of the shore and the extent of the rise and fall of the tides. Some of the more abundant inhabitants of the intertidal zone consist of algae (e.g., *Fucus*), mussels, clams, barnacles, limpets, amphipods, isopods, marine worms, and certain species of fish. The intertidal zone is used as a spawning or rearing area for many species of fish (EVOS Trustee Council, 1992) and serves as a feeding ground for marine consumers (e.g., sea otters, Dungeness crabs, juvenile shrimps, rockfish, cod, and juvenile fishes), terrestrial consumers (e.g., bears, river otters, and humans), and birds (e.g., black oystercatchers, harlequin ducks, numerous other species of ducks, and shorebirds). Because of the nature of the intertidal environment, the intertidal zone is especially vulnerable to initial and continued contamination in the event of an oil spill, as well as to the effects of cleanup operations (EVOS Trustee Council, 1992).

The oil spill caused population declines and sublethal injuries to the community of plants and animals living in the intertidal zone. Portions of 1,500 miles of coastline were oiled (350 miles heavily oiled), resulting in significant impacts to intertidal habitats, particularly in the upper intertidal zone. With tidal action, the oil penetrated deeply into cobble and boulder beaches that are relatively common on the rocky islands of the spill area. Cleaning removed much of the oil from the intertidal zone, but subsurface oil persisted in many heavily oiled beaches and in mussel beds (mussel beds which were avoided during the cleanup).

Direct oiling killed many organisms, but beach cleaning, particularly high-pressure, hot-water washing, had a devastating effect on intertidal life. Several studies have documented the combined effects of oiling and cleanup on beaches and now track the course of recovery. Because of little or no prespill data, these studies have relied on comparisons of oiled and nonoiled sites. Because of our ability to measure effects on common organisms, these comparisons have been emphasized in the injury studies. A description of these organisms and the injuries that resulted from the oil spill can be found under the Intertidal section of Biological Resources later in this chapter.

Terrestrial (Upland) Ecosystem

The EVOS area can be divided into three biogeographic regions: Prince William Sound, Kenai Peninsula, and Kodiak Archipelago/Alaska Peninsula. The landforms and vegetation present in each region vary dramatically, but all are heavily influenced by a history of glaciation. Glaciers still are present at high elevations in all three regions. At lower elevations, ecological conditions vary between the mountainous fjord and glacier-dissected rainforest areas and the flat coastal deltas of large rivers.

Because of the dramatic relief throughout the region, distinct vegetation zones are common. Terrestrial vegetation adjacent to coastal ecosystems is centered around alder thickets, devil's club, willow, mountain ash, and berries. Successive upland zones include shrubland, deciduous woodland, coniferous forest, moist tundra, alpine tundra, and barren areas. Alder predominates in the shrubland and deciduous zones while Sitka spruce (*Picea sitchensis*) and western hemlock (*Tsuga heterophylla*) dominate the coniferous forest. Interior forests may include white and black spruce with birch. At higher elevations, these trees are replaced first by dwarf shrubs, grasses, and sedges and later by lichens and moss.

Terrestrial habitats can be classified into riparian, wetlands, old-growth forest (200-years plus), mature forest (70-200 yrs), intermediate stage forest (40-70 yrs), early stage forest (0 to 20 yrs), lowland shrub, mud flats/gravel/rock, subalpine shrub, alpine shrub-lichen tundra, cliffs, islands in lakes, and snow/ice/glaciers (United States Fish and Wildlife Service [USFWS], 1983). Inland aquatic habitats include anadromous fish streams, anadromous fish lakes, resident fish streams, and resident fish lakes.

Of the 15 million acres within the oil spill area, 1.8 million are private lands (Fig. 3-2). Most of these lands were converted from public to private ownership during the last 20 years as a result of the Alaska Native Claims Settlement Act (ANCSA). Lands chosen for conversion to private uses primarily were commercially valuable timber lands. Publicly owned lands include a diverse number of designations, both State and Federal. The 5.9-million-acre Chugach National Forest surrounds Prince William Sound and is managed by the USDA Forest Service predominantly for recreation and fish and wildlife. There have been no timber harvests on the forest since the mid 1970's, and no harvests currently are planned. Nine other large Federal land-management areas are contained wholly or partially within the EVOS area. The National Park Service (NPS) administers 9 million acres in the Kenai Fjords National Park, Lake Clark National Park and Preserve, Katmai National Park and Preserve, and the Aniakchak National Monument and Preserve. Both the Kenai Fjords and Katmai National Parks consist of large areas of federally designated wilderness or wilderness study areas. The western portion the Chugach National Forest is also a wilderness study area. The Fish and Wildlife Service administers million of acres in the Kenai National Wildlife Refuge (NWR), Kodiak NWR, Alaska Peninsula NWR, and Alaska Maritime NWR. The Becharof NWR also includes federally designated wilderness areas. Numerous State classifications--including parks (such as Kachemak Bay State Park), critical habitat areas, game refuges, and marine parks--exist in the oil spill area. All of these areas are afforded some degree of protection from land uses that could adversely affect or slow the recovery of injured resources and services. Wilderness areas in particular provide strict protection against future degradation of the ecosystem, but they also preclude enhancement activities within their boundaries.

One of the issues in forest land management within the oil spill area is the prevalence and impact of infestations of bark beetles and other insects on forest health and survival. At present, there are infestations of bark beetle within the oil spill area on the Kenai Peninsula. The effects of these infestations on wildlife species that depend on old-growth forest habitat are unknown. Of the species injured by the EVOS, marbled murrelets which often nest in old-growth forests are the most likely to be affected by the infestations which may result in the loss of some nesting habitat. The spruce beetle (*Dendroctonus rufipennis)* is a pest affecting older conifer stands in throughout Alaska. Although this species can effectively kill all trees over large areas, they are most devastating to white spruce and Lutz spruce. The Sitka spruce that dominate the forested regions of the oil spill area can be affected, as is apparent by the 10,000 acre infestation in the Kachemak Bay area (Holsten, 1990).

Biological Resources

The EVOS area supports a diverse collection of wildlife. The *Exxon Valdez* oil spill occurred in March, just before the most biologically active season of the year. The spill coincided with the migration of birds and the primary breeding season for most species of birds, mammals, fish, and marine invertebrates in the spill's path. Oil from the spill affected each species differently. For some species, the population measurably declined. For example, an estimated 3,500 to 5,500 sea otters were killed by the spill, and the population is not expected to recover for many generations. Other species were killed or injured by the spill, but the injury did not measurably decrease the overall population. The populations of some species, such as marbled murrelets, pigeon guillemots, and harbor seals, were declining before the spill. Their rate of decline was accelerated by the spill, but other factors such as variations in climatic conditions, habitat loss, or increased competition for food also may have influenced long-term trends in their health and populations. Still other species may have been indirectly affected by changes in food supplies or disruption of their habitats.

The availability of population and habitat data varies from species to species. Federal and State environmental agencies had conducted baseline surveys of some native species prior to the oil spill, documenting selected species' populations and critical habitats, but some species (e.g., invertebrates such as clams and barnacles) never have been inventoried. Others, such as the brown bear and the bald eagle, are counted annually for management purposes; and a great deal is known about species that have played a significant historic or economic role in the region, such as sea otters and salmon. The following discussion summarizes the baseline conditions for species and resources found in the oil spill area. It will be used in evaluating the potential impacts, either direct or indirect, of the various restoration options.

Intertidal Resources

A great variety of plants and animals exist in the intertidal zone; however, because there was little, or no prespill data on communities within the intertidal zone, studies that documented the effects of the EVOS had to rely on the more common organisms as representatives of the entire intertidal community. These organisms: *Fucus*, clams, mussels, limpets and barnacles, and some intertidal fish communities, were studied during the damage assessment program. Of these, *Fucus*, clams and mussels are still showing continuing signs of injury.

Fucus

The most significant impacts occurred in the upper and middle intertidal zones on sheltered rocky shores, where the greatest amounts of oil stranded. In the upper and middle intertidal zones of rocky shores, the algae *Fucus gardneri* (rockweed or popweed), barnacles, limpets, periwinkles, clams, amphipods, isopods, and marine worms were less abundant at oiled than nonoiled sites. Although there were increased densities of mussels in oiled area, they were significantly smaller than mussels in the nonoiled areas; and the total biomass was significantly lower. While the percentage of intertidal areas covered by *Fucus* was reduced following the spill, the coverage of opportunistic plants (ephemeral algae) that characteristically flourish in disturbed area was increased. The average size of *Fucus* plants was reduced, as was the reproductive potential of those plants surviving the initial oiling. The lower and middle intertidal zones have recovered to a large extent, but injuries persist most strongly in the upper intertidal zone, especially on rocky sheltered shores. Natural recovery of the upper intertidal zone will occur in stages as the different species in the community respond to improved environmental conditions.

Recovery in the upper intertidal appears to depend on the return to this zone of adult *Fucus* in large numbers. In the absence of a well-developed canopy of adult plants, eggs and developing propagules of *Fucus* lack sufficient moisture to survive. The reduced canopy of rockweed in the upper intertidal zone also appears to have made it easier for oystercatchers to prey on limpets. Accordingly, the recovery of limpets and other invertebrates also is linked to the recovery of rockweed. Existing adult plants will act as centers for the outward propagation of new plants, and it is estimated that recovery of *Fucus* may take a decade (Highsmith, et.al., 1993). Full recovery of the intertidal community may take more than a decade, because it may take several years for invertebrate species to return after *Fucus* has recolonized an area.

Clams

Both oiling and cleanup activities harmed clam beds throughout the EVOS area. The magnitude of the measured differences in clam abundance and growth varied with degree of oiling and geographic area. On sheltered beaches, the data on abundance of clams in the lower intertidal zone strongly suggest that little neck clams and, to a lesser extent, butter clams were significantly affected by the spill. During the 1993 public meetings, people throughout the oil spill area, but especially in Kodiak and Alaska Peninsula communities, said they are still finding clam beds that are contaminated with oil. Clams are an important resource for subsistence and recreational use within the oil spill area, and they are preyed upon by a wide variety of other resources.

Mussels

Mussels, *Mytilus edulus* and *M. trossulus* can be found throughout the EVOS area along rocky coastlines, in bays, and in estuaries. Mussels are harvested for bait and for food. Mussels are suspension feeders and feed on dinoflagellates, organic particles, small diatoms, zoospores, ova and spermatozoa, flagellates, unicellular algae, and detritus.

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 (unweathered) oil for harlequin ducks, black oystercatchers, river otters, and juvenile sea otters, all of which feed on mussels and show signs of continuing injury. The extent and magnitude of oiled mussel beds are unknown and continue to be investigated.

Marine Mammals

The following section discusses the relevant population status, lifecycle requirements, and oil spill injuries, for harbor seals and sea otters.

Harbor Seals

The harbor seal (*Phoca vitulina richardsi*) is a protected species under the MMPA, which placed a moratorium on the taking of harbor seals except for subsistence use by Alaska Natives. The harbor seal is under the management of the National Marine Fisheries Service (NMFS).

Harbor seal prespill populations in Prince William Sound have been estimated to be between 2,000 and 5,000 individuals. The harbor seal population has been declining by approximately 11 to 14 percent annually for unknown reasons (Frost and Lowry, 1993). In portions of its geographic range, the harbor seal is in direct competition with human subsistence, recreational, and commercial resource users for fish. Throuhout Alaska, bycatch of harbor seals from commercial fishing has been estimated to cause 2,800 seal deaths a year (Lentfer, 1988); however, mortality caused by commercial fishing within the EVOS area is believed to be low (Wynne, Hicks, and Munro, 1992). The harbor seal also is harvested by Alaska Natives for subsistence use. Natural predators of harbor seals include killer whales and sharks.

Harbor seals usually occupy coastal waters less than 60 m deep. Haulout areas are especially important for harbor seals during pupping and molting. Rocks, isolated beaches with protective cliffs, ice floes, and sand or mud bars are used for resting, pupping, and nursing young (ADF&G, 1985). 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 (Pitcher, 1980).

Harbor seals breed annually once they reach sexual maturity (3 to 7 yrs), and a single pup usually is born between late May and mid-July. Pups generally are nursed for 3 to 6 weeks (ADF&G, 1985). During pupping and molting periods, harbor seals are very susceptible to disturbance and are prone to stampeding. Stampeding can cause injuries and deaths, as well as weaken the mother-pup bond, resulting in higher pup mortality (Johnson et al., 1989).

The oil spill caused population declines and sublethal injuries to harbor seals in Prince William Sound. Many were directly oiled, and an estimated 300 died. The prespill population of harbor seals in Prince William Sound was estimated to be between 2,000 to 5,000 animals. While some dead seals were recovered from the Kenai Peninsula, the extent of injury outside Prince William Sound is unknown.

Many seals were exposed to oil in 1989. At 25 haulout areas in Prince William Sound that have been regularly surveyed since 1984, 86 percent of the seals seen in the postspill spring (April) survey were extensively oiled; a further 10 percent were lightly oiled. This included many pups. By late May, 74 percent of the animals continued to be heavily oiled. Tissues from harbor seals in Prince William Sound contained many times the concentrations of aromatic hydrocarbons than did tissues from seals in the Gulf of Alaska. This trend persisted in 1990, when high concentrations of petroleum hydrocarbons again were found in the bile of surviving seals. In addition, pathology studies revealed damage to nerve cells in the thalamus of the brain, which is consistent with exposure to relatively high concentrations of low molecular weight aromatic (petroleum) hydrocarbons.

Sea Otters

The sea otter is a protected species under the MMPA, which placed a moratorium on the taking of sea otters except for subsistence use by Alaska Natives. The sea otter is under the management of the ADF&G and the USFWS. Prespill and postspill management of sea otters by these agencies has focused on population monitoring through surveys and monitoring of Native harvest.

The sea otter prespill population for the entire State of Alaska was estimated at 150,000 animals, and the population in Prince William Sound prior to the oil spill was estimated at 10,000 animals (EVOS Trustee Council, 1992). The sea otter population within the oil spill area was likely at or near an equilibrium density and was limited by prey availability when affected by the oil spill. The sea otter population in portions of its geographic range is in direct competition with recreational and commercial resource users for crabs, clams, and other benthic organisms.

Sea otters prefer shallow coastal waters that generally are less than 40 m deep. They use kelp beds as resting areas, but their geographic distribution is not dependent on kelp. Some otters use intertidal rocks, exposed beaches, and algal covered rocks. The importance of haulout sites is poorly understood. They are not considered to be essential for otter survival in California but may be very important for otters in northern climates (Jameson, 1989).

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 (Riedman and Estes, 1990). There is considerable 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 (Reidman and Estes, 1990).

Mating and pupping can occur throughout the year, although in Prince William Sound most otters mate in September and October with pups born in May and June. Once otters reach reproductive maturity (4 to 7 years) 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 generally are weaned by mid-November (EVOS Trustee Council, 1992).

The oil spill caused declines in populations of sea otters in Prince William Sound and possibly in the Gulf of Alaska. Sea otters were the most abundant marine mammal in the path of the spreading oil slick and were particularly vulnerable to its effects. Their estimated population before the spill included as many as 10,000 in Prince William Sound and 20,000 in the Gulf of Alaska. The total population in the State is estimated to be 150,000 otters.

During 1989, 1,013 sea otter carcasses were collected. Veterinarians determined that up to 95 percent of the deaths were attributable to oil. It has been estimated that 3,500 to 5,500 sea otters were killed in the first few months following the spill.

Studies conducted in 1990 and 1991 indicated that sea otters still were being affected by the spill. Carcasses found in these years included an unusually large proportion of prime-age adult otters. A study of survival of recently weaned sea otters also showed a 22-percent higher death rate during the winter of 1990–1991 and spring of 1991 in areas affected by the spill. In 1992 and 1993, juvenile mortality rates had decreased dramatically but still were higher in oiled than in nonoiled areas.

Birds

The *Exxon Valdez* oil spill (EVOS) killed an estimated 100,000 to 300,000 birds of over 90 species within the entire spill zone (Piatt et al., 1990). Perhaps as many as 25 percent of the total birds wintering in the oiled zone of Prince William Sound were killed directly by the spill, or 10 percent of Prince William Sound's entire population (Klowsiewski and Laing, written comm., 1993). In subsequent EVOS studies through 1992, six species had not yet recovered from the effects of the spill. These were bald eagles, black oystercatchers, harlequin ducks, murres, pigeon guillemots, and marbled murrelets (Draft EVOS Restoration Plan, 1993). However, by 1993, populations of bald eagles and black oystercatchers were recovering in Prince William Sound (Draft EVOS Restoration Plan, 1993), although their status outside of Prince William Sound remained unknown. This section gives background information on the four species whose populations have either not recovered from the EVOS, or whose recovery status is uncertain.

All migratory birds are included under the Migratory Bird Treaty Act (16 U.S.C. §§703-711 [1976 & Supp. V 1981]). This Act gives the U. S. Fish and Wildlife Service (USFWS) statutory responsibility to protect and manage the four bird species that are not recovering from the EVOS. Knowledge of population size is basic to wildlife management, and population monitoring is a normal function of wildlife management agencies. The USFWS's Alaska Maritime National Wildlife Refuge (AMNWR) has a long-range plan to monitor selected species at selected colonies on AMNWR land throughout Alaska. East Amatuli Island in the Barren Islands, where major injury to murres occurred, was a designated monitoring site in the refuge monitoring plan for storm-petrels and tufted puffins, but not murres. Prior to the oil spill, murres were not targeted at this site due to the difficulty and expense of monitoring murres there (V. Byrd, oral comm., 1994). The Migratory Bird Management section of the USFWS is responsible for monitoring marine birds on non-refuge lands in Alaska, including Prince William Sound. However, there is no set schedule for monitoring in Prince William Sound or elsewhere in the EVOS area.

Historically, non-game migratory birds such as seabirds have been of a lower funding priority than funding for game birds. For example, the USFWS conducted their first waterbird population survey the entire Sound in 1972-73, but then not again until 1984-1985. Additional studies were done on selected seabird species at Naked Island, Shoup Bay, and other locations since 1978, but the entire Sound was not again monitored for all waterbirds until 1989.

Harlequin Duck

The harlequin duck is a small boreal diving duck with a disjunct distribution on the east and west coasts of North America (Bellrose, 1982; American Ornithological Union [AOU], 1983). Like many species of sea ducks, the harlequin uses both marine and inland habitats (Bellrose, 1982). Harlequins nest near freshwater streams, and nonbreeders and juveniles utilize nearshore marine habitats for feeding and roosting .

Harlequin ducks breed in western North America south of the Arctic Circle, from northwestern Canada and Alaska, south to the Aleutian Islands and through southeastern Alaska to the Pacific Northwest (AOU, 1983; Bellrose, 1982).

Within its world range, harlequins may be the most abundant in the Aleutian Islands (Bellrose, 1982). Islieb and Kessel (1973) considered harlequins to be common to abundant in Prince William Sound and they estimated populations for the entire north Gulf coast - Prince William Sound region at a few 10,000's. In 1979 and 1980, an estimated 9,600 harlequins wintered in the Kodiak Archipelago, with the highest concentrations off of southeastern Kodiak Island (Forsell and Gould, 1981). An estimated 1,600 to 5,600 harlequin ducks were in Prince William Sound in July 1972 (Klosiewski and Laing, written comm., 1993).

Harlequins winter in small flocks along exposed, rocky coasts where they feed on benthic prey (see below) in intertidal and subtidal areas. In Prince William Sound, harlequins use a wider range of habitats during the winter and are dispersed throughout the nearshore area (Patten, oral comm., 1992). Populations of harlequins that winter in the EVOS area include both local breeders and birds that breed in interior Alaska (Bellrose, 1982). An estimated 9,200 to 15,800 harlequins were in Prince William Sound in March 1972, and 10,300 to 21,300 in March 1973 (Klosiewski and Laing, written comm., 1993; Agler et al., written comm., 1993).

3 Affected Environment

Harlequin ducks migrate back and forth between inland nesting habitat and coastal marine foraging habitat, which are often only a few km apart. Only a few km may separate their nesting and marine habitats, so their migration can be very short. Harlequins begin arriving on their wintering grounds in the Aleutian Islands in mid-September and remain there until May (Bellrose, 1982). In Prince William Sound, the breeding season lasts for about 2½ months between May and July (Patten, 1991), and broods are common in the coastal marine area in late July and August (Islieb and Kessel, 1973). Birds that winter and breed in south-central Alaska congregate near the mouths of suitable breeding streams in late April and early May (Patten, oral comm., 1993).

Coastal habitats are used from late summer through early spring by all sex and age classes of harlequins. Paired breeders are found in the intertidal area at the mouths of streams before they move inland to nest. Coastal habitat is used throughout the summer by nonbreeding birds, breeding males after the pair bonds are broken, and by failed-nesting females (Bellrose, 1982; Dzinbal and Jarvis, 1984). In July, males congregate in large flocks in protected bays with good foraging habitat. Nonbreeders of both sexes and failed-nesting females begin molting in August and in many of the same areas as males.

Harlequin ducks become sexually mature in their second year (Delacour, 1959; Bengtson, 1972; Bellrose, 1982). Nests are composed of thin layers of grass, twigs, and leaves and are lined with white down (Bellrose, 1982). Harlequins begin laying between May 10 and May 30 in Alaska (Bellrose, 1982), and lay at 2 - 4-day intervals until 3 to 7 eggs accumulate. The female incubates the eggs for 28 to 30 days and breaks to feed every other day (Bellrose, 1982).

Harlequin ducks generally nest along shallow (0.5 - 1.0-m deep), fast mountain streams (Bengtson, 1972). The width, turbidity, and current velocity vary considerably, but most nests are usually concealed beneath dense vegetation within 5 m of a stream, in areas with good nest-site availability and abundant macroinvertebrates (Bengtson, 1972). Harlequins are tenacious to their nest sites, often returning to within 100 m of previous years' sites, and females may use the same nest site in successive years. Harlequins are not colonial nesters, although several nests may be close together (Delacour, 1959). In Prince William Sound, Patten (oral comm., 1993) located 20 streams that were used by nesting harlequins by 1991. Many streams were turbulent, sometimes only 1-m wide, and located in timbered areas at about 1000 ft elevation (Patten, oral comm., 1993).

Little is known about the brood rearing period. Given the duration of incubation, broods would be expected to hatch in early to mid-July. Islieb reported seeing broods in Prince William Sound in July and August (Islieb and Kessel, 1973). Patten (1991) reported seeing 3.1 ducklings per hen in nonoiled areas in late summer, compared with a mean of 2.8 fully grown ducklings per breeding female in Iceland over a 4-year period (Bengtson, 1972). Bengtson (1972) described a 30 to 40 percent duckling mortality rate during the first 2 weeks.

Predation is not believed to be a major source of mortality of adult harlequin ducks, but young are taken by a variety of predators, including ravens, mink, Arctic skua, and Arctic fox (Bengtson, 1972). Duckling mortality may be as high as 30 to 40 percent in the first 2 weeks after hatching (Bengtson, 1972).

Harlequin ducks are mostly carnivorous. Birds in Iceland ate mostly insects and their aquatic larvae (Bengtson, 1972). Young broods feed mostly on surface insects and on insects from overhanging vegetation, while older broods feed like the adults. Stream bends where the current slows are used by broods for feeding and resting. Outlets from lakes, beneath waterfalls and turbulent, shallow stretches of streams are favorite feeding locations for adults.

Once salmon begin spawning, harlequins eat roe (Delacour, 1959; Dzinbal and Jarvis, 1984). Near the coast, breeding harlequins may fly from nesting areas to the mouths of the rivers to feed (Bengtson, 1972; Dzinbal and Jarvis, 1984). Harlequins feed in the intertidal area of Prince William Sound on a wide variety of prey, including limpets, snails, clams, mussels, and crabs (Patten, 1991).

Dzinbal and Jarvis (1982) studied the summer-feeding ecology of harlequins at Sawmill Bay, southwestern Prince William Sound. Harlequins studied by Dzinbal and Jarvis (1982) fed mainly in the intertidal deltas of small streams and in the intertidal areas of protected bays, and less near small rock islands and in lee waters of bays. In July, harlequins moved into the lower portions of suitable streams to feed on salmon roe. Five harlequins collected by Dzinbal and Jarvis (1982) had eaten a variety of crustaceans and invertebrates, while five others from lower Cook Inlet in 1977 had all eaten gastropods (Sanger, 1986).

Wintering harlequins forage mostly in small groups, and closer to shore than other sea ducks, and they eat mostly crustaceans and mollusks, and some insects, starfish, and fishes (Delacour, 1959; Bellrose, 1982; Dzinbal and Jarvis, 1984).

Harlequin ducks are not hunted much by humans. The annual take of harlequins in Prince William Sound is unknown, but is probably small since most harvesting is associated with using males as decorative mounts (Patten, oral comm., 1993).

EVOS Damage Assessment and Current Status in Spill Area

The EVOS killed an estimated 1,000 harlequin ducks outright (Piatt et al., 1990), and has caused continuing sublethal injuries (Patten, 1991; Patten, written comm., 1994). Two different sets of EVOS studies are available to help evaluate injury to harlequin ducks in Prince William Sound, although because of different methodology and timing, their results are not directly comparable. Bird Study 2 (Klosiewski and Laing, written comm., 1993; Agler et al., written comm., 1994) surveyed along relatively short sub-samples of oiled shoreline, and then extrapolated the results to the entire oiled zone, while Bird Study 11 (Patten, 1991; Patten, written comm., 1994) surveyed continuously along longer segments of shoreline in the oiled shoreline. The behavior of harlequin ducks must also be considered in evaluating population estimates. Post-breeding, and non-breeding males from outside the Sound arrive in the Sound to molt in July and August, but exact times are variable from year to year, and unless surveys are done at precisely the same time the results are not comparable.

Patten (1991) suggested that there had been little or no breeding by harlequin ducks within the Prince William Sound spill area since the spill through 1991. He captured no adult breeders in mist nets set across 14 potential nesting streams and found no duckling broods during late summer shoreline censuses. Comparative control studies at nonoiled sites in eastern Prince William Sound captured breeding adults in mist nets and located duckling broods, which indicated normal breeding. In subsequent studies, Patten (written comm., 1994) surveyed the shoreline of parts of the oiled zone in Prince William Sound and found the following densities of harlequin ducks: July-August 1991, 673 harlequins per 537 km of shoreline (= 1.25 per km); May-June 1992, 1,820 harlequins per 2,798 km of shoreline (=

0.65 per km); and, July-August 1992, 1,681 harlequins per 2,276 km of shoreline (= 0.74 per km).

Bird Study 2 (Klosiewski and Laing, written comm., 1993; Agler et al., written comm., 1994) surveyed segments of shoreline throughout Prince William Sound selected by "stratified random sampling" for 4 years after the spill; they derived population estimates for all bird species, including harlequin ducks, and they compared their estimates with pre spill data collected in 1972 and 1973. Estimated harlequin numbers in 1990 and 1991 in the spill area were only 23 percent of those expected, based on comparisons with pre spill surveys (Klosiewski and Laing, written comm., 1994). They concluded that the reduced numbers were an oil spill effect. The July 1993 survey (Agler et al., written comm., 1994) revealed the highest estimate (1,100 - 3,300) yet for the spill area, but a trend for population recovery is not yet indicated. The July 1990 and 1991 estimates of harlequin numbers in the spill area were (range of 95% confidence interval) 266 to 3,302, and 299 to 1,035, respectively. Current data from Bird Study 2 (S. Kendall, written comm., 1994) indicate a July 1993 estimate of 5,700 to 11,000 harlequin ducks in all of Prince William Sound

In sum, little evidence of breeding in the spill area of Prince William Sound, and population reduction compared with non-oiled areas indicate that the populations of harlequin ducks in the oiled area still shows few signs of recovery. However, this evidence needs to also be tempered with the fact that harlequin populations in oiled and non-oiled areas alike may be stabilizing at levels higher than the latest pre-spill estimates. There is very little information on harlequins in the spill area outside of Prince William Sound.

Murres

The common murre is a circumpolar species of boreal and low Arctic habitats (Nettleship and Birkhead, 1985; AOU, 1983). On the Pacific Coast of North America, common murres breed in dense colonies from mainland northwestern Alaska, on Bering Sea islands, and in the Aleutians, and thence south and east to central California (AOU, 1983). The thick-billed murre is a circumpolar Arctic and low Arctic species (Nettleship and Birkhead, 1985) that has a more restricted range than the common murre, which in Alaska is centered in the Aleutians and the Bering Sea.

About 1.4 million common and thick-billed murres nest in the Gulf of Alaska, with common murres comprising about 80 to 85 percent of the total (Sowls et al., 1978; USFWS, 1993). Where both species nest at the same colonies, thick-billed murres prefer cliff ledges, and common murres favor larger, flatter areas (Tuck, 1960). Thick-billed murres make up a small portion of Barren Islands murre populations, and they are not found elsewhere within the EVOS area. About 1.2 million murres nest in the western Gulf of Alaska on the Semidi Islands, which were not directly impacted by the EVOS. The largest colonies in the EVOS area include approximately 6,500 murres on the Chiswell Islands near Seward, approximately 130,000 on the Barren Islands at the mouth of Cook Inlet, and approximately 120,000 total at three colonies on the Alaska Peninsula (USFWS, 1993).

There are a few very small colonies of murres on the east side of Kodiak Island and at Gull Island, Kachemak Bay. The closest murre colony to the initial spill site, at Porpoise Rock, Hinchinbrook Entrance, was upstream from the spill and not directly affected by it.

Common murres form breeding colonies on seaward-facing cliffs, where they are highly social and lay single eggs (Tuck, 1960). Timing of breeding is highly synchronized. The resulting sudden abundance of eggs and chicks presents predators with the opportunity to eat a small proportion, while the large majority of chicks grows to a size too large for most predators. Breeding success is variable, with maxima of 70 to 80 percent of young fledged per breeding pair (Birkhead, 1977; Hedgren, 1980). Birkhead (1974) estimated a 6-percent annual-mortality rate for adults, which translates to an average life expectancy of 16 years. However, banded murres have lived as long as 32 years.

In spring and summer, common murres are distributed in Alaska mainly over the continental shelf (Gould et al., 1982). In late fall and winter, they often migrate into protected coastal bays and fjords of the Gulf of Alaska, including Kodiak Island (Forsell and Gould, 1981) and Prince William Sound (Agler et. al., written comm., 1993). However, this winter migration is highly variable, and there were apparently very few common murres in Prince William Sound at the time of the spill. In contrast, common murres were extremely abundant in nearshore waters of the Gulf of Alaska in winter 1992-1993, when an unknown but apparently small proportion died from unknown causes and washed ashore at several locations (Mendenhall, oral comm., 1994). An unprecedented 220,000 murres were estimated in Prince William Sound alone in March 1993 (Agler et al., 1993), perhaps attracted by large numbers of juvenile herring (Mendenhall, oral comm., 1994; Sanger, personal observations, 1993).

In summer, common murres in the Gulf of Alaska forage mainly on fish over the continental shelf (Sanger, 1987a). The presence of mysid and pandalid shrimps in their winter diet in Kachemak Bay (Sanger, 1987b) and at Kodiak (Krasnow and Sanger, 1986) shows that they capture some prey very near the bottom, thus linking themselves to a detrital food chain. Common murres have been caught in crab pots at 125 m at Kodiak (Forsell and Gould, 1981).

Effects of Spill and Current Status in Spill Area

Murres are particularly vulnerable to floating oil (King and Sanger, 1979), and the EVOS killed an estimated 120,000 to 134,000 breeders, mostly from the Chiswell Islands and the Barren Islands (Piatt et al., 1990). The oil arrived in early April just as birds began congregating at the colonies before breeding. If the mortality rate from the EVOS is adjusted for birds feeding at sea, away from their colonies, the mortality increases to an estimated 170,000 to 190,000 breeding birds. An estimated 35 to 70 percent of the breeding adults at the above colonies could have been killed by the spill. The effect of the EVOS on prebreeding juveniles is unknown.

At the Chiswell Islands, there was no laying in 1989, and laying was late in 1990. Also, through 1992, laying was a month late at Puale Bay and in the Barren and Chiswell Islands. The resulting chicks may not have had time to accumulate sufficient energy reserves before the first fall storms. Conservatively, lost production associated with delayed reproduction could have exceeded an estimated 300,000 chicks per year through 1992. Although productivity rates were near normal in 1992 and 1993 at the Barren Islands, populations were still down in 1993 (D. Roseneau, oral comm., 1994).

The EVOS also affected the timing of reproduction at oil-impacted colonies (Nysewander et al., 1993). At the Barren Islands and at Puale Bay, egg laying was about a month late in 1989, 1990, and 1991. There were indications that breeding was returning to normal at the Barren Islands in 1992. By 1993, the timing of breeding was normal, and productivity averaged over 0.5 chicks per nest (Roseneau, oral comm., 1994). The recovery status of common murres remains uncertain, however, and restoration to prespill population levels could take decades.

Pigeon Guillemot

The pigeon guillemot is a medium-small diving seabird that nests in rocky coastal habitat on the Asian and North American sides of the subarctic-temperate North Pacific (AOU, 1983). In North America, pigeon guillemots are found from mainland northwestern Alaska (Cape Lisburne), on islands in the Bering Sea and the Aleutians, and thence south to central California (AOU, 1983; Sowls et al., 1978). This distribution is one of the widest of any seabird species on the Pacific coast of North America.

An estimated 26,000 pigeon guillemots nested in the eastern Gulf of Alaska in the early 1970's (Sowls et al., 1978), with an estimated 15,000 in Prince William Sound alone (Islieb and Kessel, 1973). Since then, however, the population in Prince William Sound has declined markedly. A minimum of 3,028 breeding guillemots were counted in Prince William Sound in July 1993 (Sanger and Cody, written comm., 1993), and the entire population of breeders and juveniles was estimated at no more than 4,900 (Klowsiewski and Laing, written comm., 1993).

The EVOS killed perhaps as many as 10 percent of the guillemots in Prince William Sound, but the population undoubtedly was declining before the spill (Oakley and Kuletz, written comm., 1994). In oiled and nonoiled areas alike, maximum numbers of guillemots at colonies in 1993 were only about 20 to 50 percent of the maxima of the 1970's and 1980's (Sanger and Cody, written comm., 1994). Except for Afognak Island (Cody, Fadeley, and Gerlach, 1993), current population sizes within the EVOS area outside of Prince William Sound are unknown. However, the same factors that have caused a population decline in Prince William Sound since the 1970's could also be influencing EVOS area populations outside Prince William Sound.

In the Gulf of Alaska, as high as 25 percent of the pigeon guillemot population may occur over the continental shelf in summer (June - August) (Sanger, 1987a, as adapted from Gould et al., 1982). In fall and spring, and presumably in winter, a few guillemots were seen in the Gulf of Alaska as far offshore as the shelf break (Gould et al., 1982). Some investigators (Scott, 1973; Oakley, 1981; Ainley and Boekelheide, 1990) speculate that guillemots leave exposed coastlines for sheltered inshore waters in winter. This conclusion is not supported by population estimates from Prince William Sound, however, which suggest just the opposite, i.e., Klowsiewski and Laing, written comm., (1993) and Agler et al. (written comm., 1993) report March population levels in Prince William Sound at 20 - 70 percent lower than the preceding July.

Pigeon guillemots nest in natural cavities in cliffs and among boulders, and occasionally in earthen burrows or man-made structures (Oakley and Kuletz, written comm., 1994; Sanger and Cody, written comm., 1994; Campbell, 1977). Their extremely dispersed nesting distribution (Oakley and Kuletz, written comm., 1994) is atypical of most seabirds. For example, a 1993 survey (Sanger and Cody, written comm., 1993) located 184 guillemot colonies in Prince William Sound, with an average of only 11 guillemots per colony. Also, 1,012 guillemots were seen away from colonies, many of which were no doubt isolated nesting pairs. Guillemots lay a clutch of one or two eggs, and chicks remain in the nest for just over a month after hatching (Drent, 1965; Oakley and Kuletz, written, comm., 1994).

While the chicks are in the nest, both parents deliver single whole fish to the nest throughout the day (Thoreson and Booth, 1958; Drent, 1965; Oakley and Kuletz, written comm., 1994).

Predation on guillemot eggs and chicks is sometimes heavy, mainly by glaucous-winged gulls and northwestern crows (Drent et al., 1964; Emms and Morgan, 1989; Vermeer, Morgan, and Smith, 1993), and by mink (Oakley and Kuletz, written comm., 1994; Ewins, Carter, and Shibaev, 1993). Adult pigeon guillemots are occasionally taken by bald eagles, peregrine falcons and killer whales (Vermeer et al., 1989; Nelson, 1991; Stacey, Baird, and Hubbard-Morton, 1990).

Guillemots in the EVOS area feed on demersal or epibenthic prey mostly in near-shore waters shallower than 40 m (Kuletz, 1983; DeGange and Sanger, 1986). Fish form the bulk of guillemots' diet, but they also eat shrimp, crabs, and occasionally bivalves (Sanger, 1987a; Krasnow and Sanger, 1986). Kuletz (1983) found that guillemots at Naked Island tended to forage more over underwater rises and shelfbreaks than over even-bottom topography, and that individual birds tended to forage in the same area. Some guillemots tend to specialize on pelagic schooling fishes, while others specialize on bottom fishes like blennies (Kuletz, 1983).

Effects of Spill and Current Status in Spill Area

The population of guillemots in Prince William Sound after the spill was significantly lower than it was in the early 1970's (Klosiewski and Laing, written comm., 1993), and counts at colonies in 1993 were considerably lower than they were in the 1970's and 1980's in both oiled and nonoiled areas (Sanger and Cody, written comm., 1993). Similarly, numbers of guillemots at colonies in the Kenai Fjords have also been lower compared with the 1970's and 1980's (Rice, oral comm., 1994). After the spill, guillemot populations in the oiled area of Prince William Sound were comparatively lower than in nonoiled areas (Klosiewski and Laing., written comm., 1993). Population counts at Naked Island also declined for 4 years after the spill, and the decline along oiled shorelines was more pronounced than along nonoiled shorelines (Oakley and Kuletz, written comm., 1994; Sanger and Cody, written comm., 1994).

Reasons for the decline are unclear, although a decreased food base and increased predation are possibilities. Survey data do not yet indicate a definite population trend in all of PWS nor in the Sound's the spill zone. The recovery status of pigeon guillemots remains uncertain; however, with a clutch size of two eggs, guillemots have the potential to rebuild their population at a faster rate than many other seabird species.

Marbled Murrelet

The marbled murrelet is a small, diving seabird that ranges from central California north to the Gulf of Alaska (AOU, 1983; Sowls et al., 1978), and westward to the western Aleutians (Kessel and Gibson, 1978; Mendenhall, 1992). Nesting marbled murrelets are widely dispersed and secretive, so their breeding population sizes are conjectural (Carter and Morrison, 1992). Recent population estimates throughout their range (Carter and Morrison, 1992) relied on counts of birds at sea.

Perhaps as high as 95 percent of all marbled murrelets nest in Alaska (Mendenhall, 1992). The Alaskan population is centered from the southeastern panhandle to Kodiak where the vast majority of the population flies inland to nest on moss-covered branches of large conifers (Piatt and Ford, 1993). A small part of the population, possibly as low as 3 percent

(Mendenhall, 1992; Piatt and Ford, 1993), nests on the ground in alpine and coastal tundra, and all murrelets are ground nesters west of the limits of the conifer area on Kodiak Island.

Piatt and Ford (1993) used counts at sea from the late 1970's to estimate an Alaskan population of at least 160,000 marbled murrelets. However, this estimate included very few observations in Prince William Sound and southeastern Alaska (Gould et al., 1982), so it is likely too low. The current Alaska-wide population could be at least 250,000 (M. McAllister, pers. comm., in Mendenhall, 1992).

A July 1972 survey (Islieb and Kessel, 1972) estimated the Prince William Sound population at 206,000 to 403,000 (Klosiewski and Laing, written comm., 1993). Elsewhere in the EVOS area, estimates of murrelet populations in the Kodiak Archipelago range from 21,000 to 21,900 (Piatt and Ford, 1993; Forsell and Gould, 1982).

In the Gulf of Alaska, as high as 30 percent of the marbled murrelet population may occur over the continental shelf in summer (June - August) (Sanger, 1987a; Gould et al., 1982). From fall through spring, a few murrelets were seen in the Gulf of Alaska as far offshore as the shelfbreak (Gould et al., 1982). Klowsiewski and Laing, (written comm., 1993) and Agler et al. (written comm., 1993) report March population levels in Prince William Sound significantly lower than the preceding July, showing that most murrelets in Prince William Sound migrate offshore for the winter. It was this behavior that saved the large majority of the Prince William Sound population from destruction from the EVOS (Kuletz, 1993).

Throughout most of their range, very little is known about the breeding biology of marbled murrelets (Carter and Morrison, 1992). Several nests have been located in Alaska (Mendenhall, 1992), but virtually nothing is known about murrelets' productivity rates or other aspects of their breeding biology.

Marbled murrelets in the EVOS area feed mostly on pelagic fish within the water column, most of which they capture in nearshore waters shallower than 40 m (Sanger, 1987a; DeGange and Sanger, 1986). In winter, however, their diet in Kachemak Bay (Sanger, 1987b) and at Kodiak (Krasnow and Sanger, 1986) includes pandalid and mysid shrimps (demersal species), thus linking themselves to a detrital food web.

Effects of Spill and Current Status in Spill Area

Approximately 612 marbled murrelet carcasses were recovered following the EVOS. Based on other carcass recovery studies (Ford et al., 1991), Kuletz (1993) estimated the direct mortality of murrelets from the EVOS to be within a range of 8,000 to 12,000, with a best approximation of 8,400. The latter figure is about 4 to 7 percent of the most recent population estimate for Prince William Sound (Agler et al., written comm., 1993). On midbay transect counts at Naked Island, there were significantly fewer murrelets in 1989 compared with 1978-1980, but counts in 1990 were comparable to prespill numbers. Shoreline counts of murrelets in the Naked Island group were also lower in 1989 than before the spill, but had rebounded to prespill levels in the 1990-1992 interval (Kuletz, 1993; Kuletz, oral comm., 1994). In Kachemak Bay, Kuletz (1993) found no difference in transect counts from 1988 to 1989. There are no similar data from elsewhere in the EVOS area, although by the time surface oil from the EVOS left Prince William Sound, it could have impacted murrelets downstream from Prince William Sound (Kuletz, Marks, and Naslund, written comm., 1993).

The July population level as a whole declined from 1972 to after the spill (Klosiewski and Laing, written comm., 1993). However, these investigators did not find an oil-spill effect for lower populations in the oiled area compared with the nonoiled area of Prince William Sound, such as they found with pigeon guillemots and other species. Population estimates for all of PWS (Klosiewski and Laing, written comm., 1993; Agler et al., written comm., 1993) show that marbled murrelet numbers were within the range of 90,000 to 125,000 in 1989; 64,000 to 99,000 in 1990; 86,000 to 127,000 in 1991; and 117,000 to 201,000 in 1993. These estimates still do not indicate a stable population trend, and the recovery status of marbled murrelets remains uncertain.

Fish

The waters of the area encompassed by the EVOS include a large assemblage of fish populations. Fish habitats range from upland wetlands to deep benthic marine waters. Fishes present include sport, subsistence and commercially-important species as well as forage fish for other fish species, marine mammals, and birds. Of these, the most apparent are those that are valuable to the subsistence, commercial, or sport fishers.

Fish stocks, including both hatchery-reared salmon and wild stocks, are managed by the ADF&G in freshwaters and within a 3-mile limit in marine waters. The North Pacific Fishery Management Council (NPMFC) prepares management plans, and applies them to marine waters for the 3-mile limit to the 200-mile limit. The International North Pacific Fisheries Commission provides conservation measures that limit location, time, and number of fishing days beyond the 200-mile limit.

Although often it is difficult to differentiate between natural population variability and oil-spill-induced changes, a summary of injuries to the fish species that may have been affected by the EVOS has been presented by the EVOS Trustee Council (1992).

Pink Salmon

Pink salmon (*Oncorhynchus gorbuscha*) are the most abundant of all the species of Pacific salmon, and they have the simplest and least variable life cycle. After they emerge from the redd, the fry migrate quickly to the sea where they grow rapidly. Pink salmon mature after approximately 18 months and return to their natal streams to spawn and die.

Because of this simple life cycle, populations spawning during odd-number calendar years are effectively isolated from populations spawning during even-number years; therefore, no gene flow occurs between the alternate-year populations (Heard, 1991). As adults, pink salmon return to their natal spawning grounds to reproduce, typically within several miles from the sea (Morrow, 1980). As much as 75 percent of Prince William Sound pink salmon populations, however, spawn in the intertidal zone (ADF&G, 1985). Spawning generally occurs between mid-July and October, and hatching requires 61 - 130 days, depending on water temperature. Emergence is in April and early May (Morrow, 1980).

The diet of pink salmon fry primarily consists of invertebrate eggs, amphipods, and copepods. Juveniles primarily feed on larger invertebrates and small fishes. Young pink salmon are preyed on by other fishes, invertebrates, marine mammals, and birds (Morrow, 1980; Heard, 1991).

After the *Exxon Valdez* went aground, sublethal injuries were measured among the populations of both wild and hatchery-produced pink salmon. Bue, et al. (1993) reported that pink salmon egg mortality was significantly greater in oiled streams than in nonoiled (control) streams in 1989, 1990, and 1991. Most of the mortalities were observed in the intertidal zone, where most of the pink salmon spawning occurs. The authors did not expect these results to persist in 1991, and they hypothesize that the continued and increased mortality resulted from genetic damage to the incubating eggs and alevins in oiled streams during the winter of 1989-1990. In addition, Weidmer, et al. (1993) found that pre-emergent pink salmon fry in oiled streams had elevated concentrations of an enzyme, Cytochrome P450A, aids in the metabolism of hydrocarbons; and, when present, it indicates that the fish was exposed to petrochemicals. Fry from 38 percent of these samples (and 17 % of the samples from nonoiled streams) had histopathological lesions on internal organs. These could cause increased physiological stress and reduced survival and may affect future reproductive success.

Pink salmon fry released from hatcheries as well as wild pink salmon fry that left their natal streams in spring 1989 were also exposed to oil in the open water (Willette, 1993). Both pink salmon and chum salmon larvae were exposed to sufficient amounts of oil to induce production of the Cytochrome P450A enzymes that metabolize oil. In addition, tagged pink salmon larvae released from the hatcheries and collected in oiled areas were smaller than those collected in unoiled areas, even after accounting for the effects of food supply and temperature. The rate of return of pink salmon adults depends on the quality of rearing conditions during the fry stage; lower food supply, water temperature, and growth of the fry will result in a lower return of adults the following year (Willette, 1993). Wertheimer et al. (1993) also concluded that the reduction in growth rate of pink salmon fry in 1989 was caused by oil contamination, and that this would reduce their potential survival to the adult stage.

The mean survival rate of wild pink salmon fry to the adult stage from oiled spawning streams was lower than the survival rate of fry migrating from nonoiled streams. (Peckham et al., 1993). These authors also reported that survival rates of pink salmon fry released from two fish hatcheries after the oil spill were lower than the survival rates of fry released before the oil spill. They were, however, unwilling to attribute this to the oil spill.

Sockeye Salmon

Sockeye salmon (*Oncorhynchus nerka*) exhibit a greater variety of life-history patterns than any other Pacific salmon (Burgner, 1991). Spawning usually occurs between July and October. The female builds a redd in graveled areas that will provide sufficient water flow and dissolved oxygen for the eggs and alevins. Typically, spawning occurs in streams or rivers associated with a lake; however, some populations spawn extensively in lakes and occasionally some populations spawn in streams without lakes (Burgner, 1991; Morrow, 1980). Development usually requires 6 to 9 weeks for hatching and emergence from the gravel is usually from April to June (Morrow, 1980). Sockeye salmon fry usually use lake-rearing habitat for 1 to 3 years before they migrate to the sea as smolts. Sockeye salmon remain in the marine environment 1 to 4 years (usually 2 or 3 years) before they return to spawn (Burgner, 1991).

Adults feed primarily on euphausiids, amphipods, copepods, and young fishes. Growth in the ocean is rapid and the usual size at maturity is 3 to 5 kg (Morrow, 1980). Adults are preyed on by marine mammals and predatory fishes (Pauley et al., 1989).

Kenai River and Kodiak Island sockeye salmon stocks may have suffered population declines as well as sublethal injuries. This potential injury is unique, because it is due in part to a decision to close commercial fishing in 1989 in portions of Cook Inlet and in Kodiak waters. As a result, there were higher than usual returns (i.e., "overescapement") of spawning fish to the Kenai River and Kodiak Island systems in 1989.

The effect of spawning by large numbers of sockeye salmon is to produce a large number of fry that, in turn, consume a large amount of their food--zooplankton--from the nursery lakes. Excessive numbers of fry deplete their food supply which results in a reduction in their survival rate to the smolt stage. Schmidt et al. (1993) reported overescapements of sockeye salmon into the Kenai River system during 1987, 1988, and 1989, a pattern of declining plankton production numbers and sizes of rearing fry, and a pattern of declining numbers of sockeye salmon smolts. These observations support the hypothesis that overescapements of sockeye spawners have adversely affected sockeye salmon smolt production. These results also forecast a reduction of the numbers of adult sockeye salmon returning during 1994 and 1995. The zooplankton population composition and biomass in Akalura Lake on Kodiak Island has been following a pattern of low density, small-sized individuals and a shift in species composition, apparently because of the overescapement of sockeye salmon in 1989 (White, L., ADF&G, oral comm., 1994).

Pacific Herring

Pacific herring (*Clupea harengus pallasi*) mature between 2 and 4 years of age and spawn annually. They live offshore but spawn in nearshore coastal waters, usually over vegetation such as eelgrass, seaweed or other submerged structures. Spawning in Alaskan waters begins when the seawater temperature rises to about 4° C. Their greatest mortality occurs during the egg to juvenile stages, when mortality may be 99 percent. Adults may have a lifespan of approximately 19 years (Morrow, 1980; Pauley et al., 1988). Juvenile herring feed on euphausiids, planktonic crustaceans, and fish larvae. Pacific herring eggs are preyed upon by shorebirds, diving birds, gulls, invertebrates, and fishes. Pacific herring larvae are eaten by jellyfish, amphipods, and other fishes. Adults are a prey base for large finfishes, sharks, and marine mammals and birds (Pauley et al., 1988).

Within 2½ weeks after the start of the EVOS, Pacific herring began spawning in Prince William Sound (McGurk and Biggs, 1993). Over 40 percent of the areas used by the Prince William Sound stocks for spawning and over 90 percent of the nearshore nursery areas were exposed to the spilled crude oil (Biggs and Baker, 1993). Studies performed in 1989 demonstrated that the mean mortality of Pacific herring eggs and larvae was three times higher in the oiled sites than in the nonoiled sites although environmental conditions confounded the interpretation of these results. Hose et al. (1993), however, reported that the incidence of malformed Pacific herring embryos and larvae and evidence of genetic damage (i.e., chromosome breakage) was higher from oiled study sites than from nonoiled sites. Norcross et al. (1993) observed evidence of genetic damage which was related to jaw deformities and small size in herring larvae that were captured one to three months following hatch in 1989. This impact combined with the elevated embryonic mortality and severe post-hatch abnormalities, indicated that the mortality of herring larvae was increased because of oil exposure in 1989. Elevations in post-hatch larval deformities, both genetic and morphological, continued to occur in oiled areas in 1990, but to a much lesser degree and no differences were observed by 1991. Kocan, et al. (1993) performed an experiment to evaluate the reproductive potential of individual female Pacific herring that had been present as one-year odds in Prince William Sound at the time of the oil spill. This study demonstrated that hatching success was halved and abnormalities among larvae were doubled in offspring of fish spawning in previously-oiled sites versus nonoiled sites which suggests a possible reproductive impairment through genetic damage to the adults. This was, however, only a pilot study and the data are not yet conclusive.

It is not known the extent that the juvenile herring were exposed to oil in 1989, but Marty et. al. (1992) documented that 20 percent of adult herring captured in oiled areas suffered severe internal lesions compared to 0 percent in unoiled areas. Moles, Rice and Okihiro (1993) found that the herring captured in the oiled areas were devoid of gut parasites. The observations of lesions and absence of parasites were recreated in adult herring exposed to oil in controlled laboratory settings.

There also was an outbreak of viral hemorrhagic septicemia (VHS) in herring returning to Prince William Sound in 1993. It is known that previous exposure to toxins can affect the immune system of fish making them more susceptible to disease, but without an accurate estimate of level of exposure, it is not known if the oil spill caused this outbreak. The missing information relating to cause and effect is a common problem in oil spill damage assessment (Brown, E., ADF&G, oral comm., 1994; Meyers et al., 1993).

Rockfish

There are more than 50 species of rockfish (*Sebastes* spp. and *Sebastolobes* spp.), including yelloweye rockfish (*Sebastes ruberrimus*), quillback (*S. maliger*), and copper rockfish (*S. caurinus*), that are found in Prince William Sound, Cook Inlet, and the Gulf of Alaska. Life histories of rockfish are highly variable and not well understood. Yelloweye rockfish are live bearers and release live planktonic larvae into the water column between April and June in southeastern Alaska (Carlson and Straty, 1981). Very little is known about the early life history of larvae and juveniles; however, the yelloweye rockfish range extends from Cook Inlet in Alaska south to Baja California (Hart, 1973). Rockfish grow very slowly and reach sexual maturity between 14 and 19 years of age. Rockfish breed annually thereafter but produce few offspring. They can live up to 114 years. It is not known whether or how rockfish migrate, but older fish tend to move to deeper water (Carlson and Straty, 1981).

Yelloweye rockfish are opportunistic feeders. They feed primarily on a variety of crabs, shrimp, snails, and fishes. Small yelloweye rockfish are preyed upon by larger rockfish and other fishes (Carlson and Straty, 1981).

The oil spill may have caused sublethal injuries to rockfish, but it is unknown if population declines occurred. There is little prespill data on rockfish in the spill area. Many dead rockfish were reported to have been sighted after the spill, although only 20 adult yelloweye rockfish were recovered by biologists. Of these, only 5 were in good enough condition to chemically analyze. All 5 fish were determined to have died from oil ingestion. Samples collected from oiled areas in Prince William Sound and the outer Kenai coast indicated there was evidence of exposure to oil (in bile) in 1989 and higher than normal incidence of organ lesions in 1989, 1990, and 1991 (Hoffman, et al., 1993). There also is evidence that the incidence of organ lesions was higher in 1991 than in previous years (Marty et al., 1993).

The degree to which postspill increases in fishing pressure may be impacting rockfish is also unknown. Partially because of numerous spill-related commercial-fishing closures for salmon and herring in 1989, commercial fishers increased their take of rockfish. Rockfish harvests in Prince William Sound increased from approximately 93,000 pounds in 1989 to over 489,000 pounds in 1990. Harvests decreased since 1990, but harvests are still higher than the historic average (Bechtol, 1994). While population levels are unknown, concerns have arisen about possible overfishing. Rockfish are a slow growing species, produce relatively few young, and do not recover rapidly from overfishing.

Dolly Varden

Dolly Varden (*Salvelinus malma*) are found in fresh- and saltwater in western North America and eastern Asia. Their range extends from southern British Columbia to the Arctic coast of Alaska. Both anadromous and nonanadromous populations are found in Alaska, and they may occupy five different types of habitats, with behavioral and biological modifications for each (Morrow, 1980).

Dolly Varden commonly mature between 4 and 7 years of age. As adults, they live near their natal streams in nearshore areas of marine environments during the summer, and they migrate to freshwater lakes to overwinter. Dolly Varden return to their natal streams to spawn, usually in September and October. The eggs hatch in approximately 4 to 5 months. After they emerge, the fry remain close to the bottom for the first few days but commence active feeding soon after and begin growing rapidly. The young remain in freshwater for 3 to 4 years before moving seaward. They are found near logs and undercut banks, where they seek protection from predation (Morrow, 1980; ADF&G, 1985).

The primary diet for marine adult Dolly Varden consists of smelt, herring, juvenile salmonids, and other small fish as well as invertebrates. In the freshwater habitat, invertebrates and other small fishes are the main diet. Dolly Varden may live to be 12 or more years old (Morrow, 1980).

Both Dolly Varden and cutthroat trout feed extensively in the nearshore marine habitat and are particularly vulnerable to the effects of oil spills. Measurement of oil in the bile of Dolly Varden following the spill in 1989 showed that this species had the highest oil concentration of any fish species studied (Collier et al., 1993). Dolly Varden and cutthroat trout were captured at weirs on five streams after overwintering in 1989, 1990 and 1991 in an attempt to understand the effects of oiling. Studies of injury were not carried out in 1992. Growth and survival rates of Dolly Varden returning to oiled streams in 1990 were significantly lower than those returning to nonoiled streams (Hepler et al., 1993).

Cutthroat Trout

Cutthroat trout (*Oncorhynchus clarki*) range from northern California to Prince William Sound, Alaska (Pauley et al., 1989). Both anadromous and nonanadromous populations are found in Alaska (Morrow, 1980).

Sea-run cutthroat trout mature at 2 to 3 years of age. Males typically mature at an earlier age than females. Cutthroat trout are "repeat spawners" but postspawning mortality may approach 90 percent (Morrow, 1980). They return to their natal streams to spawn in the spring between February and May, depending on the geographic area. After spawning, adults and smolts migrate to the sea between March and July. They remain nearshore in the vicinity of the natal stream to feed, and they return to freshwater lakes to overwinter (Morrow, 1980).

Adult cutthroat trout feed primarily on small fish and shrimp and eat more fish as they increase in size. Fry and juveniles feed primarily on insects and crustaceans, but they also begin to feed on smaller fish such as sticklebacks and other salmonids as they increase in size. In the marine environment, they feed on amphipods, isopods, shrimp, immature crabs, and other salmonid fishes (Pauley et al., 1989). Fry and juveniles are preyed on by rainbow trout, brook trout, Dolly Varden, sculpins, and adult cutthroat trout, as well as a various bird species such as great blue herons and kingfishers. In the marine environment, cutthroat are preyed on by Pacific hake, sharks, marine mammals, and adult salmon (Pauley et al., 1989).

The oil spill caused some injury to the anadromous populations of cutthroat trout in Prince William Sound. Large cutthroat trout had a higher mortality rate in oiled areas than in unoiled areas. There was a 57-percent greater mortality rate in oiled streams in 1989 - 1990 and a 65-percent greater rate in 1990 - 1991 compared to unoiled streams. In addition, growth rates of cutthroat trout in oiled areas were reduced compared to unoiled areas (Hepler et al., 1993).

Social and Economic Environment

This section describes the social, cultural, and economic conditions of the communities affected by the *Exxon Valdez* Oil Spill (EVOS). It includes discussion of the sociocultural context of the region, some of the laws that pertain to the contemporary social, economic, and political environment, the composition of the affected communities and their socioeconomic bases, the impact of the spill on traditional Native and non-Native subsistence activities, cultural heritage (archaeology and culture history), recreation (commercial and noncommercial), commercial fishing, sport fishing, and designated wilderness.

The Sociocultural Context

Glaciers covered much of Alaska until the end of the last ice age, some 10,000 years ago. As they receded, the glaciers left, like plowshares, a vast land ripe for animal and plant life. As the new ecosystems took root and flourished, people were soon to follow. Native Americans early and extensively inhabited the lands affected by the EVOS. The people followed the great herds of game animals across this newly greening land and pursued sea mammals across the adjacent resource-rich waters. They fished in the oceans and streams and gathered other available resources, developing intricate and complex societies and refining their relationships to the land and waters. Indigenous peoples have thrived in Prince William Sound for over 5,000 years, on the Kodiak Archipelago and Alaska Peninsula for over 8,000 years, and on the Kenai Peninsula for perhaps as long as 10,000 years.

The first contact with Europeans followed the Russian-sponsored expedition of Bering and Cherikov, members of which set foot on Kayak Island in southeastern Prince William Sound in 1741. As Russians used Native hunters to find and acquire sea otters for trade in the China market, the societies, cultures, economies, and genetic makeup of the communities of the spill area changed rapidly, though never entirely.

Today, even though the languages and cultural traditions of the Aleuts of the Aleutian Islands are historically quite different from those of the people in the spill area, Natives of traditionally Alutiiq (or Sugpiaq) and Eyak communities often refer to themselves as "Aleuts."

After the United States acquired what title Russia had to Alaska in 1867, relatively slow but immense change enveloped the area. Increasing numbers of Westerners (Americans and others) moved into the area in search of commercial resources and a pioneering lifestyle. Several communities grew as more non-Natives moved to the area and as Native communities merged into fewer communities. The consolidation of the Native communities occurred because so many people had died of introduced diseases, and because of the greater importance of the cash economy. Commercial fishing, commercial whaling, fox farming, logging, and mining were important to the area's economy by the first half of the 20th century. The military buildup during World War II produced transportation, communication, and facilities infrastructures. This further integrated rural Alaska into the American cash economy.

Parts of the Alaska Peninsula and the Kodiak Archipelago were devastated by heavy ash fallout from the 1912 eruption of Novarupta, the second-largest volcanic eruption in recorded history. The Good Friday Earthquake of 1964 was centered in Prince William Sound and greatly affected all of southcentral Alaska. The villages of Chenega and Valdez were destroyed by the quake and the resulting tsunamis. Kodiak was badly damaged, as were almost all other communities of the area.

The EVOS affected many of the same communities, disrupting families and other social relationships, livelihoods, and the resources on which the people depended. Though the cumulative effects of natural and human disasters and disease are massive, many of the affected communities still depend heavily on subsistence for their livelihoods, cultural identities, and spiritual expression, much as their ancestors did for thousands of years prior. The effects on the commercial economies of the spill area likewise have been extreme and, similarly, have proved resilient.

Relevant State History

The Alaska Statehood Act (48 U.S.C. note prec. 21) admitted Alaska to the Union in January 1959. Section 6 of the Act empowered the State to choose about 103 million acres (an area of public lands larger than the State of California) from unreserved U.S. lands. Oil exploration and development increased after statehood was declared. A major windfall came soon after statehood, when in 1968 a discovery well at Prudhoe Bay on the North Slope tapped into the largest known oil field in the U. S. The North Slope oil lease of 1969 granted oil rights to an oil consortium and brought more than $900 million in bonuses to the State treasury.

The Alaska Native Claims Settlement Act (ANCSA) of 1971 (P.L. 92-203; 33 U.S.C. 1601-1624) attempted to settle aboriginal rights and establish the legal claims to lands in Alaska made by indigenous peoples of Alaska. It established 13 Regional Native Corporations and nearly 200 village corporations. It further provided a compensatory award of $962.5 million and an award of 40 million acres of land. This Act addressed public-land withdrawals and established a Joint Federal State Land Use Planning Commission, which began land-selection procedures that resulted in the existing pattern of Federal, State, Native, and private ownership of lands in Alaska. It also paved the way for construction of the Trans-Alaska Pipeline System from Prudhoe Bay to Valdez.

To allow transportation of oil from the North Slope to a shipping point, Congress passed the Trans-Alaska Pipeline Authorization Act in 1973. During the same year, Congress passed a bill to waive certain provisions of the National Environmental Policy Act to expedite pipeline construction. The pipeline was completed in 1977. Now the pipeline daily moves almost 2 million barrels of crude oil from Prudhoe Bay to Valdez. Since 1977, the Port of Valdez has shipped the bulk of the crude oil extracted from Prudhoe Bay (Alaska State Libraries, 1992).

In 1976 the USDOI's Minerals Management Service held Lease Sale 39, the first oil and gas lease sale for the right to drill on the outer continental shelf (OCS) of the northern Gulf of

Alaska. Sale CI for Lower Cook Inlet was held in 1977, Sale 55 for the eastern Gulf of Alaska in 1980, and Sale 60 for Lower Cook Inlet-Shelikoff Strait in 1981. Although Valdez and Prince William Sound have little or no known oil or gas potential, Lease Sales 88 (canceled) and 114 (delayed indefinitely) included this area. Ironically, the first commercial oil venture in Alaska occurred in Prince William Sound--at Katalla, near Cordova--just after the turn of the 20th century.

The Alaska National Interest Lands Conservation Act (ANILCA) of 1980 (P.L. 96-487; 16 U.S.C. § 3111 et seq.) in part implemented provisions of the ANCSA (Sec. 17.d.2) and the Statehood Act (Sec. 6). That is, it enacted into law the recommendations of the Joint Federal-State Land Use Planning Commission on (1) which lands should be included in the rest of the State's 103-million acre entitlement and (2) which lands should be included in 80 to 100 million additional acres of Federal reservations, national forests, parks, wildlife refuges, and wilderness areas. Congress also recognized through the ANILCA that it was in the national interest to regulate, protect, and conserve fish and wildlife on public lands and that an administrative structure should be established for the continuation of the opportunity for subsistence uses.

Affected Communities

The communities affected by the *Exxon Valdez* spill are grouped into four regions: the Kenai Peninsula Borough, the Kodiak Island Borough, the Lake and Peninsula Borough, and the Valdez-Cordova Census Area. There are 68 "communities" in the four regions (Alaska Department of Community and Regional Affairs [DCRA], 1994), though many of these are best described as "localities" rather than cities, towns, or villages.

Access to communities affects the variety and quantity of interaction with other communities, markets, and governments. Many of the communities are quite remote, with access by air or boat only. Others are connected to the Alaska road system and are therefore easier to access. Ease of access equates to some degree with how expensive it is to live in the community. The easier the access, the more opportunity residents have to purchase goods at less expensive prices.

Modes of access to communities within the oil spill region are varied but not extensive. The southwest system of the Alaska Marine Highway System provides ferry service to the majority of the oil spill area, carrying 43,500 passengers and 15,600 vehicles in 1989 (Alaska State Libraries, 1992). Road access is available from Anchorage to Homer and Seward on the Kenai Peninsula, and to Valdez in the EVOS Prince William Sound area. The Alaska Railroad connects Seward, Portage, and Anchorage, with a branch to Whittier. Air transport is used for locations not served by the ferry or road systems. Charter air services are available to each community. Commercial cargo barges serve all of the coastal communities.

Profiles of Affected Communities

The effects of the spill differ for each region and its communities. This is a function of the communities' locations relative to the oil spill, ease and types of access, and local economic, social, and political conditions. The following discussion was developed from 1994 DCRA data files; and, while it considers larger communities like Kenai and Seward, it concentrates primarily on the smaller, predominantly Native villages. In general, these communities have mixed economies based on both cash and subsistence and have experienced the most disruption.

Kenai Peninsula Borough

The Kenai Peninsula Borough (formed in 1964) lies south of Anchorage and includes both sides of Cook Inlet from the southern tip of the Kenai Peninsula north to the Knik Arm-Turnagain Arm split. The Kenai Peninsula cities of Seward, Soldotna, Kenai, and Homer contain most of the area's development because they are linked by roads to Anchorage. Nearly all of the borough's 44,000 people live on the Kenai Peninsula, with 63 percent in the cities of Kenai and Soldotna in the central part of the peninsula. This central area is economically dependent on the oil and gas industry, commercial fishing, agriculture, tourism, government, and commercial offices.

The southern Kenai Peninsula contains the cities of Homer and Seldovia and the Native villages of Port Graham and Nanwalek. Homer is the economic and population hub of that part of the peninsula, with revenues from commercial fishing, tourism, government, commercial offices, and agriculture. In contrast, the Native villages are largely dependent on subsistence hunting and fishing.

The Kenaitze Indians, Dena'ina Athapaskans, occupied the central and upper peninsula when Europeans first came to the area; the lower peninsula had been occupied by Alutiiq Natives. The city of Kenai was founded in 1791 as a Russian fur trading post. In the late 1800's and early 1900's, gold mining was a major industry on the peninsula. Also in the early 1900's, cannery operations and construction of the railroad spurred development. The Kenai Peninsula was the site of the first major Alaska oil strike, in 1957, and has been a center for exploration and production since that time.

The population of the borough is primarily non-Native, though several communities are predominantly Native and some others have significant proportions of Natives. The Kenai River is a major sport fishing location for Anchorage residents as well as tourists from elsewhere in Alaska and beyond. Because the river is world-famous for trophy king and silver salmon, the peninsula is heavily visited by sportsmen during the summer months. The borough economy is highly diverse, with employment provided by oil industry services and supplies, commercial and sport fishing and fish processing, transportation, timber, tourism, government, and retail services. Seward can be reached by car from Anchorage by the Seward Highway. Kenai, Soldotna, and Homer are accessible by the Sterling Highway (which connects with the Seward Highway) from Anchorage, Fairbanks, Canada and the lower 48 states. Scheduled and charter airlines and helicopter services are available. Ocean-going freighters are tendered at the city docks in Seward, Kenai, and Homer. The State ferry system regularly serves Seward and Homer.

Kodiak Island Borough

The Kodiak Island Borough includes the city of Kodiak and the six Native villages of Port Lions, Ouzinkie, Larsen Bay, Karluk, Old Harbor, and Akhiok. The borough population of about 15,245 includes Natives of Alutiiq heritage, other Natives, and non-Natives. Among the non-Natives are people of European descent, as well as immigrants from the Philippines, Central America, and Meso-America. The borough includes the islands of the Kodiak Archipelago and parts of the adjacent Alaska Peninsula. As in other parts of Alaska, Kodiak Island's population grows significantly in the summer. The economy is heavily dependent on commercial fishing. The city of Kodiak also collects revenues from the U.S. Coast Guard base, government offices, and the tourism and livestock industries. In the smaller communities, residents (mostly Native) largely depend on subsistence hunting and fishing. The borough provides some social, cultural, and economic services to villages; and the Kodiak Area Native Association provides medical and social services through the tribal governments in each village.

A paved State-run airport, a gravel municipal airport, and a float-plane facility at Lily Lake serve air traffic in the city of Kodiak. Each of the villages has runways for scheduled and charter flights. The Alaska Marine Highway System operates a ferry service from Seward and Homer to Kodiak and Port Lions. Boat harbors serve commercial and transient vessels in Kodiak, and several of the other communities have dock facilities. Approximately 140 miles of State roads connect communities on the east side of the island.

Lake and Peninsula Borough

Lake and Peninsula Borough, incorporated in 1989, is located on the Alaska Peninsula in southwest Alaska. It is comprised of 17 communities, including 5 incorporated cities, with a combined population of 1,789. These communities (Chignik, Chignik Lagoon, Chignik Lake, Ivanof Bay, and Perryville) are primarily Alutiiq, with a mixture of Eskimos and Athapascans.

Yupik Eskimos and Athapaskan Indians have jointly occupied the area for at least the past 6,000 years. The late 1800's first brought an influx of non-Native fishermen and cannery operations. An influenza epidemic in 1918 drastically reduced the Native population. Reindeer were introduced to assist the survivors, but the experiment failed to provide a food source and bolster the cash economy for the survivors. During World War II, Fort Morrow was built at Port Heiden.

During the peak commercial fishing season, the borough population increases sharply. Commercial fishing, fish processing, tourism, and sport fishing are the mainstays of the borough's economy. Government services also provide employment. Subsistence hunting and fishing are important to year-round residents. Iliamna Lake offers trophy rainbow trout and thus attracts tourists and sportsmen. Scheduled and charter air services as well as barge and ferry services provide transportation of passengers and goods in this area of the state. Travel to Dillingham, Kodiak, and Anchorage is frequent.

Valdez-Cordova Census Area (Prince William Sound)

For the purpose of this study, the region includes five communities: Chenega Bay, Cordova, Tatitlek, Valdez, and Whittier. The population of the area is about 10,000 people (Alaska State Libraries, 1992). Each community is accessible by air or water, and all have dock or harbor facilities. Only Valdez is directly accessible by road from the State's main road system, though the Alaska Railroad carries vehicles to and from Whittier.

Prince William Sound was occupied prehistorically by Chugach Alutiiq, Eyak, and Tlingit Natives; and it was in this area that the first Europeans to reach Alaska put to shore in 1741. The sea otter fur trade, commercial fishing, and the influx of non-Natives transformed the traditional cultures to incorporate the cash economy.

The present economic base of the five communities is diverse. Cordova's economy is based on commercial fishing, primarily for red salmon. As the terminus of the Trans-Alaska

Pipeline, Valdez is dependent on the oil industry; but commercial fishing and fish processing and government also are important to the local economy. Whittier residents work as government employees, longshoremen, commercial fishermen, and service providers to tourists. The people of Chenega Bay and Tatitlek (predominantly Native) augment commercial fishing and other cash-based activities with subsistence fishing, hunting, and gathering.

Cultural Heritage Resources

This report incorporates various aspects of cultural resources relating to the physical (archaeological) remains of indigenous and historic inhabitants of the EVOS area and the values inherent in those remains for contemporary and future members of the public. Restoration actions are oriented toward physical remains because those were directly injured by the EVOS. The values of these remains for local communities, whose ancestors lived and are buried at some of these sites, would be addressed through actions relating to those remains. Archaeological sites and artifacts themselves are important kinds of cultural resources, but other cultural resources such as stories associated with specifice sites or artifact types, or traditional techniques used to construct traditional items, add immense value to objects that may otherwise would provide limited insight and information. These other types of cultural resources may benefit from actions on archaeological remains, extending the positive impacts of the restoration efforts.

The greater the degree to which local community members become involved in restoration of these resources, the more fully the restoration will be completed. Some actions may be implemented in local communities as a logical extension of projects accomplished on archaeological sites. While restoration of archaeological resources is important at the local level, it is also important to the cultural patrimony of Alaska and of the United States. In keeping with that importance, all projects will be completed in compliance with applicable historical and archaeological resource protection laws.

The study of historic and prehistoric cultures of the northern Gulf of Alaska began in the late 19th century with Johan Jacobsen's archaeological excavations in lower Cook Inlet (Jacobsen, 1977). While long-running, the amount of study has not been extensive. Research into basic cultural chronology is normally a first focus of investigation, but even that has been reconstructed only partially for the EVOS area. Destruction of any part of the archaeological record for the area is therefore of the gravest concern simply because the importance of individual parts has not been established (Reger et al., 1992).

There is a regional unity of cultural interaction and change throughout much of southern Alaska for perhaps as long as 11,000 years. William Workman proposes that cultural sequences for various areas of the southern Alaskan coast are part of a larger North Pacific Maritime co-tradition. This includes the Pacific coast of the Alaska Peninsula, the Kodiak area, Cook Inlet, and Prince William Sound -- all part of the Pacific Eskimo (or Alutiiq) region (W. Workman, 1980). Coastal sections of parts of the EVOS area also were inhabited within the past millennium by Dena'ina Athapaskan and Eyak Indian groups.

Early coastal sites on either side of the EVOS area show that the southern Alaska coast was settled by at least 9,000 years ago, but archaeological evidence from interior southern Alaska and evidence for potentially earlier maritime adaptations suggest occupation in the area perhaps 11,000 years ago. This earliest occupation around the North Pacific Rim, in interior Alaska, and possibly in Southeast Alaska and British Columbia, includes a cultural complex known as the Paleoarctic tradition, which continued to around 7,500 years ago.

Beginning sometime between 6,500 and 7,000 years ago, the Ocean Bay Period continued to about 3,500 years ago. Ocean Bay sites have been identified on Kodiak Island, the Pacific coast of the Alaska Peninsula, and the southern Kenai Peninsula. No artifacts or other features definitely associated with Ocean Bay people have been found in Prince William Sound or Cook Inlet, but recently obtained dates show possible temporal overlap at least in Prince William Sound (cf. Yarborough and Yarborough, 1993). The Kachemak Period spanned from about 3,500 years ago to about 1,000 years ago over almost all of the EVOS area. There is a widespread similarity among Kachemak sites, though regional and temporal changes have been well demonstrated.

By about 1,000 years ago, local manifestations of cultures were quite diverse and clearly represent the ancestors of the various cultures encountered by the earliest Europeans to visit the area. The Koniag culture of Kodiak, the Alaska Peninsula, and perhaps the southern Kenai Peninsula was well developed. The Chugach culture of Prince William Sound and the gulf coast of the Kenai Peninsula is similar to the culture of the Koniag. Together, these peoples are considered part of the Alutiiq tradition.

In lower Cook Inlet, the archaeological record for the late prehistoric time period is made more complex by the movement into the area by Dena'ina Athapaskan Indians who adopted Alutiiq patterns of subsistence and material culture.

Native populations in the EVOS area were decimated following Russian contact in 1741, mainly through the introduction of European diseases. Warfare, subjugation and enslavement, economic dependence, and new values and technological systems disrupted traditional economic, social, and religious patterns. Many Native villages were abandoned as the populations consolidated to retain their economic and social viability. Many of these early locations are still important to local Native communities as subsistence-resource areas and as sources of connection with their long and rich cultural heritage.

As more non-Natives arrived in the EVOS area, and as the Native communities took part in an increasingly commercial, European-style economy in the 19th and 20th centuries, many new types of cultural-resource sites were created. These include sites from both the Russian and American periods and from both non-Native and Native cultures. Some of the site types are: trading posts, churches, mines, fox farms, canneries, military installations, roads and trails, and homes.

All of these sites are important for understanding and appreciating the cultural heritage of the EVOS area. All historic and prehistoric sites located on public lands in Alaska are protected by historic preservation laws. These laws include the National Historic Preservation Act, the Archaeological Resources Protection Act, and the Alaska Historic Preservation Act (Alaska Statutes 41.35).

Impacts on Historic Properties

Important Alaskan cultural properties were injured by the oil spill and by the cleanup response, mainly by increasing human activity. While the exact number of important historical properties damaged is unknown, Jesperson and Griffin (1992) have documented effects on 35. Injuries included vandalism, erosion, and oiling (Dekin, 1993:1). The major sources of potential impact were (1) direct impacts resulting from oil in direct contact with artifacts or features; (2) treatment methods employed to remove oil; and (3) human activities incidental to the response actions. Twenty-four sites have been considered for restoration efforts, with a total estimated restoration cost of nearly $872,000 (McAllister, 1992).

The types and locations of archaeological and historic sites made them particularly vulnerable to disturbances related to the oil spill. The 1964 Good Friday Earthquake and previous tectonic movements had submerged some archaeological remains below the mean-high-tide level. This placed many archaeological sites in the intertidal zone affected by the EVOS (cf. Reger et al., 1992). Sites found in the intertidal zone include stone and wooden fish weirs, petroglyphs, shipwrecks, piers, and pilings associated with historical domestic and commercial facilities, and potentially the full range of features found in the uplands. Cultural resources are known to occur in adjacent uplands, where modified deposits, villages, rock shelters, culturally modified trees, historical domestic and commercial facilities, and other features are present. The range of cultural materials includes tools, structural remains, middens, and architectural remains. The range of materials includes stone, bone, shell, various metals, wood, textiles, leather, and other organic items.

One major potential physical impact of oiling is the obscuring of intertidal artifacts from observation. Not only do the artifacts become impossible to see, their relationship to other, unobscured artifacts is lost. There also is the possibility that solidification of oil could immobilize artifacts in the intertidal zone. Both of these effects would be temporary, as wave and tidal action would remove the oil over a period of months or years. The chemical impacts of oiling are subject to debate. Some scientists have raised questions about whether contaminated organic items can still be dated using radiocarbon techniques. Laboratory studies about the effects of crude oil on radiocarbon dating with datable samples suggest that significant skewing of dates occurred (Mifflin and Associates, 1991), but others believe that the oil can be removed from crucial samples so that they may be successfully dated. Investigations at four sites in 1991 indicate that there appears to be no effect on the ability to obtain radiocarbon dates in the normal manner from oiled sites. These investigators caution, however, that their results can be applied only to these specific sites. The sites may not have been subject to the type of oiling that would contaminate them; or the oil may not have penetrated the samples, and the cleaning pretreatment successfully removed the contaminant (Reger et al., 1992).

Historical properties located in the uplands adjacent to treated shorelines were at risk when people visited those uplands. Although a blanket restriction on upland access by cleanup crews was in effect throughout the shoreline-treatment phase, some degree of access was required to efficiently undertake treatment activities. Shoreline-treatment techniques included manual removal, bioremediation, and mechanical treatment (Haggarty et al., 1991).

A variety of pedestrian upland crossings during the cleanup process resulted in damage to cultural resources, especially surface features. Vandalism and looting of cultural sites occurred as a result of uncontrolled or unsupervised access to the immediate uplands, particularly where rock shelters, historic cabins, mine sites, and other surface features or subsurface deposits were exposed. Most of the areas affected by the EVOS had not been adequately surveyed for cultural resources before the spill. Increased activity in these areas resulted in more people knowing the whereabouts of many more historic properties. This in turn resulted in looting and vandalism (Mobley et al., 1990).

Vandalism resulted from the activities of people interested in artifacts but unaware of the damage caused by uncontrolled collecting. Vandalism results in an irretrievable loss of information from sites, and damage to sites often invites further damage. Sites cannot be repaired (Corbett and Reger, 1993). This increase in knowledge of site presence and location continued after the EVOS cleanup, resulting in higher rates of potential and documented vandalism. "At many archeological sites, the damage is actually an increased threat of disruption due to wider public knowledge of the sites" (ADEC, 1993:180). Without additional education and interpretation to increase public awareness of the effect of vandalism on historic properties, and without the additional presence of stewards, monitors, or law enforcement personnel, the trend of site damage appears likely to continue in the future.

Subsistence Use

Alaska is the only state in which a significant proportion of the population lives off the land or practices a subsistence lifestyle (Campbell, 1991). Subsistence is critical to supporting the incomes and cultural values of many Alaska residents. However, the relatively small, predominantly Native communities had a larger percentage of residents greatly affected than did larger, predominantly non-Native communities (Palinkas et al., 1993).

Subsistence Definitions

While there are a variety of cultural, popular, and sociological definitions and interpretations of subsistence, Congress defined subsistence in Section 803 of the ANILCA as:

> ...the customary and traditional uses by rural Alaska residents of wild renewable resources for direct, personal or family consumption as food, shelter, clothing, tools, or transportation; for the making and selling of handicraft articles out of nonedible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade.

Court rulings on the State's interpretation of ANILCA requirements have resulted in radical changes in State and Federal roles and responsibilities regarding subsistence management in Alaska. The State of Alaska operated a program that met Federal requirements until the 1989 Alaska Supreme Court's *McDowell* decision (785 P2d 1[1989]). The court ruled that the laws used by the State to provide a subsistence priority for rural Alaskans violated the Alaska Constitution. On July 1, 1990, the Federal Government took over management of subsistence activities on Federal public lands in the State (Federal Subsistence Board, 1992). The State retains control over sport hunting and fishing on all public lands and also manages subsistence for all eligible Alaskans on State public lands.

The term "subsistence" refers to a particular pattern of activities and values associated with harvesting and using naturally occurring renewable resources. The ethnic composition of communities is important for considerations of subsistence because as the percentage of Natives in a community increases, subsistence production also increases (Wolfe and Walker, 1987). Subsistence hunting, fishing, trapping, and gathering activities represent a major focus of life for many EVOS communities; and the values associated with subsistence are different for Native communities than for non-Native communities (cf. Case, 1991).

Generally, subsistence systems are characterized by a few important attributes:

- Subsistence activities are seasonal. Fishing, hunting, and gathering follow the natural rhythm of the tides, wildlife and fish migration, and plant life cycles.

- Subsistence activities are localized. Productive, accessible sites are established for various subsistence activities.

- Subsistence is regulated by a system of traditional, locally recognized rights, obligations, and appropriated behaviors. The use of sites, division of the catch or harvest, and assignment of responsibilities are determined by tradition.

- Subsistence is opportunity-based. The subsistence resource must be harvested when and where it is available. Generally, the harvesting of each resource must be completed within a finite period.

Individuals -- both Native and non-Native -- participate in subsistence activities to supplement personal income and provide needed food; to perpetuate cultural customs and traditions; and to pursue a lifestyle reflecting deeply held attitudes, values, and beliefs centered on self-sufficiency and nature. In addition to its economic importance in rural households, the opportunity to participate in subsistence activities reinforces a variety of cultural values in both Native and non-Native communities. The distribution of fish and wildlife contributes to the cohesion of kinship groups and to community stability through sharing of resources derived through harvest activities.

Subsistence resources provide the foundation for Native culture, ranging from the totem basis of clan divisions, to norms governing the distribution of wealth, to reinforcement of basic values of respect for the earth and its resources. "Subsistence is a core cultural institution in Native communities. Damage to subsistence resources and to the meaningful activities that are part of this core institution thus damages the whole culture" (Impact Assessment, Inc., 1990). The cultural systems include kinship-based subsistence-production units; a seasonal cycle of activities tied to resource availability; complex sharing networks; traditional systems of land use; and systems of beliefs, knowledge, and values associated with resource uses that are passed between generations as cultural and oral traditions of the community (Wolfe, 1983; ICF Technology Incorporated [ICF], 1993).

The harvest of fish and game also plays important sociocultural roles in non-Native communities. It contributes to self-reliance, independence, and the ability to provide for oneself -- values that are important reasons why many people emigrate to Alaska.

Both Alaska Natives and non-Natives experience a relationship with the environment that is unique in the United States. Many of those who choose to live in Alaska and in the EVOS area forego the steady income of a city job and assign great value to the rural, subsistence-based way of life. When the environment is harmed, the basis of subsistence -- the harmonious relationship of humans to their environment -- is threatened.

Economic Implications of Subsistence

The socioeconomic environment of the EVOS area has been dominated by resource-related industries such as mining, commercial fishing, timber harvesting, and tourism. Employment in these industries is highly seasonal. Salmon return to spawn in the late spring, summer, and early fall. Snow and darkness limit timber harvesting and mineral exploration during winter months. The tourism season runs from May through early September. The EVOS-area residents who work in the resource-extraction and tourist industries often experience high levels of unemployment during the "off" seasons.

Within this context of seasonal and cyclical employment, subsistence harvests of fish and wildlife resources take on special importance. The use of these resources may play a major role in supplementing cash incomes during periods when the opportunity to participate in the wage economy is either marginal or nonexistent. Due to the high prices of commercial products provided through the retail sector of the cash economy and the limited availability of commercial products in some rural areas, the economic role of locally available fish and game is significant.

The economic aspects of the subsistence system are dependent on the availability of untainted natural resources. In the subsistence system, food and other material resources are bartered, shared, and used to supplement supplies from other sources. Subsistence resources are the foundation of the area's mixed subsistence/cash economy.

None of the rural communities in the spill area is so isolated or so traditional as to be totally uninvolved in the modern market economy. Most communities are characterized by a mixed subsistence/market economy. This label recognizes that a subsistence sector exists alongside a cash system, and that the socioeconomic system is viable because the sectors are complementary and mutually supportive. Even the most traditional subsistence hunter uses the most modern rifles, snow machines, boats, boat motors, nets, and traps that he can afford. These goods cannot be acquired without cash.

Although some food is imported into spill-area communities, a substantial subsistence harvest is hunted, fished, and gathered locally. For some residents, subsistence is the primary source of food and supplies. For others, subsistence supplements resources available from other sources. Overall, the high cost of transporting supplies combines with the cultural values of subsistence to make subsistence harvests an indispensable foundation of the communities' food supplies (ICF, 1993).

The communities affected by the oil spill are small, relatively isolated, and economically dependent on local fish and wildlife. Before the spill, subsistence harvests in these communities were relatively large and diverse, with harvests of many kinds of fish, marine invertebrates, land mammals, marine mammals, birds, and eggs, and wild plants (Fall, 1993). The noncommercial transfer and exchange of wildlife products are important institutions. The prevalence of direct consumption and nonmonetary transfer and exchange of fish, wildlife, and other natural resources and services makes it difficult to determine their economic value in terms of the value system of the cash economy.

> Our beaches and waters provide us with deer and fish and game which helps offset the high cost of food here (Kodiak Island). This is not simply a recreational question, it is everyone's livelihood and food resource that is affected (Lekovitz, 1990).

Within Alaska Native communities, not all households participate in every subsistence harvest; but food is often shared among households. Sharing subsistence resources occurs both within and among EVOS villages.

Estimates vary widely on the percentage of subsistence foods in the diet, but studies indicate that subsistence may provide 70 to 80 percent of the total protein consumed within the less accessible EVOS households. Estimates place the share of subsistence meats and fish at 200 to 600 pounds per person per year (Scott et al., 1992). As Fall (1991) points out, these are substantial harvests, considering that the average family in the western United States purchases about 222 pounds of meat, fish, and poultry per person each year. Subsistence foods provide a large portion of the diet -- a portion that families can ill afford to replace with imported substitutes.

Effects of the Spill on Subsistence

As indicated above, subsistence is the basis of a whole way of life in the oil spill area. Recognition of this perspective is essential to understanding the significance of subsistence activities, as well as the far-reaching impacts of the *Exxon Valdez* oil spill on subsistence, for Natives and non-Natives alike.

The oil spill fouled the waters and beaches used for subsistence hunting, fishing, and gathering by the EVOS communities. Destruction and contamination of subsistence resources contributed to the sense of cultural dislocation experienced by some Alaska Natives in the area.

Real and perceived habitat contamination resulted in a decline in subsistence resource harvesting ranging from 12.3 percent (in Akhiok) to 77.1 percent (in Ouzinkie) as compared to the 2 years before the spill (Fall, 1991b). It appears that as long as residents of the Native communities of the areas affected by the EVOS believe that oil remains in their environment, many will continue to refrain from using subsistence foods (Fall, 1991). The EVOS residents have been forced to seek food from outside the local environment. Subsistence harvesting was disrupted, which in turn disrupted the traditional cultural patterns of social interaction surrounding the harvesting of local natural resources. In 1989, the subsistence fishery was banned as a precaution against the possible health-threatening effects of the oil spill on fish in Prince William Sound. In several Native villages, shortages of traditional foods resulted and persist. Figure 3-2 illustrates the persistence of this reduction in use for selected villages in Prince William Sound, the Kenai Peninsula, and Kodiak Island. Communities on the Alaska Peninsula appear to be back up to prespill harvest levels.

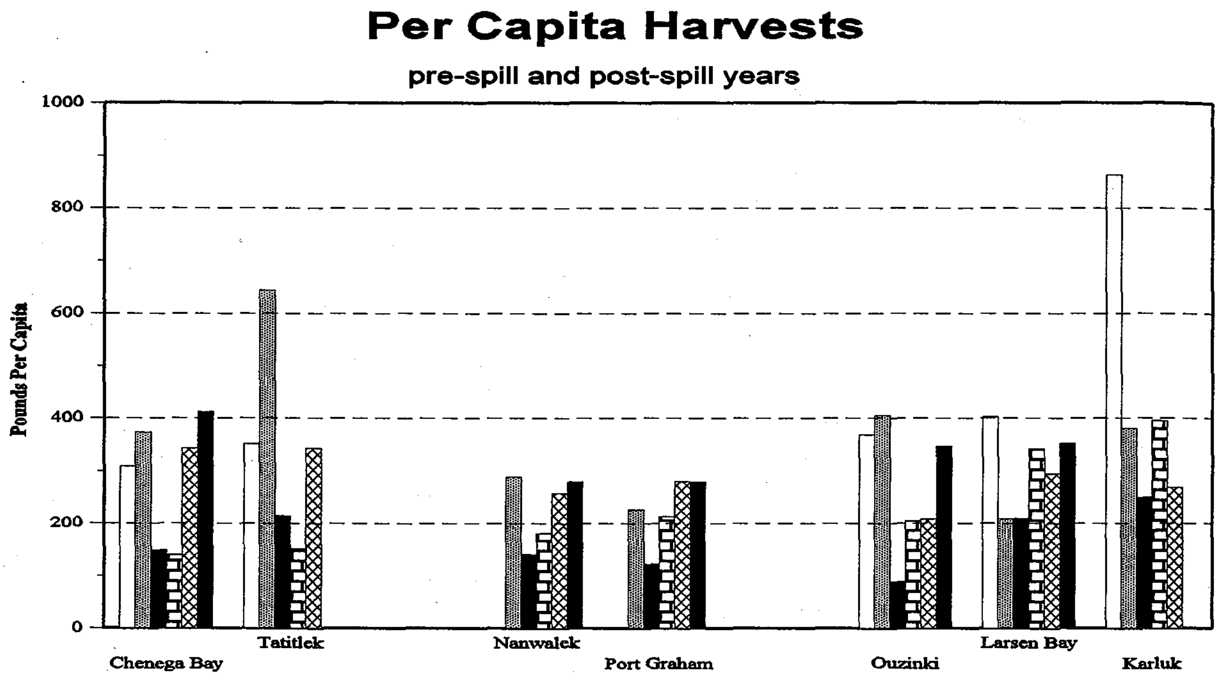
In addition to damaging the physical environment of the EVOS area, the oil spill had psychological effects on the EVOS population. Disruption of the sociocultural systems on which subsistence is based created psychological stress in EVOS communities. Disruption of the social infrastructure provided by traditional subsistence-harvest patterns and practices left many Alaska Natives dislocated from their traditional lifestyle. In some cases, oil spill-related stress contributed to social tensions that erupted into open disagreements among villagers. Some of these disagreements continue unresolved. Moreover, the sociocultural system on which the traditional Alaska Native lifestyle is based was threatened by the influx of cleanup crews and the unfamiliar demands of a cash economy.

Although a number of fisheries were closed immediately following the spill and reopened once it had been determined that local fish were safe to eat, some Alaska Natives are unwilling to eat them for fear of contamination. Spot shrimp fisheries were closed in 1989 and 1990. Clams, an important part of the Native diet, were shown to be contaminated after the spill. Fish, bear, moose, deer, and other Native meats were deemed safe to eat by Federal and State health officials; but not all Prince William Sound subsistence users were willing to go back to harvesting them.

While subsistence users were being told that the fish were safe to eat, Federal Agencies banned the commercial sale of fish that showed any level of hydrocarbon contamination. The confidence that subsistence users had in the information they were given by health officials was shaken by this inconsistency (ICF, 1993).

Throughout the restoration process, it is important to consider the effects of perceptions of contamination as well as actual contamination, because it is the perceptions that affect the decision on whether or not to harvest subsistence resources in the EVOS area.

Figure 3-2



	Chenega Bay	Tatitlek		Nanwalek	Port Graham		Ouzinki	Larsen Bay	Karluk
Pre-spill year one[1]	308.8	351.7					369.1	403.5	863.2
Pre-spill year two[2]	374.2	643.5		288.8	227.2		405.7	209	381
Spill year[3]	148.1	214.8		140.6	121.6		88.8	209.9	250.7
Post-spill year one[3]	139.2	152		181.3	214		205.3	341.8	396.2
Post-spill year two[3]	343.9	343.9		258.8	280.4		209.3	294.6	268.7
Post-spill year three[3,4]	412.5			279.5	279.6		347.1	353.3	

1. Pre-spill year one is 1984/85 for Chenega Bay; 1987/88 for Tatitlek; and 1982/83 for Kodiak Borough communities.
2. Pre-spill year two is 1985/86 for Chenega Bay; 1988/89 for Tatitlek; 1987 for Nanwalek and Port Graham; and 1986 for Kodiak Borough communities.
3. "Years" are 12 month study years from April through march, except for 1989, when the study year was a calendar year for all communities except Chenega bay and Tatitlek. The April through March study year was used there.
4. Preliminary data.

Source: Scott et al. 1993; Alaska Department of Fish and Game, Division of Subsistence Household Survey 1993.

Recreation and Tourism

Recreation use in the EVOS area is diverse, with a variety of opportunities available for both commercial (tourism) and noncommercial users. Commercial recreation includes uses by clients and operators of tourism services such as boat tours, fishing charters, and flightseeing services. Noncommercial recreational users engage in many of the same activities as commercial users but do not purchase or pay for the services of tourism businesses. Common recreational activities for all users include kayaking, camping, hiking, boating, sightseeing, photography, scuba diving, beachcombing, flying, sport fishing, hunting, gathering food, and investigating the history of an area. Recreation use occurs year round, but the majority of use from in-state and out-of-state residents occurs during the summer months from May through November (PWSRWG Draft 1994). Because of the remoteness of many of the recreational opportunities in the EVOS area, there is a blending of commercial and noncommercial recreation. That is, noncommercial recreation often entails commercially obtained services, especially transportation. For instance, to kayak in Prince William Sound, many recreationists will take the train to Whittier and charter a boat to access the more remote areas of the Sound. Sport hunters will often use charter aircraft to land them in a remote area to hunt.

Many recreational activities are nonconsumptive. Kayaking, photography, motorboating, flightseeing, and these types of nonconsumptive activities do not remove parts of the environment as an integral part of their practice. Recreational hunting, fishing, and plant gathering are, in contrast, consumptive. Animals and plants are taken from within the area for consumption. These may be consumed while recreationists are in the area or be removed from the area to be consumed in (often) urban areas. Recreational hunting will not be addressed in this document because no restoration plans are likely to be submitted which would affect populations of animals hunted for sport.

Recreation

The oil spill area offers tremendous opportunities for outdoor recreation. Much of land in the oil spill area is in public ownership and is designated as parks, refuges, or forest lands. These areas provide developed and nondeveloped recreational opportunities including: wildlife viewing, camping, sightseeing, fishing, hunting, hiking, sailing, motorboating, kayaking, flightseeing, staying in a lodge, and taking a boat (tourboat, ferry, or cruiseship) tour (PWSRWG Draft 1994). These recreational opportunities have helped create a growing tourism industry in the region.

Hiking and camping, being relatively inexpensive and easily available, are by far the preferred modes of outdoor recreation for the majority of Alaska's residents and visitors. Although there are few trails, the vast taiga and tundra terrain (along with the perpetual daylight during hiking season) offers considerable flexibility to hikers. The abundant wildlife adds the possibility of animal watching while hiking. Photographing scenery, plants, and animals goes hand in hand with hiking and camping.

For the purposes of this section, the spill area is divided into two regions: the Southcentral region which includes Anchorage, the Kenai Peninsula, and Prince William Sound; and the Southwest region which includes Kodiak Island and the Alaska Peninsula. Large tracts of private land, especially Native corporation-owned lands, exist within the EVOS area. Because the focus of this document is on public lands, those private lands will not be considered.

3 Affected Environment

Chugach National Forest, the second largest national forest in the U.S., encompasses much (5.8 million acres) of the Southcentral region. The U.S. Forest Service operates and maintains 37 public recreation cabins and 16 campgrounds within the Chugach National Forest. There are over 200 miles of trail, including two National Recreation Trails. In addition, there are 149 recreation special use permit facilities, including six resort facilities. Forty-six percent of all visitors to Alaska make the trip to the Begich-Boggs Visitor Center, at Portage Glacier, making it the most visited attraction in the State (Alaska State Libraries, 1992). The Russian River, located on the upper Kenai Peninsula, is also one of the most visited spots in Alaska. Approximately 90 percent of the recorded recreational activities in the Chugach National Forest occurs on the Kenai Peninsula. The most popular activities are camping, hiking, skiing, and fishing. Southcentral Alaska includes some of the world's premier kayaking areas. Kayaking trips are taken from Valdez, Kodiak, Homer, Whittier, and Seward to the western portion of the Prince William Sound and the bays along the Kenai Peninsula and Kodiak Island. Kayaking trips usually involve charter boat transportation to a site some distance from the port and include both kayaking and wilderness camping.

The Kenai Peninsula is the most often viewed landscape in Alaska with the Seward/Anchorage highway being the most heavily used travel route in the State. Captain Cook State Recreation Area, Kenai National Wildlife Refuge, Kenai Fjords National Park, Alaska Maritime National Wildlife Refuge, Kachemak Bay State Park, and Chugach National Forest are some of the areas affording a variety of recreational opportunities on the Kenai Peninsula. The Kenai Fjords National Park, under the management of National Park Service, encompasses 669,000 acres of ice fields and a deep-water fjord coastline providing opportunities to see whales, sea otters, northern (Steller) sea lions, harbor seals, seabirds, mountain goats, black bear, river otter, and bald eagles. At locations in the western and southern parts of the peninsula, the Alaska Department of Natural Resources maintains public access and recreation areas (including the Kachemak Bay State Park) totaling several thousand acres. Captain Cook State Recreation Area is not in the EVOS area, but other state parks and state marine parks such as Caines Head State Recreation Area, Anchor Point, and Clam Gulch are in the EVOS-affected area.

Besides the public lands, some EVOS area communities also offer recreational opportunities, and their economies, to some extent, are based on recreation and tourism. The city of Seward, located at the head of a deep-water inlet known as Resurrection Bay, offers fishing and sightseeing opportunities. The city of Soldotna, located in the central peninsula region, offers salmon fishing in the Kenai River and scenic views across Cook Inlet. The city of Kenai sits on a bluff where the Kenai River meets Cook Inlet and where some of the greatest tidal ranges in Cook Inlet occur, providing whale watching opportunities. Incoming tides actually reverse the flow of the river, influencing the movement of fish and the white beluga whales that follow them. Homer, located on the southern tip of the Kenai Peninsula, provides charter boat tours to Gull Island and other locations for viewing thousands of birds. Homer is also visited for halibut fishing.

Several communities located within the Prince William Sound area offer recreational opportunities and services. The city of Cordova offers a variety of lodging options and recreational services, including flightseeing, several boat charter services, and recreation centers. The city of Valdez, surrounded by mountains, provides a variety of local tours and sightseeing opportunities. Numerous scheduled cruises to Columbia and Shoup Glaciers start here. In addition, several guided walking and bus tours showing historic Valdez and the Alyeska Pipeline Terminal are also available.

Affected Environment 3

The Southwest region includes the Kodiak Island group and the Alaska Peninsula. Shuyak Island State Park, McNeil River State Wildlife Refuge, Katmai National Park and Preserve, Alaska Peninsula National Wildlife Refuge, Becharof National Wildlife Refuge, Kodiak National Wildlife Refuge, and Aniakchak National Monument and Preserve are located in this region, and all these areas experienced effects of the EVOS.

Kodiak Island is the largest island in Alaska and the second largest island in the U.S. Kodiak has Alaska's largest fishing fleet and its biggest brown bear population. Kodiak Refuge, established in 1941 to protect the habitat of brown bear and other wildlife, occupies about two-thirds (about 50,000 acres) of the island. Rearing and spawning habitat for five species of Pacific salmon is provided within the refuge. With over 200 species of birds, as well as large brown bear, bald eagle, red fox, river otter, Sitka black-tailed deer, snowshoe hare, mountain goat, beaver, and other wildlife populations, the refuge is ideal for wildlife viewing. Other recreational activities include photography, rafting, canoeing, camping, backpacking, hiking, hunting, and fishing. A visitor center and a limited number of recreational cabins are also located within the refuge.

The town of Kodiak, where the majority of the Kodiak Island population lives, is accessible by air and the Alaska Marine Highway System. Recreation includes fishing, hunting, sightseeing, hiking, boating, and other activities. The communities of Larsen Bay and Port Lions on Kodiak Island are visited for hiking, fishing, and hunting opportunities and their economies to a large extent are dependent on tourism.

At 4 million acres, Katmai National Park, on the Alaska Peninsula adjacent to Kodiak Island, is one of the nation's largest National Parks. Yearly, people from all over the world visit the Brooks River to fish for salmon and trout, and to view the large concentration of brown bears. The Park is home to the world's largest protected population of brown bears. The Katmai coast offers spectacular wild and rugged scenery and the opportunity to view many species of marine mammals. The Valley of Ten Thousand Smokes is an awesome reminder of the 1912 eruption of Novarupta, the second largest volcanic event in recorded history.

About 125 miles southwest of Katmai is Aniakchak National Monument and Preserve, a 600,000-acre parcel of remote wildlands. Relatively little recreation use occurs within the preserve, but the coastal area is rich in plant and animal life.

Becharof National Wildlife Refuge encompasses 1.2 million acres on the Alaska Peninsula and is home to the second largest lake in Alaska (Becharof Lake). The lake is the primary nursery for the second largest salmon run in the world (Mobley et al., 1990). The fish, brown bear, caribou, moose, wolves, wolverines, river otters, red fox, and beavers comprise the species that attract visitors for recreational viewing, photography, hunting, or fishing. Sea mammals are common in the rich coastal waters, and the wetlands, coastal estuaries, rugged shorelines, and offshore islands provide a wide range of habitats for many different species of birds.

The Alaska Peninsula National Wildlife Refuge includes some 3.5 million acres and offers many of the same attractions to recreationists as the Becharof Refuge.

The Alaska Maritime National Wildlife Refuge includes more than 2,400 islands, headlands, rocks, islets, spires, and reefs along the Alaska coastline. In the spill area, islands of importance within that Refuge for bird viewing include the Pye Islands and the Chiswell Islands near Kenai Fjords National Park, and the Barren Islands at the mouth of Cook Inlet. The Refuge also contains many large sea lion rookeries and haulouts.

3 Affected Environment

EVOS Effects on Recreation

The oil spill affected the entire spectrum of recreational activities and opportunities in the area. The nature and extent of injury varied by user group and by area of use. Although few actual recreation facilities were injured as a result of the spill, the disruption of the whole ecosystem caused a reduction in recreation quality. The primary characteristic that attracts people to recreate in Prince William Sound (and the affected EVOS area by analogy) is the area's wilderness-like setting. This entails the values of solitude, unmodified scenery, and nondevelopment. Loss of wildlife, oiled beaches, disturbance of wilderness settings (in designated wilderness and wilderness-like, nondesignated areas), and even increased use in some areas have resulted from the spill (PWSRWG Draft 1994). Resources important for wildlife viewing include killer whale, sea otter, harbor seal, bald eagle, and various seabirds. Residual oil exists on some beaches with a high value for recreation and may decrease the quality of recreational experience and discourage recreational use of these beaches (Trustee Council, 1993). Respondents to a survey of recreation users in Prince William Sound revealed a strong concern that recreational uses may be further impacted if "restoration activities" commence (PWSRWG Draft 1994). That is, developing additional or enhanced recreation facilities may increase the quantity of recreation opportunities, but at the same time actually decrease the quality of the recreation experience.

Commercial Recreation (Tourism)

Tourism is Alaska's third-largest industry behind petroleum production and commercial fishing. Tourism was, and is, an industry of growing economic importance to the State. Once regarded as a stepchild of the major traditional resource industries, the growth of commercial recreation in the 1980's gave it legitimacy as a major industry. Visitors from outside the State provide the major impetus to the industry, though Alaska residents also contribute substantially.

A visitor survey conducted by the Alaska Division of Tourism under the Alaska Visitors Statistics Program II (AVSP) revealed that more than 750,000 people visited Alaska in 1989 from around the world (McDowell Group, 1989), and of this number, 521,000 people visited in summer, generating $304 million in summer revenue alone. The Southcentral region was the major beneficiary of visitor spending, capturing 44 percent of the $304 million (Alaska State Libraries, 1992). Sixty-nine percent of the total summer visitors was vacation/pleasure visitors. Southcentral Alaska accommodated more visitors per year than any other region, including two-thirds of the vacation/pleasure tourism market. Southwest Alaska was visited by only 6 percent of the total vacation/pleasure visitors. The EVOS affected the Alaska trip planning of one in six visitors (McDowell Group, 1989).

Anchorage, Seward, Kenai/Soldotna, Homer, Valdez/Prince William Sound, and Whittier were among the most visited communities in the Southcentral region, with Portage Glacier being the number one destination in the entire State. In addition, cultural attractions and museums were popular among Southcentral visitors. The most visited attractions on the Kenai Peninsula were Kenai River, Kenai National Wildlife Refuge, Resurrection Bay, Kachemak Bay, and Kenai Fjords National Park. In the Prince William Sound area, the most visited attractions were Columbia Glacier, Valdez Pipeline Terminal, and College Fjord. In the Southwest region the most visited attractions were Kodiak Russian Orthodox Church, Katmai National Park, and Kodiak National Wildlife Refuge (McDowell Group, 1989).

Among the wide variety of recreational opportunities offered in Alaska, wildlife viewing was the most common activity in every region among the vacation/pleasure visitors. Bird watching was also common in all regions. Rafting was most popular in Southeast Alaska and Denali. Hiking was also popular, especially among the Southwest Alaska and Denali visitors. Fishing was most popular in Southwest Alaska, with twice the participation of the next leading fishing region, Southcentral (McDowell Group, 1989).

The visitors of Southcentral region rated flightseeing and day cruises highly in the tour list while rafting, hiking, and canoeing/kayaking lead the activities list in satisfaction. Southwest vacation/pleasure visitors give that region's activities the highest marks in the State. Southwest was rated highly by the vacation/pleasure visitors for fishing (fresh water more than salt water), hunting, rafting, and canoeing/kayaking. It also was rated the best for flightseeing activity in the State (McDowell Group, 1989).

Effects on Commercial Recreation

Although the nature and extent of injury varied, approximately 43 percent of the tourism businesses surveyed in 1990 felt that they had been significantly affected by the oil spill (McDowell Group, 1990). Millions of dollars were lost in 1989 due to reduced visitor spending in Southcentral and Southwest Alaska. By 1990, only 12 percent felt that their businesses were affected by the spill. Respondents also reported seeing less oil now than in 1989 and subsequent years; a slow but discernible increase in wildlife sightings; and each year a slight increase in people using the spill area for recreation activities (PWSRWG, 1993).

Overall, tourism was a major factor in business declines. Businesses in the spill-impacted area sustained a significant decline in business (up to 50%) from 1988 to 1992. Fifty-nine percent of businesses surveyed by the Prince William Sound Recreation Working Group received cancellations in bookings in 1989 (PWSRWG Draft 1994). This injury continued through fewer tourists and bookings in 1989 and 1990 as a result of a loss in the natural setting. Many of the larger tour operations had experienced more tourists and bookings by 1991, but smaller businesses whose service relates directly to the natural or wilderness character of the area have recovered much more slowly (PWSRWG Draft 1994).

Wilderness

Prior to the oil spill, the EVOS area was considered a relatively pristine wilderness with bountiful environmental resources that made the area particularly valuable to Alaska residents. The relatively unpolluted environment enriched individual lives by simply existing. This perspective is somewhat less common in the lower 48 States. For many Alaskans, the spill spoiled a pure and irreplaceable resource, a place that was fundamental to their identities and values. This section deals with both (1) federal and state designated Wilderness Areas and Wilderness Study Areas and (2) de facto wilderness, or wilderness-like settings.

Areas formally designated as Wilderness Areas or as Wilderness Study Areas not only possess the pristine qualities people often associate with isolated locales, but have been recognized by special designation from the U.S. Congress or by the Alaska Legislature as having other special values (including ecological, geological, scientific, educational , scenic, and/or historic). These lands therefore require different management techniques than other State and Federal public lands. Within the spill area, these areas include: Katmai National Park and Preserve, Lake Clark National Park and Preserve, Becharof National Wildlife Refuge, and Kachemak Bay State Wilderness Park. Four Federal areas are currently being formally considered for Wilderness designation: Kenai Fjords National Park, Lake Clark National Park, Aniakchak National Monument and Preserve, and the Nellie Juan/College Fjord area of the Chugach National Forest. Federal wilderness areas are managed according to the 1964 Wilderness Act and the Alaska National Lands Conservation Act (ANILCA) of 1980, as well as agency policies, regulations, operating guidelines, and management plans.. State Wilderness Areas are managed according to enabling legislation and subsequent management plans. Generally, the areas are managed to maintain their natural landscape, their solitude, their ecological integrity, and their wild character. Evidence of human presence is substantially unnoticeable, which generally limits uses to those that are temporary. Various State and Federal lands not legislatively designated as Wilderness or Wilderness Study Areas are managed according to each agency's enabling legislation, subsequent regulations, and management plans. These non-Wilderness public lands may allow a broader range of uses and increased human development and thus may have increased human presence.

The oil spill delivered oil in varying quantities to the adjoining waters of all designated Wilderness Areas in the spill area, and oil was deposited above the mean high tide line in many areas. During the intense cleanup seasons of 1989-1990, hundreds of workers and thousands of pieces of equipment were at work in the spill area. This activity was an unprecedented imposition of people, noise, and activity on the area's undeveloped and normally sparsely occupied landscape.

Oil remains in isolated pockets in these Wilderness Areas. Although the oil may be disappearing, it will be decades before they return to their pristine condition. As a result, direct injury to Wilderness and intrinsic values continues. The massive intrusion of people and equipment associated with oil-spill cleanup has now ended (Trustee Council, 1993).

There are large areas of wilderness-like land in the spill area that are not designated Wilderness. These are remote, relatively undeveloped areas that contain many of the same characteristics as designated Wilderness but that have no differentiating regulatory standing. A considerable amount of the private land being evaluated for habitat protection and acquisition fits this description. These now privately owned parcels have wildland characteristics such as isolation; the visual quality of relatively undeveloped landscapes (the uncut and unscarred hillsides, wildlife viewing opportunities); the quality or quantity of recreation activities (hiking, sport fishing, sport hunting, and so on); and the relative lack of people and machinery into the natural setting (mechanical action, noise, and even odors). These de facto wilderness locations fit within a relatively undisturbed complex of ecosystems. People gain much of their enjoyment of these areas from the plants and animals supported by these ecosystems.

The concern for wilderness (whether formally designated or not) touches on the concerns for all other affected resources and services. Wilderness is seen as a pristine, undisturbed natural setting that can best provide habitat for affected species, so it is important in considerations of fish (in terms of populations, commercial fishing, and subsistence), birds, and sea mammals. It is a building block of the ecosystem approach to restoration. People from all over the country and all over the world value this pristine setting, as do Alaska residents, for its ability to provide a setting generally unaffected by the human world, so wilderness is important in considerations of passive uses. Commercial recreation benefits from designated Wilderness Areas and Wilderness Study Areas in the same way as noncommercial recreation: these areas provide a focus for wildlife viewing, spectacular natural scenery, and a range of recreation opportunities. Passive use, recreation, habitat preservation, subsistence, and other issues of concern relate inherently to the idea and reality of wilderness -- whether designated Wilderness Areas, designated Wilderness Study Areas, or de facto wilderness.

For Alaska Native communities, the interconnectedness of the natural and human worlds permeates actions, understanding, and religion. This manifests itself in many ways, but runs as a common thread throughout the communities. There is probably no word in Alutiiq, Eyak, or Athapaskan that translates directly to the Wilderness Act definition of wilderness, even though these cultures have been for thousands of years intimately interwoven with the natural environment. The Western view of wilderness, as captured by the Wilderness Act, is of a landscape untrammeled by humans, where people are just visitors who come and go. The Native view is of people as part of the landscape and on par with the natural world. Their lives cannot theoretically or physically be separated from the lands -- including wilderness -- and waters on which they have always lived. (Van Zee et al., 1994).

Commercial Fishing

Commercial fishing in Alaska has become a billion-dollar-per-year industry, and Alaska is considered the most important fishing State in the United States (Alaska Blue Book, 1994). The ex-vessel value of Alaska's commercial-fishing industry ranks first among all states in the Nation; and, in 1986, if the State of Alaska had been an independent nation, it would have ranked eleventh, worldwide, by volume of fish production. In 1986, Alaskan harvests constituted 46 percent of the total production of the United States. The ex-vessel value of fishery landings in Alaska is more than twice the combined landed values of Washington, Oregon, and California (McDowell, 1989). In 1988, the harvest was worth $3 billion at the first wholesale level. The seafood industry is the largest nongovernmental employer in Alaska and provides the equivalent of approximately 16.4 percent of the State's jobs, including nearly 70,000 seasonal jobs and as many as 33,000 direct, indirect, and induced year-round jobs. Based on these figures, the 1987 estimated total seafood industry payroll was $596 million (McDowell Group, 1989; Knapp, 1993; Royce, 1991).

In 1992, approximately 5.4 billion pounds of seafood worth $1.6 billion in ex-vessel value were landed into Alaskan ports. Salmon accounted for approximately 37 percent of the total value (Alaska Blue Book, 1994). The value of the 1988 commercial fish harvest in Prince William Sound alone for salmon fisheries totalled $71 million; for herring it was $12.2 million and for shellfish it was $2.4 million (ADF&G, 1990).

The EVOS area includes portions of the commercial fishing districts of Prince William Sound, Cook Inlet, Kodiak, and Chignik. The Prince William Sound commercial fisheries management area is subdivided into 11 commercial-fishing districts. In 1985, 845 limited entry permits were issued for commercial salmon fishing: 267 were for power purse seine, 548 were for drift gill net, and 30 were for set gill net (Prince William Sound Regional Planning Team, 1986). The Cook Inlet commercial fisheries management area that is subdivided into upper and lower Cook Inlet includes seven commercial-fishing districts. In 1981, there were 1,428 limited-entry commercial-fishing permits issued for salmon: 597 were for drift gill net, 747 were for set gill net, and 84 were for purse seine (Cook Inlet Regional Planning Team, 1981). The Kodiak Salmon Management Region includes eight management districts. In 1988, 600 limited-entry permits were issued for commercial fishing: 380 were for purse seine, 32 were for beach seine, and 188 were for set gill net. The Chignik commercial salmon fishing management area is divided into five districts, and purse seine is the only legal gear type allowed in this area. In 1989, there were 101 limited-entry-permit holders in the area (Thompson and Fox, 1990).

3 Affected Environment

During the most recent 10 years of record, salmon catches in the EVOS area generally have been above historic levels (Brennan et al., 1993; Bucher and Hammarstrom, 1993; Donaldson et al., 1993; Quimby and Owen, 1994; Reusch and Fox, 1993). The species composition of the salmon harvests in the spill area are dominated by large numbers of pink and sockeye salmon. In 1992, these two species comprised nearly 90 percent of the commercial salmon harvest in this area (Table 3-2). The average size of sockeye salmon, however, is nearly twice that of pink salmon and they are worth approximately ten times more per pound than pink salmon; consequently, their value to the commercial fishers is much greater.

Table 3-2
Commercial Salmon Harvests in the EVOS Area, 1992

Management Area	Species				
	Chinook	Sockeye	Coho	Pink	Chum
Prince William Sound	41,300	1,771,600	619,500	8,637,100	334,400
Lower Cook Inlet	1,900	176,600	5,900	479,800	22,200
Upper Cook Inlet	17,200	9,108,300	316,500	776,900	626,100
Kodiak	24,300	4,167,700	280,100	3,310,500	679,500
Chignik	10,800	1,277,500	310,900	1,554,100	222,100
Total	**95,500**	**16,501,700**	**1,532,900**	**14,758,400**	**1,884,300**
Percent of total	**0**	**48**	**4**	**42**	**5**

(Summarized from Brennan, Prokopowich, and Gretsch, 1993; Bucher and Hammarstrom, 1993; Donaldson et al.,1993: Quimby and Owen,1994; Reusch and Fox,1993)

Emergency commercial fishery closures that caused large-scale disruptions in the fisheries were ordered throughout the EVOS area in 1989 to avoid the likelihood of marketing a tainted product and to avoid fouling of fishing gear (Barrett, 1990; Barrett et al., 1990; Brady et al., 1991; Schroeder and Morrison, 1990; Reusch, 1990). These closures affected salmon, herring, crab, shrimp, rockfish, and sablefish. The 1989 closures resulted in overescapement of sockeye salmon in the Kenai River drainage and in several systems on Kodiak Island. In

1990, a portion of Prince William Sound was closed to shrimp fishing. Spill-related sockeye salmon overescapement is anticipated to cause low adult returns in 1994 and 1995. This may result in closure or harvest restrictions during these and, perhaps, subsequent years (Koenings et al., 1993). Injuries occurred to populations of rockfish, pink salmon, shellfish, and herring; but the status of their recovery remains uncertain (Anon., 1993; *EVOS* Trustee Council, 1992, 1993).

The Prince William Sound Area combined commercial salmon harvest for 1989 was approximately 24.4 million fish. This catch exceeds the average harvest over the past 10 years. However, an exceptionally large portion of this catch (33%) was composed of hatchery sales fish from the private nonprofit (PNP) hatcheries, leaving a common-property portion of the catch below the 10-year average (Brady et al., 1991). The value of the combined 1989 commercial salmon harvest in Prince William Sound was estimated at $41.3 million, excluding hatchery sales (Brady et al., 1991).

Cohen (1993) estimated that the EVOS reduced the ex-vessel income for southcentral commercial fishers by between $6.4 and $41.8 million in 1989 and $11.1 and $44.5 million in 1990. Most of this reduction was from the loss of harvest of sockeye and pink salmon.

Pacific herring also are extremely valuable to commercial fishers where spawning populations are found. The Pacific herring is also an important species to the Alaskan fishing industry because herring eggs or roe are sold in large quantities, primarily to the Japanese market. Also, the herring is a vital part of the food chain and is consumed by larger commercial species of fish such as salmon and halibut (Royce, 1991). The fisheries for Pacific herring are short, but intense. In Alaska, there are four commercial herring fisheries. First, a small number of fish are caught for food and bait. Second, divers gather herring eggs or roe on kelp in shallow, open waters. Third, roe is gathered on kelp in manmade enclosures (known as the pound-kelp fishery). The fourth and most important commercial harvest is the purse seine and gill net "sac-roe" fishery, in which herring are netted to collect the egg-filled sac, or ovary, from the mature females. Each year, the State limits the sac-roe harvest to 20 percent of the estimated herring stocks (ADF&G, 1991; Royce, 1991).

In the management areas of Prince William Sound and Cook Inlet in 1992, the estimated harvest of nearly 30,000 tons of Pacific herring was worth approximately $14 million (Bucher and Hammarstrom, 1993; Donaldson et al., 1993; Reusch and Fox, 1993).

All spring Pacific herring fisheries in Prince William Sound were cancelled in 1989 as a result of the EVOS (Brady et al., 1991). The commercial harvest of Pacific herring in 1990 was excellent (Royce et al., 1991), and, although the 1989 herring-spawning population was the largest observed since the early 1970's, it also resulted in the poorest production ever observed. Consequently, the fishery managers are wary of lingering impacts of the oil spill on the Pacific herring populations (Biggs and Baker, 1993; Biggs et al., 1993).

Salmon Management

Four Alaskan agencies are involved in operating and regulating Alaska's salmon fisheries: The Alaska Board of Fisheries sets policy and promulgates the regulations; the ADF&G manages the fisheries according to the policies and regulations of the Board and State law; the Alaska Commercial Fisheries Entry Commission controls the number of fishers; and the Alaska Department of Public Safety enforces the regulations.

3 Affected Environment

The Alaska Board of Fisheries establishes the regulations that govern fisheries and allocate the resource. Actions considered by the Board include changes in timing and areas for the salmon fisheries and the allocation of harvests among the various groups of fishermen. In-season fisheries management is the responsibility of the ADF&G to determine when and where specific openings are allowed to ensure that adequate numbers of wild stocks escape to spawn. The primary management tool used by ADF&G for regulating salmon returns is emergency-order authority to open and close fishing areas. During years when the wild-stock returns are strong, a liberal weekly fishing schedule may be permitted. However, when the wild-stock returns are weak, fishing must be restricted to meet minimum spawning requirements.

The Alaska Commercial Fisheries Entry Commission is an independent, quasi-judicial State agency responsible for licensing, research, and adjudication. By regulating entry into the fisheries, they ensure the economic health and stability of commercial fishing.

The Fish and Wildlife Protection Division of the Alaska Department of Public Safety enforces the State regulations that are promulgated by the Board of Fisheries.

Fisheries Restoration and Development

The importance of fisheries resources to the people and ecology of the EVOS area have been recognized for many years and numerous attempts have been made to improve or expand these resources. After the 1964 Alaskan earthquake disrupted salmon spawning habitat and migration corridors, these fisheries restoration and development activities increased; and, after 1974, when regional planning teams became established, the planning process became more organized and more formal (Appendix C, Section 1). The Alaska Department of Fish and Game (ADF&G) has worked with the U.S. Forest Service (USFS) the private nonprofit (PNP) groups and other agencies and groups to implement management measures or in-stream projects to rehabilitate, if necessary, and increase salmon populations in the EVOS area. Past efforts have included restoring wild stocks to former levels of abundance or improving production through stream habitat improvements, fish ladders, lake fertilization and other activities to improve natural habitat conditions. Many stream-rehabilitation projects have been carried out by the USFS in cooperation with the ADF&G, because many spawning streams are located in the Chugach National Forest. Since 1962, there have been more than 50 fish habitat improvement projects completed in western Prince William Sound alone (Prince William Sound Planning Team, 1986).

Article VIII, Section 5, of the Alaska Constitution authorizes the Alaska State Legislature to "provide for facilities improvements and services to assure further utilization and development of the fisheries". In 1974, the Private Nonprofit Hatcheries Act (Chapter III, SLA 1974) was enacted which "authorized private ownership of salmon hatcheries by qualified nonprofit corporations for the purpose of contributing by artificial means to the rehabilitation of the state's depleted and depressed salmon fishery." Since that time, ADF&G, and private non-profit (PNP) groups have cooperated to build hatcheries throughout the State, including the EVOS area (Ellison, 1992).

Fish hatcheries provide a useful tool that may be applied to benefit fisheries both directly and indirectly. Fish from hatcheries may be released and imprinted in new locations to develop free-ranging stocks of fish to create new subsistence, sport or commercial fisheries. Fish from hatchery-produced stocks may be used in some locations to provide alternate opportunities for fishers to attract fishing efforts away from wild stocks. As with any tool, however, care must be taken to use it properly (Appendix C, Section 1).

The importance of hatchery-reared salmon was made apparent during the 1986 season, when approximately 11.5 million pink salmon were caught in Prince William Sound. Approximately 10.5 million fish were harvested in common property fisheries, and 909,219 fish were harvested in PNP special harvest areas. Approximately 5.8 million fish in the common property harvest were of hatchery origin. The combined common property and sales harvests of hatchery-produced fish was 6.8 million fish. This marked the first time in the history of the fishery that hatchery fish constituted more than half of the pink salmon harvest in Prince William Sound (Sharr et al., 1988). During the 1993 commercial-fishing season, approximately 12 million pink salmon were harvested at Kitoi Bay Hatchery, near Kodiak. This was more than half of the Kodiak area pink salmon harvest and approximately 49 percent of the hatchery-produced pink salmon of the entire state (ADF&G, 1994). During 1993, the preliminary estimated adult returns to the salmon hatcheries in the EVOS area exceeded 21 million fish. The greatest beneficiaries of these fish were the commercial fishers, although some of these fish were caught by sport, subsistence, and personal-use fishermen (ADF&G, 1994).

The EVOS disrupted the usual pattern of commercial salmon fisheries in 1989 in Prince William Sound; and, although the catch was above the previous 10-year average, an exceptionally large portion of this catch was pink salmon from the special-harvest areas at the PNP hatcheries, consequently, the common-property commercial-fishery harvests fell below the 10-year average (Brady et al., 1991). There is also evidence that the EVOS reduced the survival of pink salmon fry that were released from hatcheries in 1989 (Peckham et al., 1993).

Sport Fishing

Sport fishing is one of the most popular recreational activities for both residents and visitors of Alaska and it constitutes an important and distinct segment of the recreational activities in the oil-spill area region. Both marine and freshwater systems provide a variety of sport fishing opportunities in the EVOS area. Marine recreational fishing originates in all major towns on the Prince William Sound as well as Cook Inlet, Kodiak Island, and the Kenai Peninsula. Fishing trips are taken in several ways--from shore, from private boats, and from charter vessels--in both freshwater and saltwater. Within the EVOS area, several species of Pacific salmon, rockfish, halibut, Dolly Varden, rainbow trout and cutthroat trout provide important sport fisheries. Although sport fishing is popular throughout the State, over 70 percent of Alaska's sport fishing occurs in the Southcentral region (Mills, 1993). Most of this occurs on the Kenai Peninsula because access by car from Anchorage is relatively easy. Sport fishing throughout the State is conducted according to the Alaska Sport Fishing Regulations formulated by the Alaska Board of Fisheries. The fishing regulations specify bag, possession, and size limits for the fishes to be taken from different streams, rivers, lakes, and in saltwater.

Between 1984 and 1988, the number of anglers and fishing days, and the total fish harvest in the oil-affected area had been increasing at a rate of 10 to 16 percent per year. Since 1977, there has been a 4.5 percent average- annual increase in the number of residents who sport fish, while the number of nonresidents sport fishing has increased 16 percent annually. However, after the oil spill, between 1989 and 1990, a decline in sport fishing (number of anglers, fishing trips, and fishing days) was recorded for Prince William Sound, Cook Inlet, and the Kenai Peninsula. The decline occurred because of closures, fear of contamination, the unavailability of boats, and congestion at some sites outside the spill area (Carson and Hanemann, 1992). In 1992, an emergency order restricting cutthroat trout fishing was issued for western Prince William Sound because of low adult returns.

Because commercial fishing for sockeye salmon in Cook Inlet was curtailed in 1989 to avoid fouling fishing gear and processing tainted commercially caught fish, the number of sockeye salmon that spawned in the Kenai River was approximately three times the desired amount. Although sport fishers enjoyed this bounty in 1989, this spawning resulted in an overpopulation of sockeye salmon fry and a dramatic reduction in smolt production. Consequently, very weak returns are forecasted for 1994, 1995, and possibly later years as well. These weak returns are likely to lead to some sport fishing closures as well as commercial fishing closures (Koenings, Schmidt, Fried, Tarbox, and Brannian, 1993; Schmidt, Tarbox, Kyle, King, Brannian, and Koenings, 1993).

In 1986, the estimated expenditures by sport fishers in southcentral Alaska were $127.1 million. These expenditures directly supported over 2,000 jobs in sport fishing-related businesses, and the equivalent of 2,840 full-time jobs were supported in all industries in Alaska by sport fishing activity in southcentral Alaska (Jones and Stokes, 1987). Carson and Hanemann (1992) calculated that there were 127,527 and 40,669 sport fishing trips lost during 1989 and 1990, respectively, in southcentral Alaska because of the EVOS. They also calculated that the lost economic value of these trips was $31 million and ranged from $3.6 million to $50.5 million.

Economy

The 1990 economy for the EVOS area and for Anchorage is summarized in Table 3-3. Anchorage is added to the EVOS area because there are so many strong linkages between the economy of this area and Anchorage, which is the nearest large economic center to the EVOS area. This table has 12 economic sectors and 6 measures of economic performance. It is in the format of IMPLAN (IMpact PLANing), which is an economic model used for economic analysis.

The IMPLAN's output classification system is based on systems defined by the Bureau of Economic Analysis, U.S. Department of Commerce, and the Standard Industrial Classification (SIC) used by the Federal Office of Management and Budget. The analysis is conducted using 528 industries, and the results are aggregated into 12 sectors. The 12 sectors are as follows:

1. Forestry -- Forestry firms operating timber tracts, tree farms, or forest nurseries or performing forestry services.

2. Commerical Fishing -- Commercial fishing, fish hatcheries, sports fishing.

3. Mining -- Businesses extracting naturally occurring minerals.

4. Construction -- Businesses constructing new buildings and additions or making alterations and repairs.

5. Manufacturing -- Businesses mechanically or chemically transforming materials or substances into new products that are produced by other sectors (e.g., forests and fisheries) or other manufacturers.

6. Communication and Utilities -- Businesses providing to the public or to other businesses communication services, electricity, gas, steam, and/or water or sanitary or mail services.

7. Recreation Related -- Local transit, water transportation, air transportation, transportation not elsewhere classified, hotels, auto rentals, and recreation services not elsewhere classified.

8. Trade -- Businesses selling retail merchandise to households or selling wholesale merchandise.

9. Finance, Insurance, and Real Estate -- Businesses engaging in the fields of finance, insurance, and real estate.

10. Services -- Businesses providing a variety of services for individuals, businesses, governments, and other organizations, e.g., amusements; health; and legal, engineering, and other professional services.

11. Government -- Government agencies carrying out legislative, judicial, administrative, and regulatory activities of Federal, State, local, and international governments.

12. Miscellaneous -- Businesses not classified in any other industry.

The six measures of economic performance in Table 3-3 are described as follows. Final demand represents regional purchases of goods and services. Industry output represents the regional supply of goods and services. The difference between regional supply and demand is accounted for by regional imports and exports. The value added category represents the costs added within the region to produce industry output. Employee compensation and property income are its two key components. Employment is the number of person-year equivalents to produce industry output.

Table 3-3.
The Economy - EVOS Area and Anchorage 1990 in 1990$ Millions

Economic Sector	Final Demand $	Industry Output $	Employee Comp. $	Property Income $	Value Added $	Employ-ment #
Forestry	135	156	22	31	55	3245
Commercial Fisheries	206	306	6	120	134	4846
Mining	6051	6199	502	2835	4745	6335
Construction	1246	1420	495	364	862	11751
Manufacturing	949	1072	227	82	320	7655
Recreation Related	693	731	332	59	423	12782
Communication & Utilities	1429	1744	308	753	1129	7039
Trade	1126	1253	753	138	1035	33790
Finance, Insurance, Real Estate	968	1137	245	337	734	11329
Services	1830	2305	849	502	1362	42753
Government	2106	2152	1934	77	2011	46428
Miscellaneous	45	12	0	33	33	0
Total	16812	18488	5673	5333	12843	187953

Source: IMPLAN Economic Model. See text for methodology.

Chapter 4

Environmental Consequences

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Chapter 4

Environmental Consequences

Introduction

This chapter contains the analysis of the environmental consequences that could result from implementing the five alternatives described. In many environmental impact statements (EIS's) the analysis focuses on the numbers or degree of loss to various resources. It is an important distinction of this EIS that with few exceptions, the impacts estimated to occur under the various alternatives are increases in populations or services from some existing injured level.

The analysis of impacts is based in large part upon what has been learned from studies carried on since the *Exxon Valdez* Oil Spill (EVOS). Much of this research has focused on the area of Prince William Sound. As a result, most of the estimated impacts from actions in the alternatives are based on what we have learned from the Prince William Sound studies and extrapolated for analysis in the other areas of the EVOS.

The current situation provides the basis for comparing the effects of the action alternatives. In this programmatic document, it should be noted that the No Action Alternative consists of normal agency management activities and the assumptions that (1) natural recovery will be the only restoring agent at work and (2) private land owners will harvest their commercial timber lands in the long term.

If the No Action Alternative were implemented, current management would continue, no new activities or programs would be instituted as a result of the oil spill, and the scope of present activities and programs would not change. Agency monitoring of natural recovery would remain at present levels, and their responsibilities would remain unchanged. None of the remaining funds from the civil settlement would be spent at this time on restoration activities if this alternative were implemented.

4 Environmental Consequences

Monitoring and research, as actions, generally do not impact resources and services and therefore are analyzed only for their economic impacts. It is recognized that the general restoration category also includes such actions as data gathering, surveys, and analysis that would not impact the resources--thus these activities would not be included in the EIS analysis except for the impacts on the economy.

"Recovery"

The definition of the term recovery has a significant bearing on the discussion of the various alternatives described in this chapter. The settlement funds may be used for the purpose 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 goal of restoration is recovery of all injured resources and thereby the services they provide. For some resources, little is known about their injury and recovery, so it is difficult to define recovery or develop restoration strategies.

In the analysis of impacts to the various resources in the EIS, it may be that an action will accelerate the rate of recovery and not measurably impact the number of individuals in the population for several years. This is still viewed as having a significant beneficial impact on the resource analyzed.

In general, resources and services will have recovered when they return to conditions that would have existed had the spill not occurred. Because it is difficult to predict conditions that would have existed in the absence of the spill, recovery is often defined as a return to prespill conditions. For resources that were in decline before the spill, such as marbled murrelets, recovery may consist of stabilizing the population at a lower level than before the spill.

Where there were little prespill data, injury is inferred from comparison of oiled and unoiled areas, and recovery usually is defined as a return to conditions comparable to those of unoiled areas. Because the differences between oiled and unoiled areas may have existed before the spill, statements of injury and definitions of recovery based on these differences often are less certain than in those cases where prespill data exist. However, there also can be some uncertainty associated with interpreting the significance of prespill population data because populations undergo natural fluctuations. Indicators of recovery can include increased numbers of individuals, reproductive success, improved growth and survival rates, and normal age and sex composition of the injured population.

Ecosystem

This chapter analyzes the impacts of restoration actions taken to benefit resources and the associated services that were injured as a result of the oil spill. While the impacts of these actions are discussed for each of the injured resources and services, there are other ecological relationships that will have to be addressed as part of a site specific analysis before any of the proposed actions are implemented. The Trustee Council has stated that an ecosystem approach will be used for the overall restoration program, this means, among other things, that the ecological relationships between resources will be considered. Because many of the factors that would be considered need site-specific information, it is beyond the scope of this programmatic document to discuss the interrelationship between site specific restoration actions and between resources.

Intertidal Organisms

The intertidal zone has a great diversity of plant and animal populations. These organisms were especially vulnerable to injury from the EVOS and subsequent cleanup activities. The natural resources damage assessment studies focused on specific organisms as representatives of the intertidal zone. These studies documented population declines and sublethal injuries to many intertidal species, but results were highly variable between regions and habitats. By 1993, many of the populations were recovering. This DEIS focuses on the effects of restoration actions, aside from monitoring and research, on the groups of species that were still showing signs of injury from the EVOS in 1993.

Marine Mammals

This analysis focuses on the effects of restoration actions on harbor seals and sea otters. While killer whales were also injured by the oil spill, the injured pod (identified as the AB pod) appears to be recovering. At this time, it is unlikely that any restoration actions aside from monitoring and research will be implemented for killer whales. This analysis focuses on the effects of direct restoration actions and on the effects of upland habitat protection; therefore, killer whales are not part of the analysis.

For harbor seals and sea otters, determining the effects of the restoration actions that may occur in the five alternatives is complicated by limited background information. Therefore, the effects of different actions are not always discussed in terms of in the actions' ability to increase recovery, but may be analyzed on the ability to provide protection, reduce disturbance, or to reduce the risk of exposure to oil. This is especially true for harbor seals which were in decline throughout the Gulf of Alaska before the oil spill occurred in 1989. The causes of this decline are unknown and therefore predictions of recovery or of the effects of different restoration actions on the number of harbor seals are speculative.

Birds

The following factors and assumptions were considered when evaluating alternatives and actions concerning injured bird resources: (1) valuations of land that may be acquired for habitat were based on criteria and a process developed by the EVOS habitat group; (2) pre-spill baseline data are meager or nonexistent for most species; (3) population size depends on many biological, ecological, and environmental factors, and population size changes as a result of life span, productivity, and survival rate; (4) it is unknown whether or how a 19-year climatic cycle in the Gulf of Alaska has affected populations; (5) migrant species may be influenced by environmental factors far from the EVOS area; (6) population cycles are barely known for most species; and (7) the influence of commercial-fishing on seabird populations in the EVOS area are unknown, but could be substantial. For example, fishery harvests and hatchery programs could influence seabird populations in three ways: (1) prey may become less available to seabirds because fish species that occupy the same trophic levels may outcompete seabirds; (2) an increase in abundance of salmon fry and smolts may increase seabirds' prey base; and, (3) offal and discarded bycatch may increase the food base of scavenging seabirds.

Fish

Fishery resources that are included for analysis in this EIS are pink and sockeye salmon and Pacific herring. Related services that are included are sport and commercial fishing. Actions that may be proposed as general restoration projects as part of the programs described for each alternative will benefit one or several of the fishery resources and the services they provide. Forecasted feasibility, results, benefits and costs from each of these actions, however, are highly site specific, vary annually, and are difficult to quantify. Consequently, analyses and predicted impacts presented here must be general in nature. The proposed actions are intended primarily to benefit wild-stock fishery resources, either directly by habitat or population manipulations or indirectly by providing an alternate opportunity for user groups to reduce pressure on the wild stocks to allow them to recover.

Each proposed action for these fishery restoration or replacement projects is based on the basic premise that some factor or habitat need in the life history of a fish either limits the size of the population or is missing. For example, if spawning habitat is absent, there can be no fish; if spawning habitat is present (and no other factor constrains the size of the population), the number of fish will depend on the amount of spawning habitat, but it will vary annually according to environmental conditions. The basic concept for each proposed action, therefore, is to identify and overcome a limiting factor or "bottleneck" that will result in an increase in the total number of adult fish that will return to a particular home stream.

Economy

The economic analysis for the five alternatives is a combination of qualitative and quantitative approaches. The economic analysis is focused on three sectors of the economy of most concern: forestry, commercial fisheries, and recreation. Taking timberlands in or out of production is quantified in terms of dollars and jobs. However, studies and data on the economic effect of the types of actions proposed in the alternatives on the commercial fisheries and recreation are not adequate to make quantitative projections.

The Forest Service's IMPLAN (IMpact PLANning) economic computer model was used in the quantitative analysis of the economic impacts of implementing each of the proposed EVOS Restoration Plan alternatives. Alternatives 1 through 5 are compared to the "baseline" economic conditions in 1990 found in Table 3-3, Chapter 3, page 3-50.

An attempt has been made to quantitatively analyze the recreation sector of the economy in the tables generated by IMPLAN. Discrete data are not available for the recreation industry. For example, data are available for hotels, but a differentiation is not made between recreational visitors and business visitors. The recreation-related sector shown in the tables on economics are composed of several IMPLAN subcategories: local transit, water transportation, air transportation, transportation not elsewhere classified, hotels, auto rental, and recreation services not elsewhere classified. Where the term recreation is used in economic analysis, it includes tourism.

The IMPLAN as applied to this analysis for the forestry sector shows the negative effects in output and employment when timberlands are purchased and timber is not harvested. There is a corresponding increase in the services sector output and employment because of expenditures in that sector by the owners of the timberlands. Restoration expenditures have a direct effect on the construction sector.

The descriptions of the alternatives are general. This, combined with the lack of data to quantify the economic effects for the commercial fisheries and recreation sectors, results in an inability to distinguish the economic effects among the alternatives.

The IMPLAN is an economic model that is the best economic tool for analyzing the economic effects of the alternatives analyzed in this draft environmental impact statement (DEIS). However--as with any tool of economic projection--even when quantified data is available for analysis, IMPLAN is not perfect. While exact numbers of various economic measures are the outputs of the model, the results are not intended to be precise measurements. The projections from the model represent approximations of the economic future.

The IMPLAN estimates income and employment change as the product of the demand changes (e.g., an alternative) and a multiplier. Estimating multipliers requires data and a description of the regional economy. The data are the National input-output matrices that show the dollar volume of transactions among industries and final demand. The National matrices are stepped down to the borough and census-area level by using borough population and employment data and ratios of employment to output. The boroughs and census areas aggregated in this assessment are the Municipality of Anchorage, Kenai Peninsula Borough, Kodiak Island Borough, and the Valdez-Cordova Census Area. This area encompasses the EVOS area and the closest major economic center (Anchorage). The Municipality of Anchorage was included to ensure that the flow of goods and services in and out of the oil spill area is adequately accounted for in the IMPLAN economic model.

The key assumptions in the IMPLAN economic assessment are as follows: each industry has an output, and this output does not experience short-term variation; there is a fixed formula for making commodities, and there can be no substitutions; there are only constant returns to scale (i.e., to make twice as much of something, all inputs are doubled); adjustments are instantaneous, and timeliness and technology do not change.

Table 4-1 shows for each alterative the percent allocation of dollars for each restoration category (administration, monitoring, general restoration, and habitat protection) assumed for inputs into economic sectors of the IMPLAN economic model used for economic analysis. Taking Alternative 2 as an example, it is explained in Chapter 2 of this DEIS for Alternative 2 that $564 million would be used to acquire and protect lands within the spill area, $31 million would be spent on Monitoring and Research, and $25 million would be spent on Administration and Public Information. Following the percentage allocation in Table 4-1, of the $25 million to be spent on Administration and Public Information, 50 percent would be spent in the federal government sector of the economy and the other 50 percent would be spent in the state and local government sector of the economy. In a similar fashion, of the $31 spent on Monitoring and Research, 33 percent would be spent in the federal government sector, 34 percent n the state and local government sector, and 33 percent in the universities sector. In Alternative 2 no money would be spent on general restoration. Of the $564 million that would be spent on habitat protection, one half of one percent would be spent in the real estate sector of the economy and 99.5 percent would be spent in the forestry sector of the economy. Landowners would receive substantial amounts of the habitat Protection and Acquisition expenditures. Of the $564 received by landowners, landowners would spend it in the following economic sectors: 13 percent in investment in securities, 29 percent in construction, 29 percent in social services, and 29 percent by households which are shareholders in the landowning corporations. Allocations shown in Table 4-1 are made in a similar manner for alternatives 3, 4, and 5. The resulting dollar expenditures are allocated or input to the specified economic sectors of the IMPLAN economic model. The IMPLAN model, with its multipliers which link one sector to another, calculates the initial spending in a given sector to yield output in the original and other sectors of the economy. The results of the IMPLAN model are six measures of economic performance shown in a table for each of the alternatives.

See Appendix D for a further description of the methodology of economic analysis.

4 Environmental Consequences

Archaeological/ Cultural Resources

This section incorporates discussion of the various aspects of cultural resources relating to (1) the physical remains of indigenous and historic inhabitants of the EVOS area -- the archaeological resources -- and (2) the values inherent in those remains for contemporary and future members of the public. Restoration actions are likely to be oriented toward physical remains because those were directly injured by the EVOS. The values of these remains for local communities, whose ancestors lived and are buried at some of these sites, would be addressed through actions relating to those remains. Archaeological sites and artifacts themselves are important kinds of cultural resources, but other cultural resources (such as stories associated with specific sites or artifact types, or traditional techniques used to construct traditional items) add immense value to objects that may otherwise would provide limited insight and information. These other types of cultural resources may benefit from actions on archaeological remains, extending the positive impacts of the restoration efforts.

The greater the degree to which local community members become involved in restoration of these resources, the more fully the restoration will be completed. Some actions may be carried out in local communities as a logical extension of projects accomplished on archaeological sites. While restoration of archaeological resources is important at the local level, it is also important to the cultural patrimony of Alaska and of the United States. In keeping with that importance, all projects will be completed in compliance with applicable historical and archaeological resource protection laws.

Cumulative Effects Scenario

The Council on Environmental Quality (CEQ) regulations define cumulative effects as ". . . the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal, or non-Federal) or person undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (40 CFR 1508.7). The discussions of cumulative effects on the various resources are based on the interrelationship of the alternatives with other major current and proposed projects and other conditions creating impacts. The projects considered were:

- Whittier road access
- Whittier harbor expansion
- Cordova road access
- Lower Cook Inlet oil development
- Shepard Point harbor development (Cordova)
- Trans-Alaska Gas Pipeline
- Childs Glacier recreation development
- Previously approved EVOS projects (Fiscal Years 1992-1994)

Table 4-1

Percent Allocation of Restoration Expenditure by Economic Sector Assumed in Economic Analysis

Restoration Category/ Economic Sector	Alternatives 1	2	3	4	5
Administration and Public Information					
Federal Government	-	50%	50%	50%	50%
State & Local Government	-	50%	50%	50%	50%
Monitoring and Research					
Federal Government	-	33%	33%	33%	33%
State & Local Government	-	34%	34%	34%	34%
Universities	-	33%	33%	33%	33%
General Restoration					
State & Local Government	-	-	33%	33%	33%
Fisheries Services	-	-	34%	34%	34%
Construction	-	-	33%	33%	33%
Habitat Protection and Acquisition					
Real Estate	-	0.5%	0.4%	0.3%	0.3%
Forestry	-	99.5%	99.6%	99.7%	99.7%
Restoration Reserve					
Banks	-	-	-	-	100%
Respending by Landowners					
Securities	-	13%	13%	0%	0%
Construction	-	29%	29%	40%	40%
Social Services	-	29%	29%	40%	40%
Household Spending	-	29%	29%	20%	20%

Table 4-2
Definitions of Impact Levels

Resource	NEGLIGIBLE	LOW	MODERATE	HIGH
Intertidal organisms	Little or no improvement in the resource's ability to recover, or in the quality of its habitat. Little or no reduction in impacts from human interactions.	Proposed restoration actions may reduce negative impacts from the spill or from some anticipated, or current, human activities. These reduced negative effects do not create an improvement in the ability of the injured population to recover either locally or regionally.	Proposed restoration actions have a high potential to reduce negative impacts from the spill or from anticipated, or current, human activities. These reduced negative effects could improve the ability of the injured population to recover more rapidly but measurable increases would only occur in localized areas.	Proposed restoration actions have a high potential to change the ability of the injured population to recover, so that the expected time period to reach recovery is reduced on a regional basis.
Marine Mammals	Little or no improvement in the resource's ability to recover, or in the quality of its habitat. Little or no reduction in impacts from human interactions.	Proposed restoration actions may reduce negative impacts from the spill or from some anticipated, or current, human activities. These reduced negative effects do not create an improvement in the ability of the injured population to recover either locally or regionally.	Proposed restoration actions have a high potential to reduce negative impacts from the spill or from anticipated, or current, human activities. These reduced negative effects could improve the ability of the injured population to recover more rapidly but measurable increases would only occur in localized areas.	Proposed restoration actions have a high potential to change the ability of the injured population to recover, so that the expected time period to reach recovery is reduced on a regional basis.
Birds	Little or no change expected in population level, productivity rate, or sub-lethal injury.	Unlikely to affect regional recovery of population level, productivity rate, or sub-lethal injury, but may enhance recovery of local segment of population.	Likely to enhance to a measurable degree the regional recovery of population level, productivity rate, or to reduce sub-lethal injury, and may substantially enhance recovery of local segment of population.	High probability of substantially enhancing population level, productivity rate, or for reducing sub-lethal injury throughout EVOS region.

Table 4-2 (cont.)

Definitions of Impact Levels

Resource	NEGLIGIBLE	LOW	MODERATE	HIGH
Fish	Little or no increase or recovery of the injured resource sooner than by natural recovery; or, little or no protection of the habitat from disturbance.	Unlikely or small increase or recovery of the injured resource sooner than by natural recovery; or, limited protection of the habitat from disturbance.	Moderate increase or partial recovery of the injured resource or service sooner than by natural recovery; or, high benefits in limited area(s); or, moderate protection of the habitat from disturbance.	Recovery of the injured resource sooner than by natural recovery; or, recovery of the injured resource to a greater than pre-spill amounts; or, substantial protection of the habitat from disturbance.
Cultural Resources	Little or no protection for achaeological or historic sites; or little or no improvement of the understanding or appreciation of cultural resource values within the EVOS area.	Small increase in protection for archaeological or historic sites; or small improvement of the understanding or appreciation or cultural resource values in limited locations within the EVOS area.	Moderate increase in protection for achaeological or historic sites; or moderate improvement of the understanding or appreciation of cultural resource values througout the EVOS area; or substantial improvement of the understanding or appreciation of cultural resource values in limited locations within the EVOS area.	Substantial increase in protection for archaeological or historic sites; or substantial improvement of the understanding or appreciation of cultural resource values throughout the EVOS area.
Subsistence	Little or no change in populations of subsistence harvest species injured by EVOS; or small increase in confidence levels that subsistence users in affected communities have in lack of contamination in subsistence foods.	Small increase in populations of subsistence harvest species injured by the EVOS; or small increase in confidence levels that subsistence users in affected communities have in the lack of contamination in subsistence foods. Increases may be localized or throughout the EVOS area.	Moderate increase in populations of subsistence harvest species negatively affected by EVOS; or moderate increase in the confidence levels that subsistence users in affected communities have in the lack of contamination in subsistence foods throughout the EVOS area; or substantial increases in populations or confidence levels in localized areas.	Substantial increase in populations of subsistence harvest species negatively affected by EVOS; or substantial increase in the confidence levels that subsistence users in affected communities have in the lack of contamination in subsistence foods throughout the EVOS area.

Table 4-2 (cont.)

Definitions of Impact Levels

Resource	NEGLIGIBLE	LOW	MODERATE	HIGH
Recreation & Tourism	Little or no change in numbers of users, or on the quality of their experience.	Small increase in numbers of users, or small increase in protection or improvement of recreation quality in localized areas within the EVOS area.	Moderate increase in numbers of users, or moderate increase in protection or improvement of recreation quality throughout the EVOS area; or substantial increase in numbers of users or substantial improvement of recreation quality in localized areas within the EVOS area.	Substantial increase in numbers of users, or substantial increase in protection or improvement of recreation quality throughout the EVOS area.
Wilderness	Little or no reduction of residual oil and materials left from clean-up activities, and no change in public perception of injury to Wilderness.	Small reduction of residual oil and materials left from clean-up activities, or small change in public perception of injury to Wilderness.	Moderate reduction of residual oil and materials left from spill clean-up activities, or moderage change in perception of injury to Wilderness.	Substantial reduction of residual oil spill and materials left from clean-up activities and substantial change in perception of injury to Wilderness.
Commercial Fishing & Sport Fishing	Little or no increase or recovery of the injured service sooner than by natural recovery; or, little or no protection of the habitat from disturbance.	Unlikely or small increase or recovery of the injured service sooner than by natural recovery; or, limited protection of the habitat from disturbance.	Moderate increase or partial recovery of the injured service sooner than by natural recovery; or, high benefits in limited area(s); or, moderate protection of the habitat from disturbance.	Recovery of the injured service sooner than by natural recovery; or, recovery of the injured resource to a greater than pre-spill amounts; or, substantial protection of the habitat from disturbance.
Economy	Barely measurable contribution to employment and economic output over a 10-year period or longer.	Less than a substantial contribution to employment and economic output over a 10-year period or longer.	Moderately substantial contribution to employment and economic output over a 10-year period or longer.	Very substantial contribution to employment and economic output over a 10-year period or longer.

Alternative 1 - No Action

Introduction

The No Action Alternative is required by CEQ guidelines to provide an understanding of what may occur if no actions are implemented to restore the injured resources to their pre-spill conditions. It is intended to be a forecast or projection of conditions from the present status of the injured resource and associated services to a future status if no actions are taken. It also provides additional background for analysis and comparison to forcast impacts from possible actions in other alternatives. In this DEIS, the No Action Alternative describes what would happen to the resources and services injured by EVOS if no restoration actions were implemented. Because none of the civil settlement funds would be spent to aid recovery, the only actions undertaken within the spill area would be the result of normal agency management or private enterprise. For biological resources, recovery from oil spill injuries would be unaided (natural recovery) and could be complicated by other human activities that could cause further injuries or habitat loss. The recovery of other resources or services also may be influenced by other nonoil spill-related actions.

Biological Resources

Impact on Intertidal Resources

The intertidal zone was especially vulnerable to injury from the EVOS and from the subsequent cleanup operations. The oil spill caused population declines and sublethal injuries to the plants and animals of the intertidal zone. Portions of 1,500 miles of coastline were oiled (350 miles were heavily oiled), resulting in significant impacts to intertidal habitats, particularly in the upper intertidal zone. Direct oiling killed many organisms, but beach cleaning, particularly high-pressure, hot-water washing, had a devastating effect on intertidal life (Houghton, Lees, and Driskall, 1993).

Coastal habitat studies documented changes in many species of algae, invertebrates, and fish; the injuries were highly variable between species, regions, and habitats (Highsmith, Stekoll and Barber, 1993). For most of the intertidal zone, the effects of the oil spill were probably short term. Studies in 1992 and 1993 showed that many of the differences in habitats and organisms that were documented in 1989 and 1990 were recovered (Houghton, Lees, and Driskall, 1993; Highsmith, Stekoll and Barber, 1993). However, some areas had not yet begun to recover or were recovering very slowly. This was especially evident in the upper 1 meter vertical drop (MVD) of sheltered rocky habitats where the algae *Fucus gardneri* is the dominant plant species (Highsmith, Stekoll and Barber, 1993; Highsmith et al., 1993; Houghton, Lees, and Driskall, 1993). This discussion focuses on the organisms and habitats that are the least likely to have recovered.

Fucus

This algae, or rockweed, is an important component of the upper intertidal zone because it provides food for many invertebrates, as well as shelter from predation and desiccation for many plants and animals (Highsmith et al., 1993). The oil spill and subsequent cleanup destroyed many of the plants in the upper meter and reduced the reproductive capacity of the adult plants that survived (Highsmith et al., 1993). These injuries were documented in all regions of the spill area but were highly variable between tidal elevations and habitats (Highsmith, Stekoll and Barber, 1993).

The Herring Bay Experimental and Monitoring study (Highsmith et al., 1993) provided information on the recovery of plants and invertebrates in the intertidal zone. Recovery in the upper intertidal appears to depend on the return of adult *Fucus* in large numbers to this zone. In the absence of a well-developed canopy of adult plants, eggs and developing propagules of *Fucus* lack sufficient moisture and shelter to survive. Existing adult plants act as centers for the expansion of the community. *Fucus* plants in the sample sites were estimated to take 3 to 4 years to become fully mature. Because eggs generally settle within 0.5 m of the parent plant, the Herring Bay study estimated that *Fucus* communities are able to expand at a rate of 0.5 m every 3 to 4 years (Highsmith et al., 1993). It is unknown how these results would vary in areas outside of Herring Bay where habitat conditions differ.

Limpets, Barnacles, and Other Invertebrates

The recovery of limpets, barnacles, and other invertebrates also is linked to the recovery of rockweed. Because there were no baseline data for intertidal communities, the exact composition of the community structure is unknown. Full recovery, based on the community structure of comparable nonoiled sites, of the intertidal community may take more than a decade because it may take several years for some invertebrate species to return after *Fucus* has recolonized an area.

Mussels

The oil spill injured mussels throughout the EVOS area. Coastal habitat studies documented changes in the presence of large mussels and in total biomass of mussel communities between oiled and nonoiled areas (Highsmith et al., 1993, and Highsmith, Stekoll and Barber, 1993). Oil was found in the sediments beneath mussels (Rounds et al., 1993) and hydrocarbons were identified in mussel tissues (Babcock et al., 1993). Mussels occur in loose aggregations attached to intertidal rocks, or in dense aggregations (mussel beds) over pea gravel and silt sediments. Because mussels form a dense matt over the sediments and rocks, oil that was trapped beneath the mussels was not exposed to weathering and still remains toxic. Feasibility studies to develop techniques to clean the sediments beneath mussel beds are under way in the EVOS area. The results of these studies are still preliminary but suggest it may be possible to clean the mussel beds without destroying the community.

In this alternative, no further attempts would be made to clean mussel beds. It is not known how long the trapped oil would remain toxic. Because mussels are an important prey species for many other organisms--including sea otters, harlequin ducks, and black oystercatchers that were injured by the spill--it is possible that the trapped oil will be a continuing source of contamination to the coastal ecosystem in the EVOS area. The consequences of this source of contamination is unknown; however, mussel beds are known to be one of several locations where *Exxon Valdez* oil still may be transmitted into the environment. For instance, oil also is trapped beneath mussel aggregations that are not classified as "mussel beds". No techniques have been proposed that would clean these areas without killing the mussels.

Clams

Marginal declines in clam populations were noted in 1989. Native littleneck and butter clams were impacted both by oiling and cleanup, particularly high-pressure, hot-water washing. Littleneck clams transplanted to oiled areas in 1990 grew significantly less than those transplanted to nonoiled sites. Reduced growth rates were recorded at oiled sites in 1989, but not in 1991 (EVOS Trustee Council, November 1993), suggesting that the effects of the spill on growth rates were diminishing. Is has been suggested that the availability of substrates suitable for clams were reduced as a consequence of cleanup activities (EVOS Trustee Council, December 1993).

The magnitude of measured differences in the abundance of clams varied with the degree of oiling and geographic area. On sheltered beaches, the data on abundance of clams in the lower intertidal zone suggest that littleneck clams and, to a lesser extent, butter clams were significantly affected by the spill (EVOS Trustee Council, November 1993). During the 1993 public meetings, people throughout the oil spill area, but especially in Kodiak and Alaska Peninsula communities, said they still are finding clam beds that are contaminated with oil (EVOS Trustee Council, August 1993). Clams are an important resource for subsistence and recreational use within the oil spill area, and they are preyed upon by a wide variety of other resources.

Conclusions

With the exception of certain habitats and specific organisms, the intertidal zone has largely recovered from the effects of EVOS. *Fucus* and the organisms associated with the rockweed, still have not recovered in the upper intertidal zone, and many mussel beds are still contaminated with oil. With no intervention, it may take over a decade before the algal based communities resemble the prespill condition. The oil that is trapped beneath mussels is likely to remain unweathered for many years. The consequences of the presence of these sources of relatively fresh oil are unknown, but they may have negative impacts on other organisms that rely on mussels for prey.

Impact on Marine Mammals

Harbor Seals

Harbor seals are protected from commercial harvesting, harassment, and indiscriminate killing by the Marine Mammal Protection Act of 1972 (MMPA). Traditional subsistence harvest by Alaska Natives is exempted from the MMPA. The MMPA also allows for some loss from incidental take by commercial fishermen.

Harbor seal populations have responded to the protection that outlawed indiscriminate killing and commercial harvesting by increasing in many parts of their range (Harvey et al., 1990). Documented rates of increase have been as high as 22 percent per year (5-22% range) (Stewart et al., 1988; Harvey, Brown, and Mate, 1990; Olesiuk, Bigg, and Ellis, 1990). Most of these increases have been from populations that were exploited prior to the MMPA and show a response to reduced mortality. There have been no long-term studies to document changes to harbor seal populations as a result of oil spills (Stewart, Yochem, and Jehl, 1992) or from other habitat perturbations.

In contrast to harbor seal populations in other areas, seals in the central and western regions of the Gulf of Alaska have been declining since the mid-1970's (Pitcher, 1990). Population trend indices, based on counts at haulout sites, have shown a drastic decline (about 85%) in the population near Tugidak Island, in the Kodiak Archipelago. Similar declines, approximately 11 percent per year since 1984, were documented in Prince William Sound prior to the oil spill. Why these populations show decreases when other populations are increasing puzzles scientists and complicates understanding the effects and potential recovery from the *Exxon Valdez* oil spill.

Subsistence harvest and interactions with commercial fisheries (e.g., entanglement and drowning in gear, or through being shot to protect catch) may be contributing to the decline but are not thought to be the cause (Pitcher, 1990; Frost and Lowry, 1993). Records of subsistence harvest at Tatitlek and Chenega Bay, the two largest seal harvesting communities in Prince William Sound, have been gathered only intermittently; but from April 1990 to March 1991, 133 seals were harvested (ADF&G Division of Subsistence, unpublished data). This represents approximately 5 percent of the population counted during molting surveys (Loughlin, 1992, in Frost and Lowry, 1993). Although this level of harvest is unlikely to cause the decline in seal numbers, any additional mortality may slow recovery.

Interactions between harbor seals and commercial fisheries also may affect the recovery of the seal population. Seals can become entangled and drown in lost gear, or they may become injured or killed as fishermen attempt to protect their catch and nets. In 1990 and 1991, a marine mammal observer program documented interactions between the Prince William Sound salmon driftnet fishery and harbor seals. The results showed that although encounters were frequent, the number of harbor seals injured or killed were low (Wynne, Hicks, and Munro, 1992). Because this study focused on only one of the fisheries operating in the Sound, and because the sample size of documented injuries and death was very small, it is impossible to predict total interactions between seals and the commercial fisheries in Prince William Sound. However, the study does indicate that interactions with commercial fisheries within Prince William Sound are unlikely to be the cause of the long-term decline in the local seal population.

Disturbance has been documented as adversely affecting harbor seals and other pinnipeds in other parts of their range (Allen, et al., 1984; Esipenko, 1986; Johnson, et al., 1989). These studies have shown that the greatest impacts from disturbances are at haulout sites during pupping and molting. During pupping, disturbance can result in higher pup mortality caused by abandonment, or from being crushed as the adults panic and return to the water (Johnson, 1977). The greatest disturbance is caused when people walk near or through haulout sites (Johnson, et al., 1989), but disturbance also can be caused by low-flying aircraft and by boats that approach too close to the haulouts. Within the EVOS area, there have been no studies to document the amount or effects of disturbance. Without these data, it is impossible to determine if current activities, or activities likely to occur in the future, will hamper the recovery of the population. However, it is reasonable to assume that increasing disturbance at haulouts used for pupping and molting could cause additional stress and mortality.

The *Exxon Valdez* oil spill killed an estimated 300 harbor seals from the Prince William Sound population. Recent population-trend counts indicate that the population may be stabilizing from the long-term decline (Frost et al., in press); however, until the population begins to increase, it will be impossible to predict how long it will take the population to recover. In Prince William Sound, there are at least three possible ways to define recovery from the oil spill for the local harbor seal populations.

- Recovery could occur when the population has increased by 300 individuals (to compensate for the 300 lost in the oil spill) in the oiled areas.

- Recovery could occur when the population has returned to its 1970's levels of abundance. This would show recovery not only from the spill, but also whatever was causing the long-term decline.

- Recovery could occur when the trend in population is similar to those of nonoiled areas.

There are no data on injury in other regions of the oil spill area, although oiled seals were observed, and the impacts on harbor seals in these areas are unknown. However, recent trend counts near Tugidak Island (vicinity of Kodiak Island) give no indication that the long-term decline is abating (Frost and Lowry, in press). Until research is conducted to determine what is causing the long-term decline, or until monitoring shows that the populations are increasing, any estimates of recovery will be speculative.

Conclusions

At this time, there is too little information available to predict when the populations within the EVOS area will recover. Recovery is unknown for all regions of the spill area.

Sea Otters

Sea otters are expected to eventually recover to prespill numbers in all regions of the spill area. The amount of time needed before the populations have recovered from the effects of the spill will vary between regions because the level of injury differed greatly between areas. Approximately 1,000 carcasses were recovered throughout the oil spill area in 1989, but the largest numbers were collected from western Prince William Sound. As the oil moved farther from Prince William Sound, fewer sea otters apparently died from direct oiling. Because sea otters in Prince William Sound experienced the highest mortality, the subsequent Natural Resource Damage Assessment (NRDA) studies focused on Prince William Sound. There are no data on recovery or the current status of sea otters in other regions of the spill area; although surveys in 1989 could not document any population loss (Ballachey and Bodkin, pers. comm.). For the purposes of this analysis, it is assumed that the oiled portions of the Prince William Sound population represent the worse-case scenario for populations throughout the spill area.

Damage assessment studies in 1990 through 1992 indicated higher than usual mortality in prime aged animals (Monson, 1993), -- which typically is the age group least susceptible to mortality. It also was apparent that young sea otters just weaned from their mothers were not surviving well (Monnett and Rotterman, 1992). The causes of these continuing signs of injury are unknown, but one hypothesis is that the sea otters are continuing to be exposed to oil through their prey. In 1992 and 1993, the prime aged mortality rates were closer to normal (Ballachey and Bodkin, pers. comm., 1994). The weanling survival rates were improving but still were different than in the nonoiled areas of the Sound (Ballachey and Bodkin, pers. comm., 1994).

There are several ways to define recovery for the injured sea otter populations. For the purposes of this DEIS, sea otters will have recovered when the populations in the oiled portions of the EVOS area have returned to their prespill numbers with no unusual additional mortality. For Prince William Sound, recovery will occur when the population in the western sound has recovered the 2,500 (approximately) individuals estimated to have been lost from the spill (Garrott, Eberhardt, and Burn, 1993).

Once the sea otter population begins to increase in the oiled area, the rate of recovery depends on the growth rate of the injured population and on the number of sea otters that move into the oiled areas from the nearby unoiled regions (immigration rate) or vice versa (emigration rate). The population growth rate for sea otters depends largely on the size of the existing population and on the condition of the habitat and the available prey. Sea otters are notorious for altering their habitat through heavy predation on certain prey species (Kvitek et al., 1989; Riedman and Estes, 1990). In the absence of sea otters, prey species such as sea urchins, crabs, and clams become plentiful again. Sea otters were exterminated from much of their historic range, including most of the EVOS area, from overharvesting for their fur. Over the last century, they have recolonized many parts of their historic range.

Research has shown that when sea otters move into an area with abundant prey, they can increase their population by as much as 20 percent per year (Estes, 1990). For sea otter populations already established in an area like Prince William Sound, it is reasonable to assume that the growth rate would be less than the theoretical maximum of 20 percent. For any population growth to occur, the habitat must be able to support more sea otters. None of the NRDA or restoration research studies have specifically examined the carrying capacity of the oiled areas for sea otters; however, studies of the subtidal and mid- to lower intertidal zones are encouraging and suggest that portions of these important areas are on their way towards recovery (Highsmith et al., December 1993).

The immigration and emigration rate of sea otters to and from nonoiled areas also will influence the recovery of the injured sea otter population. Because the boundaries of the spill area extend beyond the areas immediately oiled, there are populations of sea otters within the spill area that were not directly affected by the oil spill and that may help to recolonize the oiled areas. Based on information from a telemetry study of female and weanling sea otters in Prince William Sound, there were no signs of movements between oiled (western Prince William Sound) and nonoiled (eastern Prince William Sound) areas (Monnett and Rotterman, 1992). Hinchinbrook Entrance is a deep-water area with strong tidal fluxes and may serve as a substantial barrier for migrating sea otters (Monnett and Rotterman, 1992). This analysis assumes that the patterns also apply to the movements of male sea otters and that the immigration rate equals the emigration rate and will, therefore, be zero.

Another factor that will influence the rate of recovery is the level of subsistence harvest. Although sea otters are protected from commercial harvest and harassment under the MMPA, there is an exemption that allows for subsistence harvest by Alaska Natives. At this time, reported subsistence harvest of sea otters within the spill area is fairly low but is increasing throughout the area. Sea otters are not harvested for food, but some are harvested to use their fur for subsistence, crafts, and artwork. In the mid-1980's, a ruling broadened the interpretation of what types of products could be made from sea otter pelts and increased the list of products that could be sold. After this ruling, sea otter harvests increased significantly. Within the oil spill area, records of reported sea otter harvests showed that before the ruling (1972 to 1987), approximately 250 sea otters were harvested in 14 communities within the spill area. Records for 1988 through 1993 show that the harvest increased to approximately 700 animals for the spill area (USFWS, unpublished data).

So what type of an estimate of recovery can be made for sea otters in Prince William Sound? Current estimates of the number of sea otters that died as a result of the oil spill in the western portion of Prince William Sound range between 2,000 and 3,000 (Garrot, Eberhardt, and Burn, 1993). For purposes of illustration, assume a constant growth rate that can be as high as 10 percent or as low as 2 percent and that the subsistence harvest remains low; then, regaining the 2,500 individuals lost could take from 7 to 35 years. There are no signs that the population in the western Sound is beginning to increase; therefore, the 7- to 35-year estimates are delayed until the population shows signs of increasing. These estimates assume that the subsistence harvest remains low in the affected areas. If harvest rates rise substantially in the oiled areas, then the recovery estimates based on a 10-percent growth rate are unlikely, and it is possible that the more conservative estimate of 35 years would be extended.

Sea otters in other regions of the oil spill area are believed to have suffered lower mortality than sea otters in Prince William Sound. For the Kenai Peninsula, the highest mortality estimates are approximately 500 individuals (DeGange et al., 1993). Based on a population of approximately 2,200 and the same assumptions used for Prince William Sound, the recovery estimates would vary between 3 and 12 years. For Kodiak and the Alaska Peninsula, it is reasonable to assume that once populations begin to increase, which already may have begun, they will return to their prespill populations more quickly.

Conclusions

Assuming moderate growth rates, a low immigration rate, and that the subsistence level remains negligible, sea otters in Prince William Sound could recover in 7 to 35 years after the population begins to increase. For other regions in the EVOS area, the populations should return to their prespill levels in less time.

Impact on Birds

Harlequin Duck

July surveys of post spill harlequin duck populations in Prince William Sound have shown significantly higher numbers since the spill than indicated by surveys in the 1970's and 1980's. Regardless, a substantial portion of the harlequin duck population was killed by the EVOS, populations remains depressed in the spill zone compared with the nonoiled zone, and there still is little evidence of breeding in the spill zone. Not acquiring upland habitat possibly would put nesting habitat at risk from logging or other development, thus further assaulting the injured population. Oil is still buried in the sediments beneath several mussel beds in the oiled areas. Cleaning these mussel beds would not happen under this alternative, resulting in possible continuing sublethal injury. Harlequin duck populations need to be monitored at regular intervals to determine their recovery status, but monitoring would cease under this alternative

Conclusions

In the short term through 1995, populations likely will remain at 1990 - 1993 levels in both oiled and nonoiled areas. However, if reproductive failure continues in harlequin ducks in the oiled area, natural mortality would cause the population to decrease. No measures to restore the injured harlequin duck population would be taken, nor would the status of the injured population be known. The long-term effects of this alternative would possibly be a loss of critical nesting habitat in forested riparian habitat and subsequent reduction of reproduction capacity in the EVOS area.

Murres

Under this alternative, restoration measures to replace common murres lost to the EVOS would not be taken, nor would possible measures be taken to eliminate disturbance that may impede reproduction at injured colonies. Murre populations and productivity need to be monitored regularly to determine their recovery status, but such monitoring would be unlikely under this alternative.

Common murres reproduced normally at the Barren Islands in 1992 and 1993, but population levels have shown little sign of recovery. The earliest that post-EVOS young from the Barren Islands may reproduce is 1995, and the population should therefore start growing slowly in 1995 or 1996 as young birds begin joining the breeding population. Immigration of young murres from colonies not affected by the EVOS would accelerate population recovery over natural productivity at the colony. However, it seems unlikely that immigration would add much to natural population recovery.

Conclusions

Over the long term, this alternative could take the Barren Islands population 20 to 80 years to recover fully. However, recent insight on population recovery of common murre populations, based on 20 years of data from the Bering Sea, suggests that the population at the Barren Islands may recover within 20 years (Roseneau, oral comm., 1994).

Pigeon Guillemot

Numbers of pigeon guillemots had declined throughout Prince William Sound - from about 15,000 birds in the 1970's - up to the time of the EVOS. Population estimates since the spill indicate a continued depressed pigeon guillemot population in the spill area compared with the nonoiled area. Pigeon guillemot populations and productivity need to be monitored at regular intervals to determine their recovery status, but this will not occur under this alternative.

Guillemot colonies occur in a narrow zone immediately adjacent to tidewater in steep, rocky habitat. If development of a type that could possibly interfere with normal breeding at a guillemot colony were to occur in this zone, recovery of the injured guillemot population could be impeded to some degree. However, guillemots sometimes nest in and near man-made structures, so coastal development would not necessarily mean the demise of a given colony. However, there is little information about the effects of specific kinds of development on guillemot colonies. Also, the lack of predator control under this alternative may result in predators such as northwestern crows and mink helping to keep the population depressed, thus slowing recovery of the injured pigeon guillemot population.

Conclusions

The short-term effects of this alternative on the injured pigeon guillemot population in Prince William Sound through 1995 are expected to be negligible. Expected effects outside of Prince William Sound are unknown. The local population at Naked Island may continue to decrease slowly on the short term, but on the long term through 2001, the guillemot population for all of Prince William Sound should stabilize or slowly increase. This alternative would have a low-negative overall effect on recovery of the pigeon guillemot population.

Marbled Murrelet

The EVOS directly killed an estimated 8,400 marbled murrelets, although studies that detected reduced populations of other bird species in the oiled zone compared with the nonoiled zone did not detect a similar reduction in marbled murrelet numbers. Numbers of marbled murrelets had declined from the 1970's up to the time of the EVOS, although July population estimates since the spill indicate that the Sound-wide population may be stabilizing, and counts at Naked Island are now similar to pre spill levels.

Clear-cut logging of private land in eastern Prince William Sound in the Port Fidalgo area since 1991, and on the outer coast of Montague Island (Patton Bay) since 1993, has reduced potential murrelet nesting habitat in the EVOS area. Continued development of private land will possibly put additional segments of the murrelet population at risk, thus further assaulting the injured Prince William Sound murrelet population.

Conclusions

Projected logging with the accompanying loss of nesting habitat, on the long term, may have a low-to-moderate negative effect on recovery of the injured murrelet population.

Impact on Fish

Pink Salmon

If actions are not implemented to restore or rehabilitate populations of injured pink salmon resources in the EVOS area, this resource will recover to prespill levels or stabilize at a new level only because of natural processes of time and because of a continuation of normal resource management activities by the responsible agencies. Monitoring studies and activities would not be performed to document the rate, level, or time of recovery. The long-term natural recovery of pink salmon to prespill conditions or a new stable condition will require an estimated 20 years (EVOS Trustee Council, April 1993). This amounts to 10 generations of pink salmon.

Wild stocks of pink salmon populations, however, may never fully recover to prespill conditions. Wild stocks that spawned in oiled streams had significantly greater egg mortality than stocks that spawned in nonoiled streams (Bue et al., 1993). Contrary to expectations, these differences have continued to persist and, during 1993, it was determined that stocks that had spawned in oiled habitat have developed an inheritable character that reduces egg survival. This increase in egg mortality may result in as much as a 10-percent decline for the entire pink salmon run in Prince William Sound (Spies, 1994). It is likely that this genetic damage will persist for some time in the population.

According to Alternative 1, habitat protection for this resource will rely only on those measures that are included as part of the normal planning and permitting activities of State and Federal agencies (Appendix C). Any potential developmental activities that may be proposed on either private or public lands must be reviewed as part of the permitting process before it is allowed to proceed. Although this affords substantial protection for anadromous streams and coastal waters, the protection is incomplete and various activities may occur outside a prescribed buffer zone that may result in a degradation of fish spawning or rearing habitat and, consequently, have a negative impact on fish populations. Thus, without habitat protection and acquisition, or other restoration actions it is likely that the fish populations will suffer a long-term decline and may never recover to prespill conditions.

Conclusions

No changes are expected within one lifecycle, however, long-term recovery of the injured pink salmon resource is expected to require approximately 20 years (10 generations), however, the recovery of wild stocks may never recover to 100 per cent of the prespill population (EVOS Trustee Council, April 1993). Because of the inheritable changes in egg survival, it is likely that there will be a 10-percent reduction of the population of pink salmon within Prince William Sound (Spies, 1994). Fortunately, this reduction is not expected throughout the entire EVOS area. Wherever spawning habitat may become reduced as a result of developmental activities, however, pink salmon populations will be further affected.

Sockeye Salmon

If actions are not implemented to restore or rehabilitate injured populations of sockeye salmon, recovery will be slow, aided only by natural processes and very conservative management activities of the responsible agency. Monitoring studies would occur only as part of the normal annual monitoring activities of the management agencies. In the Kenai River drainage and Akalura Lake, on Kodiak Island, recovery will occur only after the zooplankton populations have recovered and the sockeye salmon fry populations have become reestablished at prespill levels without any other complications (Burgner, 1991). This long-term natural recovery rate may have begun and may be completed within 10 years (2 generations), or it may require as much as 50 years (10 generations) (EVOS Trustee Council, April 1993).

Although the exact mechanism that caused these injuries to sockeye salmon are not fully understood, it is clear that there was an overescapement of spawners into these drainages in 1989 because of the oil spill. Observations suggest that the unusually large number of spawners produced unusually large numbers of young sockeye salmon that overpopulated their lake-rearing habitat. The available food was not sufficient to meet the needs of the fish and fewer fry were able to survive their first winter in the lakes. This resulted in a smaller number of smolts that migrated to the ocean. The estimated smolt production in the Kenai River system was 30,000,000 in 1989, 6,000,000 in 1990, 2,500,000 in 1992 and 1993, and fewer than 1,000,000 in 1993. The forecasted returns of adult sockeye salmon in 1994 and 1995 are not expected to achieve spawning escapement needs (Spies, 1994). Although a lowered escapement will result in a lower fry production which, in turn, will allow the population of food organisms to recover, it will likely also result in lowered escapements by future generations of sockeye salmon as well.

According to this alternative, there will be no effort to increase normal fisheries management capabilities. Consequently, the management approach will be conservative; and,not only will it take longer to verify if recovery is achieved, but it will be more difficult as well.

In addition, according to Alternative 1, habitat protection for this resource will rely only on those measures that are included as part of the normal planning and permitting activities of State and Federal agencies (Appendix C). Any potential developmental activities that may be proposed on either private or public lands must be reviewed as part of the permitting process before it is allowed to proceed. Although this affords substantial protection for anadromous streams and coastal waters, the protection is incomplete and various activities may occur outside a prescribed buffer zone that may result in a degradation of fish spawning or rearing habitat and, consequently, have a negative impact on fish populations. Thus, without habitat protection and acquisition, or other restoration actions it is likely that the fish populations will suffer some long-term decline and may never recover to prespill conditions.

Conclusions

No recovery can be expected to accrue in one lifecycle, but a long-term recovery may be expected within 10 to 50 years and it is reasonable to expect that the injured populations may recover to prespill conditions (EVOS Trustee Council, April 1993). However, there also is a moderate risk that the prey populations of zooplankton and predator populations of sockeye salmon fry may never achieve the same balance of prespill conditions or that some habitat degradation may occur because of developmental activities.

Pacific Herring

If there are no actions implemented to improve the injured Pacific herring populations, recovery to prespill conditions can occur only through long-term natural processes and normal conservative fishery management approaches by the responsible agency. Although sublethal impacts by the oil have been documented, it still is unclear if the population has been injured because Pacific herring have a long generation time, complex population dynamics, and a widely fluctuating natural population (Brady et al., 1991). In addition, there is evidence that the oil may have affected their reproductive capability and the oil is implicated in an outbreak of a virus in the Prince William Sound Pacific herring population (Spies, 1994). Although Pacific herring runs in 1992 and 1993 (and again in 1994) were low, it still is uncertain if this was caused by the impact of the oil; however, only about 5 to 10-percent of the Pacific herring spawning areas were affected (Spies, 1994).

According to this alternative, there will be no effort to increase normal fisheries management capabilities; consequently, the management approach will be conservative and it will take longer to verify if recovery is achieved. In addition, according to this alternative, habitat protection for this resource will depend only on those measures that are included as part of the normal planning and permitting activities of State and Federal agencies (Appendix C). Any potential developmental activities that may be proposed on either private or public lands must be reviewed as part of the permitting process before it is allowed to proceed. Although this affords substantial protection for anadromous streams and coastal waters, the protection is incomplete and various activities may occur outside a prescribed buffer zone that may result in a degradation of fish spawning or rearing habitat and, consequently, have a negative impact on fish populations. Thus, without habitat protection and acquisition, or other restoration actions it is likely that the fish populations will suffer some long-term decline and may never recover to prespill conditions.

Conclusions

No improvements are expected to accrue within one life- cycle. The long-term recovery of Pacific herring is unknown because, although there is evidence to suggest that the EVOS had an effect on Pacific herring reproduction, it is not possible to blame their population declines solely on the oil spill (Spies, 1994). Ultimately, however, some spawning groups may not recover to prespill conditions and some can be expected to recover sooner than others.

4 Environmental Consequences

Social and Economic Impacts

Archaeological / Cultural Resources

Injury to cultural resources resulted from oiling, from cleanup activities, and from post cleanup activities. Physical damage to archaeological and historic sites occurred through erosion, looting, and vandalism, all of which were exacerbated by the response to the oil spill. This damage is ongoing at some locations and will continue unless specific types of actions are taken. It is estimated that the oil spill area contains between 2,600 and 3,137 cultural properties, including 1,287 known archaeological sites as recorded by the Alaska Heritage Resources Survey. The extent of damage to 24 sites has been documented and can serve as a base from which to infer the trajectory of site degradation should the No Action Alternative be selected. The exact number of injured archaeological sites is unknown, but estimates suggest that 113 sites were damaged. Damage to the cultural heritage values associated with archaeological and historical sites is hard to measure, and no assessment data is available. It is assumed here that restoration actions that address damage to archaeological and historical sites also will assist in recovery of cultural heritage values damaged by the spill.

Archaeological and historical sites cannot recover in the same sense as biological species or organisms. They represent a category of finite, nonrenewable resources. Their importance was emphasized in over 100 public comments received from throughout the State of Alaska.

The effects of oil on carbon for radiocarbon dating remains uncertain. Archaeologists will remain leery of dates obtained from oiled sites without further research on these effects. Destruction of any part of the archaeological record for the area is of serious concern simply because the importance of individual parts has not been established. Besides the artifacts and archaeological associations lost through these injuries, the loss of cultural properties has a deleterious effect on local communities and the cultural patrimony of the Nation. The Native peoples of Prince William Sound, the Kenai Peninsula, the Kodiak Archipelago, and the Alaska Peninsula see these sites as a tangible connection to their ancestral heritage. Among these sites are burial areas where the human remains and associated objects remain an important cultural and spiritual link between contemporary people and their ancestors. To lose these sites affects the connection these people have with the past, their sense of cultural continuity, and their community cohesiveness. Losing these sites also would be an affront to the Nation's spirit of religious protection, historic preservation, and archaeological knowledge as expressed in numerous laws and their implementing regulations.

In their current state, cultural properties in the spill area are in danger of vandalism, looting, and erosion. Erosion destroys the context by which archaeologists identify, classify, and explain sites, sometimes leaving only a few artifacts as clues. This has resulted largely from disturbance to vegetation that stabilizes deposits exposed to the ocean or streams. These exposed artifacts are then subject to weathering. Casual visitors or looters may destroy or collect these artifacts. Exposure of artifacts also may spark the interest of visitors otherwise unaware of archaeological remains at a site, prompting unpermitted and damaging digging or collecting.

Vandalism already has seriously affected some sites. Key diagnostic artifacts have been illegally taken, ancient burial sites have been violated, and potholes dug by looters have destroyed critical evidence contained in the layered sediments. The extent of the vandalism as compared with the effect of the oil spill response on cultural resources has been determined only in a few cases, but it is documented that vandalism is a serious threat to cultural properties.

Should the No Action Alternative be selected, injuries will not be repaired to any degree through stabilization of eroding sites, nor would eroded artifacts be removed, restored (if oiled), and stored in an appropriate facility. Sites and artifacts would not be protected from further injury from looting and vandalism. The actual extent of damage would not be known because no monitoring would be done. Sites would not be excavated to retrieve scientific and cultural knowledge before irreparable damage resulted.

Short-term effects would be negligible, since change in site condition would be gradual. Within 10 years and beyond, increased public knowledge of site locations (knowledge spread because of the oil spill response) may escalate the level of looting and vandalism. For the purposes of this analysis, 10 years will be considered long-term because the available information does not allow for reasonable estimates of effects beyond that time. In the long term, of all or part of at least 24 sites are likely to be damaged or destroyed. The estimated long-term effects of this alternative are expected to extend to beyond the estimated 113 sites already damaged because of increased knowledge of site location. Also, a documented increase in numbers of recreational and tourist visitors will translate to increased impacts on sites, whether or not such impacts are intentional.

Conclusions

Short-term effects:	Negligible. No immediate changes to the condition of archaeological resources would take place, and changes are expected to be gradual.
Long-term effects:	Low Negative Effect. The proposed action may cause continued lack of protection of archaeological resources, resulting in damage to several sites.

Subsistence Uses

If no projects are funded that would facilitate either (1) the recovery of species on which subsistence users depend or (2) the recovery of subsistence users' confidence in the lack of health risk associated with subsistence use, present trends in subsistence use will continue. In the short term, the effect of this alternative would be negligible. The level of subsistence harvest, as measured in pounds per person, would continue rising to, or beyond, prespill levels in some communities. Because of a lack of restoration actions, harvest levels would remain below prespill levels in other communities, with the Native villages of Tatitlek, Chenega Bay, and Ouzinki at most risk of continued lowered harvest levels. Under this alternative, lands in the spill area that now provide important habitat for some subsistence species (such as salmon, seals, and clams) would remain unprotected from extractive economic activities like logging and mining. Should those activities happen in environmentally sensitive areas, the resulting degradation of habitat may cause additional instability in the populations of species important for subsistence, possibly leading eventually to reduced populations of target species and reduced levels of subsistence activities. This would be a long-term high-level negative effect. Long term, for the purposes of this analysis, is considered 10 years because present information does not allow a reasonable projection of conditions beyond that length of time.

A major long-term effect of this alternative to subsistence use would be the likely continued uncertainty of the safety of subsistence foods. There is a persisting fear of remaining contamination in traditional foods. This may cause continued stress to community members and further degradation of subsistence lifestyle as younger people (1) are not taught the methods and attitudes that accompany subsistence activities and (2) become more dependent on imported foods.

Even if species on which subsistence users depend were to recover unassisted over the long term, the negative effect of the hiatus in subsistence use as it relates to reintegration of cultural values into the communities would likely be high. These cultural values are intertwined with stories, lessons, techniques, history, place names, and so on that are relevant only in subsistence activities. They are not passed on outside that context and are impossible to fully reconstruct if not passed down.

Conclusions

Short-term effects:	Negligible. Any changes to the existing situation would be slow and gradual.
Long-term effects:	High Negative Effect. Persistent fear of remaining contamination in subsistence foods and instability in populations of species used for subsistence may result in lack of recovery in subsistence uses in some communities.

Recreation and Tourism

The No Action Alternative would have a negligible effect on recreation or tourism in the short term. Present trends of increased levels of tourism and shifts in recreation locations and activities would continue. These trends include higher visitor rates, especially tourist user groups such as cruise ship passengers, State Ferry passengers, and lodge guests. They also include shifting of recreation activities away from oiled beaches.

Damage to tourism came from two main sources: damage to natural resources negatively affecting people's desire to visit the area and displacement of usually tourist-oriented services to spill-oriented services.

The oil spill is estimated to have caused the potential loss of 9,400 visitors for the summer of 1989, representing $5.5 million in in-State expenditures. However, strongly spill-related business in some major cleanup areas such as Kodiak, Homer, Seward, Valdez, and Anchorage gained business because of the oil spill. Business sectors like hotels/motels, car/RV rentals, and air taxi and boat charters were among those to benefit. For these businesses, business otherwise lost through lack of vacation/pleasure visitors was offset through cleanup-related business. The large decline in business for tourism associated with 1989 were less severe in 1990, with 12 percent of businesses showing negative impacts. Negative impacts continued through 1990, with fewer bookings because of the spill, particularly among fishing lodges in Southwest Alaska (McDowell Group, 1990). The No Action Alternative would probably not cause a reduction in the trend of tourism-related business regaining prespill service levels and so is likely to have no effect.

Because oil fouled beaches, there was and still is a reduction of quality destinations available to some recreation users. There also was a reduction in quality of remote destinations in the spill area because cleanup activities inserted people, noise, and large motorized equipment throughout the spill area and disturbed the area's undeveloped and normally sparsely occupied landscape. This is no longer a significant effect in the spill area because the level of cleanup activity has decreased dramatically. However, some materials used during cleanup remain dispersed throughout the spill area, and the effects of having so many people on the shores and adjacent uplands remain visible in many places. In the No Action Alternative, no funds would be expended to conduct activities that would reduce these effects.

Public-use cabin rentals and visitor-use data from the State of Alaska, Chugach National Forest, and Kenai Fjords National Park show fewer visits in some of the spill area in 1989 and 1990. Decreased use is an injury to those who would like to have used the area but avoided it because of the spill. Some recreation users were temporarily or permanently displaced from their customary or preferred sites due to spill-related changes such as crowding, presence of oil, or other factors. Because of the oil spill, others changed the type or location of recreation use in which they historically engaged. While fewer people visited some areas, other areas experienced increased use. In some cases, increased use is causing additional resource damage and decreased enjoyment of overused areas.

Under the No Action Alternative, no actions would be taken to readjust shifted use patterns. In the short term, this would have negligible effect. However, in the long term, continued decreased use in some areas is likely to continue. Also in the long term, overuse of some areas may lead to further shifting of recreation activities as overuse areas become no longer desirable. This would decrease visitor satisfaction and place greater stress on land owners (both public and private) to reduce impacts to new, potentially unauthorized areas. New areas may be on or near sensitive locations: habitat for recovering or protected species, traditional subsistence use areas, or cultural sites.

The oil spill caused injury to the way people perceive recreation opportunities in the spill area. Public comment indicates that people experienced an increased sense of vulnerability of the ecosystem concerning future oil spills and erosion of wilderness character. There is a continued sense of permanent change, including unknown or unseen ecological effects and complete disruption of the ecosystem and contamination of the food chain.

People who used the spill area before the oil spill occurred generally have greater perceptions of injury than first-time recreation users of the spill area. Perceptions change more often for shore-based recreation users than those who remain on vessels. The No Action Alternative will not, in the short term, affect people's perceptions of recreation opportunities in the spill area. Over the long term, people's perceptions of recreation opportunities are tied to the recovery of natural resources in the spill area. Some displaced users are returning to the spill area, and if more species recover and evidence of oil and cleanup dissipates, then perceptions of opportunities for recreation in the spill area will be enhanced. The converse is true as well--if natural resources do not recover, perceptions of injury to recreation opportunities likely will not improve.

If this alternative is selected, logging and/or mining may occur throughout portions of the spill area important for recreation and tourism, producing a long-term negative effect. Effects would be twofold, including more direct and less direct aspects. Direct aspects are those that reduce the immediate recreation quality. These include such things as reducing the visual quality of relatively undeveloped landscape (the uncut and unscarred hillsides, wildlife viewing opportunities), and the insertion of people and machinery into the natural setting (mechanical action, noise, and even odors). Indirect effects on recreation are those that affect the ecosystem on which these services depend, including reduction in wildlife habitat.

There are some long-term effects that differ among user groups. Tourist user groups (cruise ship passengers, ferry passengers, lodge guests, and boaters who do not often put to shore) will experience low to negligible level of impact from the residual effects of the EVOS. Tourist services will continue to increase as new facilities are developed, adding time to long-term recovery unless extensive mining and logging occur. This is in contrast to remote and dispersed recreation (those activities like kayaking, beachcombing, and motor boating, where people spend considerable time in the intertidal and adjacent coastline zones), which are likely to experience continued negative impact in the long term. Shifting of recreation activities from oiled to non-oiled areas is likely to continue on a long-term basis, thereby impacting specific areas and facilities through continued human use.

Some recreation facilities were injured by the spill, most from overuse or misuse during 1989 and 1990. The No Action Alternative will not affect this injury in the short term, but the long-term scenario would be of continued damage, leading to closure or destruction of affected facilities.

Conclusions

Short-term effects:	Negligible. Changes in the existing situation are expected to be gradual.
Long-term effects:	Low to Moderate Negative Effects. The proposed action may result in continuation of existing trends in recreational and tourism use, leading to damage to the resources on which these services depend.

Designated Wilderness

Designated Wilderness and Wilderness Study areas will have recovered when oil is no longer encountered in these areas and the public perceives them as recovered from the spill. This alternative will develop no means to address the presence of oil or public perceptions of recovery in Wilderness areas. This will accrue a negligible short-term effect. The long-term effect will be persistence of oil in designated Wilderness areas and Wilderness Study areas, although these pockets of oil are expected to eventually weather to a level of insignificance. Public perception of damaged Wilderness will persist as well.

The proposed actions would provide for no efforts to maintain the wilderness character of *de facto* wilderness, i.e. those lands with wildland characteristics of isolation, relatively undeveloped landscapes, and few and temporary visits by people, but which have not been designated by the Federal or State governments as Wilderness Areas or Wilderness Study Areas. This would cause a negligible effect in the short term. It is estimated that without efforts to protect these lands from extractive activities, a moderate to high degree of negative impact to the wilderness character of these lands would occur over the long term.

Conclusions

Short-term effects:	Negligible. Changes to designated Wilderness Areas and Wilderness Study Areas, as well as to *de facto* wilderness, are expected to be slow.

Long-term effects: Moderate to High Negative Effects. The proposed action may result in continued presence of oil and public perception on damage to the wilderness qualities of designated Wilderness Areas and Wilderness Study Areas, as well as to *de facto* wilderness.

Commercial Fishing

If no actions are taken to restore or augment injured commercial fish species or to provide new alternate commercial fishing opportunities, the recovery of these fisheries will depend solely on the natural recovery of the injured pink salmon, sockeye salmon and Pacific herring populations and normal conservative management practices of the responsible agency. Most commercial fisheries in the EVOS area can be expected to be managed very conservatively by the resource manager until the injured resource populations are demonstrated or are believed to be recovered. This attitude may persist for 10 to 50 years depending on the injured resource and the specific population. Any real or perceived uncertainty about the status of the recovery of these populations by the management agency will be reflected in the most conservative approach to the management of that resource.

If the commercial fisheries do not recover, the fishers may be forced out of this area or their profession or they may convert their personal resources to target other fishery opportunities. In response to commercial fishery closures in 1989, for example, harvests of rockfish increased dramatically. These secondary effects may result in declines of other fishery resources and may also affect fishery management strategies.

In addition, according to this alternative, habitat protection for this resource will rely only on those measures that are included as part of the normal planning and permitting activities of State and Federal agencies (Appendix C). Any potential developmental activities that may be proposed on either private or public lands must be reviewed as part of the permitting process before it is allowed to proceed. Although this affords substantial protection for anadromous streams and coastal waters, the protection is incomplete and various activities may occur outside a prescribed buffer zone that may result in a degradation of fish spawning or rearing habitat and, consequently, have a negative impact on fish populations. Thus, without habitat protection and acquisition, or other restoration actions it is likely that the fish populations and commercial fisheries will suffer some long-term decline and may never recover to prespill conditions.

Conclusions

No observable improvements are expected within one life cycle of the commercially-important species, Pacific herring and pink and sockeye salmon. Long-term recovery can be expected through the natural process although some areas or commercial fisheries may never recover to pre-spill conditions and some populations may recover sooner than others.

Sport Fishing

If no actions are taken to restore injured sport fish species or to provide new alternate opportunities, the recovery of this service will depend solely upon natural recovery rates of the injured populations of cutthroat trout, Dolly Varden, and sockeye and pink salmon through normal management agency activities. Any uncertainty by the fishers or the resource manager about the recovery of these resources will result in more conservative actions.

In addition, according to this alternative, habitat protection for this resource will depend only on those measures that are included as part of the normal planning and permitting activities of State and Federal agencies (Appendix C). Any potential developmental activities that may be proposed on either private or public lands must be reviewed as part of the permitting process before it is allowed to proceed. Although this affords substantial protection for anadromous streams and coastal waters, the protection is incomplete and various activities may occur outside a prescribed buffer zone that may result in a degradation of fish spawning or rearing habitat and, consequently, have a negative impact on fish populations. Thus, without habitat protection and acquisition, or other restoration actions it is likely that the fish populations and the sport fisheries will suffer some long-term decline and may never recover to prespill conditions.

Conclusions

No improvements are expected within one life cycle. Long-term recovery to at or near prespill levels can be expected although some resources and some populations will recover sooner than others, and some resources or populations may never recover to pre-spill levels. Confidence in the rates of recovery will be low without monitoring. Real or perceived recovery of the injured resources and thereby the services they provide may require 10 or more years (EVOS Trustee Council, April 1993).

Economy

Qualitative analysis indicates that Alternative 1 will result in moderate negative economic effects in commercial fisheries and recreation and moderate economic benefits in forestry as a result of timber harvesting. Quantitative analysis reflects effects resulting from habitat acquisition on forestry and other sectors but not effects on commercial fishing and recreation because data are not available to quantify in these sectors. The quantitative analysis follows.

The title "No Action Alternative" is somewhat misleading with respect to economic impacts. Under Alternative 1, no lands would be purchased for habitat or facilities would be constructed or services purchased for restoration. However, it is assumed for the purpose of economic analysis for this alternative that the $620 million would be invested. Therefore, as indicated in Table 4-3 , Alternative 1, the most significant economic effects are in the finance, insurance, and real estate sector, for which there is a $1.6 million increase in output, and in the services sector, for which there is a $0.76 million increase. The total increase in output is $3 million. The employment increase is 21 in finance, insurance, and real estate and 15 in services. The total increases for all sectors are $3.04 million for output and 47 jobs.

See the introduction to economics in Chapter 4 and Appendix D, Economics Methodology, for a more detailed discussion of methodology.

Conclusions

Short-term effects: Negligible. Short-term impacts are anticipated to negligible.

Long-term effects: Qualitative analysis indicates that Alternative 1 will result in moderate negative effects in commercial fisheries and recreation. Quantitative analysis reflects effects resulting in several sectors from investment but not effects on commercial fishing or recreation. Quantitative analysis indicates that Alternative 1 results in annual averages in output for a 10-year period in increases of $1.6 million for the finance, insurance, and real estate sector; $0.76 million in the services sector; and $3 million for all other sectors. Employment increases jobs by 21 in the finance, insurance, and real estate sector; 15 in services; and 47 total.

Table 4-3. Alternative 1: 100% Invested, 0% Administration, 0% Monitoring, 0% Restoration, 0% Habitat Protection
Change from Base in 1990$ Millions

Economic Sector	Final Demand $	Industry Output $	Employee Comp. $	Property Income $	Value Added $	Employment #
Forestry	0.000	0.000	0.000	0.000	0.000	0
Commercial Fisheries	0.000	0.000	0.000	0.000	0.000	0
Mining	0.005	0.013	0.001	0.006	0.010	0
Construction	0.000	0.019	0.010	0.004	0.014	0
Manufacturing	0.004	0.018	0.005	0.003	0.007	0
Recreation Related	0.034	0.012	0.005	0.002	0.007	0
Communication & Utilities	0.008	0.107	0.030	0.040	0.071	1
Trade	0.038	0.047	0.028	0.006	0.034	1
Finance, Insurance, Real Estate	1.511	1.603	0.628	0.351	1.033	21
Services	0.579	0.765	0.298	0.219	0.512	15
Government	0.446	0.457	0.450	0.002	0.452	8
Miscellaneous	0.000	0.000	0.000	0.000	0.000	0
Total	2.595	3.041	1.444	0.641	2.146	47

Source: IMPLAN Economic Model. See text for methodology.

Alternative 2: Habitat Protection

Introduction

This Alternative focuses on increasing the protection of the greater EVOS ecosystem through protecting strategic lands and habitats important to resources and thereby the services they provide injured by the spill. For purposes of analysis in this alternative, 91 percent of the remaining settlement funds would be used for habitat acquisition and protection. Fee title acquisition, conservation easements, or other less-than-fee-simple methods would be used to provide protection to habitats on private lands. Increasing the protection of habitat throughout the oil-spill area will be beneficial to the entire ecosystem by reducing further habitat degradation that may compound the effects of the oil spill. Monitoring activities would follow the progress of natural recovery for the injured resources.

Impacts on Biological Resources

Impact on Intertidal Resources

In this alternative, the restoration program concentrates exclusively on habitat-protection actions that prevent or reduce habitat loss and disturbance to resources and thereby the services they provide injured by the EVOS. This analysis considers the impacts of protecting the 81 upland parcels described in the Comprehensive Habitat Protection Process; Large Parcel Evaluation & Ranking Volume I and Volume II (EVOS Restoration Team, 1993). Smaller parcels that also may be considered for protection under this alternative are currently under solicitation and evaluation.

The habitat protection process used to evaluated the 81 parcels for their potential benefits to injured resources and thereby the services they provide combined intertidal and subtidal biota and used the following criteria for ranking the parcels:

- High for parcels adjacent to areas with a known high species abundance and diversity; high quality habitat for intertidal and subtidal biota;

- Moderate for parcels adjacent to extensive intertidal habitat with observed or probable moderate species diversity and abundance; and,

- Low for parcels with little intertidal habitat with low species abundance (EVOS Restoration Team, 1993).

Of the 81 parcels evaluated using these criteria, 25 of the parcels were ranked High, 33 were ranked Moderate, 19 were ranked Low, and 4 were not associated with the coastline and had no rating for intertidal/subtidal organisms (EVOS Restoration Team, 1993).

The benefits to intertidal and subtidal organisms through the protection of upland habitats comes in two forms. First, the protection can prevent the intertidal and subtidal areas from being altered by the actions that may occur on the parcels. Some actions can cause indirect adverse effects through siltation or increased pollution, while other actions such, as the construction of a dock or creating a new harbor, directly could alter the intertidal and subtidal habitats. The second type of protection reduces the disturbance caused by increased human activity (e.g., more people walking through the intertidal area; more pollution from littering or from bilge discharge). Obviously, the type of activity that may occur on a given parcel can substantially change the degree of benefit that is gained from protecting upland parcels adjacent to the intertidal and subtidal zones.

The overall benefit from protecting all of the 81 parcels identified in the large parcel process is Moderate based on the evaluation criteria, but the actual benefit gained by the intertidal and subtidal organisms depends on the type and location of the activities that may occur. In areas where construction activities are anticipated in the intertidal zone, the protection would be especially effective. If the parcels correspond to areas of the intertidal zone that are still not recovering from the effects of the oil spill, the benefits could be even greater.

Conclusions

Short-term effects:	Negligible. A change in ownership would not necessarily translate into a change in current activities.
Long-term effects:	Moderately Beneficial. The protection can span a large portion of the intertidal zone, but the potential for reducing disturbance or preventing additional injury would vary substantially between parcels.

Impact on Marine Mammals

Harbor Seals

In this alternative, the restoration program concentrates exclusively on habitat protection actions that prevent or reduce habitat loss and disturbance to resources and thereby the services they provide injured by the EVOS. This analysis considers the impacts of protecting the 81 upland parcels described in the Comprehensive Habitat Protection Process; Large Parcel Evaluation & Ranking Volume I and Volume II (EVOS Restoration Team, 1993). Smaller parcels that also may be considered for protection under this alternative, are currently under solicitation and evaluation.

Harbor seals use haulout sites that are either in the intertidal zone or immediately adjacent to the intertidal zone; therefore, actions that occur on the uplands are not likely to destroy the habitat. However, it is possible that habitat changes to the uplands may increase the amount of disturbance currently experienced at haulout sites on or near the parcel. Disturbance has been documented as adversely affecting harbor seals and other pinnipeds in other parts of their range (Allen et al., 1984; Esipenko, 1986; Johnson et al., 1989). These studies have shown that the greatest impacts from disturbances are at haulout sites during pupping and molting. During pupping, disturbance can result in higher pup mortality caused by abandonment, or from being crushed as the adults panic and return to the water (Johnson, 1977). The greatest disturbance is caused when people walk near or through haulout sites (Johnson, et al., 1989), but disturbance also can be caused by low-flying aircraft and by boats that approach too close to the haulouts.

Habitat-protection criteria for parcels that may benefit harbor seals include ratings of:

- High for parcels known to have a haulout of 10 or more seals on or immediately adjacent to the parcel;

- Moderate for parcels with known haulouts with sporadic use and less than 10 seals, or probable haulouts in the vicinity of the parcel or probable feeding in nearshore waters; and,

- Low for possible feeding sites located in nearshore waters adjacent to the parcel (EVOS Restoration Team, 1993).

Of the 81 parcels evaluated in the large parcel process, 25 of the parcels were ranked High, 19 of the parcels were ranked Moderate, 35 were ranked Low, and 2 parcels were ranked as having no benefit to harbor seals. The overall value of these parcels, based on these rankings, is moderate, although individual parcels may have exceptional value.

The actual impact that development on these parcels will have on harbor seals depends on, among other things, the type of disturbance caused, the length and duration of the disturbance, and whether or not the haulout area is used for pupping or molting. Within the EVOS area, there have been no studies to document the amount or effects of current activities that may cause disturbance to harbor seals, so baseline data are unavailable. However, it is reasonable to assume that protection of upland habitats near haulout sites will reduce the risk of disturbance to the injured population.

Conclusions

Short-term effects:	Negligible. Compared to the existing condition of the habitat, the protection of upland parcels is not expected to produce any notable change in disturbance.
Long-term effects:	Low to Moderate benefits. Of the 81 parcels included in this analysis, over half include haulout sites near or on the parcels. Although the type of use at these haulout sites is not known, many of them may be used during pupping and molting.

Sea Otters

In this alternative, the restoration program concentrates exclusively on habitat-protection actions that prevent or reduce habitat loss and disturbance to resources and services injured by the EVOS. This analysis considers the impacts of protecting the 81 upland parcels described in the Comprehensive Habitat Protection Process; Large Parcel Evaluation & Ranking Volume I and Volume II (EVOS Restoration Team, 1993). Smaller parcels that also may be considered for protection under this alternative, are currently under solicitation and evaluation.

As with harbor seals, the benefit to sea otters of habitat-protection actions on upland parcels is through reducing potential or actual disturbance. Sea otters appear to have a high tolerance to certain human activities, as evidenced by their abundance in highly travelled areas such as Orca Inlet near Cordova; however, their response to large-scale disturbances has not been studied. Large-scale disturbances, such as log-transfer sites, may force resident sea otters to leave the immediate area and may cause a long-term change in food availability as debris from the logs covers the substrate. Disturbance is more likely to cause adverse effects to females with pups that concentrate in high-quality habitats with abundant prey in the intertidal zones.

Habitat-protection criteria for parcels that may benefit sea otters include ratings of:

- High for parcels adjacent to known pupping concentrations;

- Moderate for parcels adjacent to concentration areas for feeding and/or shelter or potential pupping areas; and,

- Low for feeding sites located in adjacent waters (EVOS Restoration Team, 1993).

Of the 81 parcels evaluated in the large parcel process, 20 of the parcels were ranked High, 16 of the parcels were ranked Moderate, 42 were ranked Low, and 3 parcels were ranked as having no benefit to sea otters. The average value of these parcels for sea otters, based on these rankings, is low to moderate, although individual parcels may be near habitat of exceptional value.

Conclusions

Short-term effects:	Negligible. Compared to the existing condition of the habitat, the protection of upland parcels is not expected to produce any notable change in disturbance or in the health of the population.
Long-term effects:	Low benefits. Assuming that adverse effects of disturbance are likely to be most notable when large-scale disturbances are near concentrations of females and pups the benefits of habitat protection would be low. Of the 81 parcels included in this analysis, 25 percent are near known pupping concentrations. Of these, several are in areas where there is less risk of large-scale disturbances. However, because the effects of disturbance are unknown, the benefits may be greater than anticipated here.

Impact on Birds

Harlequin Duck

Under this alternative, nesting and riparian habitat of harlequin ducks that is presently unprotected would receive maximum protection, thus assuring that their reproductive potential is not reduced. Reducing breeding habitat would further assault the injured population. The effect on the ecosystem of larger populations of harlequin ducks would likely be low-to-negligible increases in predation on bottom fauna of the intertidal and shallow subtidal zones due to increasing populations of harlequins back to pre-spill levels.

The 81 parcels that were evaluated in the large parcel process were rated as high, moderate or low value for harlequin ducks based on the following definitions. High, for known nesting or molting concentrations on the parcel, and where feeding occurs on the parcel. Moderate rankings for parcels with probable nesting or molting on or adjacent to the parcel, and with probable feeding in the streams, estuary or intertidal area in or adjacent to the parcels. Low rankings were assigned to parcels where feeding and loafing adjacent to the parcel are possible; or where some offshore molting occurs (EVOS Restoration Team, 1993). Of the 81 parcels evaluated using these criteria, 24 were ranked High, 25 were ranked Moderate, 32 were ranked Low, and none had no value to harlequin ducks (EVOS Restoration Team, 1993). Overall, habitat protection and acquisition under this alternative has a high value to harlequin ducks.

Conclusions

Short-term effects:	Negligible. The short-term effects through 1995 of land acquisition on harlequin duck recovery are likely to be negligible, and populations would remain at levels observed during 1990 to 1993 surveys.
Long-term effects:	High. The highly beneficial long-term effects of this alternative would provide maximum protection of existing reproductive potential of harlequin ducks, therefore guarding against possible future loss of nesting and feeding habitat through development.

Murres

Protection of habitat would have relatively little overall benefit to the injured murre population, because there are no sizeable colonies and very few smaller colonies that are not already protected. This can be demonstrated with an analyses of the value to common murres of parcels being considered for acquisition in the "large parcel process." Of the 81 parcels that are being considered for this alternative in this process, none were determined to be of high value to murres, 7 more were considered to be of moderate value, and 73 were of low or no value to murres. The overall benefit to common murres of these parcels is low. A seabird colony on privately-owned Gull Island in Kachemak Bay has a colony of 10,000 common murres, and it is an attraction that several commercial tour boats visit daily in summer. Gull Island is considered to be a "small parcel," and is not included in the large parcel analysis

Conclusions

Short-term effects:	Negligible. All large colonies of murres, and most smaller ones, are already protected, so the benefit of habitat protection to murres would be negligible.
Long-term effects:	Low. The effect of this alternative on murre populations throughout the EVOS area would be low. However, acquisition of Gull Island in Kachemak Bay would ensure protection of this colony, and thus may have a moderate long-term local benefit to murres.

Pigeon Guillemot

In Prince William Sound, the large majority of pigeon guillemot colonies are on U. S. Forest Service (USFS) land (Sanger and Cody, written comm., 1994) that is within the Nellie Juan-College Fjord Wilderness Study Area. Under current Forest Service policy, the study area is being managed as wilderness until such time as Congress resolves the Study Area's final status, and this area is thus not slated for logging (USDA, Forest Service, 1994). Two of the largest colonies in Prince William Sound, on The Pleiades and Bligh Islands, total approximately 3 percent of the 1993 breeding population, and are on private land (Sanger and Cody, written comm., 1994). In the 1970's, both of these colonies probably had larger numbers of nesting guillemots than presently.

Two small colonies adjacent to private land that currently is being logged on the eastern, nonoiled portion of Prince William Sound had very few guillemots in 1993; it is unlikely that they were affected by the inland logging operations (Sanger and Cody, written comm., 1994). Outside of Prince William Sound, Seal Bay on Afognak Island has low numbers of pigeon guillemots and has already been acquired. The current status of guillemot colonies elsewhere in the EVOS area, including Kenai Fjords National Park, is uncertain because there have been no surveys specifically designed for this species, an essential requirement for accurate counts of breeding populations (Sanger and Cody, written comm., 1994; USFWS, 1993).

The 81 parcels that were evaluated in the large parcel process were rated as high, moderate or low value for pigeon guillemots based on the following definitions. High, for parcels with known colonies on or immediately adjacent to the parcel, and with known feeding concentrations in nearshore waters. Moderate rankings for parcels with probable nesting and known feeding in nearshore waters. Low rankings were assigned to parcels with a low likelihood of nesting; but with possible feeding in nearshore waters (EVOS Restoration Team, 1993). Of the 81 parcels that are being considered for this alternative in this process, 20 were determined to be of high value to pigeon guillemots, 23 more were considered to be of moderate value, and 31 were of low value, and 6 were considered to be of no value to pigeon guillemots. The overall benefit to pigeon guillemots of these parcels is moderate.

Conclusions

Short-term effects: Negligible. Habitat acquisition would have a negligible effect on pigeon guillemot population recovery on the short term, because there appears to be no development slated for private land with known colonies.

Long-term effects: Moderate. On the long term, protecting habitat where two of the largest colonies in Prince William Sound are located would be moderately beneficial in allowing population recovery and in preventing further inroads to the injured population through habitat degradation.

Marbled Murrelet

Details of habitat use by marbled murrelets are being clarified, and studies in Prince William Sound showed that large, moss-covered limbs of old-growth conifers comprise prime nesting habitat. Current and possible future logging of such habitat on private land is the single greatest threat to population recovery of marbled murrelets, and it poses the additional threat of reducing the population more. Acquisition of prime nesting habitat would thus maximize the potential for the injured marbled murrelet population to recover while preventing further injury to the population.

The 81 parcels that were evaluated in the large parcel process were rated as high, moderate or low value for marbled murrelets based on the following definitions. High, for parcels with known nesting or where there is high confidence that nesting occurs, and where feeding occurs in adjacent nearshore waters. Moderate rankings for parcels with probable nesting, and with known feeding areas in adjacent nearshore waters. Low rankings were assigned to parcels with a low likelihood of nesting; and possible feeding in nearshore waters (EVOS Restoration Team, 1993). Of the 81 parcels that are being considered for this alternative in this process, 21 were determined to be of high value to marbled murrelets, 42 more were considered to be of moderate value, and 18 were of low value, and none were considered to be of no value to marbled murrelets. The overall benefit to marbled murrelets of these parcels is high.

Conclusions

Short-term effects:	High. Depending on the potential for imminent logging on land parcels that contain prime habitat, the short-term effect of protecting habitat under this alternative could be beneficially high.
Long-term effects:	High. On the long term, acquisition of old-growth forest habitat would have the highest possible benefit for ensuring murrelet population recovery.

Impact on Fish

Pink Salmon

Alternative 2 includes only one restoration action to assist natural recovery of wild-stock pink salmon populations: habitat protection and acquisition (EVOS Trustee Council, 1993).

Habitat protection criteria for parcels that may benefit pink salmon include ratings of High for parcels with a high density of pink salmon streams or streams known to have exceptional value; Moderate for parcels with an average density of pink salmon streams or streams with average production, and, Low for parcels with few or no pink salmon streams or streams with no production (EVOS Restoration Team, 1993).

Habitat protection that may benefit wild-stock pink salmon populations, according to Alternative 2, includes purchase of all available parcels. This is expected to provide low to moderate benefit for the pink salmon resource (Appendix A). Of the 81 parcels that may be purchased from the estimated budget that is forecasted for this alternative, 0, 38, 25, and 18 have been rated as no, low, moderate, and high value, respectively, for pink salmon. Although the average value of forecasted habitat acquisition may not have a high overall rating for pink salmon, individual parcels may have exceptional value. In the event that some of these parcels may not be protected through acquisition, the habitat will continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

Conclusions

Short-term effects.	Negligible. No benefits from habitat protection would be accrued within one lifecycle.
Long-term effects.	Moderate. Habitat protection and acquisition actions would have a long-term benefit to pink salmon stocks in the EVOS area by helping to ensure maintenance of wild-stock production. More than half of the parcels that may be purchased have moderate or high value for pink salmon.

Sockeye Salmon

Alternative 2 includes only one restoration action to assist natural recovery of wild-stock sockeye salmon populations: habitat protection and acquisition (EVOS Trustee Council, 1993).

Habitat protection criteria for parcels that may benefit sockeye salmon include ratings of High for parcels with sockeye salmon streams or systems known to have exceptional value; Moderate for parcels with sockeye salmon streams or systems with average production; and, Low for parcels with few or no sockeye salmon streams or systems with low production (EVOS Restoration Team, November 1993).

Habitat protection that may benefit wild-stock sockeye salmon populations, according to Alternative 2, includes purchase of all available parcels. This is expected to provide an overall low benefit (Appendix A). Of the 81 parcels that may be purchased from the estimated budget that is forecasted for this alternative, 16, 48, 8, and 9, have been rated as no, low, moderate, and high value; respectively, for sockeye salmon. Although the average value of forecasted habitat protection and acquisition may not have a high overall rating for sockeye salmon, individual parcels may have exceptional value. In the event that some of these parcels may not be protected through acquisition, the habitat will continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

Conclusions

Short-term effects.	Negligible. No benefits from habitat protection can be expected within one life cycle.
Long-term effects.	Moderate. Habitat protection and acquisition actions would have a long-term benefit to sockeye salmon stocks in the EVOS area by helping to ensure maintenance of wild-stock production; however, fewer than one-fourth of the individual parcels that may be purchased are rated as moderate or high value for sockeye salmon. Some parcels, however, can be expected to have unique value.

Pacific Herring

Alternative 2 includes only one restoration action to assist natural recovery of Pacific herring; habitat protection and acquisition (EVOS Trustee Council, 1993).

Habitat protection criteria for parcels that may benefit Pacific herring include ratings of High for parcels with a documented consistent annual Pacific herring spawning along the parcel shoreline, Moderate for parcels with occasional spawning along the parcel shoreline, and, Low for parcels with no documented Pacific herring spawning along the parcel shoreline, but a possible feeding area (EVOS Restoration Team, 1993).

Habitat protection that may benefit Pacific herring populations includes the purchase of all available parcels and is expected to provide moderate benefit (Appendix A). Of the 81 parcels that may be purchased from the estimated budget that is forecasted according to this Alternative, 7,30,29, and 15, have been rated as no, low, moderate, and high value, respectively, for Pacific herring. Although the average value of forecasted habitat acquisition may not have a high overall rating for Pacific herring, individual parcels may have exceptional value. In the event that some of these parcels may not be protected through acquisition, the habitat will continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

Conclusions

Short-term effects.	Negligible. No benefits would be accrued within one lifecycle.
Long-term effects.	Moderate. Habitat-protection and -acquisition actions would have a long-term benefit to Pacific herring stocks in the EVOS area by helping to ensure maintenance of production. Over half of the parcels that may be purchased have moderate or high value for Pacific herring.

Social and Economic Impacts

Archaeological / Cultural Resources

It is assumed that 81 large parcels would be purchased under this alternative. These parcels contain low (no known or suspected cultural resources/sites on parcel), moderate (no significant cultural resources/sites on or adjacent to parcel), or high (documented concentration or significant cultural resources/sites on parcel) potential for benefiting cultural resources as analyzed by the Habitat Protection Work Group (November 30, 1993). If low potential benefit on a parcel is assigned a value of 1, moderate potential benefit a value of 2, and high potential benefit a value of 3, these parcels average 1.9 (or slightly lower than moderate). These estimates reflect known sites in the EVOS area, not all of the sites believed present through use of archaeological models. Not all sites have been found, so the actual benefit to cultural resources may be greater than reflected in these estimates. This analysis does not consider small-parcel acquisition, which is currently under evaluation.

A change in land status from private to public management would put these lands within the purview of historic preservation laws that are otherwise not applicable. Under the present situation, only laws protecting private lands from trespass and theft may be used to protect archaeological and historical resources. A selection of laws that would newly apply includes: the National Historic Preservation Act, the Archaeological Resources Protection Act, the Alaska Historic Preservation Act, the Native American Graves Protection and Repatriation Act, and Executive Order 11593. Under these laws, historic properties must be inventoried and taken into consideration when activities could impact them. Penalties are prescribed for damaging historic properties without appropriate permits and consultation, and the concerns of interested parties must be considered. Which laws apply depends on whether the lands are under management of the State of Alaska or the Federal Government. This may be an immediate benefit to the cultural resources on acquired parcels, and would remain in effect for the long term.

Under this alternative, lands otherwise open to extractive economic activities (like logging and mining) may be closed to those activities. This would increase the level of protection to archaeological sites and historical sites in the long term. The locations and types of archaeological properties are not fully known, so inadvertent damage or destruction to undiscovered sites may be reduced in this alternative.

There are 1,287 known archaeological or historical sites in the spill area. While it is estimated that between 2,600 and 3,137 sites are present, those estimates are based on a minimal inventory. While archaeological surveys were conducted along much of the shoreline of the EVOS area, very little work has been accomplished in the uplands before, during, or since the spill and resulting cleanup. Because there is so little knowledge about the cultural resources in the spill area, and because many of these sites contain human remains important to specific groups of people, any actions taken to significantly protect these resources from damage will be considered a high benefit to the resource. This alternative would affect all of the parcels and additionally could establish the basis for inventorying lands upland from the intertidal zone. This alternative would not in itself provide any new information about cultural resources in the spill area but may help ensure the potential for gaining new information in the future.

Conclusions

Short-term effects:	Low Benefits. There would be immediate effect of extending cultural resource protection laws to acquired lands, though changes to the condition of archaeological resources would be gradual.
Long-term effects:	Moderate Benefits. The proposed action could improve site protection over much of the spill area.

Subsistence Uses

It is assumed that 81 large parcels would be purchased under this alternative. These parcels contain low (status as a subsistence-use area is unknown); moderate (known historic subsistence-use area, which may be used again); or high (known current subsistence-use area) potential for benefiting subsistence uses as analyzed by the Habitat Protection Work Group (November 30, 1993). If low potential benefit on a parcel is assigned a value of 1, moderate potential benefit a value of 2, and high potential benefit a value of 3, these parcels average 2.4 (or between moderate and high). Under this alternative, there will be no change in subsistence regulations, activities, or locations. This means there will be no direct short-term effects. Indirect effects include further protection of habitat from potential degradation from extractive economic activities. As this alternative is intended to enhance the ability of the environment in the EVOS area to restore plants and wildlife, it also may enhance the area's capability to support plants and animals for subsistence harvest in the long term. The degree to which this is true depends on the location of acquired land. Some lands under consideration are excellent habitat for subsistence foods while others are less productive; so, effects are likely to be local enhancements of some species populations. Discussion of the effect of this alternative on each of the species important for subsistence is included in the sections on specific resources in this alternative. Please refer to those sections for additional information. The perception of continued contamination of subsistence food resources will not be addressed by this alternative.

Conclusions

Short-term effects: Negligible. Under the proposed action, there would be no change in subsistence regulations, activities, or locations.

Long-term effects: Low to Moderate Benefits. The proposed action may help stabilize or locally increase some species important for subsistence use.

Recreation

It is assumed here that 81 large parcels would be purchased. These parcels contain low (low to no recreation use; access may be difficult); moderate (receives occasional public use; adjacent waters used for recreational boating; adjacent area receives high public use); or high (receives regular, high directed public use; highly visible to a large number of recreationists/tourists) potential for benefiting recreation and tourism as analyzed by the Habitat Protection Work Group (November 30, 1993). If low potential benefit on a parcel is assigned a value of 1, moderate potential benefit a value of 2, and high potential benefit a value of 3, these parcels average 1.8 (or slightly lower than moderate).

Acquiring lands potentially available for logging and/or mining may allow for better protection of the condition of those lands that make them valuable for recreation and tourism. The benefit is twofold, including more or less direct aspects. The direct aspects are those that reduce the potential for negative impacts to immediate recreation quality. These include reducing the quality (visual, auditory, etc.) of relatively undeveloped landscapes (the uncut and unscarred hillsides, wildlife viewing opportunities) and the insertion of people and machinery into the natural setting (mechanical action and noise). The indirect effects on recreation are those that affect the ecosystem on which these services depend, including reduction in wildlife habitat. It is estimated that this alternative may allow increased numbers of visitors, and that recreation quality would increase in some locations. Through protection of recreational quality and by maintaining some degree of existing viable habitat for species important for recreational activities, this alternative may produce an overall moderate positive benefit to recreation and tourism in the long term. The benefits of this alternative would vary by parcel. These benefits would be negligible in the short term.

Conclusions

Short-term effects: Negligible. The proposed action require some time after implementation before any changes could be expected.

Long-term effects: Moderate Benefits. The proposed action may help maintain the quality of the landscapes and the stability of the ecosystems on which these services depend.

Designated Wilderness

It is assumed here that 81 parcels would be purchased. These parcels contain low (high/moderate evidence of human development and/or ongoing activities); moderate (area remote; evidence of human development and/or ongoing activities); or high (area remote; little or no evidence of human development) potential for benefiting wilderness as analyzed by the Habitat Protection Work Group (November 30, 1993). If low potential benefit on a parcel is assigned a value of 1, moderate potential benefit a value of 2, and high potential benefit a value of 3, these parcels average 2.3 (or slightly higher than moderate). These rankings consider wilderness character (not formal Wilderness designation) because designated Wilderness is already under public management. Parcels being considered for acquisition are now private lands, so have no formal Wilderness designation.

Habitat acquisition could increase the boundaries of designated Wilderness, either actually or *de facto*. If inholdings within designated Wilderness were acquired, these lands potentially could be subsumed as part of the Wilderness, thereby increasing management efficiency for those lands. These inholdings may or may not become designated Wilderness. If lands adjacent to designated wilderness were acquired, they would effectively extend the range of the Wilderness protection, though they would be outside of formal designation. Similarly, acquisition of lands within Wilderness Study Areas could convert those acquired lands to Wilderness Study Area status. However, lands acquired outside of established Wilderness Areas or Wilderness Study Areas would become Wilderness Areas or Wilderness Study Areas themselves only if designated as such by state or federal legislatures.

Acquiring these types of lands may increase protection for plants and animals, as well as wilderness qualities associated with remoteness and an undeveloped landscape, through reducing the potential for impacts by logging and/or mining in the long term. Short term, there would be no significant benefits. Residual oil would not be removed, and public perception of damage to Wilderness would not be addressed. Long-term benefits to designated Wilderness and Wilderness Study Areas may, therefore, be low.

There are large areas of wilderness-like land in the spill area that are not designated Wilderness. These are remote, relatively undeveloped areas that contain many of the same characteristics as designated Wilderness but that have no differentiating regulatory standing. A considerable amount of the private land being evaluated for habitat protection and acquisition fits this description. The effects on these areas under this alternative are essentially the same as for recreation. That is, habitat acquisition may decrease the potential for negative impacts to wildland characteristics, impacts such as reducing the quality of relatively undeveloped landscapes (the uncut and unscarred hillsides, wildlife viewing opportunities); reducing the quality or quantity of recreation activities (hiking, sport fishing, sport hunting, and so on); and the insertion of people and machinery into the natural setting (mechanical action, noise, and even odors). Acquision may also benefit wilderness settings through helping to maintain the ecosystem on which the quality of those settings depend, including reduction in wildlife habitat.

Conclusions

Short-term effects: Neglibible. Any changes expected under the proposed action are expected to take considerable time.

Long-term effects: Low to Moderate Benefits. The proposed acion may result in extending protection to now-private lands having considerable wilderness character.

Commercial Fishing

Alternative 2 includes only one restoration action, habitat protection and acquisition, to assist recovery and maintenance of commercial fishing activities (EVOS Trustee Council, April 1993).

Habitat protection may benefit commercial-fishing opportunities by providing long-term protection for natural production and stability of wild stocks of pink and sockeye salmon and Pacific herring. This action is expected to provide low to moderate benefit because of the protection accorded to those stocks (Appendix A). In the event that some of these parcels may not be protected through acquisition, the habitat will continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

Conclusions

Short-term effects. Negligible. No benefits will be accrued within one life cycle of the protected species.

Long-term effects. Moderate. Habitat protection and acquisition actions may have a long-term benefit to salmon and Pacific herring stocks in the EVOS area by helping to ensure maintenance of wild-stock production to support the commercial fishing industry.

Sport Fishing

Alternative 2 includes only one restoration action, habitat protection and acquisition, to assist recovery and maintenance sport-fishing activities. (EVOS Trustee Council, April 1993).

Habitat protection may benefit sport fishing by providing long-term protection and stability for production of pink and sockeye salmon, Dolly Varden, and cutthroat trout. Forecasted habitat acquisition that may benefit sport fishing is expected to provide low to moderate benefit for the long-term production of sport fishes (Appendix A). Although the average value of forecasted habitat acquisition may not have a high overall rating for sport fishing values, individual parcels may have exceptional value. In the event that some of these parcels may not be protected through acquisition, the habitat will continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C). In addition, some of the benefits accrued through habitat acquisition for recreation in the EVOS area also will benefit sport fishing by providing access to new fisheries and development of recreational sites and boat-launching facilities. Some habitat degradation will occur, however, wherever recreational sites are provided or new sport-fishing opportunities are developed.

Conclusions

Short-term effects. Negligible. No benefits will be accrued for sport fishing opportunities immediately upon a purchase.

Long-term effects. Moderate. Habitat protection and acquisition actions may have a long-term benefit to sport fishing activities in the EVOS area by helping to ensure maintenance of fish production and access for the sport-fishing activities.

Economy

Qualitative analysis indicates that Alternative 2 will result in moderate economic benefits in commercial fisheries and recreation and moderate negative effects in forestry. Quantitative analysis reflects effects resulting from habitat acquisition on forestry and other sectors but not effects on commercial fishing and recreation, because data are not available to quantify in these sectors. The quantitative analysis follows.

In Alternative 2 significant timberlands will be acquired and it is assumed that signficant timber will not be harvested. As shown in Table 4-4 Alternative 2 annual average industry output is projected to decline by $38.8 million and employment is anticipated to decline by 440 employees.

Spending of money by timberland owners has a direct effect on the construction sector as shown in Table 4-4 alternative in the amount of $7.3 million in industry output. Spending of money by timberland owners also has a direct effect on the services sector in the amount of $6 million in final demand and 959 employees.

Spending in the construction and service sectors by timberland owners is not enough to offset the negative effects in the forestry sector. The net effect is shown in the total lline which has negative quantitites for four out of the six economic measures; only emmployee compensation and employment are positive.

Habitat acquisition and general restoration expenditures will have economic benefits for the commercial fisheries and recreation sectors of the economy. However, these benefits are not reflected in the IMPLAN projections presented in Table 4-4 . Therefore, this table does not quantify important economic benefits in commercial fishing and recreation because these benefits are not quantified. Of the three most important economic sectors for this analysis, only forestry is quantified. The typical projects in various combinations, such as fish ladders, fish hatcheries, and preservation of habitat will economically enhance the commercial fisheries and recreation sectors of the economy. However, because studies and data are not available that quantify in terms of dollars or employment, it is not possible to quantify the economic effects for these two sectors of the economy. In Table 4-4 the quantities for the commercial fisheries and recreation sectors are reflections of the indirect effects of other sectors of the economy only; they are not reflections of the anticipated but unquantified effects on those sectors.

Short-term impacts are anticipated to be negligible.

See the introduction to Chapter 4 on economics and Appendix D, Economics Methodology, for a more detailed discussion of methodology.

Conclusions

Short-term effects: <u>Negligible.</u> Short-term impacts are anticipated to be negligible.

Long-term effects: Qualitative analysis indicates that Alternative 2 will result in moderate economic benefits in commercial fisheries and recreation and moderate negative effects in forestry. Quantitative analysis reflects effects resulting from habitat acquisition on forestry and other sectors but not effects on commercial fishing and recreation. Quantitative analysis indicates that Alternative 2 results, in annual averages for a 10-year period, in a loss of approximately $38 million in forestry industry output, an increase of $7 million in construction industry output, and $3 million in services. The corresponding changes in employment are a loss of 440 jobs in forestry, an increase of 65 in construction, and an increase of 959 in services.

Table 4-4. Alternative 2: 4% Administration, 5% Monitoring, 0% Restoration, 91% Habitat Protection
Annual Average Change from Base in 1990$ Millions

Economic Sector	Final Demand $	Industry Output $	Employee Comp. $	Property Income $	Value Added $	Employment #
Forestry	-31.977	-38.823	-8.219	-5.236	-14.642	-440
Commercial Fisheries	0.000	0.001	0.000	0.000	0.000	0
Mining	0.065	-0.043	-0.003	-0.020	-0.033	-0
Construction	8.066	7.376	2.705	1.100	3.824	65
Manufacturing	0.062	-0.610	-0.097	-0.028	-0.142	-1
Recreation Related	0.062	0.033	0.015	0.001	0.020	1
Communication & Utilities	0.111	0.143	0.034	0.071	0.106	1
Trade	0.530	0.235	0.116	0.024	0.149	9
Finance, Insurance, Real Estate	2.563	2.324	0.586	0.163	0.788	52
Services	6.026	2.833	4.620	-1.127	3.497	959
Government	0.809	0.677	0.730	-0.019	0.711	14
Miscellaneous	0.000	0.000	0.000	0.000	0.000	0
Total	-13.702	-25.854	0.486	-5.115	-5.722	659

Source: IMPLAN Economic Model. See text for methodology.

Alternative 3: Limited Restoration

Introduction

In this alternative, the General Restoration program focuses only on the components of the ecosystem that were most injured by the oil spill. General restoration actions are sometimes able to help resources and thereby the services they provide, recover to their prespill conditions more rapidly than if the actions were not implemented. The general restoration program would be limited to the most effective actions in order to maximize the available funds for habitat protection activities. Habitat Protection and Acquisition can provide protective benefits to all resources and services injured by the spill as well as to other resources and human uses that are important to the greater EVOS ecosystem. Increasing the protection of habitat throughout the oil spill area would be beneficial to the entire ecosystem by reducing further habitat degradation that may compound the effects of the oil spill. The Monitoring and Research Program would evaluate the effectiveness of restoration actions and follow the recovery progress of the injured resources and thereby the services they provide.

Impacts on Biological Resources

Impacts on Intertidal Resources

There are three actions that affect the intertidal zone that have been identified for this alternative--habitat protection, accelerating the recovery of *Fucus* in the upper intertidal zone, and cleaning oiled mussel beds.

Habitat Protection and Acquisition

Although there are several types of actions that apply under this restoration category, this analysis considers only the types of benefits that may be gained from protecting the 81 upland parcels identified in the Comprehensive Habitat Protection Process; Large Parcel Evaluation & Ranking, Volumes I and II (EVOS Restoration Team, 1993). Other aspects of the habitat protection category, such as the small parcels available for protection, are still being developed and cannot be analyzed in this DEIS.

The habitat protection process used to evaluate the 81 parcels for their potential benefits to injured resources and services combined intertidal and subtidal biota and used the following criteria for ranking the parcels:

- "High" for parcels adjacent to areas with a known high species abundance and diversity; high quality habitat for intertidal and subtidal biota;

- "Moderate" for parcels adjacent to extensive intertidal habitat with observed or probable moderate species diversity and abundance; and,

- "Low" for parcels with little intertidal habitat with low species abundance (EVOS Restoration Team, 1993).

Of the 81 parcels evaluated using these criteria, 25 of the parcels were ranked high, 33 moderate, and 19 low, and 4 were not associated with the coastline and had no rating for intertidal/subtidal organisms (EVOS Restoration Team, November 1993). If a higher cost per acre is assumed for the protection of these parcels, fewer of the parcels that were ranked low in the overall ranking for multiple resources and thereby the services they provide are likely to be protected. Because most of these parcels also were evaluated as being of low benefit to intertidal/subtidal, the differences between the more restrictive list and the total list are minimal.

The benefits to intertidal and subtidal organisms through the protection of upland habitats come in two forms. First, protection can prevent the intertidal and subtidal areas from being altered by the actions that may occur on the parcels. Some actions can cause indirect adverse effects through siltation, or increased pollution, while other actions, such as the construction of a dock or creation of a new harbor, could directly alter the intertidal and subtidal habitats. The second type of protection reduces the disturbance caused by increased human activity (e.g., more people walking through the intertidal area; more pollution from littering or bilge discharge). Obviously, the type of activity that may occur on a given parcel can substantially change the degree of benefit that is gained from protecting upland parcels adjacent to the intertidal and subtidal zones.

The overall benefit from protecting most or all of the 81 parcels identified in the large parcel process is moderate based on the evaluation criteria, but the actual benefit gained by the intertidal and subtidal organisms depends on the type and location of the activities that may occur. In areas where construction activities are anticipated in the intertidal zone, the protection would be especially effective. If the parcels correspond to areas of the intertidal zone that are still not recovering from the effects of the oil spill, the benefits could be even greater.

General Restoration

The other two actions that have been identified for this alternative can directly affect the intertidal zone. These actions affect specific organisms, *Fucus* and mussels, but are meant to provide broader benefits to the other organisms that live or feed in these communities.

Accelerate the recovery of the upper intertidal zone. Recovery may be accelerated by re-establishing *Fucus*. The upper intertidal area, specifically the upper 1 meter vertical drop (1MVD), probably is the upper extent of suitable habitat for *Fucus* to grow. This means that the conditions are more extreme than in other habitats and would be more difficult to colonize. *Fucus* germlings that colonize in the upper intertidal area are subject to longer periods of high temperatures and dryness during low tides. Without the shelter and moisture that is provided by adult *Fucus* plants the germlings can become desiccated and die. Studies conducted in Herring Bay, Prince William Sound, suggest that it may take 3 to 4 years for *Fucus* communities to expand 0.5m beyond their existing boundaries (Highsmith et al., 1993).

Feasibility studies of techniques for accelerating the recovery of *Fucus* were begun in 1992. Attempts to transplant mature *Fucus* plants were generally unsuccessful (Stekoll, pers. comm., 1994). Another technique which uses a biodegradable cloth to cover seeded areas is currently being tested (Stekoll, pers. comm., 1994), and results of this experiment will be known after the summer of 1994. In theory, the cloth will substitute for the adult *Fucus* by providing moisture and protection to the germlings during low tides. Because the technique is still being tested, it is impossible to know how successful the action may be, or how easily it can be applied to the areas that could benefit from the action. If the technique is highly successful, the established germlings could become fully mature in 3 to 4 years and the associated invertebrates would also recolonize in the upper intertidal zone. At this time, however, it is impossible to know the outcome of the research; therefore, any benefits from this action are unknown.

Cleaning Oiled Mussel Beds. This has been considered as a possible method to reduce the hydrocarbon exposure for sea otters, harlequin ducks, and black oystercatchers. These animals depend on mussels for a large portion of their diet (Webster 1941; Dzinbel and Jarvis, 1982; Doroff and Bodkin, 1993). Mussels occur in loose aggregations attached to intertidal rocks, or in dense aggregations (mussel beds) over pea gravel and silt sediments. Because mussels form a dense matt over the sediments and rocks, oil that was trapped beneath the mussels was not exposed to weathering and still remains toxic. It may be possible to clean mussels in mussel beds, but cleaning will not be possible in all habitats where mussels occur.

One of the possible explanations for continuing signs of injury to sea otters, river otters, harlequin ducks, and black oystercatchers is that they continue to be exposed to hydrocarbon contamination by eating oiled mussels. Concern over this possible continuing source of contamination led to feasibility studies to develop techniques to clean the sediments beneath the oiled mussel beds. One technique to be tested in 1994 lifts sections of the mussel beds and replaces the contaminated sediments with clean sediments without serious damage to the mussel beds (Babcock, pers. comm., 1994). Other techniques are likely to damage the existing mussels when contaminated sediments are removed. Approximately 60 locations with oiled mussel beds have been identified in Prince William Sound. Oiled mussels beds have been identified and sampled from the Alaska Peninsula and Kodiak, however, estimates on the number of exisiting oiled mussel beds are unavailable.

The extent and distribution of oiled mussel beds is still being determined and will be important in understanding the potential benefits that can be gained for other organisms by this action. There have been no studies to determine whether eating contaminated mussels is causing injury to other species within the EVOS area. However, other studies have documented reproductive impairment in some seabirds after ingesting oil (Epply and Robega, 1990; Fry and Addiego, 1988). The intent of cleaning oiled mussel beds is largely to eliminate a source of continuing contamination to other organisms. Studies that examined the effects of oil on the mussel beds noted a reduction in the number of large mussels and overall biomass of the mussel beds, but there did not appear to be a shortage of new recruits (smaller mussels) to the mussel beds (Highsmith, Stekoll and Barber, 1993). It is unknown whether the trapped oil beneath the mussel beds will ultimately cause further injury to the mussels; however, continued high levels of hydrocarbons have been found in mussel tissues, which indicates that the mussels may be continuing to be contaminated.

If the technique described above is successful, then this action is unlikely to cause an adverse effect and may provide tangible benefits to the mussels at the cleaned sites. Presumably, this technique would be applicable throughout the EVOS area, however, there is less information on the location of oiled mussel beds in areas outside of Prince William Sound.

Conclusions

Short-term effects: Negligible.

Long-term effects: Unknown effects. For direct restoration actions, effects are unknown because both of these actions still are being tested. The long-term effects of the Habitat Protection actions for reducing disturbance or preventing additional injury to intertidal organisms are moderately beneficial and will vary substantially between parcels.

Impacts on Marine Mammals

Harbor Seals

The greatest way to benefit the injured harbor seal populations is to determine what has caused the long-term decline of populations throughout the Gulf of Alaska. Such research activities cannot be analyzed in this DEIS because the environmental effects are dependent on the outcome of the research and how the results can be used for restoration. For this analysis we can consider only the effects of habitat protection and the two types of general restoration actions proposed in Chapter 2. Both of the proposed actions are information based programs that would be designed to change the impact of commercial fisheries or of subsistence harvest on the recovering seal populations.

General Restoration

Subsistence harvest is not believed to be the cause of the long-term decline of harbor seal populations in the Gulf of Alaska; however, any additional mortality may slow the recovery of injured populations. The subsistence harvest in Prince William Sound declined as a result of the oil spill; and in 1991, harvest levels probably were less than 5 percent of the population. A healthy seal population would be able to easily sustain that level of harvest. Depending on the distribution, sex, and age of the animals harvested, a 5- percent harvest could negatively affect an injured population.

Establish a Cooperative Program between Subsistence Users and Research Scientists or Agency Managers. One of the proposed actions would establish a cooperative program between subsistence users and research scientists or agency managers. The program would be designed to provide a two-way exchange of information that would provide benefits to all parties and could benefit the injured harbor seal population. For example, recent studies indicate that harbor seals may have a high site fidelity to molting and pupping areas (e.g., the same individuals consistently use the same areas) (Pitcher, 1990). If some of these areas show greater declines than other sites within Prince William Sound, redirecting harvest towards the healthier,--or the nonoiled, areas--could reduce any negative effects from the harvest without actually changing the number of animals harvested.

Establish a Cooperative Program between Commercial Fishermen and Agency Managers. This program also could reduce pressure on the injured seal populations. The program would provide information on deterrent methods and regulations. Ideally it would provide information to the scientists on the extent of the interactions between the commercial fisheries and the seals, and it would reduce the number of seal mortalities. The interactions with commercial fisheries probably would result in fewer deaths than from the subsistence harvest and are unlikely to be the cause of the seal decline; however, the more that can be done to minimize the effects of human-caused injury and mortality, the more likely it will be that the population will stabilize and recover.

Habitat Protection and Acquisition

Harbor seals use haulout sites that are either in the intertidal zone or immediately adjacent to the intertidal zone; therefore, actions that occur on the upland are not likely to destroy the habitat. However, it is possible that habitat changes to the uplands may increase the amount of disturbance currently experienced at haulout sites on or near the parcel. Disturbance has been documented as adversely affecting harbor seals and other pinnipeds in other parts of their range (Allen et al., 1984; Esipenko, 1986; Johnson et al., 1989). These studies have shown that the greatest impacts from disturbances are at haulout sites during pupping and molting. During pupping, disturbance can result in higher pup mortality caused by abandonment, or from being crushed as the adults panic and return to the water (Johnson, 1977). The greatest disturbance is caused when people walk near or through haulout sites (Johnson et al., 1989), but disturbance also can be caused by low-flying aircraft and by boats that approach too close to the haulouts.

Habitat-protection criteria for parcels that may benefit harbor seals include ratings of:

- "High" for parcels known to have a haulout of 10 or more seals on or immediately adjacent to the parcel;

- "Moderate" for parcels with known haulouts with sporadic use and less than 10 seals; or, probable haulouts in vicinity of the parcel; or probable feeding in nearshore waters; and,

- "Low" for possible feeding sites located in nearshore waters adjacent to the parcel (EVOS Restoration Team, 1993).

Of the 81 parcels evaluated in the large parcel process, 25 of the parcels were ranked high, 19 moderate, and 35 low and 2 parcels were ranked as having no benefit to harbor seals. Based on these rankings, the overall value of these parcels is moderate, although individual parcels may have exceptional value. If a higher cost per acre is assumed for the protection of these parcels, fewer of the parcels that are ranked low for multiple resources and services are likely to be protected. Under this scenario there would be limited effect on the benefits to harbor seals because most highly or moderately ranked parcels are still included.

The actual impact that development on these parcels will have on the harbor seals depends on, among other things, the type of disturbance caused, the length and duration of the disturbance, and whether the haulout area is used for pupping or molting. Within the EVOS area, there have been no studies to document the amount or effects of current activities that may cause disturbance to harbor seals; so baseline data are unavailable. However, it is reasonable to assume that protection of upland habitats near haulout sites will reduce the risk of disturbance to the injured population.

Aside from monitoring and research activities, and assuming that the actions previously described are implemented, none of the other actions proposed under this alternative for other resources or services are likely to impact harbor seals.

Conclusions

Short-term effects:	Negligible. All of the proposed actions require some time after implementation before any changes could be expected.

Long-term effects: Moderate Benefits. The proposed actions could reduce negative impacts on harbor seals and may result in increased recovery rates in local areas.

Sea Otters

There are three types of actions aside from research or monitoring that are considered in this alternative: habitat acquisition, cleanup of oiled mussel beds, and creation of a cooperative program between subsistence users and sea otter scientists and managers.

Habitat Protection and Acquisition

The benefit to sea otters of habitat protection actions on upland parcels is through reducing potential or actual disturbance. Sea otters appear to have a high tolerance to certain human activities, as evidenced by their abundance in highly travelled areas such as Orca Inlet near Cordova; however, their response to large-scale disturbances has not been studied. Large-scale disturbances, such as log-transfer sites, may force resident sea otters to leave the immediate area and may cause a long-term change in food availability as debris from the logs covers the substrate. Disturbance is more likely to cause adverse effects on females with pups that concentrate in high quality habitats with abundant prey in the intertidal zones.

Habitat-protection criteria for parcels that may benefit sea otters include ratings of:

- "High" for parcels adjacent to known pupping concentrations;

- "Moderate" for parcels adjacent to concentration areas for feeding and/or shelter; or, potential pupping areas; and

- "Low" for feeding sites located in adjacent waters (EVOS Restoration Team, 1993).

Of the 81 parcels evaluated in the large parcel process, 20 of the parcels were ranked high, 16 moderate, and 42 low, and 3 parcels were ranked as having no benefit to sea otters. Based on these rankings, the overall value of these parcels is low to moderate, although individual parcels may be near habitat of exceptional value. If a higher cost per acre is assumed for the protection of these parcels, fewer of the parcels that are ranked low for multiple resources and services are likely to be protected. Because most of these parcels also were evaluated as being of low benefit to sea otters, the differences in the potential benefit to sea otters would change very little because most highly or moderately ranked parcels are still included.

General Restoration

Cleaning Oiled Mussel Beds. This has been considered as a possible method to reduce the hydrocarbon exposure. Sea otters, especially juvenile otters and females with pups, depend on mussels for a large portion of their diet (Doroff and Bodkin, 1993). Mussels are found in shallower areas and are easier to obtain than other prey. Mussels occur in loose aggregations attached to intertidal rocks, or in dense aggregations (mussel beds) over pea gravel and silt sediments. Because mussels form a dense matt over the sediments and rocks, oil that was trapped beneath the mussels was not exposed to weathering and still remains toxic. It may be possible to clean mussels in mussel beds, but this will not be possible in all habitats where oiled mussels occur.

One of the possible explanations of the poor survival rate of post-weanling juveniles in the oiled areas is that they are continuing to be exposed to hydrocarbon contamination by eating oiled mussels. Concern over the possible continuing source of contaminations to sea otters and other higher order animals (e.g., black oystercatchers and harlequin ducks) led to feasibility studies to develop techniques to clean the sediments beneath the oiled mussel beds. One technique to be tested in 1994 lifts sections of the mussel beds and replaces the contaminated sediments with clean sediments without serious damage to the mussel beds (Babcock, pers. comm., 1994). Approximately 60 locations with oiled mussel beds have been identified in Prince William Sound.

The extent and distribution of oiled mussel beds is still being determined and will be important in understanding the potential benefit to sea otters that can be gained from cleaning. There have been no studies to determine whether eating contaminated mussels is causing injury to the sea otter population. However, it is possible to consider the potential benefit in terms of the level of risk to exposure. For example, the telemetry study by Monnett and Rotterman (1992) indicated that females and weanling sea otters did not range great distances between oiled and unoiled areas. If a group of sea otters spends many months feeding in bays that have several oiled mussel beds, they are at greater risk of exposure than sea otters that feed in areas with few or no oiled mussels. Of the oiled mussel beds identified so far, there are approximately 20 in Herring Bay off Knight Island; cleaning half or all of these mussel beds would greatly reduce the risk to the local population. If only 1 or 2 beds in the area were cleaned, it might not reduce the risk of exposure at all. Similarly, if the only source of oil in an entire bay was from one mussel bed, removing that contamination could eliminate the majority of the risk to the local sea otters.

Cleaning oiled mussel beds would be a labor intensive task that may last for several days at each location. Some short-term disturbance probably would occur; however, it is not likely to permanently displace the local sea otters.

It is reasonable to assume that the ability of this action to reduce the risk of exposure is equally valid in other regions of the spill area. However, there is less information on the location of mussel beds and on the injury to the sea otter population.

Establish Cooperative Program between Subsistence Users and Research Scientists or Agency Managers. Establishing a cooperative program between subsistence users and research scientists or agency managers is another action that is appropriate under this alternative. The program would be designed to provide a two-way exchange of information that would provide benefits to all parties and could benefit the injured sea otter population. Recent records of the subsistence harvest of sea otters in the oil spill area indicate that harvest levels are relatively low but increasing throughout the EVOS area. If subsistence levels increase in areas where the populations were affected by the spill, the additional harvest may slow or prevent localized recovery. For example, the densities of sea otters in some oiled areas is still very low (Bodkin and Ballachey, pers. comm., 1994). If these areas are consistently harvested, redirecting harvest towards the healthier or the nonoiled areas could reduce any negative effects without actually changing the number of animals harvested. Likewise, sea otters can sustain a greater harvest of males and juveniles than of breeding females.

Without any restoration actions, it may be reasonable to estimate that sea otters in Prince William Sound will recover to their prespill abundance in 7 to 35 years once the population begins to increase. If subsistence harvest rates rise substantially in the oiled areas, recovery estimates based on a 10-percent growth rate are unlikely and it is possible that the more conservative estimate of 35 years would be extended. If a cooperative program can be established, it may be possible to sustain a higher harvest rate without changing the recovery rate of the injured population.

Actions implemented for other resources or services are not expected to impact the sea otter populations or their recovery.

Conclusions

Short-term effects.	Negligible. All of the proposed actions will take time before any results could be expected.
Long-term effects.	Moderate Benefits. The proposed actions improve the habitat quality through reducing the risk of exposure to oil, the potential for disturbance, and the impacts from subsistence harvest. These benefits could produce a change in abundance of sea otters in some areas but are not likely to produce a notable increase on a regional scale.

Impact on Birds

Harlequin Duck

Habitat Protection and Acquisition

The main value to harlequin ducks from upland habitat acquisition is that their riparian nesting and feeding habitat will be secured, and therefore their reproductive potential will not be jeopardized by development. Eighty-one land parcels were evaluated for benefits to harlequin ducks in the "large parcel process." Assuming a relatively high cost per parcel that would result in acquisition of only 62 parcels, 23 of these parcels were determined to be of high value to harlequin ducks, and 21 more were considered to be of moderate value. Together, 71% of the parcels in this package have a moderate-to-high value for harlequin ducks, resulting a high overall benefit to this injured resource. By assuming a lower cost per parcel that would allow purchase of all 81 parcels, only one parcel of high value, and 4 more of moderate value would be added to the package. Acquiring the more restrictive package of parcels would translate into a higher average benefit.

General Restoration

Cleaning Oiled Mussel Beds. Cleaning oiled mussel beds is considered to be a possible means of reducing hydrocarbon exposure to harlequin ducks via their food chain. Mussels, clams, and other bottom prey of harlequin ducks continue to be contaminated by oil still buried in the sediments. Harlequin ducks eat the contaminated prey, thus contaminating their body tissues. Although as yet unproven, this sublethal contamination is suspected to interfere with normal reproduction, resulting in few new broods being seen in the oiled area since the spill. Production in the oiled area could eventually resume once the buried oil is removed, followed by a population increase.

Conclusions

Short-term effects: Negligible. The short-term effects through 1995 of land acquisition on harlequin duck population recovery are expected to be negligible, and populations are expected to remain at 1990-1993 levels.

Long-term effects: High. The long-term effects of this alternative would have a high benefit for maintaining, protecting, and increasing the reproductive potential of harlequin ducks. Cleaning oiled mussel beds would eliminate the source of hydrocarbon contamination of body tissues, and also enhance the food base of local populations.

Murres

Habitat Protection and Acquisition

Protection of habitat would have a low overall benefit to the injured murre population, because there are no sizeable colonies and very few smaller colonies that are not already protected. This can be demonstrated with an analyses of the value to common murres of parcels being considered for acquisition in the "large parcel process." Assuming a relatively high cost per parcel that would result in acquisition of 62 of the 81 parcels that are being considered in this process, only one was determined to be of high value to murres, 7 more were considered to be of moderate value, and the remaining 54 were of low or no value to murres. The remaining 14 parcels in the large parcel process that could be purchased with a lower average parcel cost all have a low value to murres. The overall value to common murres of either package of parcels is low. A seabird colony on privately-owned Gull Island in Kachemak Bay has a colony of 10,000 common murres, and it is an attraction that several commercial tour boats visit daily in summer. Gull Island is considered to be a "small parcel," and is not included in the large parcel analysis.

Conclusions

Short-term effects: Negligible. All large colonies of murres, and most smaller ones, are already protected, so the benefit of habitat protection to murres would be negligible.

Long-term effects: Low. The effect of this alternative on murre populations throughout the EVOS area would be low. However, acquisition of Gull Island in Kachemak Bay would ensure protection of this colony, and thus may have a moderate long-term local benefit to murres.

Pigeon Guillemot

Habitat Protection and Acquisition

In Prince William Sound, the large majority of pigeon guillemot colonies are on Forest Service (USDA, Forest Service) land (Sanger and Cody, written comm., 1994) that is within the Nellie Juan-College Fjord Wilderness Study Area. Under current Forest Service policy, the study area is being managed as wilderness until such time as Congress resolves the Study Area's final status, and this area is thus not slated for logging (USDA, Forest Service, 1994). Two of the largest colonies in Prince William Sound, at The Pleiades and on Bligh Island, totaling approximately 3 percent of the 1993 breeding population, are on private land (Sanger and Cody, written comm., 1994). In the 1970's, both of the latter colonies probably harbored larger numbers of nesting guillemots than at present. It is unlikely that two small colonies adjacent to private land that is currently being logged on the eastern, nonoiled portion of Prince William Sound, have been affected by the inland logging operations (Sanger and Cody, written comm., 1994).

Prince William Sound and the Seal Bay area on Afognak Island (Cody, Fadeley and Gerlach, 1993) are the only locations within the EVOS area with current, comprehensive knowledge of pigeon guillemot colonies, and the Seal Bay area has already been acquired. Knowledge of guillemot *colonies* elsewhere in the EVOS area, including Kenai Fjords National Park, is old and incomplete (USFWS, 1993). Specially-designed surveys are essential to locate and count guillemots at their colonies (Sanger and Cody, written comm., 1994), and these have not been done within the EVOS area outside of Prince William Sound and Seal Bay.

The 81 parcels that were evaluated in the large parcel process were rated as high, moderate or low value for pigeon guillemots based on the following definitions. High, for parcels with known colonies on or immediately adjacent to the parcel, and with known feeding concentrations in nearshore waters. Moderate rankings for parcels with probable nesting and known feeding in nearshore waters. Low rankings were assigned to parcels with a low likelihood of nesting; but with possible feeding in nearshore waters (EVOS Restoration Team, 1993). By assuming a relatively high average cost that would allow acquisition of 62 of the 81 parcels, 18 (28%) each were characterized as having a high or moderate value to guillemots, 23 (37%) had a low value, and the remaining 3 had no value to pigeon guillemots. Assuming a relatively low cost per parcel that would result in acquisition of all 81 parcels adds 3, 5, 8, and 3 parcels, respectively, with high, moderate, low, and no value to pigeon guillemots. This exercise thus suggests that habitat protection would have an overall moderately beneficial effect on recovery of the injured pigeon guillemot population.

General Restoration

<u>Predator Control</u> Predator control has the potential to increase productivity of pigeon guillemots, but little is known about the nature of predation on guillemots throughout the EVOS area. Possible predator control methods might include live trapping and translocating predators; removing eggs from the nests of avian predators and replacing the live eggs with artificial ones so the adults do not lay a second clutch; installing predator exclosures; and deploying predator-proof nesting boxes. Studies are needed to determine the severity of predation at individual colonies, and if warranted, to design specific methods to reduce predation. An EVOS predator control project on Simeonoff and Chernebura Islands just outside the EVOS area will allow recolonization and a modest population increase by pigeon guillemots (V. Byrd, oral comm., 1994). Little is known about the current status of guillemot colonies elsewhere in the EVOS area (USFWS, 1993).

Conclusions

Short-term effects: <u>Negligible</u>. Because there appears to be no development planned on private lands with known colonies of pigeon guillemots, the short-term effects of this alternative on population recovery would be negligible.

Long-term effects: Moderate. In the long term, acquiring habitat where two of the largest colonies in Prince William Sound are located would moderately benefit population recovery and prevent further inroads to the injured population through habitat degradation.

Marbled Murrelet

Habitat Protection and Acquisition

Details of habitat use by marbled murrelets are still being clarified, although studies in Prince William Sound have shown that large, moss-covered limbs of old-growth conifers are the keystone of prime nesting habitat. Current and possible future logging on private land is the single greatest threat to population recovery of marbled murrelets, and it poses the additional threat of reducing the population more. Acquisition of prime nesting habitat would thus maximize the potential for the injured marbled murrelet population to recover while preventing further injury to the population through reduction of nesting habitat.

Analyzing the value to marbled murrelets of land parcels being considered for acquisition in the "large parcel process" will help evaluate the overall effects of this alternative on marbled murrelet population restoration. By assuming a relatively high average cost that would allow acquisition of 62 parcels, 19 parcels (31%) were characterized as having a high value to murrelets, 31 (50%) more had a moderate value, 12 (19%) had a low value, and none were considered to have no value to pigeon guillemots. Assuming a relatively low cost per parcel that would result in acquisition of all 81 parcels would add 3, 5, 8, and 3 parcels, respectively, with high, moderate, low, and no value to pigeon guillemots. Thus, this exercise suggests that this alternative would have an overall moderately beneficial effect on recovery of the injured pigeon guillemot population.

Conclusions

Short-term effects: High. Depending on the potential for imminent logging on individual land parcels that contain prime murrelet nesting habitat (i.e., old growth coniferous forest), the short-term effects of land acquisition could be of high benefit.

Long-term effects: High In the long term, acquisition of old growth forest habitat would have a the highest possible benefit for enhancing murrelet population recovery.

Impact on Fish

Pink Salmon

Although Alternative 3 would provide limited restoration actions to assist natural recovery of wild-stock pink salmon populations, the only action that has been identified to restore wild-stock pink salmon populations is habitat protection and acquisition (EVOS Trustee Council, April, November 1993).

Habitat Protection and Acquisition

The criteria for parcels that may benefit pink salmon include ratings of high for parcels with a high density of pink salmon streams or streams known to have exceptional value, moderate for parcels with an average density of pink salmon streams or streams with average production, and low for parcels with few or no pink salmon streams or streams with no production (EVOS Restoration Team, 1993).

Habitat protection that may benefit wild-stock pink salmon populations according to Alternative 3 will depend on the average cost per acre and the final budget allocation, therefore, the number of parcels that may be purchased is expected to range between 62 parcels and all parcels that are available. If all available parcels are purchased, the benefit is expected to provide moderate value for the pink salmon resource (Appendix A). Of the 81 parcels that may be purchased from the estimated budget that is forecasted for this alternative, 0, 38, 25, and 18 have been rated as no, low, moderate, and high value, respectively, for pink salmon. A total of 53 percent of the parcels is rated as moderate or high value.

If only 62 parcels are purchased, the benefit is expected to provide moderate value for the pink salmon resource (Appendix A). Of the 62 parcels that may be purchased from the estimated budget that is forecasted for this alternative, 0, 25, 20, and 17 have been rated as no, low, moderate, and high value, respectively, for pink salmon. A total of 60 percent of the parcels is rated as moderate or high value.

Although the average value of forecasted habitat acquisition may not have a high overall rating for pink salmon, individual parcels may have exceptional value. In the event that some of these parcels may not be protected through acquisition, the habitat will continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

Conclusions

Short-term effects.	Negligible. No benefits from habitat protection would accrue within one lifecycle.
Long-term effects.	Moderate. Habitat protection and acquisition actions would assist the recovery of the injured wild stocks of pink salmon by protecting important habitats. Long-term benefits, however, might accrue to only portions of the EVOS area.

Sockeye Salmon

Alternative 3 provides limited restoration actions to assist natural recovery of wild-stock sockeye salmon populations. Actions that may be implemented to restore these populations as part of Alternative 3 include habitat protection, and actions that may improve survival rates of sockeye salmon eggs by using egg incubation boxes, net-pen rearing or hatchery rearing (EVOS Trustee Council, April, November, 1993).

Habitat Protection and Acquisition

The criteria for parcels that may benefit sockeye salmon include ratings of high for parcels with sockeye salmon streams or systems known to have exceptional value, moderate for parcels with sockeye salmon streams or systems with average production, and low for parcels with few or no sockeye salmon streams or systems with low production (EVOS Restoration Team, 1993).

Forecasted habitat protection that may benefit wild-stock sockeye salmon populations according to Alternative 3 would depend on the average cost per acre and the final budget allocation. Therefore, the number of parcels that may be purchased is expected to range between 62 parcels and all parcels that are available. If all available parcels are purchased, the benefit is expected to provide low value for the sockeye salmon resource (Appendix A). Of the 81 parcels that may be purchased from the estimated budget that is forecasted for this alternative, 16, 48, 8, and 9 have been rated as no, low, moderate, and high value, respectively, for sockeye salmon. A total of 21 percent is rated as moderate or high value.

If only 62 parcels are purchased, the benefit is expected to provide low value for the sockeye salmon resource (Appendix A). Of the 34 parcels that may be purchased from the estimated budget that is forecasted for this alternative, 16, 33, 6, and 7 have been rated as no, low, moderate, and high value, respectively, for sockeye salmon. A total of 21 percent is rated as moderate or high value.

Although the average value of forecasted habitat acquisition may not have a high overall rating for sockeye salmon, individual parcels may have exceptional value. In the event that some of these parcels may not be protected through acquisition, the habitat will continue to have some measure of protection through the protective actions of normal resource agency planning and permitting requirements (Appendix C).

General Restoration

Action 1: Egg incubation boxes. These boxes have been used highly successfully in the Copper River drainage to develop a small wild-stock population of sockeye salmon into an estimated annual total return of approximately 200,000 adult fish, with an estimated annual commercial harvest of over 100,000 fish (Roberson and Holder, 1993). Other experiments to incubate sockeye and chum salmon eggs in egg incubation boxes in Prince William Sound were less successful (Jackson, 1974), however, when properly installed, these units control the water flow, substrate type, sedimentation, and predation to provide egg-to-fry survival rates as high as 90 percent. This compares quite favorably with an expected survival rate of 12 to 43 percent of eggs laid in redds by spawning sockeye salmon (Drucker, 1968) where survival may be affected by extremes of environmental conditions.

The potential contribution of egg incubation boxes for the restoration of sockeye salmon stocks in the oil spill area would be limited to drainages with: (1) limited successful reproduction; (2) spring areas with appropriate physical features and water quality and quantity; and (3) underutilized rearing capacity for the sockeye salmon fry that are produced.

Although extensive surveys to locate potential sites to apply this technique have not been performed, if suitable locations can be identified within drainages that presently support small populations of sockeye salmon, this technique may be applied to help restore those populations without a major intrusion into the environment or the fish stock.

<u>Action 2: Net-pen rearing</u>. This practice has been widely applied to increase the survival rate of all salmon species. This technique, however, has only recently been applied successfully for sockeye salmon because most previous attempts have failed because sockeye salmon are particularly susceptible to the disease, infectious hematopoietic necrosis virus (IHNV) (Mr. Terry Ellison, ADF&G, oral comm. 1994).

Although the net-pen rearing technique has been applied in both freshwater and saltwater, most success has been achieved with freshwater rearing because the early lifestages from only a few stocks of sockeye salmon can survive in saltwater. Burke (1993), however, described a highly successful program for rearing juvenile sockeye salmon in saltwater net pens to the smolt stage, but only after they had been fed first in freshwater hatchery raceways. Consequently, although net-pen rearing of sockeye salmon in saltwater may have excellent potential for a hatchery-based application, it is of limited value for protection and restoration of wild stocks except where it may be used to create an alternate opportunity for commercial fishermen.

Juvenile sockeye salmon typically spend up to 3 years rearing in freshwater (Burgner, 1991). During this period, the mortality rate between the fry and smolt stages may range from 86 to 99 percent (Roberson and Holder, 1993); but fry held in net pens are largely protected from predators and food is provided, so the mortality rate is low while they are in the pens. Net-pen rearing of sockeye salmon fry in freshwater has not been widely applied; however, Schollenberger (1993) and Zadina and Haddix (1990) have reported good success with this strategy.

Net-pen rearing of sockeye salmon fry to increase their survival rate potentially may be employed in many systems throughout the EVOS area. Only two key ingredients are necessary: a source of fry and a suitable site to anchor and service the net pens. Fry may be captured from a spawning stream or transferred from a hatchery. Careful application of the net-pen rearing technique would increase the numbers of emigrating sockeye salmon smolts and returning adults with minimal undesirable effects on the population or the lake-rearing system. The magnitude of the benefit will depend on the numbers of captive fry that can be accommodated.

Although restoration, development, and enhancement of wild salmon stocks with fish-cultural techniques has been widely applied in the Pacific northwest, this strategy is not fully accepted within the fisheries profession (Hilborn, 1992; Martin, Webster and Edwards, 1992). Hatchery-produced fish typically can be harvested at a higher rate than most wild stocks. Consequently, if wild stocks are harvested with hatchery-produced fish, there may be a danger that the wild stocks may be overharvested (Hilborn, 1992). A good harvest-management strategy must be developed so the hatchery-produced stocks can be harvested in a separate time or place. Every fish-culture program must be carefully structured, planned, and controlled to avoid or minimize potential risks of change in the genetic makeup and health of the wild stocks (Hindar, Ryman and Utter, 1991; ADF&G, 1983; Holland-Bartels, Burger, and Klein, 1994; Meyers et al., 1988; Davis et al., 1985). Additional state and federal permits and a site-specific NEPA compliance review may also be required before a project is implemented (Appendix C, Section 1).

<u>Action 3: Hatchery Rearing</u>. This method of rearing sockeye salmon has had a long history in Alaska; however, during the last decade, this strategy has been improved and it has produced dramatic innovations and results (Ellison, 1992). In Alaska, cultured juvenile sockeye salmon have been released as fry, presmolts, and smolts. Each life stage has its own particular logistical, biological, and fish cultural constraints and advantages. Fry are less expensive to rear, transport, and release; but they require at least 1 year of rearing in a lake before they smoltify, and they would not survive to the adult stage as well as presmolts or smolts. Fry that are retained and fed in hatchery raceways may be released in late fall as presmolts. These young fish require few resources from the lake system during the winter and emigrate as smolts in the spring. Smolts are expensive to rear and transport, but they will survive better to the adult stage; however, they can be released as migrants without reliance on freshwater rearing.

Injured wild stocks may be helped directly by a rearing and release program for those stocks; or the wild stocks may be helped indirectly by creating an alternate opportunity for the commercial fishers to divert fishing pressure away from the injured wild stocks. For direct restoration, fry-rearing programs would be limited to those drainages where the forage is underutilized by the naturally produced fry. Presmolt- and smolt-rearing programs, however, can provide direct restoration with little or no effect on plankton populations.

Although restoration, development, and enhancement of wild salmon stocks with fish-cultural techniques has been widely applied in the Pacific northwest, this strategy is not fully accepted within the fisheries profession (Hilborn, 1992; Martin, Webster and Edwards, 1992). Hatchery-produced fish typically can be harvested at a higher rate than most wild stocks. Consequently, if wild stocks are harvested with hatchery-produced fish, there may be a danger that the wild stocks may be overharvested (Hilborn, 1992). A good harvest-management strategy must be developed so the hatchery-produced stocks can be harvested in a separate time or place. Every fish-culture program must be carefully structured, planned, and controlled to avoid or minimize potential risks of change in the genetic makeup and health of the wild stocks (Hindar, Ryman and Utter, 1991; ADF&G, 1983; Holland-Bartels, Burger, and Klein, 1994; Meyers et al., 1988; Davis et al., 1985). Additional state and federal permits and a site-specific NEPA compliance review may also be required before a project is implemented (Appendix C, Section 1).

Conclusions

Short-term effects.	Low. Some benefits in some drainages may accrue within one lifecycle.
Long-term effects.	High. These actions will assist the recovery of the injured wild sockeye salmon stocks, however, some of these actions may be more beneficial in certain portions of the EVOS area and some other populations may not become restored.

Pacific Herring

Alternative 3 includes only one restoration action to assist the natural recovery of Pacific herring--habitat protection and acquisition (EVOS Trustee Council, April 1993).

Habitat Protection and Acquision

The criteria for parcels that may benefit Pacific herring include ratings of high for parcels with documented consistent annual Pacific herring spawning along the parcel shoreline, moderate for parcels with occasional spawning along the parcel shoreline, and low for parcels with no documented Pacific herring spawning along the parcel shoreline, but a possible feeding area (EVOS Restoration Team, 1993).

Habitat protection that may benefit Pacific herring populations according to Alternative 3 would depend on the average cost per acre and the final budget allocation. Therefore, the number of parcels that may be purchased is expected to range between 62 parcels and all parcels that are available. If all available parcels are purchased, the benefit is expected to provide moderate value for the Pacific herring resource (Appendix A). Of the 81 parcels that may be purchased from the estimated budget that is forecasted for this alternative, 7, 30, 29, and 15 have been rated as no, low, moderate, and high value, respectively, for Pacific herring. A total of 54 percent of the parcels is rated as moderate or high value.

If only 62 parcels are purchased, the benefit is expected to provide moderate value for the Pacific herring resource (Appendix A). Of the 62 parcels that may be purchased from the estimated budget that is forecasted for this alternative, 3, 20, 25, and 14 have been rated as no, low, moderate, and high value, respectively, for Pacific herring. A total of 63 percent of the parcels is rated as moderate or high value.

Although the average value of forecasted habitat acquisition may not have a high overall rating for Pacific herring, individual parcels may have exceptional value. In the event that some of these parcels may not be protected through acquisition, the habitat will continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

Conclusions

Short-term effects.	Negligible. No benefits will accrue within one lifecycle.
Long-term effects.	Moderate. Habitat protection and acquisition actions may have a long-term value to Pacific herring stocks in the EVOS area by helping to assure maintenance of reproductive potential. Some habitat areas would recover sooner than others.

Social and Economic Impacts

Archaeological / Cultural Resources

Habitat Protection and Acquisition

It is assumed that 62 large parcels would be purchased under this alternative. These parcels contain low (no known or suspected cultural resources/sites on parcel), moderate (no significant cultural resources/sites on or adjacent to parcel), or high (documented concentration or significant cultural resources/sites on parcel) potential for benefiting cultural resources as analyzed by the Habitat Protection Work Group (November 30, 1993). If low potential benefit on a parcel is assigned a value of 1, moderate potential benefit a value of 2, and high potential benefit a value of 3, these parcels average 2.1 (or slightly higher than moderate). These estimates reflect known sites--not all of the sites present--in the EVOS area. Not all sites have been found, so the actual benefit to cultural resources may be greater than reflected in these estimates.

This analysis does not take into consideration small parcel acquisition, which is currently under evaluation. It also is possible that land prices will be lower or higher than those assumed here. That may result in the purchase of more parcels (possibly all 81 identified parcels) or fewer parcels. Habitat acquisition and protection may have a low short- term benefit. Moderate long-term benefits from habitat acquisition are likely to accrue primarily through (1) placing private lands under public management and application of Federal and State cultural resource-protection laws, and (2) reducing the likelihood of damage to cultural resources resulting from extractive economic activities, such as mining and logging.

General Restoration

The 12 percent of total funding available for general restoration under this alternative could fund projects that directly affect the cultural resources of the EVOS area. General-restoration actions may include activities on individual sites (site stabilization, site-salvage excavations, site monitoring and stewardship) or in local communities (archaeological repositories). On-site work often can be combined with community activities, as is envisioned in the site stewardship program. Each of the proposed actions considered here could be implemented independently or in combination with any of the others. The most effective approach is comprehensive, tailoring combinations of actions within each community whose cultural resources were injured by the spill.

Stabilize Archaeological Sites. Archaeological sites affected through erosion begun or worsened by oil spill activities may be stabilized to slow or stop the erosion. Stabilization may entail recontouring parts of the sites to cover up exposed archaeological deposits. This would reduce the visibility of artifacts and so reduce chances of looting or vandalism. This is a relatively nondestructive alternative when compared to archaeologically excavating the sites or allowing damage to continue.

Stabilization is a site-specific activity that may be accomplished through several different methods. Some sites are located along high-energy shorelines or in high-energy intertidal areas and may not be suited to stabilization. Also, stabilization techniques that produce contrast with surrounding terrain may draw visitation rather than protect against visitation. The benefit of stabilization is to preserve the temporary (requiring periodic maintenance) or permanent integrity of the site. This would have an immediate benefit of moderate to high level in the short term but may have the potential to preserve sites and reduce damage at a high level over the long term.

Excavate Archaeological Sites. Not all sites can be stabilized, whether for physical or economic reasons. Ongoing vandalism, looting, and erosion of archaeological sites in the EVOS area can be mitigated through salvage excavation instead of stabilization. Excavation and stabilization can also be done on the same site. Scientific excavation of the sites most in danger of destruction can yield information important to understanding the history and prehistory of the EVOS area, a major element of Alaska's cultural heritage. Excavation can also remove human remains and funerary objects associated with the ancestors of contemporary people living in communities in the spill area. These remains could be moved to locations less likely to be disturbed by looters or vandals, or unearthed by ongoing erosion.

One effect of excavation is permanent destruction of the excavated portions of the sites. This destruction, however, is controlled and exactly delimited, allowing for the appropriate care and analysis of removed items and associations. Without archaeological excavation, damage to, and eventual destruction of, several of the sites may continue with neither the public nor the resource benefiting. The short- and long-term benefits of salvage excavation of highly endangered sites therefore would be high. This action both protects the sites from further looting and vandalism and mitigates the spill-related damage already incurred. Some salvage-excavation projects have already been funded by the Trustee Council.

Site Monitoring and Stewardship. Archaeological site-stewardship programs active in Arizona, Arkansas, and Texas have demonstrated the utility of public education and increased oversight of sites for reducing continuing vandalism. A site-stewardship program for the EVOS area would combine public education and site monitoring through recruitment, training, coordination, and maintenance of a corps of interested local citizens to watch over nearby archaeological sites. Sites to be monitored by local residents would be identified by landowners and managers on the basis of past and ongoing vandalism and erosion. Law enforcement officials may be involved during investigations or when called to sites to intercept active vandalism.

The benefits of site stewardship would be an increased knowledge and appreciation of archaeological methods of site monitoring and decreased site vandalism. These benefits may begin within the first year of implementation and continue for an indefinitely long term. The benefits of this action in the short term would be low but are potentially high in the long term as site stewards become better trained and knowledge of the program is disseminated among people who are or may be inclined to damage sites. The action has additional importance in its involvement of local individuals and communities in protecting cultural resources.

Archaeology Repositories. Communities within the spill-affected area increasingly express a desire that archaeological materials remain in (or at least are regularly returned to) their area of origin for display and interpretation. Local preservation of artifacts and interpreting of Native heritage is proposed as a means to offset the increasing loss of artifacts and disturbance of Native graves in the spill area.

Placing artifacts in a local repository and using that repository as a base for interpreting cultural resources could help better educate residents and area visitors about practices of the past and the continuity of that past with the present and the future. These repositories may be established through modifying existing structures or by building new structures to accommodate collections. These would be located in communities within the oil spill area and could serve as local foci for heritage-oriented activities. The short-term benefit of this action may be to restore a feeling of involvement with and oversight of the cultural heritage of which local communities are part. This would be immediate but moderate. Long-term benefits are high in terms of enhanced community involvement. It is this involvement that would address spill-related injury to the sense of cultural continuity and connectedness within the local communities.

Conclusions

Short-term effects:	Moderate. The proposed actions would extend cultural resource law protection to some lands now under private ownership. These actions would also begin restoration of damaged archaeological resources.
Long-term effects:	Moderate. The proposed actions could reduce negative impacts to cultural properties and accomplish restoration of some damaged archaeological resources.

Subsistence Uses

Habitat Protection and Acquisition

It is assumed here that 62 large parcels would be purchased. These parcels contain low (status as a subsistence-use area unknown), moderate (known historic subsistence-use area, which may be used again), or high (known current subsistence-use area) potential for benefiting subsistence as analyzed by the Habitat Protection Work Group (November 30, 1993). If low potential benefit on a parcel is assigned a value of 1, moderate potential benefit a value of 2, and high potential benefit a value of 3, these parcels average 2.4 (or between moderate and high).

The short-term benefits of habitat protection and acquisition on the recovery of subsistence species and subsistence use may be low because of a lack of immediate change in the existing condition. Protecting lands from the habitat degradation associated with extractive economic activities like mining and logging may help keep recovering subsistence resources from being further impacted and might help them recover more quickly. As a result, long-term benefits to subsistence would likely be low to moderate.

This analysis does not take into consideration small-parcel acquisition, which is currently under evaluation. It also is possible that land prices may be lower or higher than those assumed here. That would result in the purchase of more parcels (possibly all 81 identified parcels) or fewer parcels.

General Restoration

The additional funds allotted for general restoration could field projects that directly affect subsistence resources and activities within the EVOS area.

Subsistence-harvest levels appear to be at or near prespill levels in most communities in the EVOS area. However, many subsistence users believe that subsistence food sources remain contaminated and are therefore dangerous to eat. The perception persists among village residents that subsistence species continue to decline or have not recovered form the oil spill. Health advisories against eating clams from obviously oiled beaches are still in effect. Shifting to noncustomary species or noncustomary subsistence locations also persists. The cultural values provided by gathering, preparing, and sharing food are not yet reintegrated into community life.

Several general restoration actions that meet the criteria for this alternative and that could directly and beneficially affect subsistence species have been identified. These proposed actions could be conducted independently from each other or in combination. The following summarizes some of the information from other resource-specific sections for this alternative as they apply to subsistence. Please refer to those sections concerning individual species elsewhere in the discussion of Alternative 3 for additional detail.

Harbor Seals. The decline in the subsistence harvest of harbor seals may have helped stabilize the population. The proposed action to implement cooperative programs between subsistence users and agencies to assess the effects of the subsistence harvest may help in sorting out which localities would be best utilized (or best left alone) for subsistence use in order to optimize natural recovery of the populations. This would be a moderate long-term benefit, taking as long as 5 to 10 years to establish a measurably significant benefit. This action has the advantages of relatively low cost and spinoff value in improving communication between agency biologists and subsistence users. Cooperative programs proposed for reducing incidental take of harbor seals during fishing likewise may have low short-term benefits but may have moderate long-term benefits in 5 to 10 years. Reducing disturbance at haulout sites in the oil spill area may have a negligible benefit in the short term and a moderate benefit in the long term.

Sea Otters. One of the proposed actions would establish a cooperative program between subsistence users and research scientists or agency managers. While subsistence harvests are not a significant impact on sea otter populations, both agency biologists and subsistence users would benefit from the additional interaction and information sharing that would grow from such an action. Traditional knowledge of sea otter behavior and their relation to other parts of the ecosystem may be more extensive than is presently recognized by agency biologists. Similarly, the present range and concentration of sea otters may be better understood by agency biologists than is presently recognized by many subsistence users. This type of action may have little benefit immediately or in the short term on the recovery of sea otters, but the long-term benefit on management efforts--and so on the sea otter populations--could be significant.

Intertidal Organisms. *Fucus*, one of the central elements in intertidal ecosystems, is important to subsistence users as food and as habitat for other subsistence resources. A proposed pilot project would transplant *Fucus* to increase its population in the high intertidal zone. Recovery of *Fucus* is estimated at a decade. This would have insignificant short-term benefits but may have moderate long-term benefits to subsistence users.

Sockeye Salmon. The use of egg incubation boxes has been proposed to restore or enhance sockeye salmon populations in the spill area. It is estimated that short-term benefits would be moderate, drainage-specific increases in populations. Long-term benefits would be low because of the scarcity of appropriate sites. If appropriate sites are found near villages, this technique has the potential for working very well locally to increase the amount of sockeye salmon available (in both the long and short terms) for subsistence use.

Net-pen rearing of sockeye salmon fry has been proposed to increase their survival rate. Since there are many appropriate locations for net pens in the EVOS, it is estimated that this technique would have locally high short- and long-term benefits on the sockeye salmon populations. The advantage to subsistence users would be a corollary benefit.

Hatchery rearing of sockeye salmon has been proposed, with release possible as fed fry, presmolts, and smolts. A number of project types are applicable, using different combinations of biological, physical, logistical, and technological factors. The short-term benefit of this type of action is likely to be low because it would take some time to establish the populations. The long-term benefit to sockeye salmon populations is estimated to be high, as several generations of improved survival rates to the smolt stage leading to the increased numbers of returning adults. The benefit to subsistence users may increase as populations of sockeye salmon increased. The benefit to subsistence users may increase if wild stocks were separated from hatchery stocks. Concentration on hatchery stocks by commercial fisheries could reduce competition for wild stocks.

Subsistence Food Testing. One of the main elements in the damage to subsistence users in the spill area is the fear that once-safe subsistence foods are no longer safe to eat. An action has been proposed to conduct tests on subsistence foods to determine the amount of contamination, if any, in various types of subsistence foods. This action would provide immediate information to subsistence users, providing short and long-term high level benefit to their sense of security.

Conclusions

Short-term effects: Low Benefits. The proposed actions would start stabilization or enhancement of species important for subsistence use, but higher levels of change are expected to accrue over an extended time period.

Long-term effects: Moderate Benefits. The proposed actions may help locally to reduce the negative impacts on species important to subsisence use, as well as improve subsistence user's confidence in determining the healthfulness of subsistence foods.

Recreation and Tourism

Habitat Protection and Acquisition

It is assumed that 62 large parcels would be purchased under this alternative. These parcels contain low (low to no recreational use; access may be difficult), moderate (receives occasional public use; adjacent waters used for recreational boating; adjacent area receives high public use), or high (receives regular, high directed public use; highly visible to a large number of recreationists/tourists) potential for benefiting cultural resources as analyzed by the Habitat Protection Work Group (November 30, 1993). If low potential benefit on a parcel is assigned a value of 1, moderate potential benefit a value of 2, and high potential benefit a value of 3, these parcels average 1.9 (or slightly lower than moderate). The benefit to recreation and tourism of habitat protection and acquisition may be low in the short term but moderate to high in the long term. These benefits would derive from protection of the scenic, wildlife, and undeveloped characteristics important for recreation values in the parcels being evaluated for acquisition. Extractive economic activities may reduce the recreational visual appeal of the landscape, shift or reduce wildlife-viewing possibilities, and eliminate the relative lack of developed (logged or mined) character, thereby reducing the overall utility of those and surrounding areas for recreational purposes.

General Restoration.

General restoration strategies for recreation and tourism are to preserve or improve the recreation and wilderness values of the spill area, remove or reduce residual oil if it is cost-effective and less harmful than leaving it in place, and monitor recovery. In this alternative, the focus would be on removing residual oil and residual cleanup materials.

Recovery of recreation and tourism is largely dependent on the recovery of natural resources. Shifting of recreational use sites from injured to uninjured areas is likely to continue as long as injured sites appear injured. Once sites are returned to an uninjured condition, they may again be used by recreationists. Removing residual oil and traces of cleanup activities is an integral part of re-establishing previous recreation and tourism use areas. In the meantime, sites not injured directly by the spill are being impacted through new or increased use. Use patterns continue to change in relation to the recovery of the resources, perceptions, and the benefits of restoration projects. Removing residual oil on beaches important for recreational use may have moderate short-term benefits. The long-term benefits of this action may be high locally, but are estimated to be moderate overall.

Conclusions

Short-term effects:	Low Benefits. The proposed actions require some time after implementation before low amounts of change in numbers of visitors or locations of recreation or tourism activities are noticeable.
Long-term effects:	Moderate Benefits. The proposed actions would provide some level of protection for lands against extractive activities, and may locally stabilize existing recreation opportunities.

Designated Wilderness

Habitat Protection and Acquisition

It is assumed that 62 large parcels would be purchased under this alternative. These parcels contain low (high/moderate evidence of human development and/or ongoing activities), moderate (area remote; evidence of human development and/or ongoing activities), or high (area remote; little or no evidence of human development) potential for benefiting Wilderness as analyzed by the Habitat Protection Work Group (November 30, 1993). If low potential benefit on a parcel is assigned a value of 1, moderate potential benefit a value of 2, and high potential benefit a value of 3, these parcels average 2.4 (or somewhat higher than moderate). This analysis does not take into consideration small parcel acquisition, which is currently under evaluation. It also is possible that land prices will be lower or higher than those assumed here. That may result in the purchase of more parcels --possibly all identified parcels -- or fewer parcels. Short term, there would be negligible change in the existing conditions of Wilderness Areas, and so negligible effect. Acquisition of parcels of land adjacent to or near designated Wilderness may extend protection to the wilderness character of those parcels, and so expand the Wilderness areas *de facto*, i.e., without extending the actual Wilderness designation. This would cause a long-term moderate level of protection to this expanded *de facto* wilderness, with benefits derived from protecting areas from extractive activities.

Acquisition of private lands with high levels of wilderness qualities such as isolation and lack of development may help maintain those lands in that condition. This would result in a negligible short term benefit, and is estimated to result in a moderate long term benefit, to the wilderness character of the spill area. No lands would become designated Wilderness Areas or Wilderness Study Areas without formal state or federal legislative action.

General Restoration

Some on-the-ground general restoration actions could be funded as general restoration projects. General restoration actions could include any that assist recovery of injured resources or that prevent further injury. Any of these may have spinoff effects that would improve wilderness values in the EVOS area.

Recovery of designated Wilderness areas hinges on removal of traces of oil, material left over from cleanup activities, and public perception that the areas are recovered. The concentration in this alternative would be on projects that remove residual oil and/or residual cleanup materials still existing in isolated pockets in Wilderness areas. Public information and marketing would not be funded. Short- term benefits would be immediate but low. Long-term benefits are estimated to be moderate, since actions could not be funded under this alternative to promote public education or marketing projects that explain how and where residual oil or materials were removed, i.e., public perception that the Wilderness areas are recovered would not be addressed.

Conclusions

Short-term effects:	Low Benefits. The proposed actions may provide local recovery of wilderness character, but substantial changes are expected to occur gradually.
Long-term effects:	Moderate Benefits. The proposed actions could reduce negative impacts on designated Wilderness Areas and Wilderness Study Areas, and extend some degree of protection to wilderness character of *de facto* wilderness lands.

Commercial Fishing

Alternative 3 would provide restoration actions to assist replacement of harvest opportunities that were lost because of fishing closures or harvest restrictions that occurred as a result of the EVOS. Actions that may be implemented as part of Alternative 3 include habitat protection and acquisition and creation of new hatchery-produced runs (EVOS Trustee Council, April, November 1993).

Habitat Protection and Acquisition

Habitat protection may benefit commercial fishing opportunities by providing long-term protection for natural production and stability of wild stocks of pink and sockeye salmon and Pacific herring. The criteria for these parcels that may benefit commercial fisheries depend on the values assigned for those species (EVOS Restoration Team, 1993).

Habitat protection that may benefit replacement of lost opportunities for commercial fishing according to Alternative 3 will depend on the average cost per acre and the final budget allocation. Therefore, the number of parcels that may be purchased is expected to range between 62 parcels and all 81 parcels that are available. If all available parcels are purchased, the benefit is expected to provide low to moderate value for commercial fisheries. If only 62 parcels are purchased, the benefit is expected to provide low to moderate value (Appendix A).

Although the average value of forecasted habitat acquisition may not have a high overall rating for commercial fisheries, individual parcels may have exceptional value. In the event that some of these parcels may not be protected through acquisition, the habitat will continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

General Restoration

Create New Hatchery Runs. For commercial fishing resources, actions considered under Alternative 3 may replace lost opportunities by creating new hatchery-produced runs of salmon. Development of new runs of pink, sockeye, and chum salmon may benefit commercial fishing by providing an alternate location, timing, or stock for commercial fishing activities and if the brood-stock selection for these new runs and the release site were carefully selected, there would be minimal interception of injured wild stocks. Good fishery management practices combined with a redistribution of the fishing fleet, would enable an intensive commercial fishery to harvest these stocks.

Specific actions that may be considered can be expected --either alone or collectively-- produce new runs of sufficiently large numbers of adult pink, sockeye or chum salmon to accommodate a reasonable portion of the fishing fleet and provide a harvest that may be separated in time or space from existing fisheries. Several potential actions that may provide these fish by development of new hatchery runs entail actions that have been described for restoration of wild stocks of pink and sockeye salmon (e.g., rear and release fry, presmolts, or smolts) or habitat manipulation to increase production of selected stocks (e.g., lake fertilization, migration corridor improvements, spawning channels, etc.) (Appendix C). The actions and methods remain the same, but the brood stock selection (e.g., source, species, timing, etc.), release strategies (e.g., age, size, location, etc.), and the harvest management (harvest rate, timing, location, etc.) may be selected to benefit commercial fishers and, perhaps, particular gear types.

ADF&G and PNP aquaculture organizations have established a modern fisheries enhancement program in the EVOS area and have developed new runs of salmon for harvest by commercial fishers. Excellent success has been achieved with most of these programs which have developed new self-sustaining or hatchery-produced runs of fish (Ellison, 1992); however, some locations that are accessible to the fishing fleets remain as opportunities for juvenile fish imprinting and adult fish terminal harvest areas.

Every fisheries restoration, development, or enhancement program must be carefully planned and managed to avoid risks to wild stocks, and the fish-culture program must be carefully structured and controlled to avoid or minimize potential changes in the genetic makeup and health of the wild stocks that might be caused by the program. Although restoration, development, and enhancement of wild salmon stocks with fish-cultural techniques has been widely applied in the Pacific northwest, this strategy is not fully accepted within the fisheries profession (Hilborn, 1992; Martin, Webster and Edwards, 1992). Hatchery-produced fish typically can be harvested at a higher rate than most wild stocks. Consequently, if wild stocks are harvested with hatchery-produced fish, there may be a danger that the wild stocks may be overharvested (Hilborn, 1992; Seeb, 1993). A good harvest-management strategy must be developed so the hatchery-produced stocks can be harvested in a separate time or place. Every fish-culture program must be carefully structured, planned, and controlled to avoid or minimize potential risks of change in the genetic makeup and health of the wild stocks (Hindar, Ryman and Utter, 1991; ADF&G, 1983; Holland-Bartels, Burger, and Klein, 1994; Meyers et al., 1988; Davis et al., 1985; Seeb, 1993). Additional state and federal permits and a site-specific NEPA compliance review may also be required before a project is implemented (Appendix C, Section 1).

Conclusions

Short-term effects.	Negligible. New runs probably cannot be established within one life cycle to support new commercial fisheries to replace opportunities lost because of fishing closures or reduced harvests.
Long-term effects.	Moderate. These actions would assist the replacement of lost commercial fishing opportunities; however, some portions of the EVOS area would obtain greater benefits than others.

Sport Fishing

Sport fishing was disrupted throughout most of the EVOS area because of the oil spill, and populations of several important sport fish species were damaged. Lost sport fishing opportunities may be replaced by creating new sport fisheries for salmon or trout. Alternative 3 would provide restoration actions to assist replacement of harvest opportunities that were lost because of fishing closures or harvest restrictions that occurred as a result of the EVOS. Actions that may be implemented as part of Alternative 3 include habitat protection and acquisition and creation of new hatchery-produced runs (EVOS Trustee Council, April, November 1993).

Habitat Protection and Acquisition

Habitat protection may benefit sport fishing opportunities by providing long-term protection for natural production and stability of wild stocks of pink and sockeye salmon, Dolly Varden, and cutthroat trout. The criteria for these parcels that may benefit sport fisheries depends on the values assigned for those species (EVOS Restoration Team, 1993).

Habitat protection that may benefit replacement of lost opportunities for sport fishing would depend on the average cost per acre and the final budget allocation. Therefore, the number of parcels that may be purchased is expected to range between 62 parcels and all 81 parcels that are available. If all available parcels are purchased, the benefit is expected to provide low to moderate value for sport fisheries. If only 62 parcels are purchased, the benefit is expected to provide low to moderate value (Appendix A).

Although the average value of forecasted habitat acquisition may not have a high overall rating for sport fisheries, individual parcels may have exceptional value. In the event that some of these parcels may not be protected through acquisition, the habitat would continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

General Restoration

Establish Hatchery Run. The establishment of new hatchery-produced runs of salmon or trout would provide some benefit for all fishers by providing new opportunities with new locations and stocks that anglers may use. Typically, a run of a few thousand fish will provide tens of thousands of angler/days of recreation (Mills, 1993). Sport fisheries, however, would be successful only if they are located where they would be accessible by anglers. The ADF&G already has employed this strategy to improve sport fishing opportunities for trout and salmon in the EVOS area by stocking catchable-sized trout and salmon smolts at accessible locations, often where self-sustaining runs cannot be established. Actions are similar or identical to those described in Appendix C.

A small number of fish in a good, accessible location can provide angling to accommodate a substantial number of angler/days of recreation. Wherever large numbers of fishers concentrate to harvest a concentrated population of fish, some portions of the adjacent habitat may be affected. While new sport fisheries would readily create new recreational opportunities, these likely would be for different species in new locations.

Every fisheries restoration, development, or enhancement program must be carefully planned and managed to avoid risks to wild stocks, and the fish-culture program must be carefully structured and controlled to avoid or minimize potential changes in the genetic makeup and health of the wild stocks that might be caused by the program. Although restoration, development, and enhancement of wild salmon stocks with fish-cultural techniques has been widely applied in the Pacific northwest, this strategy is not fully accepted within the fisheries profession (Hilborn, 1992; Martin, Webster and Edwards, 1992). Hatchery-produced fish typically can be harvested at a higher rate than most wild stocks. Consequently, if wild stocks are harvested with hatchery-produced fish, there may be a danger that the wild stocks may be overharvested (Hilborn, 1992; Seeb,1992). A good harvest-management strategy must be developed so the hatchery-produced stocks can be harvested in a separate time or place. Every fish-culture program must be carefully structured, planned, and controlled to avoid or minimize potential risks of change in the genetic makeup and health of the wild stocks (Hindar, Ryman and Utter, 1991; ADF&G, 1983; Holland-Bartels, Burger, and Klein, 1994; Meyers et al., 1988; Davis et al., 1985; Seeb, 1992). Additional state and federal permits and a site-specific NEPA compliance review may also be required before a project is implemented (Appendix C, Section 1).

Conclusions

Short-term effects.	Negligible. New sport fisheries probably cannot be established within one life cycle to replace lost sport fishing opportunities.
Long-term effects.	High. After hatchery production is expanded newly established sport fisheries would provide substantial recreational benefits.

Economy

Qualitative analysis indicates that Alternative 3 would result in moderate economic benefits to commercial fisheries and recreation and moderate negative effects on forestry. Quantitative analysis reflects effects resulting from habitat acquisition on forestry and other sectors but no effects on commercial fishing and recreation because data is not available to quantify these sectors. The quantitative analysis follows.

In Alternative 3 significant timberlands will be acquaired and it is assumed that signficiant timber will not be harvested. As shown in Table 4-5 alternative 3 annual average industry outputs i s projected to decline by $32.6 million and employment is anticipated to decline by 330 employees.

Spending of moneyby timberland owners has a direct effect on the construction sector as shown in Table 4-5 Alternative 3 in the amount of $7.8 milion in inudstry output. Spending of money by timberland owners also has a direct effect on the services sector in the amount of $5.1 million in final demand and 766 emmployees.

Spending in the construction and service sectors is not enough to offset the negative effects in the forestry sector. The net effect is shown in the total line which has negative quantities for four out of the six economic measures; only employee compensation and employment are positive.

Habitat acquisition and general restoration expenditures will have economic benefits for the commercial fisheries and recreation sectors of the economy. However, these benefits are not reflected in the IMPLAN projections presented in Table 4-5. Therefore, this table does not quantify important economic benefits in commercial fishing and recreation because these benefits are not quantified. Of the three most important economic sectors for this analysis, only forestry is quantified. The typical projects in various combinations, such as fish ladders, fish hatcheries, and preservation of habitat will economically enhance the commercial fisheries and recreation sectors of the economy. However, because studies and data are not available that quantify in terms of dollars or employment, it is not possible to quantify the economic effects for these two sectors of the economy. In Table 4-5 the quantities for the commercial fisheries and recreation sectors are reflections of the indirect effects of other sectors of the economy only; they are not reflections of the anticipated but unquantified effects on those sectors.

Short-term impacts are anticipated to be negligible.

See the introduction to Chapter 4 on economics and Appendix D Economics Methodology for a more detailed discussion of methodology.

Conclusions

Short-term effects:	Negligible. Short-term impacts are anticipated to be negligible.
Long-term effects:	Qualitative analysis indicates that Alternative 3 will result in moderate economic benefits in commercial fisheries and recreation and moderate negative effects in forestry. Quantitative analysis reflects effects resulting from habitat acquisition on forestry and other sectors but not effects on commercial fishing and recreation. Quantitative analysis indicates that Alternative 3 results, in annual averages for a 10-year period, in a loss of approximately $32 million in forestry industry output, an increase of $8 million in construction industry output, and $3 million in services. The corresponding changes in employment are a loss of 330 jobs in forestry, an increase of 70 in construction, and an increase of 766 in services.

Table 4-5. Alternative 3: 6% Administration, 7% Monitoring, 12% Restoration, 75% Habitat Protection
Average Annual Change from Base in 1990$ Millions

Economic Sector	Final Demand $	Industry Output $	Employee Comp. $	Property Income $	Value Added $	Employment #
Forestry	-26.601	-32.616	-7.221	-4.167	-12.409	-330
Commercial Fisheries	0.000	0.001	0.000	0.000	0.000	0
Mining	0.058	0.001	0.000	0.001	0.001	0
Construction	8.428	7.859	2.907	1.177	4.107	70
Manufacturing	0.065	-0.338	-0.052	-0.011	-0.073	-1
Recreation Related	0.046	0.070	0.025	0.014	0.041	1
Communication & Utilities	0.099	0.191	0.051	0.083	0.135	1
Trade	0.472	0.811	0.168	0.097	0.229	10
Finance, Insurance, Real Estate	2.064	1.863	0.464	0.132	0.631	41
Services	5.155	2.503	3.777	-0.847	2.935	766
Government	1.545	1.438	1.478	-0.014	1.464	28
Miscellaneous	0.000	0.000	0.000	0.000	0.000	0
Total	-8.580	-18.728	1.598	-3.599	-2.941	587

Source: IMPLAN Economic Model. See text for methodology.

Alternative 4: Moderate Restoration

Introduction

This Alternative broadens the General Restoration program to include all resources with documented injuries from the oil spill. It differs from Alternative 3 by addressing injured biological resources whose populations did not decline as a result of the spill. This alternative also allows for settlement funds to be used outside of the spill area, and allows for increasing opportunities for human uses of the area. This alternative also encourages using only the most effective restoration measures for general restoration actions.

A large part of this alternative is dedicated to Habitat Protection and Acquisition which provides protective benefits for all resources and thereby the services they provide injured by the oil spill, as well as to other resources and human uses that are important to the greater EVOS ecosystem. Increasing the protection of habitat throughout the spill area may be beneficial to the entire ecosystem by reducing further habitat degradation that may compound the effects of the oil spill. The general restoration actions may help resources or services recover to their prespill conditions more rapidly than if the actions were not implemented. A third component of the restoration program is Monitoring and Research. These activities track the progress of recovery and provide valuable information that can be used to help the resources, and the overall ecosystem, recover from the oil spill and from other factors that may be delaying recovery.

Impacts on Biological Resources

Impacts on Intertidal Resources

There are three actions that affect the intertidal zone that have been identified for this alternative: habitat protection, accelerating the recovery of *Fucus* in the upper intertidal zone, and cleaning oiled mussel beds. This alternative differs from Alternative 3 only by its more restrictive scenario of the habitat protection opportunity.

Habitat Protection and Acquisition

Although there are several types of actions that apply under this restoration category, this analysis only considers the types of benefits that may be gained from protecting the 81 upland parcels identified in the Comprehensive Habitat Protection Process; Large Parcel Evaluation & Ranking Volume I and II (EVOS Restoration Team, November 1993). Other aspects of the habitat protection category, such as the small parcels available for protection, are still being developed and cannot be analyzed in this DEIS.

The Habitat Protection process used to evaluate the 81 parcels for their potential benefits to injured resources and services combined intertidal and subtidal biota and used the following criteria for ranking the parcels:

- high for parcels adjacent to areas with a known high species abundance and diversity; high quality habitat for intertidal and subtidal biota;

- moderate for parcels adjacent to extensive intertidal habitat with observed or probable moderate species diversity and abundance; and,

- low for parcels with little intertidal habitat with low species abundance (EVOS Restoration Team, November 1993).

In Alternative 4, it is possible to protect all of the 81 parcels if it is assumed that the cost per acre is low. If a higher cost per acre is assumed for these parcels, fewer of the parcels that were ranked low in the overall ranking for multiple resources and services are likely to be protected. Under this scenario, the potential benefit would change from 25 to 19 parcels ranked high, from 33 to 10 parcels ranked moderate and 19 to 4 parcels ranked low.

The benefits to intertidal and subtidal organisms through the protection of upland habitats come in two forms. First, the protection could prevent the intertidal and subtidal areas from being altered by the actions that may occur on the parcels. Some actions could cause indirect adverse effects through siltation, or increased pollution, while other actions such as the construction of a dock or creating a new harbor, could directly alter the intertidal and subtidal habitats. The second type of protection would reduce the disturbance caused by increased human activity (e.g., more people walking through the intertidal area; more pollution from littering or from bilge discharge). Obviously, the type of activity that could occur on a given parcel could substantially change the degree of benefit that is gained to the intertidal and subtidal zones.

The overall benefit from protecting most or all of the 81 parcels identified in the large parcel process is moderate, but the actual benefit gained by the intertidal and subtidal organisms depends on the type and location of the activities that may occur. In areas where construction activities are anticipated in the intertidal zone, the protection would be especially effective. If the parcels correspond to areas of the intertidal zone that are still not recovering from the effects of the oil spill, the benefits could be even greater.

General Restoration

The other two actions that have been identified for this alternative can directly affect the intertidal zone. These actions affect specific organisms, *Fucus* and mussels, but are meant to provide broader benefits to the other organisms that live or feed in these communities.

Accelerate the Recovery of the Upper Intertidal Zone. This would be done by re-establishing *Fucus*. The upper intertidal area, specifically the upper 1-meter vertical drop (1MVD), is probably the upper extent of suitable habitat for *Fucus* to grow. This means that the conditions are more extreme than in other habitats and would be more difficult to colonize. *Fucus* germlings that colonize in the upper intertidal area are subject to longer periods of high temperatures and dryness during low tides. Without the shelter and moisture that is provided by mature *Fucus* plants, the germlings can become desiccated and die. Studies conducted in Herring Bay, Prince William Sound, suggest that it may take 3 to 4 years for *Fucus* communities to expand 0.5 m beyond their existing boundaries (Highsmith et al., 1993).

Feasibility studies of techniques for accelerating the recovery of *Fucus* were begun in 1992. Attempts to transplant mature *Fucus* plants were generally unsuccessful (Stekoll, pers. comm., 1994). Another technique which uses a biodegradable cloth to cover seeded areas is currently being tested (Stekoll, pers. comm., 1994), and results of this experiment will be known after the summer of 1994. In theory, the cloth will substitute for the adult *Fucus* by providing moisture and protection to the germlings during low tides. Because the technique is still being tested, it is impossible to know how successful the action may be, or how easily it can be applied to the areas that could benefit from the action. If the technique is highly successful, the established germlings could become fully mature in 3 to 4 years and the associated invertebrates would also recolonize in the upper intertidal zone. At this time, however, it is impossible to know the outcome of the research; therefore, any benefits from this action are unknown.

Cleaning Oiled Mussel Beds. This has been considered as a possible method to reduce the hydrocarbon exposure for sea otters, harlequin ducks, and black oystercatchers. These animals depend on mussels for a large portion of their diet (Webster 1941; Dzinbel and Jarvis, 1982; Doroff and Bodkin, 1993). Mussels occur in loose aggregations attached to intertidal rocks, or in dense aggregations (mussel beds) over pea gravel and silt sediments. Because mussels form a dense matt over the sediments and rocks, oil that was trapped beneath the mussels was not exposed to weathering and still remains toxic. It may be possible to clean mussels in mussel beds, but cleaning will not be possible in all habitats where mussels occur.

One of the possible explanations for continuing signs of injury to sea otters, river otters, harlequin ducks, and black oystercatchers is that they continue to be exposed to hydrocarbon contamination by eating oiled mussels. Concern over this possible continuing source of contamination led to feasibility studies to develop techniques to clean the sediments beneath the oiled mussel beds. One technique to be tested in 1994 lifts sections of the mussel beds and replaces the contaminated sediments with clean sediments without serious damage to the mussel beds (Babcock, pers. comm., 1994). Other techniques are likely to damage the existing mussels when contaminated sediments are removed. Approximately 60 locations with oiled mussel beds have been identified in Prince William Sound. Oiled mussels beds have been identified and sampled from the Alaska Peninsula and Kodiak, however, estimates on the number of exisiting oiled mussel beds are unavailable.

The extent and distribution of oiled mussel beds is still being determined and will be important in understanding the potential benefits that can be gained for other organisms by this action. There have been no studies to determine whether eating contaminated mussels is causing injury to other species within the EVOS area. However, other studies have documented reproductive impairment in some seabirds after ingesting oil (Epply and Robega, 1990; Fry and Addiego, 1988). The intent of cleaning oiled mussel beds is largely to eliminate a source of continuing contamination to other organisms. Studies that examined the effects of oil on the mussel beds noted a reduction in the number of large mussels and overall biomass of the mussel beds, but there did not appear to be a shortage of new recruits (smaller mussels) to the mussel beds (Highsmith, Stekoll and Barber, 1993). It is unknown whether the trapped oil beneath the mussel beds will ultimately cause further injury to the mussels; however, continued high levels of hydrocarbons have been found in mussel tissues, which indicates that the mussels may be continuing to be contaminated.

If the technique described above is successful, then this action is unlikely to cause an adverse effect and may provide tangible benefits to the mussels at the cleaned sites. Presumably, this technique would be applicable throughout the EVOS area, however, there is less information on the location of oiled mussel beds in areas outside of Prince William Sound.

Conclusions

Short-term effects: Negligible.

Long-term effects: <u>Unknown.</u> For direct restoration actions, effects are <u>unknown</u> because both of these actions still are being tested. The long-term benefits of the Habitat Protection actions for reducing disturbance or preventing additional injury to intertidal organisms are <u>moderate</u> and will vary substantially between parcels.

Impacts on Marine Mammals

<u>Harbor Seals</u>

The restoration program for harbor seals under Alternative 4 is very similar to the program discussed in Alternative 3. In this alternative differs the Habitat Protection capabilities differ if the higher cost per acre is considered; and actions proposed that increase the number of people using an area can increase the potential for disturbance.

The best way to benefit the injured harbor seal populations is to determine what has caused the long-term decline of populations throughout the Gulf of Alaska. Such research activities cannot be analyzed in this DEIS because the environmental effects are dependent on the outcome of the research and how the results can be used for restoration. For this analysis we can only consider the effects of habitat protection and the two types of General Restoration actions proposed in Chapter 2. Both of the proposed actions are information based programs that would be designed to change the impact of commercial fisheries or of subsistence harvest on the recovering seal populations.

Subsistence harvest is not believed to be the cause of the long-term decline of harbor seal populations in the Gulf of Alaska; however, any additional mortality may slow the recovery of injured populations. Subsistence harvest in Prince William Sound declined as a result of the oil spill, and in 1991 harvest levels were probably less than 5 percent of the population. A healthy seal population would be able to easily sustain that level of harvest. Depending on the distribution, sex and age of the animals harvested, a 5-percent harvest could negatively affect an injured population.

<u>Establish a Cooperative Program between Subsistence Users and Research Scientists or Agency Managers</u>. This proposed action would be designed to provide a two-way exchange of information that would benefit all parties and could benefit the injured harbor seal populations. For example, recent studies indicate that harbor seals may have a high site fidelity to molting and pupping areas (e.g., the same individuals consistently use the same areas) (Pitcher, 1990). If some of these areas show greater declines than other sites within Prince William Sound, then redirecting harvest towards the healthier, or the nonoiled areas, could reduce any negative effects from the harvest without actually changing the number of animals harvested.

<u>Establish a Cooperative Program with Commercial Fishermen</u>. This program also could reduce pressure on the injured seal populations. This program would provide information on deterrent methods and regulations. Ideally, it would provide information to the scientists on the extent of the interactions between the commercial fisheries and the seals, and would reduce the number of seal mortalities. Interactions with commercial fisheries probably result in fewer deaths than from the subsistence harvest and are unlikely to be the cause of the seal decline; however, the more that can be done to minimize the effects of human-caused injury and mortality, the more likely it will be that the population will stabilize and recover.

Habitat Protection and Acquisition.

Harbor seals use haulout sites that are either in the intertidal zone or immediately adjacent to the intertidal zone; therefore, actions that occur on the upland are not likely to destroy the habitat. However, it is possible that habitat changes to the uplands may increase the amount of disturbance currently experienced at haulout sites on or near these parcels. Disturbance has been documented as adversely affecting harbor seals and other pinnipeds in other parts of their range (Allen et al., 1984; Esipenko, 1986; Johnson et al., 1989). These studies have shown that the greatest impacts from disturbances are at haulout sites during pupping and molting. During pupping, disturbance can result in higher pup mortality caused by abandonment, or from being crushed as the adults panic and return to the water (Johnson, 1977). The greatest disturbance is caused when people walk near or through haulout sites (Johnson et al., 1989), but disturbance can also be caused by low-flying aircraft and by boats that approach too close to the haulouts.

Habitat protection criteria for parcels that may benefit harbor seals include ratings of:

- high for parcels known to have a haulout of 10 or more seals on or immediately adjacent to the parcel;

- moderate for parcels with known haulouts with sporadic use and less than 10 seals; or, probable haulouts in the vicinity of the parcel; or probable feeding in nearshore waters; and,

- low for possible feeding sites located in nearshore waters adjacent to the parcel (EVOS Restoration Team, November 1993).

Of the 81 parcels evaluated in the large parcel process, 25 of the parcels were ranked high, 19 of the parcels were ranked moderate, 35 were ranked low and 2 parcels were ranked as having no benefit to harbor seals. The overall value of these parcels, based on these rankings, is moderate, although individual parcels may have exceptional value.

In Alternative 4, it is possible to consider the value of all 81 parcels if it is assumed that the cost per acre is low; however, if the cost per acre is higher, fewer acres of land are likely to be purchased. If a higher cost per acre is assumed for these parcels, fewer of the parcels that are ranked low for multiple resources and services are likely to be protected. Under this scenario, the potential benefit to harbor seals would change from 25 to 18 parcels ranked high, from 19 to 6 parcels ranked moderate, and from 35 to 6 parcels ranked low.

The actual impact that development on these parcels would have on harbor seals depends on, among other things, the type of disturbance caused, the length and duration of the disturbance, and whether or not the haulout area is used for pupping or molting. Within the EVOS area, there have been no studies to document the amount or effects of current activities that could cause disturbance to harbor seals, so baseline data are unavailable. However, it is reasonable to assume that protection of upland habitats near haulout sites would reduce the risk of disturbance to the injured population.

Restoration Actions for Other Resources/Services. If actions are taken to increase recreation and commercial tourism activities, or construct large facilities such as hatcheries in the oil spill area, careful site selection away from key haulout areas could avoid a long-term impact on harbor seals.

Conclusions

Short-term effects:	Negligible . All of the proposed actions require some time after implementation before any changes could be expected.
Long-term effects:	Moderate Benefits. The proposed actions could reduce negative impacts on harbor seals, and could result in increased recovery rates in local areas.

Sea Otters

The effects of actions under Alternative 4 are expected to be identical to those described in Alternative 3 with the exception of the amount of habitat that would be protected.

There are three types of actions aside from Research or Monitoring that are considered in this alternative: habitat acquisition, cleaning oiled mussel beds, and creating a cooperative program between subsistence users and sea otter scientists and managers.

Habitat Protection and Acquisition

The benefit to sea otters from habitat protection actions on upland parcels is achieved through reducing potential or actual disturbance. Sea otters appear to have a high tolerance to certain human activities, as evidenced by their abundance in highly travelled areas such as Orca Inlet near Cordova; however, their response to large-scale disturbances has not been studied. Large-scale disturbances, such as log-transfer sites, may force resident sea otters to leave the immediate area and may cause a long-term change in food availability as debris from the logs cover the substrate. Disturbance is more likely to cause adverse effects to females with pups that concentrate in high-quality habitats with abundant prey in the intertidal zones.

Habitat protection criteria for parcels that may benefit sea otters include ratings of:

- high for parcels adjacent to known pupping concentrations;

- moderate for parcels adjacent to concentration areas for feeding and/or shelter; or, potential pupping areas; and,

- low for feeding sites located in adjacent waters (EVOS Restoration Team, November 1993).

Of the 81 parcels evaluated in the large parcel process, 20 of the parcels were ranked high, 16 of the parcels were ranked moderate, 42 were ranked low, and 3 parcels were ranked as having no benefit to sea otters. The overall value of these parcels, based on these rankings, is low to moderate, although individual parcels may be near habitat of exceptional value.

In Alternative 4, it is possible to consider the value of all 81 parcels if it is assumed that the cost per acre is low; however, if the cost per acre is higher, fewer acres of land are likely to be purchased. If a higher cost per acre is assumed for these parcels, fewer of the parcels that are ranked low for multiple resources and services are likely to be protected. Under this scenario the potential benefit to sea otters would change from 20 to 14 parcels ranked high, from 16 to 8 parcels ranked moderate, and from 42 to 10 parcels ranked low.

General Restoration

Cleaning Oiled Mussel Beds. This has been considered as a possible method to reduce the hydrocarbon exposure. Sea otters, especially juvenile sea otters and females with pups, depend on mussels for a large portion of their diet (Doroff and Bodkin, 1993). Mussels are found in shallower areas and are easier to obtain than other prey. Mussels occur in loose aggregations attached to intertidal rocks, or in dense aggregations (mussel beds) over pea gravel and silt sediments. Because mussels form a dense matt over the sediments and rocks, oil that was trapped beneath the mussels was not exposed to weathering and still remains toxic. It may be possible to clean mussels in mussel beds, but cleaning will not be possible in all habitats where mussels occur.

One possible explanation for the poor survival rate of postweanling juveniles in the oiled areas is that they are continuing to be exposed to hydrocarbon contamination by eating oiled mussels. Concern over the possible continuing source of contamination to sea otters and other higher order animals (e.g., black oystercatchers and harlequin ducks) led to feasibility studies to develop techniques to clean the sediments beneath the oiled mussel beds. One technique that will be tested in 1994, lifts sections of the mussel beds and replaces the contaminated sediments with clean sediments without serious damage to the mussel beds (Babcock, pers. comm., 1994). Approximately 60 locations with oiled mussel beds have been identified in Prince William Sound.

The extent and distribution of oiled mussel beds is still being determined and will be important in understanding the potential benefits to sea otters that can be gained from cleaning. There have been no studies to determine whether or not eating contaminated mussels is causing injury to the sea otter population. However, it is possible to consider the potential benefits in terms of the level of risk to exposure. For example, the telemetry study by Monnett and Rotterman (1992) indicated that females and weanling sea otters did not range great distances between oiled and unoiled areas. If a group of sea otters spends many months feeding in bays that have several oiled mussel beds, then they are at greater risk of exposure than sea otters that feed in areas with few or no oiled mussels. Of the oiled mussel beds identified so far, there are approximately 20 in Herring Bay off of Knight Island; cleaning half or all of these mussel beds would greatly reduce the risk to the local population. If only one or two beds in the area were cleaned, it might not reduce the risk of exposure at all. Similarly, if the only source of oil in an entire bay was from one mussel bed, removing that contamination could eliminate the majority of the risk to the local sea otters.

Cleaning oiled mussel beds would be a labor intensive task that may last for several days at each location. Some short-term disturbance probably would occur; however, it is not likely to permanently displace the local sea otters.

It is reasonable to assume that the ability of this action to reduce the risk of exposure is equally valid in other regions of the spill area. However, there is less information on the location of mussel beds and on the injury to the sea otter population.

Establishing a Cooperative Program between Subsistence Users and Research Scientists or Agency Managers. This action also is appropriate under this alternative. The program would be designed to provide a two-way exchange of information that would provide benefits to all parties and could benefit the injured sea otter population. Recent records of subsistence harvest of sea otters in the oil -spill area indicate that harvest levels are relatively low but increasing throughout the EVOS area. If subsistence levels increase in areas where the populations were affected by the spill, the additional harvest may slow or prevent localized recovery. For example, the densities of sea otters in some oiled areas still is very low (Bodkin and Ballachey, pers. comm., 1994). If these areas are consistently harvested, then redirecting harvest towards the healthier or nonoiled areas could reduce any negative effects without actually changing the number of animals harvested. Likewise, sea otters can sustain a greater harvest of males and juveniles than of breeding females.

Without any restoration actions, it may be reasonable to estimate that sea otters would recover to their prespill abundance in 7 to 35 years once the population begins to increase. If subsistence harvest rates rise substantially in the oiled areas, then the recovery estimates based on a 10-percent growth rate are unlikely, and it is possible that the more conservative estimate of 35 years would be extended. If a cooperative program can be established, it may be possible to sustain a higher harvest rate without changing the recovery rate of the injured population.

Restoration Actions for Other Resources or Services are not expected to impact the sea otter populations or their recovery.

Conclusions

Short-term effects:	Negligible. All of the proposed actions would take time before any results could be expected.
Long-term effects:	Moderate benefits. The proposed actions improve the habitat quality through reducing the risk of exposure to oil, the potential for disturbance, and the impacts from subsistence harvest. These benefits could produce a change in abundance of sea otters in some areas, but would not likely produce a notable increase on a regional scale.

Impacts on Birds

Harlequin Duck

Habitat Protection and Acquisition

Acquiring nesting habitat along streams on forested lands is an effective means of preventing further injury to the harlequin duck population. Such acquisition would maximize protection of the harlequin ducks' reproductive potential, thus fostering population recovery to pre-EVOS levels. The 81 parcels that were evaluated in the large parcel process were rated as high, moderate or low value to harlequin ducks based on the following definitions. High, for known nesting or molting concentrations on the parcel, and where feeding occurs on the parcel. Moderate rankings for parcels with probable nesting or molting on or adjacent to the parcel, and with probable feeding in the streams, estuary or intertidal area in or adjacent to the parcels. Low rankings were assigned to parcels where feeding and loafing adjacent to the parcel are possible; or where some offshore molting occurs (EVOS Restoration Team, 1993).

Assuming a relatively low cost per parcel that would allow purchase of all 81 parcels, 24 were ranked high, 25 were ranked moderate, 32 were ranked low, and none had no value to harlequin ducks. Assuming 50% of the settlement funds are available for habitat acquisition, 19 parcels were ranked of high value to harlequin ducks, 10 moderate, 5 low, and no parcels were rated as having no value to harlequin ducks.

General Restoration

Cleaning Oiled Mussel Beds. Cleaning oiled mussel beds is considered to be a possible means of reducing hydrocarbon exposure to harlequin ducks via their food chain. Mussels, clams, and other bottom prey of harlequin ducks continue to be contaminated by oil still buried in the sediments. Harlequin ducks eat the contaminated prey, thus contaminating their body tissues. Although as yet unproven, this sublethal contamination is suspected to interfere with normal reproduction, resulting in few new broods being seen in the oiled area since the spill. Production in the oiled area could eventually resume once the buried oil is removed, followed by a population increase.

Conclusions

Short-term effects: Negligible. The short-term effects through 1995 of this alternative on harlequin duck population recovery are expected to be negligible, and populations should remain at 1990-1993 levels.

Long-term effects: High. The long-term effects of this alternative would have a high benefit for maintaining, protecting, and increasing the reproductive potential of harlequin ducks. Cleaning oiled mussel beds would eliminate the source of hydrocarbon contamination of body tissues, and also enhance the food base of local populations.

Murres

Habitat Protection and Acquisition

Acquisition of habitat would have lower benefits to the injured murre population than other injured species because there are no sizeable colonies, and very few smaller colonies, that are not already protected. A seabird colony on privately owned Gull Island in Kachemak Bay has a colony of 10,000 common murres that is visited daily by commercial tour boats in summer. Acquisition of this island, which is currently being evaluated under the small parcel process, would assure its long-term protection.

The 81 parcels that were evaluated in the large parcel process were rated as high, moderate, or low value for common murres based on the following definitions. High, for known nesting on or immediately adjacent to the parcel. Moderate, with known feeding concentration in adjacent nearshore waters. Low rankings were assigned to parcels where feeding is possible in adjacent waters (EVOS Restoration Team, 1993). The low benefit of the habitat protection action to common murres is illustrated by examining the rankings of common murre in the large parcel process. Assuming a relatively low cost per parcel that would allow purchase of all 81 parcels, none were ranked of high value to common murres, 7 were ranked moderate, 65 were ranked low, and 8 had no value to common murres. Assuming 50% of the settlement funds are available for habitat acquisition, only 1 was determined to be of high value to common murres, and 4 more were considered to be of moderate value, 27 were of low value, and 2 were of no value to murres.

General Restoration

Predator Control. The reproductive behavior of murres has evolved to produce a sudden abundance of eggs and chicks. The result is that predators are able to eat relatively few eggs and chicks while the large majority of chicks grow too large for predators to handle. Mammalian predators are generally not a problem for murres because their island colonies are usually free of such predation, and murre nest sites are inaccessible. Bald eagles, ravens, northwestern crows, and especially glaucous-winged gulls eat murre eggs and chicks in the EVOS area, although little is known about their impact on specific colonies. Recent work in Europe has shown that measures such as fiberglass poles placed on nesting colonies perpendicular to the cliff face reduces avian predation, and this measure might be effective in the EVOS area (Roseneau, oral comm., 1994).

Mammalian predators are normally not a problem for murres because their colonies are located on offshore islands and inaccessible mainland cliffs. A notable exception in Alaska is on islands where descendants of foxes introduced by fur farmers in the 1920's and 1930's have reduced or eliminated seabird populations, including murres. The U. S. Fish and Wildlife Service has identified 2 such island in the Gulf of Alaska, 15 more in the Aleutians, and another in the Pribilofs (Otter Island) (Byrd, oral comm., 1994). Predator control is permissible on these islands under the restoration policy for this alternative that states that restoration make take place "... anywhere there is a link to injured resources ..." Two islands in the Gulf of Alaska, Chernebura and Simeonoff, in the Shumagin group, are just outside the EVOS area, are being removed of foxes in a 1994 EVOS project, but they contain no murres. Kagamil Island in the western Aleutians, which does have a remnant murre population, is slated for fox removal in 1994 with non-EVOS USFWS funds.

Conclusions

Short-term effects:	Negligible. There would be a negligible short-term effect to the injured murre population from this action within the EVOS area.
Long-term effects:	Low. Predator control outside the EVOS area, and acquisition of carefully-selected parcels would provide a low overall benefit to murre populations.

Pigeon Guillemot

Habitat Protection and Acquisition

In Prince William Sound, the majority of pigeon guillemot colonies are on U. S. Forest Service (USFS) land (Sanger and Cody, written comm., 1994) that is not slated for logging (USDA, Forest Service, 1994). Two of the largest colonies in Prince William Sound are on private land at the Pleiades Islands and on Bligh Island, and guillemots there total about 3 percent of the 1993 breeding population (Sanger and Cody, written comm., 1994). In the 1970's, both of the latter colonies probably harbored larger numbers of nesting guillemots than at present. Two colonies adjacent to private land that is currently being logged on the eastern, nonoiled portion of Prince William Sound had very few guillemots in 1993, but it is unlikely that they were affected by the inland logging operations (Sanger and Cody, written comm., 1994).

Prince William Sound and the Seal Bay area on Afognak Island (Cody, Fadeley and Gerlach, 1993) are the only locations within the EVOS area with current, comprehensive knowledge of pigeon guillemot colonies, and the Seal Bay area has already been acquired. Knowledge of guillemot *colonies* elsewhere in the EVOS area, including Kenai Fjords National Park, is old and incomplete (USFWS, 1993). Specially-designed surveys are essential to locate and count guillemots at their colonies (Sanger and Cody, written comm., 1994), and these have not been done within the EVOS area outside of Prince William Sound and Seal Bay.

The 81 land parcels that were evaluated for possible acquisition in the large parcel process were rated as high, moderate or low value for pigeon guillemots based on the following definitions. High, for parcels with known colonies on or immediately adjacent to the parcel, and with known feeding concentrations in nearshore waters, and moderate rankings for parcels with probable nesting and known feeding in nearshore waters. Low rankings were assigned to parcels with a low likelihood of nesting; but with possible feeding in nearshore waters (EVOS Restoration Team, 1993). A moderate benefit of protection action to pigeon guillemots may be illustrated by examining their rankings in the large parcel process. Assuming a relatively low cost per parcel that would result in acquisition of all 81 parcels, 20 were determined to be of high value to pigeon guillemots, 23 more were considered to be of moderate value, 31 were of low value, and 6 were of no value to guillemots. Assuming that 50% of the settlement funds were available for land acquisition would result in purchase of 34 parcels, where in the large parcel process 16 were determined to be of high value to pigeon guillemots, 7 more were considered to be of moderate value, 9 were of low value, and 2 were of no value to guillemots.

General Restoration

Predator Control. Predator control has the potential to increase productivity of pigeon guillemots, but little is known about the nature of predation on guillemots throughout the EVOS area. Possible predator control methods might include live trapping and translocating predators; removing eggs from the nests of avian predators and replacing the live eggs with artificial ones so the adults do not lay a second clutch; installing predator exclosures; and deploying predator-proof nesting boxes. Studies are needed to determine the severity of predation at individual colonies, and if warranted, to design specific methods to reduce predation. An EVOS predator control project in 1994 on Simeonoff and Chernebura Islands just outside the EVOS area will allow recolonization and a modest population increase by pigeon guillemots (V. Byrd, oral comm., 1994). Little is known about the current status of guillemot colonies elsewhere in the EVOS area (USFWS, 1993).

Reduce Disturbance. Human disturbance is not a pervasive problem at pigeon guillemot colonies. Most colonies are located in remote areas, and in steep habitat that generally holds little appeal for recreational or other uses. However, because of the reduced size of the guillemot population throughout Prince William Sound and the injury suffered by the population in the oiled area, it would be wise to take precautions to assure that there is no inadvertent disturbance during the May - August nesting season. This could be done by educating land management entities about the locations of guillemot colonies on their lands, and by posting colonies that are especially sensitive. Chief among the latter is the cluster of colonies at Jackpot Island, located on USFS land just offshore from Jackpot Bay in southwestern Prince William Sound. Jackpot Island has two beaches suitable for camping, and Jackpot Bay is a popular area for recreational boaters and fishermen, so there seems to be potential for inadvertent disturbance from recreationists.

Conclusions

Short-term effects:	Negligible. This alternative would likely have negligible short-term effects for pigeon guillemots through 1996.
Long-term effects:	Moderate. In the long term, acquiring habitat where two of the largest colonies in Prince William Sound are located, one of which is included in the high-priority-acquisition package, would have a moderate effect on allowing population recovery and in preventing further inroads to the injured population through habitat degradation.

Marbled Murrelet

Habitat Protection and Acquisition

Details of habitat use by marbled murrelets are being clarified, and studies in Prince William Sound are showing that large, moss-covered limbs of old-growth conifers are the cornerstone of prime nesting habitat for marbled murrelets. Current and possible future logging of such habitat on private land is the single greatest threat to population recovery of marbled murrelets, and it poses the additional threat of reducing the population more. Logging will ultimately occur on private lands and reduce murrelet habitat. Acquisition of prime nesting habitat would thus have a high benefit for allowing the injured marbled murrelet population to recover while preventing further injury to the population.

The 81 parcels that were evaluated in the large parcel process were rated as high, moderate or low value for marbled murrelets based on the following definitions. High, for parcels with known nesting or where there is high confidence that nesting occurs, and where feeding occurs in adjacent nearshore waters. Moderate rankings for parcels with probable nesting, and with known feeding areas in adjacent nearshore waters. Low rankings were assigned to parcels with a low likelihood of nesting; and possible feeding in nearshore waters (EVOS Restoration Team, 1993). Assuming a relatively low cost per parcel that would result in acquisition of all 81 parcels, 21 were determined to be of high value to marbled murrelets, 42 more were considered to be of moderate value, 18 were of low value, and none were of no value to marbled murrelets. Assuming that 50% of the settlement funds were available for land acquisition would result in purchase of 34 parcels, where in the large parcel process 14 were determined to be of high value to marbled murrelets, 15 more were considered to be of moderate value, 5 were of low value, and none were of no value to marbled murrelets.

Conclusions

Short-term effects:	High. Depending on the potential for imminent logging on individual land parcels that contain prime murrelet nesting habitat

(i.e., old growth coniferous forest), the short-term effects of land acquisition could be of high benefit.

Long-term effects: High In the long term, acquisition of old growth forest habitat would have a the highest possible benefit for enhancing murrelet population recovery.

Impacts on Fish

Pink Salmon

Alternative 4 would provide moderate restoration actions to assist natural recovery of wild-stock pink salmon populations. Actions that could be implemented to restore wild-stock pink salmon populations as part of Alternative 4 include: habitat protection and acquisition and relocation of hatchery-produced runs (EVOS Trustee Council, April; November 1993).

Habitat Protection and Acquisition

Criteria for parcels that may benefit pink salmon include ratings of high for parcels with a high density of pink salmon streams or streams known to have exceptional value; moderate for parcels with an average density of pink salmon streams or streams with average production; and, low for parcels with few or no pink salmon streams or streams with no production (EVOS Restoration Team, 1993).

Habitat protection that could benefit wild-stock pink salmon populations according to Alternative 4 would depend on the average cost per acre and the final budget allocation. Therefore, the number of parcels that could be purchased is expected to range between 34 parcels and all 81 parcels that are available. If all available parcels are purchased, the benefit is expected to provide moderate value for the pink salmon resource (Appendix A). Of the 81 parcels that may be purchased from the estimated budget that is forecasted for this alternative, 0, 38, 25, and 18 parcels have been rated as no, low, moderate, and high value, respectively, for pink salmon. A total of 53 percent of the parcels is rated as moderate or high value.

If only 34 parcels are purchased, the benefit is expected to provide moderate value for the pink salmon resource (Appendix A). Of the 34 parcels that may be purchased from the estimated budget that is forecasted for this alternative, 0, 10, 12, and 12 parcels have been rated as no, low, moderate, and high value, respectively, for pink salmon. A total of 71 percent of the parcels is rated as moderate or high value.

Although the average value of forecasted habitat acquisition may not have a high overall rating for pink salmon, individual parcels may have exceptional value. In the event that some of these parcels may not be protected through acquisition, the habitat would continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

General Restoration

Relocating Hatchery Runs. The relocation of hatchery runs would provide a benefit for wild stocks of pink salmon by providing an alternate location, timing or stock for commercial fishing activities. If the locations or timing for the relocated runs are carefully selected, the commercial fishery can be displaced and proceed with little or no interception of injured wild stocks. Combined with good fishery management practices and a redistribution of the commercial fishing fleet, fishing pressure could be diverted away from the wild stocks and refocused on the relocated hatchery runs. This will remove the fishing mortality from the injured wild stocks and allow them to recover (Appendix C).

The ADF&G and PNP aquaculture organizations have established a modern fisheries enhancement program that began in the mid-1970's that has included the establishment of new runs; however, some locations remain that provide ideal opportunities for juvenile fish imprinting and adult fish terminal-harvest areas that are readily accessible to the fishing fleets.

Every fisheries restoration, development, or enhancement program must be carefully planned and managed to avoid risks to wild stocks, and the fish-culture program must be carefully structured and controlled to avoid or minimize potential changes in the genetic makeup and health of the wild stocks that might be caused by the program. Although restoration, development, and enhancement of wild salmon stocks with fish-cultural techniques has been widely applied in the Pacific northwest, this strategy is not fully accepted within the fisheries profession (Hilborn, 1992; Martin, Webster and Edwards, 1992). Hatchery-produced fish typically can be harvested at a higher rate than most wild stocks. Consequently, if wild stocks are harvested with hatchery-produced fish, there may be a danger that the wild stocks may be overharvested (Hilborn, 1992). A good harvest-management strategy must be developed so the hatchery-produced stocks can be harvested in a separate time or place. Every fish-culture program must be carefully structured, planned, and controlled to avoid or minimize potential risks of change in the genetic makeup and health of the wild stocks (Hindar, Ryman and Utter, 1991; ADF&G, 1983; Holland-Bartels, Burger, and Klein, 1994; Meyers et al., 1988; Davis et al., 1985). Additional state and federal permits and a site-specific NEPA compliance review may also be required before a project is implemented (Appendix C, Section 1).

Conclusions

Short-term effects.	Low. Although some benefits may be accrued quickly, it is not reasonable to expect substantial results within one life-cycle.
Long-term effects.	Moderate. It can be expected that these actions will assist the recovery of the injured wild stocks of pink salmon. Long-term benefits, however, may be accrued in only portions of the EVOS area.

Sockeye Salmon

Alternative 4 would provide moderate restoration actions to assist natural recovery of wild-stock sockeye salmon populations. Actions that could be implemented to restore wild-stock sockeye salmon populations as part of Alternative 4 include: habitat protection, lake fertilization, and actions that may improve survival rates of sockeye salmon eggs by using egg incubation boxes, net pen rearing, or hatchery rearing (EVOS Trustee Council, April; November 1993).

Habitat Protection and Acquisition

Habitat protection criteria for parcels that would benefit sockeye salmon include ratings of high for parcels with sockeye salmon streams or systems known to have exceptional value; moderate for parcels with sockeye salmon streams or systems with average production; and, low for parcels with few or no sockeye salmon streams or systems with low production (EVOS Restoration Team, 1993).

Habitat protection that could benefit wild-stock sockeye salmon populations according to Alternative 4 would depend on the average cost per acre and the final budget allocation. Therefore, the number of parcels that could be purchased is expected to range between 34 parcels and all 81 parcels that are available. If all available parcels are purchased, the benefit is expected to provide low value for the sockeye salmon resource (Appendix A). Of the 81 parcels that may be purchased from the estimated budget that is forecasted for this alternative, 16, 48, 8, and 9 parcels have been rated as no, low, moderate, and high value, respectively, for sockeye salmon. A total of 21 percent of the parcels is rated as moderate or high value.

If only 34 parcels are purchased, the benefit is expected to provide low to moderate value for the sockeye salmon resource (Appendix A). Of the 34 parcels that may be purchased from the estimated budget that is forecasted for this alternative, parcels 8, 13, 6, and 7 have been rated as no, low, moderate, and high value, respectively, for sockeye salmon. A total of 38 percent is rated as moderate or high value.

Although the average value of forecasted habitat acquisition may not have a high overall rating for sockeye salmon, individual parcels may have exceptional value. In the event that some of these parcels may not be protected through acquisition, the habitat would continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

General Restoration

Action 1, Migration Corridor Improvements. These improvements entail mitigation of a barrier to fish migration that could prevent access to previous unavailable habitat for spawning or rearing and typically include installation of a fishpass or removal of a migration barrier. The construction of a fishpass (i.e., fish ladder or steep pass) is a permanent form of habitat modification to enable fish to access spawning and rearing habitat above an impassable barrier such as a steep stream gradient or a waterfall.

This technique has been widely applied throughout the EVOS area to increase populations of wild salmon stocks and to establish new self-sustaining populations by providing access to new or additional spawning habitat. However, it is effective for sockeye salmon only where the newly-produced fry have access to rearing habitat that is presently underutilized. The potential benefit will usually be limited by the amount of rearing habitat rather than the amount of new spawning habitat that is accessed. Installation is usually permanent, with a long lifespan. Within the EVOS area, potential benefits for sockeye salmon may be limited by the ability to identify new sites for application of this action where they will not interfere with management of other nearby wild stocks.

Action 2, Egg Incubation Boxes These boxes have been highly successful in the Copper River drainage to develop a small wild-stock population of sockeye salmon into an estimated annual total return of approximately 200,000 adult fish with an estimated annual commercial harvest of over 100,000 fish (Roberson and Holder, 1993). Other experiments to incubate sockeye and chum salmon eggs in egg incubation boxes in Prince William Sound were less successful (Jackson, 1974); however, when properly installed, these units control the water flow, substrate type, sedimentation, and predation to provide egg-to-fry survival rates as high as 90 percent. This compares quite favorably with an expected survival rate of 12 to 43 percent of eggs laid in redds by spawning sockeye salmon (Drucker, 1968) where survival may be affected by extremes of environmental conditions.

The potential contribution of egg incubation boxes for the restoration of sockeye salmon stocks in the EVOS area will be limited to drainages with: (1) limited successful reproduction; (2) spring areas with appropriate physical features and water quality and quantity; and, (3) underutilized rearing capacity for the sockeye salmon fry that are produced.

Although extensive surveys to locate potential sites to operate this technique have not been performed, if suitable locations can be identified within drainages that presently support small populations of sockeye salmon, this technique could be applied to help restore those populations without a major intrusion into the environment or the fish stock.

Action 3, Net-pen Rearing. This practice has been widely applied to increase the survival rate of all salmon species. This technique, however, has only recently been applied successfully for sockeye salmon because most previous attempts failed because sockeye salmon are particularly susceptible to the disease, infectious hematopoietic necrosis virus (IHNV) (Mr. Terry Ellison, ADF&G, oral comm.).

Although the net-pen rearing technique has been applied in both freshwater and in saltwater, most success has been achieved with freshwater rearing because the early lifestages from only a few stocks of sockeye salmon can survive in saltwater. Burke (1993), however, described a highly successful program for rearing juvenile sockeye salmon in saltwater net pens to the smolt stage, but only after they had been fed first in freshwater hatchery raceways. Consequently, although net-pen rearing of sockeye salmon in saltwater may have excellent potential for a hatchery-based application, it may be of limited value for protection and restoration of wild stocks except where it may be used to create an alternate opportunity for commercial fishermen.

Juvenile sockeye salmon typically require rearing in freshwater for up to three years (Burgner, 1991). During this period, the mortality rate between the fry and smolt stages may range from 86 to 99 percent (Roberson and Holder, 1993), but fry held in net pens are largely protected from predators and food is provided, so the mortality rate is low. Net-pen rearing of sockeye salmon fry in freshwater has not been widely applied; however, Schollenberger (1993) and Zadina and Haddix (1990) have reported good success with this strategy.

Net-pen rearing of sockeye salmon fry to increase their survival rate potentially may be employed in many systems throughout the EVOS area. Only two key ingredients are necessary: a source of fry and a suitable site to anchor and service the net pens. Fry may be captured from a spawning stream or transferred from a hatchery. Careful application of the net-pen rearing techniques will increase the numbers of emigrating sockeye salmon smolts and returning adults with minimal undesirable effects on the population or the lake rearing system. The magnitude of the benefit will depend on the numbers of captive fry that can be accommodated.

Every fisheries restoration, development, or enhancement program must be carefully planned and managed to avoid risks to wild stocks, and the fish-culture program must be carefully structured and controlled to avoid or minimize potential changes in the genetic makeup and health of the wild stocks that might be caused by the program. Although restoration, development, and enhancement of wild salmon stocks with fish-cultural techniques has been widely applied in the Pacific northwest, this strategy is not fully accepted within the fisheries profession (Hilborn, 1992; Martin, Webster and Edwards, 1992). Hatchery-produced fish typically can be harvested at a higher rate than most wild stocks. Consequently, if wild stocks are harvested with hatchery-produced fish, there may be a danger that the wild stocks may be overharvested (Hilborn, 1992). A good harvest-management strategy must be developed so the hatchery-produced stocks can be harvested in a separate time or place. Every fish-culture program must be carefully structured, planned, and controlled to avoid or minimize potential risks of change in the genetic makeup and health of the wild stocks (Hindar, Ryman and Utter, 1991; ADF&G, 1983; Holland-Bartels, Burger, and Klein, 1994; Meyers et al., 1988; Davis et al., 1985). Additional state and federal permits and a site-specific NEPA compliance review may also be required before a project is implemented (Appendix C, Section 1).

Action 4, Hatchery Rearing. Hatchery rearing of sockeye salmon has had a long history in Alaska; however, during the last decade, this strategy has been improved, and it has produced dramatic innovations and results (Ellison, 1992). In Alaska, cultured juvenile sockeye salmon have been released as fry, presmolts, and smolts. Each lifestage has its own particular logistical, biological, and fish-cultural constraints and advantages. Fry are less expensive to rear, transport, and release, but they require at least one year of rearing in a lake before they smoltify, and they will not survive to the adult stage as well as presmolts or smolts. Fry that are retained and fed in hatchery raceways may be released in late fall as presmolts. These young fish require few resources from the lake system during the winter and emigrate as smolts in the spring. Smolts are expensive to rear and transport, but they will survive better to the adult stage; however, they can be released as migrants without reliance on freshwater rearing.

Injured wild stocks may be helped directly by a rearing and release program for that stock, or the wild stocks may be helped indirectly by creating an alternate opportunity for the commercial fishers to divert fishing pressure away from the injured wild stocks. For direct restoration, fry-rearing programs will be limited to those drainages where the forage is underutilized by the naturally produced fry. Presmolt- and smolt-rearing programs, however, can provide direct restoration with little or no effect on plankton populations.

Every fisheries restoration, development, or enhancement program must be carefully planned and managed to avoid risks to wild stocks, and the fish-culture program must be carefully structured and controlled to avoid or minimize potential changes in the genetic makeup and health of the wild stocks that might be caused by the program. Although restoration, development, and enhancement of wild salmon stocks with fish-cultural techniques has been widely applied in the Pacific northwest, this strategy is not fully accepted within the fisheries profession (Hilborn, 1992; Martin, Webster and Edwards, 1992). Hatchery-produced fish typically can be harvested at a higher rate than most wild stocks. Consequently, if wild stocks are harvested with hatchery-produced fish, there may be a danger that the wild stocks may be overharvested (Hilborn, 1992). A good harvest-management strategy must be developed so the hatchery-produced stocks can be harvested in a separate time or place. Every fish-culture program must be carefully structured, planned, and controlled to avoid or minimize potential risks of change in the genetic makeup and health of the wild stocks

(Hindar, Ryman and Utter, 1991; ADF&G, 1983; Holland-Bartels, Burger, and Klein, 1994; Meyers et al., 1988; Davis et al., 1985). Additional state and federal permits and a site-specific NEPA compliance review may also be required before a project is implemented (Appendix C, Section 1).

Conclusions

Short-term effects.	Low. Some benefits in some drainages may be accrued within one life cycle.
Long-term effects.	High. It can be expected that these actions would assist the recovery of the injured wild stocks of sockeye salmon. Certain actions, however, may be useful in only portions of the EVOS area, and not all populations may be totally restored.

Pacific Herring

Alternative 4 includes only one restoration action to assist natural recovery of Pacific herring: habitat protection and acquisition (EVOS Trustee Council, April 1993).

Habitat Protection and Acquisition

Habitat protection and acquisition criteria for parcels that may benefit Pacific herring include ratings of high for parcels with documented consistent annual Pacific herring spawning along the parcel shoreline; moderate for parcels with occasional spawning along the parcel shoreline; and, low for parcels with no documented Pacific herring spawning along the parcel shoreline, but a possible feeding area (EVOS Restoration Team, 1993).

Habitat protection that could benefit Pacific herring populations according to Alternative 4 would depend on the average cost per acre and the final budget allocation. Therefore, the number of parcels that could be purchased is expected to range between 34 parcels and all 81 parcels that are available. If all available parcels are purchased, the benefit is expected to provide moderate value for the Pacific herring resource (Appendix A). Of the 81 parcels that may be purchased from the estimated budget that is forecasted for this alternative, 7, 30, 29, and 15 parcels have been rated as no, low, moderate, and high value, respectively, for Pacific herring. A total of 54 percent is rated as moderate or high value.

If only 34 parcels are purchased, the benefit is expected to provide moderate value for the Pacific herring resource (Appendix A). Of the 34 parcels that may be purchased from the estimated budget that is forecasted for this alternative, parcels 2, 9, 14, and 9 have been rated as no, low, moderate, and high value, respectively, for Pacific herring. A total of 68 percent is rated as moderate or high value.

Although the average value of forecasted habitat acquisition may not have a high overall rating for Pacific herring, individual parcels may have exceptional value. In the event that some of these parcels could not be protected through acquisition, the habitat would continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

Conclusions

Short-term effects.	Negligible. No benefits would be accrued within one life cycle.
Long-term effects.	Moderate. Habitat protection and acquisition actions can be expected to have a long-term value to Pacific herring stocks in the EVOS area by helping to assure maintenance of production potential. Some habitat areas would recover sooner than others.

Social and Economic Impacts

Archaeological / Cultural Resources

Habitat Protection and Acquisition

It is assumed in this alternative that 34 large parcels would be purchased. These parcels contain low (no known or suspected cultural resources/sites on parcel), moderate (no significant cultural resources/sites on or adjacent to parcel), or high (documented concentration or significant cultural resources/sites on parcel) potential for benefiting cultural resources as analyzed by the Habitat Protection Work Group (November 30, 1993). If low potential benefit on a parcel is assigned a value of 1, moderate potential benefit a value of 2, and high potential benefit a value of 3, these parcels average 2.2, or slightly higher than moderate. These estimates reflect known sites in the EVOS area but not all of the sites present. Not all sites have been found, so the actual benefit to cultural resources may be greater than reflected in these estimates. This analysis does not take into consideration small-parcel acquisition, which is currently under evaluation. It is also possible that land prices may be lower or higher than those assumed here. That would result in the purchase of more parcels (possibly all 81 identified parcels) or fewer parcels.

Habitat acquisition and protection may have minor short-term benefits on site protection. Moderate long-term benefits to archaeological site protection from habitat acquisition would accrue primarily through: (1) placing private lands under public management and applying Federal and State cultural resource protection laws; and, (2) reducing the likelihood of damage to cultural resources resulting from extractive economic activities such as mining and logging.

General Restoration

General restoration actions could include activities on individual sites (site stabilization, site-salvage excavations, site monitoring and stewardship), or in local communities (archaeological repositories, acquiring replacement artifacts). Often, onsite work could be combined with community activities, as is envisioned in the site stewardship program. Each of the proposed actions considered here could be implemented independently or in combination with any of the others. The most effective approach is comprehensive, tailoring combinations of actions within each community where cultural resources were injured by the spill. Actions considered applicable under Alternative 4 are discussed below:

Stabilize Archaeological Sites. Archaeological sites affected through erosion begun or worsened by oil-spill activities could be stabilized to slow or stop the erosion. Stabilization might entail recontouring parts of the sites to cover up exposed cultural deposits. This may reduce the visibility of artifacts and in this way reduce chances of looting or vandalism. This is a relatively nondestructive alternative when compared to archaeologically excavating the sites or allowing damage to continue.

Stabilization is a site-specific activity that could be accomplished through several different methods. Some sites are located along high-energy shorelines, or in high- energy intertidal areas, and might not be suited to stabilization. Also, stabilization techniques that contrast with surrounding terrain might serve as magnets for visitation rather that protection against visitation. The benefit of stabilization is to preserve the integrity of the site, an effect that may be temporary (requiring periodic maintenance) or permanent. This would have an immediate benefit of a moderate to high level in the short term but has the potential to preserve sites and reduce damage at a high level over the long term.

Excavate Archaeological Sites. Not all sites can be stabilized, whether for physical or economic reasons. Ongoing vandalism, looting, and erosion of archeological sites in the EVOS area could be mitigated through salvage excavation instead of stabilization. Excavation and stabilization also could be done on the same site. Scientific excavation of the sites most in danger of destruction could yield information important to understanding the history and prehistory of the EVOS area, a major element of Alaska's cultural heritage. Excavation could also remove human remains and funerary objects associated with the ancestors of contemporary people living in communities in the spill area. These remains could be moved to locations less likely to be disturbed by looters or vandals, or unearthed by ongoing erosion.

One effect of excavation is permanent destruction of the excavated portions of the sites. This destruction, however, is controlled and exactly delimited, allowing for the appropriate care and analysis of removed items and associations. Without archaeological excavation, damage to, and eventual destruction of, several of the sites would continue with neither the public nor the resource benefiting. The short-term and long-term benefit of salvage excavation of highly endangered sites is therefore high. This action both protects the sites from further looting and vandalism and mitigates any spill-related damage already incurred. Some salvage excavation projects have already been funded by the EVOS Trustee Council.

Site Monitoring and Stewardship. Archaeological site-stewardship programs active in Arizona, Arkansas, and Texas have demonstrated the utility of public education and increased oversight of sites for reducing continuing vandalism. A site-stewardship program for the EVOS area would combine public education and site monitoring through recruitment, training, coordination, and maintenance of a corps of locally interested citizens to watch over nearby archaeological sites. Sites to be monitored by local residents would be identified by land owners and managers on the basis of past and ongoing vandalism and erosion. Law enforcement officials could be involved during investigations or when called to sites to intercept active vandalism.

The benefits of site stewardship would be an increased knowledge and appreciation of archaeological methods of site monitoring and decreased site vandalism. These benefits may begin within the first year of implementation and continue for an indefinite term. The benefits of this action in the short term may be low, but benefits are potentially high in the long term, as site stewards become better trained and knowledge of the program is disseminated among people who could be inclined to damage sites. The action has additional importance in its involvement of local individuals and communities in protecting cultural resources.

Archaeology Repositories. Communities within the spill-affected area have increasingly expressed a desire that archaeological materials remain in (or at least are regularly returned to) their area of origin for display and interpretation. Local preservation of artifacts and the interpreting of Native heritage is proposed as a means to offset the increasing loss of artifacts and disturbance of Native graves in the spill area.

Placing artifacts in a local repository and using that repository as a base for interpreting cultural resources could help better educate residents and area visitors about practices of the past and the continuity of that past with the present and the future. These repositories could be established through modifying existing structures or by building new structures to accommodate collections. These would be located in communities within the oil-spill area and could serve as local foci for heritage-oriented activities. The short-term benefit of this action may be to restore a feeling of involvement with and oversight of the cultural heritage of local communities. This would be immediate but moderate. Long-term benefits may be high in terms of enhanced community involvement. It is this involvement that would address spill-related injury to the sense of cultural continuity and connectedness within the local communities.

Acquisition of Replacement Artifacts. Museums, agencies, and other repositories outside the spill area hold collections containing artifacts originally from the spill area. An action has been identified that would acquire some of these artifacts as a means of replacing a portion of the cultural heritage lost through the oil spill and subsequent cleanup activities. Many of these artifacts were removed from the spill area through ethnographic collecting and archaeological investigations in the 19th and early 20th centuries, and many reside outside of Alaska--in the lower 48 states, Europe, and Russia. Returning part of this diverse artifactual heritage to the spill area may have a low but immediate benefit in the communities within the spill area, allowing the people of the communities to more fully see the range of materials that represents a tangible part of their past. The long-term benefits of this approach are potentially high. By establishing a seed of improved cultural connectedness and fostering a sense of cultural continuity, this approach could grow into a major factor in producing a sense of recovery from the effects of the spill among the residents of those communities most affected.

This action could work through partnerships with existing museums or other regional repositories, or be combined with the establishment of local artifact repositories and interpretive centers. It is likely that communities would react differently to this approach. Individual consultations with each community would be required to assess the importance and effectiveness of this approach in each community.

Conclusions

Short-term effects:	Moderate Benefits. The proposed actions would increase the level of protection for archaeological resources, and improve the understanding or appreciation of cultural resource values.
Long-term benefits:	Moderate to High Benefits. The proposed actions may increase protection for archaeological resources and substantially improve the understanding or appreciation of cultural resource values.

Subsistence Uses

Habitat Protection and Acquisition

It is assumed in this alternative that 34 parcels would be purchased. These parcels contain low (status as a subsistence use area unknown), moderate (known historic subsistence use area, which may be used again), or high (known current subsistence use area) potential for benefiting subsistence as analyzed by the Habitat Protection Work Group (November 30, 1993). If low potential benefit on a parcel is assigned a value of 1, moderate potential benefit a value of 2, and high potential benefit a value of 3, these parcels average 2.4 (or between moderate and high).

Short-term benefits of habitat protection and acquisition on the recovery of subsistence species and subsistence use would be low, but the long-term benefits may be low to moderate. Protecting lands from habitat degradation associated with extractive economic activities like mining and logging may help recovering subsistence resources recover more quickly.

This analysis does not take into consideration small-parcel acquisition, which is currently under evaluation. It is also possible that land prices may be lower or higher than those assumed here. That would result in the purchase of more parcels (possibly all 81 identified parcels) or fewer parcels.

General Restoration

The additional 35 percent of the funding allotted for general restoration could provide the base for projects that directly affect the subsistence resources and subsistence activities within the EVOS area. These actions are summarized below. Please refer to the appropriate sections of this alternative for more detail on effects on individual species. These proposed actions could be conducted independently from each other or in combination.

Harbor Seals. The decline in subsistence harvest of harbor seals could have helped stabilize the population. The proposed action to implement cooperative programs between subsistence users and agencies to assess the effects of subsistence harvest could help in sorting out which localities would be best utilized (or best left alone) for subsistence use in order to optimize natural recovery of the populations. This may be a moderate long-term benefit, taking as long as 5 to 10 years to establish a measurably significant benefit. This action has the advantages of having a relatively low cost and the spin-off value of improving communication between agency biologists and subsistence users. Cooperative programs proposed for reducing incidental take of harbor seals during fishing likewise would have low short-term benefits, but may have moderate long-term benefits in 5 to 10 years. Reducing disturbance at haulout sites in the oil-spill area would have a negligible benefit in the short term and may produce a moderate benefit long term.

Sea Otters. One of the proposed actions would establish a cooperative program between subsistence users and research scientists or agency managers. While subsistence harvests are not a significant impact on sea otter populations, agency biologists and subsistence users may both benefit from the additional interaction and information sharing that would grow from such an action. Traditional knowledge of sea otter behavior and its relation to other parts of the ecosystem could be more extensive than is presently recognized by agency biologists. Similarly, the present range and concentration of sea otters could be better understood by agency biologists than is presently recognized by many subsistence users. This type of action would have little benefit immediately or in the short term on the recovery of sea otters, but the long-term benefit on management efforts; and to sea otter populations, could be significant.

Intertidal Organisms. A project has been proposed to reduce hydrocarbon levels in oiled mussel beds by temporarily removing mussels, replacing oiled sediments, and returning the mussels. Part of this action would be to monitor treated and untreated mussel beds to document the differential rates of recovery. This action may have low short-term and moderate long-term benefits on subsistence users, and the benefits would be localized.

Fucus, one of the central elements in intertidal ecosystems, is important for subsistence users as food and as habitat for other subsistence resources. A pilot project has been proposed to transplant *Fucus* to increase its population in the high intertidal zone. The recovery of *Fucus* is estimated at a decade. This would have insignificant short-term benefits, but could have moderate long-term benefits to subsistence users.

The recruitment of intertidal clams on cleaned beaches would remain low until a substrate of appropriate grain size is re-established, either naturally or through restoration efforts. A project (94068) has been proposed to study the feasibility of depositing fine-grained sediments to enhance larval recruitment and population recovery. Should this prove feasible, it would be possible under this alternative to fund expansion of the technique within the spill area. The hypothesis is that population recovery could occur within one or two years. Should this hypothesis be substantiated, and if subsistence users could be assured of the safety of eating clams produced in the enhanced habitat, both long-term and short-term benefits on subsistence use would be high.

Pink Salmon. Relocation of hatchery runs has been identified as a means to divert the commercial fishing fleet away from wild stocks of pink salmon. The resultant recovery of stocks would benefit subsistence uses of pink salmon. The benefits of this action on subsistence mirror those of the pink salmon population: negligible in the short term, but high in the long term of 5 to 10 years.

Sockeye Salmon. The use of egg incubation boxes has been proposed to restore or enhance sockeye salmon populations in the spill area. It is estimated that short-term benefits may be moderate, drainage-specific increases in populations. Long-term benefits may be low because of the scarcity of appropriate sites. If appropriate sites are found near villages, this technique has the potential for working very well locally to increase the amount of sockeye salmon available (both long term and short term) for subsistence use.

Net-pen rearing of sockeye salmon fry has been proposed to increase their survival rate. Since there are many appropriate locations for net pens in the EVOS, it is estimated that this technique would have strong short-term and long-term benefits on sockeye salmon populations. The advantage to subsistence users may be a corollary benefit.

Hatchery rearing of sockeye salmon has been proposed with release possible as fed fry, presmolts, and smolts. A number of project types are applicable, using different combinations of biological, physical, logistical, and technological factors. The short-term benefit of this type of action is likely to be low because it would take some time to establish the populations. The long-term benefit to sockeye salmon populations is estimated to be high because of several generations of improved survival of the smolt stage that would lead to increased numbers of returning adults. The benefit to subsistence users may increase as populations of sockeye salmon increase. The benefit to subsistence users increases if wild stocks are separated from hatchery stocks. Concentration on hatchery stocks by commercial fisheries could reduce competition for wild stocks.

Fertilizing lakes to improve sockeye rearing success and to increase sockeye populations also has been proposed. Sockeye salmon populations have been successfully increased through lake fertilization, but there could be few candidate lake systems for this application. The short-term benefit of this action on subsistence users would be negligible, while the long-term outlook may be substantially increased numbers of sockeye in specific stream systems, a high long- term benefit for subsistence users in some locations..

Relocation of hatchery runs has been identified as a means to divert the commercial fishing fleet away from wild stocks of sockeye salmon. The resultant recovery of stocks would benefit subsistence users of sockeye salmon. The benefits of this action on subsistence mirror those of the sockeye salmon population: negligible in the short term, but high in the long term of 6 to 10 years.

Subsistence Food Testing. One of the main elements in the damage to subsistence uses in the spill area is the fear that once safe subsistence foods are no longer safe to eat. An action has been proposed to conduct tests on subsistence foods to determine the amount of contamination, if any, in various types of subsistence foods. This action would provide immediate information to subsistence users, providing short-term and long-term high-level benefits to subsistence users' sense of security.

Conclusions

Short-term effects: Low Benefits. The proposed actions require some time after implementation before any changes could be expected.

Long-term effects: Moderate to High Benefits. The proposed actions are expected to moderately increase populations of subsistence harvest species negatively affected by the EVOS and substantially increase the confidence of subsistence users in determining the healthfulness of subsistence foods.

Recreation and Tourism

Habitat Protection and Acquisition

It is assumed here that 34 parcels would be purchased under Alternative 4. These parcels contain low (low to no recreation use; access may be difficult), moderate (receives occasional public use; adjacent waters used for recreational boating; adjacent area receives high public use), or high (receives regular, high directed public use; highly visible to a large number of recreationists/tourists) potential for benefiting recreation and tourism as analyzed by the Habitat Protection Work Group (November 30, 1993). If low potential benefit on a parcel is assigned a value of 1, moderate potential benefit a value of 2, and high potential benefit a value of 3, these parcels would average 2.1 (or slightly above moderate).

The benefits to recreation and tourism of habitat protection and acquisition derive from protecting of the scenic, wildlife, and undeveloped characteristics important for recreation values in the parcels being evaluated for acquisition. Extractive economic activities may reduce the recreational visual appeal of the landscape, shift or reduce wildlife viewing possibilities, and eliminate the relative lack of developed (logged or mined) character, thereby reducing the overall utility of those and surrounding areas for recreation purposes. These benefits may be low in the short term but moderate to high in the long term. This analysis does not take into consideration small-parcel acquisition, which is currently under evaluation. Also it is possible that land prices may be lower or higher than those assumed here. This would result in the purchase of more parcels (possibly all identified parcels) or fewer parcels.

General Restoration

Restoration strategies for recreation and tourism are to preserve or improve the recreation and wilderness values of the spill area, remove or reduce residual oil if it is cost effective and less harmful than leaving it in place, and monitor recovery. Alternative 4 focuses on stabilizing and improving existing recreation opportunities. It does not allow for funding projects that create new recreation opportunities or promote public land recreation use.

Specific actions identified under this alternative are discussed below. Where restoration actions are successful in increasing the number of recreationists/tourists or causing a higher use level of mechanized transport, there is a concurrent change in the wilderness quality of the recreation experience. Some recreation users may consider this change a negative impact. Depending on the extent of development and the volume of visitors, this benefit could be either widespread or localized.

Removing Residual Oil. Under this alternative, the short-term benefits to populations of harvestable subsistence resources, and so to subsistence use, would be low. The long-term benefits of habitat protection may be low to moderate. General restoration actions may produce moderate to high benefits. Subsistence harvests at prespill levels, stabilization of subsistence activities, perception of subsistence species recovery and consumption safety, and reintegration of many of the cultural values associated with subsistence activities into the communities are likely to occur within 5 to 10 years, especially if several actions are undertaken concurrently.

Easement Identification. Easement identification has been proposed as a means to reduce trespass and land-use conflicts between private landowners and the general public. This may improve recreation and tourism by letting people know where public land access exists. The short-term benefit may be low, because dissemination of the knowledge about the existence of public land could--as a result of increased use--accumulate impact over several years. The long-term benefit may be moderate to high, but might be very localized.

Conclusions

Short-term effects:	Low Benefits. The proposed actions may increase numbers of visitors, types of recreation opportunities available, and quality of experiences, but this is expected to occur gradually.
Long-term effects:	Moderate to High Benefits. The proposed actions may increase recreational use levels, types, and opportunities. This is expected to occur locally in some cases and throughout the spill area in other cases.

Designated Wilderness

Habitat Protection and Acquisition

It is assumed here that 34 parcels would be purchased under Alternative 4. These parcels contain low (high/moderate evidence of human development and/or ongoing activities), moderate (area remote; evidence of human development and/or ongoing activities), or high (area remote; little or no evidence of human development) potential for benefiting wilderness as analyzed by the Habitat Protection Work Group (November 30, 1993). If low potential benefit on a parcel is assigned a value of 1, moderate potential benefit a value of 2, and high potential benefit a value of 3, these parcels would average 2.3 (or slightly above moderate). The short-term benefits on designated Wilderness and Wilderness Study Areas, as well as to the wilderness quality of non-Wilderness lands, would be low since there would be little appreciable change to the lands in the short term. The long-term benefits may be low, with benefits derived from protecting wilderness settings from extractive activities. This analysis does not take into consideration small parcel acquisition, which currently is under evaluation. Also, it is possible that land prices may be lower or higher than those assumed here. This may result in the purchase of more parcels (possibly all identified parcels) or fewer parcels.

Acquisition of private lands with high levels of wilderness qualities such as isolation and lack of development may help maintain those lands in that condition. This would result in a negligible short term benefit, and is estimated to result in a low to moderate long term benefit to the wilderness character of the spill area. No lands would become designated Wilderness Areas or Wilderness Study Areas without formal state or federal legislative action.

General Restoration

General restoration actions could include actions that assist recovery of injured resources or prevent further injury. Any of these may have spinoff benefits that could improve wilderness values in the EVOS area. Recovery of designated Wilderness areas, and Wilderness Study Areas, hinges on removal of traces of oil and cleanup activities and public perception that the areas are recovered. Public awareness projects or marketing projects that may affect public perception of the recovery of Wilderness areas could be undertaken under this alternative, so long as they are restricted to protecting and increasing existing use.

Under this alternative, the concentration would be on projects that remove residual oil and/or residual cleanup materials still existing in isolated pockets in Wilderness areas. These types of projects may only occur if they provide substantial improvement over natural recovery. Short-term benefits may be immediate but low. Long-term benefits to recovery of wilderness character may be moderate.

Conclusions

Short-term effects:	Low Benefits. All of the proposed actions require some time after implementation before any changes could be expected.
Long-term effects:	Moderate Benefits. The proposed actions could reduce negative impacts on designated Wilderness Areas and Wilderness Study Areas, and extend some degree of protection to wilderness character of *de facto* wilderness lands.

Commercial Fishing

Alternative 4 would provide restoration actions to assist replacement of harvest opportunities that were lost because of fishing closures or harvest restrictions that occurred as a result of the EVOS. Actions that may be implemented as part of Alternative 4 include habitat protection and acquisition and creation of new hatchery-produced runs (EVOS Trustee Council, April and November 1993).

Habitat Protection and Acquisition

Habitat protection may benefit commercial-fishing opportunities by providing long-term protection for natural production and stability of wild stocks of pink and sockeye salmon and Pacific herring. The criteria for these parcels that may benefit commercial fisheries depends on the values assigned for those species (EVOS Restoration Team, 1993).

Habitat protection that may benefit replacement of lost opportunities for commercial fishing according to Alternative 4 will depend on the average cost per acre and the final budget allocation. Therefore, the number of parcels that may be purchased is expected to range between 34 parcels and all 81 parcels that are available. If all available parcels are purchased, the benefit is expected to provide moderate value for commercial fisheries. If only 34 parcels are purchased, the benefit may also provide moderate value (Appendix A).

Although the average value of forecasted habitat acquisition may not have a high overall rating for commercial fisheries, individual parcels may have exceptional value. If some of these parcels were not protected through acquisition, the habitat would continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

General Restoration

Create New Hatchery Runs. For commercial fishing resources, actions considered under Alternative 4 may replace lost opportunities by creating new hatchery-produced runs of salmon. Development of new runs of pink, sockeye, and chum salmon may benefit commercial fishing by providing an alternate location, timing, or stock for commercial fishing activities and if the brood-stock selection for these new runs and the release site were carefully selected, there would be minimal interception of injured wild stocks. Good fishery management practices combined with a redistribution of the fishing fleet, would enable an intensive commercial fishery to harvest these stocks.

Specific actions that may be considered can be expected --either alone or collectively-- produce new runs of sufficiently large numbers of adult pink, sockeye or chum salmon to accommodate a reasonable portion of the fishing fleet and provide a harvest that may be separated in time or space from existing fisheries. Several potential actions that may provide these fish by development of new hatchery runs entail actions that have been described for restoration of wild stocks of pink and sockeye salmon (e.g., rear and release fry, presmolts, or smolts) or habitat manipulation to increase production of selected stocks (e.g., lake fertilization, migration corridor improvements, spawning channels, etc.) (Appendix C). The actions and methods remain the same, but the brood stock selection (e.g., source, species, timing, etc.), release strategies (e.g., age, size, location, etc.), and the harvest management (harvest rate, timing, location, etc.) may be selected to benefit commercial fishers and, perhaps, particular gear types.

ADF&G and PNP aquaculture organizations have established a modern fisheries enhancement program in the EVOS area and have developed new runs of salmon for harvest by commercial fishers. Excellent success has been achieved with most of these programs which have developed new self-sustaining or hatchery-produced runs of fish (Ellison, 1992); however, some locations that are accessible to the fishing fleets remain as opportunities for juvenile fish imprinting and adult fish terminal harvest areas.

Every fisheries restoration, development, or enhancement program must be carefully planned and managed to avoid risks to wild stocks, and the fish-culture program must be carefully structured and controlled to avoid or minimize potential changes in the genetic makeup and health of the wild stocks that might be caused by the program. Although restoration, development, and enhancement of wild salmon stocks with fish-cultural techniques has been widely applied in the Pacific northwest, this strategy is not fully accepted within the fisheries profession (Hilborn, 1992; Martin, Webster and Edwards, 1992). Hatchery-produced fish typically can be harvested at a higher rate than most wild stocks. Consequently, if wild stocks are harvested with hatchery-produced fish, there may be a danger that the wild stocks may be overharvested (Hilborn, 1992; Seeb, 1993). A good harvest-management strategy must be developed so the hatchery-produced stocks can be harvested in a separate time or place. Every fish-culture program must be carefully structured, planned, and controlled to avoid or minimize potential risks of change in the genetic makeup and health of the wild stocks (Hindar, Ryman and Utter, 1991; ADF&G, 1983; Holland-Bartels, Burger, and Klein, 1994; Meyers et al., 1988; Davis et al., 1985; Seeb, 1993). Additional state and federal permits and a site-specific NEPA compliance review may also be required before a project is implemented (Appendix C, Section 1).

Conclusions

Short-term effects.	<u>Negligible</u>. New runs probably cannot be established within one lifecycle to support new commercial fisheries that would replace opportunities lost because of fishing closures or reduced harvests.
Long-term effects.	<u>Moderate</u>. These actions would assist the replacement of lost commercial-fishing opportunities; however, some portions of the EVOS area would obtain greater benefits than in other portions.

<u>Sport Fishing</u>

Sport fishing was disrupted throughout most of the EVOS area because of the oil spill, and populations of several important sport fish species were damaged. Lost sport fishing opportunities may be replaced by creating new sport fisheries for salmon or trout. Alternative 4 would provide restoration actions to assist replacement of harvest opportunities that were lost because of fishing closures or harvest restrictions that occurred as a result of the EVOS. Actions that might be implemented as part of Alternative 4 include habitat protection and acquisition and creation of new hatchery-produced runs (EVOS Trustee Council, April and November 1993).

Habitat Protection and Acquisition

Habitat protection may benefit sport fishing opportunities by providing long-term protection for natural production and stability of wild stocks of pink and sockeye salmon, Dolly Varden, and cutthroat trout. The criteria for these parcels that may benefit sport fisheries depends on the values assigned for these species (EVOS Restoration Team, 1993).

Under Alternative 4, the forecasted habitat protection that may benefit replacement of lost opportunities for sport fishing will depend on the average cost per acre and the final budget allocation. Therefore, the number of parcels that may be purchased is expected to range between 34 parcels and all 81 parcels that are available. If all available parcels are purchased, the benefit is expected to provide low to moderate value for sport fisheries. If only 34 parcels are purchased, the benefit may also provide low to moderate value (Appendix A).

Although the average value of forecasted habitat acquisition may not have a high overall rating for sport fisheries, individual parcels may have exceptional value. If some of these parcels were not protected through acquisition, the habitat would continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

General Restoration

Establish Hatchery Runs. The establishment of new hatchery-produced runs of salmon or trout would provide some benefit for all fishers by providing new opportunities with new locations and stocks that anglers may use. Typically, a run of a few thousand fish will provide tens of thousands of angler/days of recreation (Mills, 1993). Sport fisheries, however, would be successful only if they are located where they would be accessible by anglers. The ADF&G already has employed this strategy to improve sport fishing opportunities for trout and salmon in the EVOS area by stocking catchable-sized trout and salmon smolts at accessible locations, often where self-sustaining runs cannot be established. Actions are similar or identical to those described in Appendix C.

A small number of fish in a good, accessible location can provide angling to accommodate a substantial number of angler/days of recreation. Wherever large numbers of fishers concentrate to harvest a concentrated population of fish, some portions of the adjacent habitat may be affected. While new sport fisheries would readily create new recreational opportunities, these likely would be for different species in new locations.

Every fisheries restoration, development, or enhancement program must be carefully planned and managed to avoid risks to wild stocks, and the fish-culture program must be carefully structured and controlled to avoid or minimize potential changes in the genetic makeup and health of the wild stocks that might be caused by the program. Although restoration, development, and enhancement of wild salmon stocks with fish-cultural techniques has been widely applied in the Pacific northwest, this strategy is not fully accepted within the fisheries profession (Hilborn, 1992; Martin, Webster and Edwards, 1992). Hatchery-produced fish typically can be harvested at a higher rate than most wild stocks. Consequently, if wild stocks are harvested with hatchery-produced fish, there may be a danger that the wild stocks may be overharvested (Hilborn, 1992; Seeb,1992). A good harvest-management strategy must be developed so the hatchery-produced stocks can be harvested in a separate time or place. Every fish-culture program must be carefully structured, planned, and controlled to avoid or minimize potential risks of change in the genetic makeup and health of the wild stocks (Hindar, Ryman and Utter, 1991; ADF&G, 1983; Holland-Bartels, Burger, and Klein, 1994; Meyers et al., 1988; Davis et al., 1985; Seeb, 1992). Additional state and federal permits and a site-specific NEPA compliance review may also be required before a project is implemented (Appendix C, Section 1).

Conclusions

Short-term effects.	Negligible. New sport fisheries to replace lost sport fishing opportunities probably cannot be established within one lifecycle.
Long-term effects.	High. After hatchery production is expanded, and newly-established sport fisheries would provide substantial recreational benefits.

Economy

Qualitative analysis indicates that Alternative 4 would result in moderate economic benefits in commercial fisheries and recreation and moderate negative effects in forestry. This analysis reflects effects resulting from habitat acquisition on forestry and other sectors but not effects on commercial fishing and recreation because data in these sectors is not available to quantify. The quantitative analysis follows.

In Alternative 4 significant timberlands will be acquired and it is assumed that significant timber will not be harvested. As shown in Table 4-6 alternative 4 annual average industry output is projected to decline by $22.9 million and employment is anticipated to declline by 143 employees.

Spending of money by timberland owners hasa direct effect on the construction sector as shown in Table 4-6 Alternative 4 in the amount of $10.6 million in industry output. Spending of money by timberland owners also has a direct effect on the services sector in the amount of $2.6 milllion in final demand and 306 employees.

Spending in the construction and service sectors i not enough to offset the negative effects in the forestry sector for three measures in the total line: final demand, industry output and porperty inocme. However, employee compensation, value added and employment are positive.

Habitat acquisition and general restoration expenditures will have economic benefits for the commercial fisheries and recreation sectors of the economy. However, these benefits are not reflected in the IMPLAN projections presented in Table 4-6. Therefore, this table does not quantify important economic benefits in commercial fishing and recreation because these benefits are not quantified. Of the three most important economic sectors for this analysis, only forestry is quantified. The typical projects in various combinations, such as fish ladders, fish hatcheries, and preservation of habitat will economically enhance the commercial fisheries and recreation sectors of the economy. However, because studies and data are not available that quantify in terms of dollars or employment, it is not possible to quantify the economic effects for these two sectors of the economy. In Table 4-6 the quantities for the commercial fisheries and recreation sectors are reflections of the indirect effects of other sectors of the economy only; they are not reflections of the anticipated but unquantified effects on those sectors.

Short-term impacts are anticpated to be negligible.

See the introduction to Chapter 4 on economics and Appendix D of this EIS, Economics Methodology, for a more detailed discussion of methodology.

Conclusions

Short-term effects: Negligible. Short-term impacts are anticipated to be neglible.

Long-term effects: Qualitative analysis indicates that Alternative 4 would result in moderate economic benefits in commercial fisheries and recreation and moderate negative effects in forestry. Quantitative analysis reflects there would be effects resulting from habitat acquisition on forestry and other sectors but not on commercial fishing and recreation. Quantitative analysis indicates that Alternative 4 would result, in annual averages for a 10-year period, in a loss of approximately $23 million in forestry industry output, an increase of $11 million in construction industry output, and $2 million in government. The corresponding changes in employment would be a loss of 143 jobs in forestry, an increase of 96 in construction, an increase of 306 in services, and an increase of 45 in government.

Table 4-6. Alternative 4: 7% Administration, 8% Monitoring, 35% Restoration, 50% Habitat Protection
Average Annual Change from Base in 1990$ Millions

Economic Sector	Final Demand $	Industry Output $	Employee Comp. $	Property Income $	Value Added $	Employment #
Forestry	-17.815	-22.918	-5.772	-2.329	-8.960	-143
Commercial Fisheries	0.000	0.000	0.000	0.000	0.000	0
Mining	0.031	0.066	0.005	0.031	0.051	0
Construction	11.034	10.646	4.001	1.608	5.637	96
Manufacturing	0.029	0.128	0.024	0.067	0.043	0
Recreation Related	0.025	0.127	0.037	0.033	0.073	2
Communication & Utilities	0.053	0.207	0.065	0.072	0.140	2
Trade	0.254	0.360	0.211	0.049	0.304	9
Finance, Insurance, Real Estate	0.244	-0.116	-0.083	0.009	-0.057	-3
Services	2.682	0.803	1.512	-0.499	1.020	306
Government	2.463	2.392	2.120	-0.010	2.410	45
Miscellaneous	0.000	0.000	0.000	0.000	0.000	0
Total	-1.001	-8.305	2.120	-1.020	0.662	315

Source: IMPLAN Economic Model. See text for methodology.

The Proposed Action Alternative 5: Comprehensive Restoration

Introduction

In this alternative, the General Restoration program focuses on the status of recovery of injured resources rather than on the degree of injury caused by the oil spill. In this way, the components of the ecosystem that are having most difficulty recovering receive the greatest efforts, if there are general restoration actions that can realistically help. This alternative also increases the opportunity to conduct research into other aspects of the ecosystem that may be influencing the recovery of the resources and thereby the services they provide injured by the oil spill. A Restoration Reserve fund would be established to provide funding for research, monitoring, and restoration activities to continue beyond the 10-year settlement period.

The Habitat Protection and Acquisition program is a primary component of the overall restoration program, receiving the largest portion of the remaining settlement funds. Habitat protection and acquisition provides protective benefits to all resources and thereby the services they provide injured by the oil spill as well as to other resources and human uses that are important to the greater EVOS ecosystem. Increasing the protection of habitat throughout the spill area will be beneficial to the entire ecosystem by reducing further habitat degradation that may compound the effects of the oil spill. The general restoration actions can help resources or services recover to their prespill conditions more rapidly than if the actions were not implemented. A third component of the restoration program is Monitoring and Research. These activities track the progress of recovery and provide valuable information that can be used to help the resources, and the overall ecosystem, recover from the oil spill and from other factors that may be delaying recovery.

Impacts on Biological Resources

Impacts on Intertidal Resources

In Alternative 5, the restoration program for intertidal resources differs from the previous alternatives by adding an additional action and by providing three possible scenarios for the Habitat Protection program. These changes are presented at the beginning of the discussion below, followed by the actions that are identical to those described in Alternatives 3 and 4.

Habitat Protection and Acquisition

Although there are several types of actions that apply under this restoration category, this analysis only considers the types of benefits that may be gained from protecting the 81 upland parcels identified in the Comprehensive Habitat Protection Process; Large Parcel Evaluation & Ranking Volume I and II (EVOS Restoration Team, November 1993). Other aspects of the habitat protection category, such as the small parcels available for protection, are still being developed and cannot be analyzed in this DEIS.

The habitat protection process used to evaluated the 81 parcels for their potential benefits to injured resources and services combined intertidal and subtidal biota and used the following criteria for ranking the parcels:

- High for parcels adjacent to areas with a known high species abundance and diversity; high-quality habitat for intertidal and subtidal biota;

- Moderate for parcels adjacent to extensive intertidal habitat with observed or probable moderate species diversity and abundance; and

- Low for parcels with little intertidal habitat with low species abundance (EVOS Restoration Team, November 1993).

In Alternative 5, it is possible to consider the value of all 81 parcels if it is assumed that the cost per acre is low; however, if the cost per acre is higher, fewer acres of land are likely to be purchased. In this alternative, there is a range of funds available for Habitat Protection and Acquisition actions, so there are two more restrictive estimates that need to be assessed based on a higher cost per acre. For this analysis, when a higher cost per acre is assumed for these parcels, fewer of the parcels that are ranked Low for multiple resources and services likely would be protected. Some of these parcels still may have High or Moderate value for intertidal and subtidal resources, even though their total ranking is Low when evaluated for all of the injured resources and services combined. Table 4-7 shows how the distribution of habitat evaluated as high, moderate or low would change for intertidal/subtidal benefits when all 81 parcels are considered or when the parcels are reduced from higher cost and/or less money is dedicated to habitat protection.

Table 4-7

Number of habitat parcels within each rating category that may be protected to benefit intertidal resources with different purchase scenarios for Alternative 5

	High Benefits	Moderate Benefits	Low Benefits
All 81 parcels considered (same in all alternatives)	25 parcels	33 parcels	19 parcels
Higher parcel cost with 50% remaining funds	19 parcels	10 parcels	4 parcels
Higher parcel cost with 45% remaining funds	18 parcels	9 parcels	3 parcels

Under the most restrictive scenario, 72 percent of the 81 parcels evaluated ranked high for their intertidal/subtidal habitat and still would be protected. The benefits to intertidal and subtidal organsims through the protection of upland habitats come in two forms. First, the protection could prevent the intertidal and subtidal areas from being altered by the actions that may occur on the parcels. Some actions could cause indirect adverse effects through siltation or increased pollution, while other actions, such as the construction of a dock or creating a new harbor, could directly alter the intertidal and subtidal habitats. The second type of protection would reduce the disturbance caused by increased human activity (e.g., more people walking through the intertidal area; more pollution from littering or from bilge discharge). Obviously, the type of activity that may occur on a given parcel could substantially change the degree of benefit that is gained to the intertidal and subtidal zones.

The actual benefit gained by the intertidal and subtidal organisms would depend on the type and location of the activities that may occur. In areas where construction activities are anticipated in the intertidal zone, the protection would be especially effective. If the parcels correspond to areas of the intertidal zone that still are not recovering from the effects of the oil spill, the benefits could be even greater.

General Restoration

Clam Mariculture Program. This alternative includes establishing a clam- mariculture program to help the recovery of subsistence uses in the spill area (also see the discussion on impacts to subsistence users in this alternative). This program would create a bivalve hatchery that would provide seed sources for creating new clam beds or re-establishing clam beds injured by the oil spill. Because this action is targeted towards subsistence activities, the areas that would benefit from this action probably would be close to villages within the spill area. Eyak, Tatitlek, Chenega Bay, Nanwalek, and Port Graham are some of the villages that have been discussed as benefiting from this action (EVOS Trustee Council, October 1992). The spillwide distribution of clam beds that were injured from the oil spill and cleanup activities is unknown. To the extent that this action re-establishes clam beds that are still exhibiting lower abundance of clams than unoiled areas, this action substantially can accelerate the recovery of the clam beds. If the mariculture program targets new areas to create clam beds, other intertidal habitats could be lost. Mariculture facilities that are designed like a commercial operation should have negligible effects on the intertidal communities.

The other two actions that have been identified for this alternative would directly affect the intertidal zone. These actions affect specific organisms, *Fucus* and mussels, but are meant to provide broader benefits to the other organisms that live or feed in these communities.

Accelerate the Recovery of the Upper Intertidal Zone. This would be done by re-establishing *Fucus*. The upper intertidal area, specifically the upper 1-meter-vertical drop (1MVD), is probably the upper extent of suitable habitat for *Fucus* to grow. This means that the conditions are more extreme than in other habitats and would be more difficult to colonize. *Fucus* germlings that colonize in the upper intertidal area are subject longer periods of high temperatures and dryness during low tides. Without the shelter and moisture that is provided by mature *Fucus* plants, the germlings can become desiccated and die. Studies conducted in Herring Bay, Prince William Sound, suggest that it may take 3 to 4 years for *Fucus* communities to expand 0.5 m beyond their existing boundaries (Highsmith et al., 1993).

Feasibility studies of techniques for accelerating the recovery of *Fucus* were begun in 1992. Attempts to transplant mature *Fucus* plants were generally unsuccessful (Stekoll, pers. comm., 1994). Another technique which uses a biodegradable cloth to cover seeded areas is currently being tested (Stekoll, pers. comm., 1994), and results of this experiment will be known after the summer of 1994. In theory, the cloth will substitute for the adult *Fucus* by providing moisture and protection to the germlings during low tides. Because the technique is still being tested, it is impossible to know how successful the action may be, or how easily it can be applied to the areas that could benefit from the action. If the technique is highly successful, the established germlings could become fully mature in 3 to 4 years and the associated invertebrates would also recolonize in the upper intertidal zone. At this time, however, it is impossible to know the outcome of the research; therefore, any benefits from this action are unknown.

Cleaning Oiled Mussel Beds. This has been considered as a possible method to reduce the hydrocarbon exposure for sea otters, harlequin ducks, and black oystercatchers. These animals depend on mussels for a large portion of their diet (Webster 1941; Dzinbel and Jarvis, 1982; Doroff and Bodkin, 1993). Mussels occur in loose aggregations attached to intertidal rocks, or in dense aggregations (mussel beds) over pea gravel and silt sediments. Because mussels form a dense matt over the sediments and rocks, oil that was trapped beneath the mussels was not exposed to weathering and still remains toxic. It may be possible to clean mussels in mussel beds, but cleaning will not be possible in all habitats where mussels occur.

One of the possible explanations for continuing signs of injury to sea otters, river otters, harlequin ducks, and black oystercatchers is that they continue to be exposed to hydrocarbon contamination by eating oiled mussels. Concern over this possible continuing source of contamination led to feasibility studies to develop techniques to clean the sediments beneath the oiled mussel beds. One technique to be tested in 1994 lifts sections of the mussel beds and replaces the contaminated sediments with clean sediments without serious damage to the mussel beds (Babcock, pers. comm., 1994). Other techniques are likely to damage the existing mussels when contaminated sediments are removed. Approximately 60 locations with oiled mussel beds have been identified in Prince William Sound. Oiled mussels beds have been identified and sampled from the Alaska Peninsula and Kodiak, however, estimates on the number of exisiting oiled mussel beds are unavailable.

The extent and distribution of oiled mussel beds is still being determined and will be important in understanding the potential benefits that can be gained for other organisms by this action. There have been no studies to determine whether eating contaminated mussels is causing injury to other species within the EVOS area. However, other studies have documented reproductive impairment in some seabirds after ingesting oil (Epply and Robega, 1990; Fry and Addiego, 1988). The intent of cleaning oiled mussel beds is largely to eliminate a source of continuing contamination to other organisms. Studies that examined the effects of oil on the mussel beds noted a reduction in the number of large mussels and overall biomass of the mussel beds, but there did not appear to be a shortage of new recruits (smaller mussels) to the mussel beds (Highsmith, Stekoll and Barber, 1993). It is unknown whether the trapped oil beneath the mussel beds will ultimately cause further injury to the mussels; however, continued high levels of hydrocarbons have been found in mussel tissues, which indicates that the mussels may be continuing to be contaminated.

If the technique described above is successful, then this action is unlikely to cause an adverse effect and may provide tangible benefits to the mussels at the cleaned sites. Presumably, this technique would be applicable throughout the EVOS area, however, there is less information on the location of oiled mussel beds in areas outside of Prince William Sound.

Conclusions

Short-term effects: Negligible.

Long-term effects: Unknown effects. For direct restoration actions, effects are unknown because both of these actions still are being tested. The long-term benefits of the Habitat Protection actions for reducing disturbance or preventing additional injury to intertidal organisms are moderate and will vary substantially between parcels.

Impacts on Marine Mammals

Harbor Seals

The restoration program for harbor seals that is possible under Alternative 5 differs from the previous alternatives by adding an additional action. The Habitat Protection capabilities also may differ from those described in Alternatives 2 and 4, because our estimated range of potential funding reduces the amount of uplands that could be protected slightly more than the more restrictive scenario presented in Alternative 4. It also is possible that efforts made to increase or create new recreation- and commercial-tourism use of the oil-spill area could increase the level of disturbance on the harbor seal populations. These changes are presented at the beginning of the discussion below, and are followed by a repeat of the discussions that are applicable here from other alternatives.

Habitat Protection and Acquisition

Habitat protection of upland parcels can help reduce disturbance to harbor seals. Harbor seals use haulout sites that are either in the intertidal zone or immediately adjacent to the intertidal zone; therefore, actions that occur on the uplands likely would not destroy the habitat. However, it is possible that habitat changes to the uplands may increase the amount of disturbance currently experienced at haulout sites on or near the parcel.

Habitat-protection criteria for parcels that may benefit harbor seals include ratings of

- High for parcels known to have a haulout of 10 or more seals on or immediately adjacent to the parcel;

- Moderate for parcels with known haulouts with sporadic use and less than 10 seals, or probable haulouts in vicinity of the parcel or probable feeding in nearshore waters; and,

- Low for possible feeding sites located in nearshore waters adjacent to the parcel (EVOS Restoration Team, November 1993).

Of the 81 parcels evaluated in the large parcel process, 25 were ranked high, 19 were ranked moderate, 35 were ranked low, and 2 were ranked as having no benefit to harbor seals. The overall value of these parcels based on these rankings is moderate, although individual parcels may have exceptional value.

In Alternative 5, it is possible to consider the value of all 81 parcels if it is assumed that the cost per acre is low; however, if the cost per acre is higher, fewer acres of land likely would be purchased. In this alternative, there is a range of funds available for Habitat Protection and Acquisition actions, so there are two more restrictive estimates that need to be assessed based on a higher cost per acre. For this analysis, when a higher cost per acre is assumed for these parcels, fewer of the parcels that are ranked low for multiple resources and services are likely to be protected. Under the scenario where 50 percent of the remaining settlement funds are available for habitat-protection actions, the potential benefit to harbor seals would be identical to the changes described in Alternative 4. Table 4-8 shows how the distribution of habitat evaluated as high, moderate, or low would change when all 81 parcels are considered, or when the parcels are reduced from higher cost and/or less money dedicated to habitat protection.

Table 4-8

Number of habitat parcels within each rating category that may be protected to benefit harbor seals with different purchase scenarios for Alternative 5.

	High Benefits	Moderate Benefits	Low Benefits
All 81 parcels considered (same in all alternatives)	25 parcels	19 parcels	35 parcels
Higher parcel cost with 50% remaining funds	18 parcels	6 parcels	7 parcels
Higher parcel cost with 45% remaining funds	17 parcels	5 parcels	6 parcels

Under the most restrictive scenario, 68 percent of the 81 parcels evaluated ranked high for harbor seals and still would be protected. Because the actual impact that development on these parcels would have on the harbor seals depends on, among other things, the type of disturbance caused, the length and duration of the disturbance, and whether or not the haulout area is used for pupping or molting, it is impossible to know what change in the protection to sites with haulouts would have on the recovering harbor seal population. Within the EVOS area, there have been no studies to document the amount or effects of current activities that may cause disturbance to harbor seals, so baseline data are unavailable. However, it is reasonable to assume that protection of upland habitats near haulout sites would reduce the risk of disturbance to the injured population.

Reduce Disturbance at Haulout Sites in the Oil-Spill Area. This is the only new action proposed for harbor seals in this alternative. Several studies have documented the effects of disturbances on harbor seals and other pinnipeds (Allen et al., 1984; Esipenko, 1986; Johnson et al., 1989). These studies have shown that the greatest impacts from disturbance occur during pupping and molting seasons. During pupping, disturbance can result in higher pup mortality caused by abandonment or from being crushed as the adults panic and return to the water (Johnson, 1977). During molting, seals are under physiological stress and may be more susceptible to disease and injury. The greatest disturbance is caused when people walk near or through haulout sites (Johnson et al., 1989); but disturbance also can be caused by low-flying aircraft and by boats that approach too close to haulouts. Within the EVOS area, no studies have been made to document the amount or effects of disturbance. Without these data, it is impossible to determine if working with recreation and tourism groups would reduce seal mortality and aid recovery; however, it may become increasingly important as recreational use and commercial tourism of the EVOS area expands.

Restoration Actions for Other Resources/Services. If actions are taken to increase or create new recreation and commercial tourism activities in the oil-spill area, there could be a negative, long-term impact on harbor seals. These impacts could be avoided or minimized by implementing education programs to minimize the level of human-caused disturbance. Aside from monitoring and research activities, and assuming that the actions previously described are implemented, none of the other actions proposed under this alternative for other resources or services likely would impact harbor seals.

General Restoration

The remaining actions were described in Alternatives 3 and 4 and are repeated here. Both of the proposed actions are information-based programs that would be designed to change the impact of commercial fisheries or of subsistence harvest on the recovering seal populations.

Subsistence harvest is not believed to be the cause of the long-term decline of harbor seal populations in the Gulf of Alaska; however, any additional mortality may slow the recovery of injured populations. Subsistence harvest in Prince William Sound declined as a result of the oil spill and, in 1991, harvest levels probably were less than 5 percent of the population. A healthy seal population easily would be able to sustain that level of harvest. Depending on the distribution, sex, and age of the animals harvested, a 5-percent harvest negatively could affect an injured population.

Establish a Cooperative Program Between Subsistence Users and Research Scientists or Agency Managers. Such a program would be designed to provide a two-way exchange of information that would provide benefits to all parties and could benefit the injured harbor seal populations. For example, recent studies indicated that harbor seals may have a high site fidelity to molting and pupping areas (e.g., the same individuals consistently use the same areas) (Pitcher, 1990). If some of these areas show greater declines than other sites within Prince William Sound, then redirecting harvest towards the healthier or the nonoiled areas could reduce any negative effects from the harvest without actually changing the number of animals harvested.

Cooperative Program with Commercial Fishermen. This program also could reduce pressure on the injured seal populations. This program would provide information on deterrent methods and regulations. Ideally, it would provide information to the scientists on the extent of the interactions between the commercial fisheries and the seals and would reduce the number of seal mortalities. The interactions with commercial fisheries probably result in fewer deaths than from the subsistence harvest and are unlikely to be the cause of the seal decline; however, the more that can be done to minimize the effects of human -caused injury and mortality, the more likely it will be that the population will stabilize and recover.

Conclusions

Short-term effects:	Negligible . All of the proposed actions require some time after implementation before any changes could be expected.

Long-term effects: Moderate. The proposed actions could reduce negative impacts on harbor seals and may result in increased recovery rates in local areas.

Sea Otters

The effects of actions under Alternative 5 are expected to be identical to those described in Alternatives 3 and 4 with the exception of the amount of habitat that could be protected.

There are three types of actions besides research or monitoring that are considered in this alternative: habitat acquisition, cleaning oiled mussel beds, and creating a cooperative program between subsistence users and sea otter scientists and managers.

Habitat Protection and Acquisition

The benefit to sea otters of habitat-protection actions on upland parcels is through reducing potential or actual disturbance. Sea otters appear to have a high tolerance to certain human activities, as evidenced by their abundance in highly travelled areas such as Orca Inlet near Cordova; however, their response to large-scale disturbances has not been studied. Large-scale disturbances, such as log-transfer sites, may force resident sea otters to leave the immediate area and may cause a long-term change in food availability as debris from the logs covers the substrate. Disturbance more likely would cause adverse effects to females with pups that concentrate in high-quality habitats with abundant prey in the intertidal zones.

Habitat-protection criteria for parcels that may benefit sea otters include ratings of:

- High for parcels adjacent to known pupping concentrations,

- Moderate for parcels adjacent to concentration areas for feeding and/or shelter or potential pupping areas, and

- Low for feeding sites located in adjacent waters (EVOS Restoration Team, November 1993).

In this alternative, there is a range of funds (45-50 %) available for Habitat Protection and Acquisition actions, so there are two more restrictive estimates that need to be assessed based on a higher cost per acre. The differences are shown in Table 4.XXX. Under the first scenario, all of the 81 large parcels described in the Comprehensive Habitat Protection Process; Large Parcel Evaluation & Ranking Volume I and Volume II (EVOS Restoration Team, November 1993) are considered in the analysis (this scenario is possible under all alternatives if a low cost per acre is assumed). When a higher cost per acre is assumed for these parcels, fewer of the parcels that are ranked low for multiple resources and services likely would be protected. Under the scenario where 50 percent of the remaining settlement funds are available for habitat protection actions, the potential benefit to sea otters is identical to the changes described in Alternative 4. Table 4-9 shows how the distribution of habitat evaluated as high, moderate, or low would change when all 81 parcels are considered, or when the parcels are reduced from higher cost and/or less money dedicated to habitat protection.

Table 4-9

Number of habitat parcels within each rating category that may be protected to benefit sea otters with different purchase scenarios for Alternative 5.

	High Benefits	Moderate Benefits	Low Benefits
All 81 parcels considered (same in all alternatives)	20 parcels	16 parcels	42 parcels
Higher parcel cost with 50% remaining funds	14 parcels	10 parcels	10 parcels
Higher parcel cost with 45% remaining funds	14 parcels	8 parcels	9 parcels

Under the most restrictive scenario, 70 percent of the 81 parcels evaluated 70 percent ranked high for sea otters and still would be protected. These areas are associated with pupping concentrations that most likely would be sensitive to disturbance from human activities.

General Restoration

The following discussion of restoration actions and their potential benefits are identical to Alternatives 3 and 4.

Cleaning Oiled Mussel Beds. This is considered to be a possible method to reduce the hydrocarbon exposure. Sea otters, especially juvenile otters and females with pups, depend on mussels for a large portion of their diet (Doroff and Bodkin, 1993). Mussels are found in shallower areas and are easier to obtain than other prey. Mussels occur in loose aggregations attached to intertidal rocks, or in dense aggregations (mussel beds) over pea gravel and silt sediments. Because mussels form a dense matt over the sediments and rocks, oil that was trapped beneath the mussels was not exposed to weathering and still remains toxic. It may be possible to clean mussels in mussel beds, but cleaning will not be possible in all habitats where mussels occur.

One of the possible explanations of the poor survival rate of postweanling juveniles in the oiled areas is that they continue to be exposed to hydrocarbon contamination by eating oiled mussels. Concern over the possible continuing source of contamination to sea otters and other higher order animals (e.g., black oystercatchers and harlequin ducks) led to feasibility studies to develop techniques to clean the sediments beneath the oiled mussel beds. One technique that will be tested in 1994 lifts sections of the mussel beds and replaces the contaminated sediments with clean sediments without serious damage to the mussel beds (Babcock pers. comm., 1994). Approximately 60 locations with oiled mussel beds have been identified in Prince William Sound.

The extent and distribution of oiled mussel beds still is being determined and will be important in understanding the potential benefit to sea otters that can be gained from cleaning. No studies have been made to determine whether or not eating contaminated mussels is causing injury to the sea otter population. However, it is possible to consider the potential benefit in terms of the level of risk to exposure. For example, the telemetry study by Monnett and Rotterman (1992) indicated that females and weanling sea otters did not range great distances between oiled and unoiled areas. If a group of sea otters spends many months feeding in bays that have several oiled mussel beds, then they are at greater risk of exposure than sea otters that feed in areas with few or no oiled mussels. Of the oiled mussel beds identified so far, there are approximately 20 in Herring Bay off of Knight Island; cleaning half or all of these mussel beds would greatly reduce the risk to the local population. If only 1 or 2 beds in the area were cleaned, it may not reduce the risk of exposure at all. Similarly, if the only source of oil in an entire bay was from one mussel bed, removing that contamination could eliminate the majority of the risk to the local sea otters.

Cleaning oiled mussel beds would be a labor intensive task that may last for several days at each location. Some short-term disturbance probably would occur; however, it is not likely to permanently displace the local sea otters.

It is reasonable to assume that the ability of this action to reduce the risk of exposure is equally valid in other regions of the spill area. However, there is less information on the location of mussel beds and on the injury to the sea otter population.

Establish a Cooperative Program Between Subsistence Users and Research Scientists or Agency Managers. This program would be designed to provide a two-way exchange of information that would provide benefits to all parties and could benefit the injured sea otter population. Recent records of subsistence harvest of sea otters in the oil-spill area indicate that harvest levels are relatively low but increasing throughout the EVOS area. If subsistence levels increase in areas where the populations were affected by the spill, the additional harvest may slow or prevent localized recovery. For example, the densities of sea otters in some oiled areas still is very low (Bodkin and Ballachey, pers. comm., 1994). If these areas are consistently harvested, then redirecting harvest towards the healthier or nonoiled areas could reduce any negative effects without actually changing the number of animals harvested. Likewise, sea otters can sustain a greater harvest of males and juveniles than of breeding females.

Without any restoration actions, it may be reasonable to estimate that sea otters in Prince William Sound would recover to their prespill abundance in 7 to 35 years once the population begins to increase. If subsistence harvest rates rise substantially in the oiled areas, then the recovery estimates based on a 10-percent growth rate are unlikely and it is possible that the more conservative estimate of 35 years would be extended. If a cooperative program can be established, it may be possible to sustain a higher harvest rate without changing the recovery rate of the injured population.

Restoration Actions for Other Resources or Services. Other actions proposed for this alternative are not expected to adversely impact the sea otter populations or their recovery.

Conclusions

Short-term effects. Negligible. All of the proposed actions will take time before any results could be expected.

Long-term effects. Moderate Benefits. The proposed actions improve the habitat quality through reducing the risk of exposure to oil, the potential for disturbance, and the impacts from subsistence harvest. These benefits could produce a change in abundance of sea otters in some areas but are not likely to produce a notable increase on a regional scale.

Impacts on Birds

Harlequin Duck

Habitat Protection and Acquisition

Acquiring nesting and feeding habitat along streams on forested lands is an effective means of preventing further injury to the harlequin duck population. Such acquisition would maximize protection of the harlequin ducks' reproductive potential, thus fostering population recovery to pre-EVOS levels. The 81 parcels that were evaluated in the large parcel process were rated as high, moderate or low value to harlequin ducks based on the following definitions. High, for known nesting or molting concentrations on the parcel, and where feeding occurs on the parcel. Moderate rankings for parcels with probable nesting or molting on or adjacent to the parcel, and with probable feeding in the streams, estuary or intertidal area in or adjacent to the parcels. Low rankings were assigned to parcels where feeding and loafing adjacent to the parcel are possible; or where some offshore molting occurs (EVOS Restoration Team, 1993).

Assuming a relatively low cost per parcel that would allow purchase of all 81 parcels, 24 were ranked high, 25 were ranked moderate, 32 were ranked low, and none had no value to harlequin ducks. Two additional scenarios were used to evaluate habitat protection to harlequin ducks under the large parcel process. Assuming 50% of the settlement funds are available for habitat acquisition, 19 parcels were ranked of high value to harlequin ducks, 10 moderate, 5 low, and no parcels were rated as having no value to harlequin ducks. Lastly, by assuming 45% of the settlement funds are available for habitat acquisition changes the last scenario only slightly, with 18 parcels ranked of high value to harlequin ducks, 9 moderate, 4 low, and no parcels were rated as having no value to harlequin ducks.

General Restoration

Cleaning Oiled Mussel Beds. This is considered to be a possible means of reducing hydrocarbon exposure to harlequin ducks via their food chain. Mussels, clams, and other bottom prey of harlequin ducks continue to be contaminated by oil still buried within the sediments. The harlequin ducks eat the contaminated prey, thus contaminating their body tissues. Although as yet unproven, this sublethal contamination is suspected of interfering with normal reproduction, resulting in few new broods being seen in the oiled area since the spill. Removal of the oil thus could result in resumed production in the oiled area followed by a population increase.

Conclusions

Short-term effects: Negligible. The short-term effects through 1996 of the proposal on harlequin duck recovery would be , and populations likely remain at 1990 to 1993 levels in both oiled and nonoiled areas.

Long-term effects: High. Acquisition of the high priority package of land parcels would maximize the recovery potential of the injured harlequin duck population by guarding against loss of feeding and nesting habitat. Cleaning oiled mussel beds would eliminate the source of hydrocarbon contamination of body tissues that may be interfering with reproduction, and also enhance the food base of local populations. The long-term effects of this alternative would have a high benefit to help maintain, protect the reproductive potential of harlequin ducks.

Murres

Habitat Protection and Acquisition

Acquisition of habitat would have only moderate benefit to the injured murre population because there are no sizeable colonies and very few smaller colonies that are not already protected. A seabird colony on privately owned Gull Island in Kachemak Bay has a colony of 10,000 common murres that is visited daily by commercial-tour boats in summer. Acquisition of this colony would ensure its long-term protection, although there are no imminent plans for development.

The 81 parcels that were evaluated in the large parcel process were rated as high, moderate or low value for common murres based on the following definitions. High, for known nesting on or immediately adjacent to the parcel. Moderate, with known feeding concentration in adjacent nearshore waters. Low rankings were assigned to parcels where feeding is possible in adjacent waters (EVOS Restoration Team, 1993).

A breakdown of the ranking to common murres in the large parcel process illustrates the low overall value of habitat acquisition to common murres. Assuming a relatively low cost per parcel that would allow purchase of all 81 parcels, none were ranked high, 7 were ranked moderate, 65 were ranked low, and 8 had no value to common murres. Two additional scenarios were used to evaluate habitat protection to common murres under the large parcel process. Assuming 50% of the settlement funds are available for habitat acquisition, 1 parcel was ranked of high value to common murres, 4 moderate, 27 low, and 2 parcels were rated as having no value to common murres. Lastly, by assuming 45% of the settlement funds are available for habitat acquisition changes the last scenario only slightly, with 1 parcel ranked of high value to common murres, 3 moderate, 25 low, and 2 parcels were rated as having no value to common murres.

General Restoration

Predator Control. The reproductive behavior of murres has evolved to produce a sudden abundance of eggs and chicks. The result is that predators are able to eat only a relatively few eggs and chicks, while the large majority of chicks grow too large for predators to handle. Mammalian predators generally are not a problem for murres, because their island colonies are usually free of mammalian predators and murre nest sites are inaccessible. Bald eagles, ravens, northwestern crows, and especially glaucous-winged gulls, eat murre eggs and chicks in the EVOS area, although little is known about their impact on specific colonies. Studies at injured colonies would be needed to determine the impact of avian predators and to design measures to deal with them. Recent work in Europe has shown that measures such as fiberglass poles placed perpendicular to the cliff face on nesting colonies reduces avian predation (D. Roseneau, oral comm., 1994).

Reduce Disturbance. Murres are sensitive to disturbance, especially loud noise, during the nesting period. Sudden loud noises like gunshots will scare murres off their nests, which has two deleterious effects (1) eggs and chicks are knocked off the cliffs as the panicked adults leave *en masse*, and (2) the remaining exposed eggs and chicks fall easy prey to avian predators. Gunfire appears to be a potential problem near the Barren Islands during the nesting season, when halibut fishermen routinely shoot the fish before landing them. This appears to occur fairly frequently. While such disturbance may not be a problem for a healthy population, it could delay recovery of an affected colony, such as that at the Barren Islands.

This action first would fund a program to educate fisherman and charter-boat captains and seek their voluntary reduction of disturbance. If voluntary actions were not effective, the next step would be to develop regulations that prohibited disturbance at the Barren Islands. With mandatory regulations, enforcement also may be necessary, which could require additional funding. If gunshot noise near the Barren Island murre colonies were eliminated, there is a good chance for a low to moderate benefit to the recovering murre populations at the Barren Islands. If disturbance proves to be an important problem, there are methods for preventing these disturbances.

This action could have a moderately beneficial effect on reducing the recovery time at colonies where human activities disturb the birds during nesting. This action most likely would have the greatest benefit at the Barren Islands. Murres at the Chiswell Islands colonies appear to have habituated to tour boats, so protective measures there, where gunshots are infrequent, would have limited effect.

Conclusions

Short-term effects:	Negligible. There would be a negligible short-term benefit to the injured murre population from this action within the EVOS area.
Long-term effects:	Low. Reducing disturbance that causes additional mortality at the Barren Islands would allow population recovery to proceed at a faster rate than otherwise possible, resulting in a low overall benefit to the injured murre population.

Pigeon Guillemot

Habitat Protection and Acquisition

In Prince William Sound, the large majority of pigeon guillemot colonies are on U. S. Forest Service (USFS) land (Sanger and Cody, written comm., 1994) that is not slated for logging (USDA, Forest Service, 1994). Two of the largest colonies in Prince William Sound are on private land at The Pleiades Islands and on Bligh Island, and guillemots there total about 3 percent of the 1993 breeding population (Sanger and Cody, written comm., 1994). In the 1970's, both of the latter colonies probably harbored larger numbers of nesting guillemots than at present. Two colonies adjacent to private land that currently is being logged on the eastern, nonoiled portion of Prince William Sound had very few guillemots in 1993, but it is unlikely that they were affected by the inland logging operations (Sanger and Cody, written comm., 1994). Outside of Prince William Sound, the Seal Bay area on Afognak Island has low numbers of pigeon guillemots and already has been acquired; and an EVOS predator-control project at Kagamil Island in the Shumagin Islands will allow recolonization and modest population increase by pigeon guillemots. Little is known about the current status of guillemot colonies elsewhere in the EVOS area (USFWS, 1993).

The 81 parcels that were evaluated in the large parcel process were rated as high, moderate or low value for pigeon guillemots based on the following definitions. High, for parcels with known colonies on or immediately adjacent to the parcel, and with known feeding concentrations in nearshore waters. Moderate rankings for parcels with probable nesting and known feeding in nearshore waters. Low rankings were assigned to parcels with a low likelihood of nesting; but with possible feeding in nearshore waters (EVOS Restoration Team, 1993).

A breakdown of the ranking in the large parcel process illustrates the moderate overall value of habitat acquisition to pigeon guillemots. Assuming a relatively low cost per parcel that would allow purchase of all 81 parcels, 20 were ranked high, 23 were ranked moderate, 31 were ranked low, and 6 had no value to pigeon guillemots. Two additional scenarios were used to evaluate habitat protection to pigeon guillemots under the large parcel process. Assuming 50% of the settlement funds are available for habitat acquisition, 16 parcels was ranked of high value to pigeon guillemots, 7 moderate, 9 low, and 2 parcels were rated as having no value to pigeon guillemots. Lastly, by assuming 45% of the settlement funds are available for habitat acquisition changes the last scenario only slightly, with 15 parcels ranked of high value to pigeon guillemots, 6 moderate, 8 low, and 2 parcels were rated as having no value to pigeon guillemots.

General Restoration

Predator Control. Predator control has the potential to increase productivity of pigeon guillemots, but little is known about the nature of predation on guillemots throughout the EVOS area. Possible predator control methods might include live trapping and translocating predators, removing eggs from the nests of avian predators and replacing the live eggs with artificial ones so the adults do not lay a second clutch, installing predator exclosures at key colonies, and deploying predator-proof nesting boxes. Studies being conducted in Prince William Sound in 1994 may shed light on effective methods to control predators throughout the EVOS zone.

Reduce Disturbance. Human disturbance is not a pervasive problem at pigeon guillemot colonies. Most colonies are located in remote areas in steep habitat that generally holds little appeal for recreational or other uses. However, because of the reduced size of the guillemot population throughout Prince William Sound and the injury suffered by the segment of the population in the oiled area, it would be wise to take precautions to ensure that there is no inadvertent disturbance. This could be done by educating land management entities about the locations of guillemot colonies on their land and by posting colonies that are especially sensitive during the May - August nesting and chick-rearing periods. Chief among the latter are the 3 colonies at Jackpot Island located on USFS land just offshore from Jackpot Bay in southwestern Prince William Sound. Jackpot Island has two beaches that are suitable for camping, and Jackpot Bay is a popular area for recreational boaters and fishermen, so there seems to be potential for inadvertent disturbance from recreationists.

Conclusions

Short-term effects: Negligible. This alternative likely would have negligible short-term effects for pigeon guillemots through 1996.

Long-term effects: Moderate. On the long term, acquiring habitat where two of the largest colonies in Prince William Sound are located--one of which is included in the high priority acquisition package--would have a moderately beneficial effect on population recovery and in preventing further inroads to the injured population through habitat degradation.

Marbled Murrelet

Habitat Protection and Acquisition

Details of habitat use by marbled murrelets are being clarified, and studies in Prince William Sound are showing that large, moss-covered limbs of old-growth conifers are the keystone of prime nesting habitat. Current and possible future logging of such habitat on private land is the single greatest threat to population recovery of marbled murrelets, and it poses the additional threat of reducing the population more. Acquisition of prime nesting habitat thus would maximize the potential for the injured marbled murrelet population to recover while preventing further injury to the population.

The 81 parcels that were evaluated in the large parcel process were rated as high, moderate or low value for marbled murrelets based on the following definitions. High, for parcels with known nesting or where there is high confidence that nesting occurs, and where feeding occurs in adjacent nearshore waters. Moderate rankings for parcels with probable nesting, and with known feeding areas in adjacent nearshore waters. Low rankings were assigned to parcels with a low likelihood of nesting; and possible feeding in nearshore waters (EVOS Restoration Team, 1993).

A breakdown of the ranking to marbled murrelets in the large parcel process illustrates the high overall value of habitat acquisition to marbled murrelets. Assuming a relatively low cost per parcel that would allow purchase of all 81 parcels, 21 were ranked high, 42 were ranked moderate, 18 were ranked low, and none had no value to marbled murrelets. Two additional scenarios were used to evaluate habitat protection to marbled murrelets under the large parcel process. Assuming 50% of the settlement funds are available for habitat acquisition, 14 parcelsl was ranked of high value to marbled murrelets, 15 moderate, 5 low, and no parcels were rated as having no value to pigeon guillemots. Lastly, by assuming 45% of the settlement funds are available for habitat acquisition changes the last scenario only slightly, with 13 parcels ranked of high value to pigeon guillemots, 13 moderate, 4 low, and no parcels were rated as having no value to marbled murrelets.

Conclusions

Short-term effects: High. The short-term effects of land acquisition for the injured marbled murrelet population could have a high benefit if logging is imminent.

Long-term effects: <u>High</u>. On the long term, land acquisition is the highest possible benefit to the injured murrelet population.

Impacts on Fish

Pink Salmon

Alternative 5 would provide comprehensive restoration actions to assist natural recovery of wild-stock pink salmon populations. Actions that may be implemented as part of this alternative include habitat protection and acquisition, migration corridor improvements, egg incubation boxes, net-pen rearing, hatchery rearing, habitat improvement, and relocation of hatchery-produced runs and other methods (EVOS Trustee Council, April; November 1993).

Habitat Protection and Acquisition

The criteria for parcels that may benefit pink salmon wild-stocks include ratings of high for parcels with a high density of pink salmon streams or streams known to have exceptional value, moderate for parcels with an average density of pink salmon streams or streams with average production, and low for parcels with few or no pink salmon streams or streams with no production (EVOS Restoration Team, November 1993).

Habitat protection that may benefit wild-stock pink salmon populations according to Alternative 5 would depend on the average cost per acre and the final budget allocation. Therefore, the maximal number of parcels that may be purchased includes all 81 parcels that are available and the minimal number that may be purchased ranges between 31 and 34 parcels.

If all habitat parcels are protected, approximately a moderate benefit for the pink salmon resource is expected and 53 per cent would be rated as moderate or high value (Table 4-10) (Appendix A). If between 31 and 34 parcels can be purchased, the expected protective value would also be rated as moderate (Appendix A.). Of these parcels that may be purchased, 71 percent are rated as moderate or high value (Table 4-10).

Table 4-10
Number of habitat parcels within each rating category that may be protected to benefit pink salmon with different purchase scenarios for Alternative 5.

Total Number of Parcels	Number of Parcels with Benefit Values Rated			
	High	Moderat e	Low	None
81	18	25	38	0.00
34	12	12	10	0.00
31	12	10	9	0.00

Although the average value of forecasted habitat acquisition may not have a high overall rating for pink salmon, individual parcels may have exceptional value. In the event that some of these parcels may not be protected through acquisition, the habitat will continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

General Restoration

<u>**Action 1. Migration corridor improvements**</u>. This action would entail mitigation of a barrier to pink salmon migration that may prevent access to new spawning habitat. This typically involves installation of a fishpass or removal of a migration barrier. The construction of a fishpass (i.e., fish ladder or steep pass) is a permanent form of habitat modification to enable fish to access habitat that is upstream from an impassable barrier, such as a steep waterfall (Appendix C).

This technique has been widely applied throughout the EVOS area, especially in Prince William Sound, to increase populations of wild-stock pink salmon and to establish new populations by providing access to new or additional spawning habitat. Pink salmon migrate directly to saltwater after they emerge from the spawning gravel and they do not require freshwater rearing habitat; consequently, population benefits would be accrued for pink salmon wherever access can be provided to new or underutilized spawning habitat. Because this technique has been so widely applied, however, the most valuable locations in much of the EVOS area already have been developed.

The potential benefit from migration-corridor improvements for pink salmon is in direct proportion to the amount of new spawning habitat that is accessed. Within the EVOS area, potential benefits from this action may be limited by the ability to identify new sites for application of this action, however, Willette, et al. (1993) recently reported a number of candidate locations.

<u>**Action 2: Egg Incubation Boxes**</u>. In the Copper River drainage, egg incubation boxes were highly successful in developing a small wild-stock population of sockeye salmon into an estimated annual total return of approximately 200,000 adult fish, with an estimated annual commercial harvest of over 100,000 fish (Roberson and Holder, 1993). Other experiments to incubate sockeye and chum salmon eggs in egg incubation boxes in Prince William Sound were less successful (Jackson, 1974); however, Mr. Terry Ellison (ADF&G, 1994, oral comm.) reports that egg incubation boxes were used effectively for several years to increase the numbers of pink salmon returning to Cannery Creek in Prince William Sound. These and other results demonstrate the importance of proper site selection, installation, and operational techniques.

In-stream egg incubation boxes provide a low-cost restoration or enhancement technique that is ideally suited for small-scale, low-technology operations at remote sites that meet the selection criteria. When they are used for enhancement of indigenous stocks, these units can minimize the fish genetic and pathology concerns associated with transport of eggs or fry.

The potential contribution of egg incubation boxes for the restoration or improvement of wild pink salmon stocks in the EVOS area may be very good in drainages that have reasonably accessible spring areas or year-round free-flowing water. Where suitable locations can be identified, this action may be applied to help restore or improve pink salmon populations without a major intrusion into the environment or the wild fish stocks. Within individual drainages, it can be used to benefit individual stocks; however, logistical costs may constrain widespread small-scale development.

Action 3. Net-pen Rearing. This practice has been widely applied to increase the survival rate of all salmon species. This is a common technique that has been widely used in ADF&G and PNP programs in the EVOS area and throughout the State of Alaska to improve the survival rate of juvenile pink salmon (Ellison, 1992). Although net-pen rearing has not been commonly applied for wild stocks of pink salmon, this technique potentially may be employed in many systems throughout the EVOS area to increase the survival rate of wild-stock pink salmon fry where there is a source of fry and a suitable site to anchor and service the net pens. The wild-stock fry may be captured as they emigrate from a spawning stream.

Careful application of the net-pen rearing technique can be expected to increase the survival rate of juvenile pink salmon and, consequently, returning adults. The magnitude of the benefit would depend on the numbers of captive fry that can be accommodated. Whenever any organisms are held captive in high density, they become more susceptible to disease or other catastrophic loss and there is a risk of disrupting natural genetic selection; however, these risks have been successfully minimized with good fish cultural practices (Schollenberger, 1993) and by following appropriate planning and permitting procedures (Appendix C).

Action 4: Hatchery Rearing. Hatchery rearing of pink salmon fry to increase the survival rate to the adult stage has had a long history in Alaska. Typically, these operations have been based on a large, established hatchery brood stock that was derived from a donor wild stock; however, individual wild stocks also may be used annually to supply the eggs. As the fry emerge, they must be transported to the estuarine rearing site at the stream mouth.

Hatchery rearing for pink salmon fry may be a useful technique to restore pink salmon populations in many drainages in the EVOS area; however, the wild stocks must be carefully evaluated and selected for egg takes, and the fry rearing pens must be operated at the mouth of the systems that are selected. Candidate locations must have enough spawners to supply the eggs, and the physical features of the stream mouths must accommodate the net pens.

Injured wild stocks may be helped directly by a rearing and release program for that stock; or the wild stocks may be helped indirectly by creating an alternate opportunity for the commercial fishers to divert fishing pressure away from the injured wild stocks. For direct restoration, fry-rearing programs will be limited to those drainages that can provide brood stock and accommodate a rearing program. The magnitude of the increase would depend on the physical and biological constraints of that drainage system and the magnitude of the restoration effort. Whenever any organisms are held captive in high density, they become more susceptible to disease or other catastrophic loss and there is a risk of disrupting natural genetic selection; however, these risks have been successfully minimized with good fish cultural practices (Schollenberger, 1993) and appropriate planning (Appendix C).

Action 5. Habitat Improvement. Habitat-improvement techniques are used to overcome a factor in the environment of a fish population that may limit the full potential production from that system. Habitat improvement to achieve increased production usually focuses on one of the life-history needs that may limit production within that drainage. Consequently, it is important to determine what aspect of the life history is the limiting factor and what must be done to improve conditions for increased production. Because pink salmon use the freshwater environment only for spawning, habitat-improvement opportunities are limited primarily to improving migration corridors and creating new spawning habitat.

Fishpasses and migration habitat-improvement applications are discussed in Action 1. If lack of adequate spawning habitat limits pink salmon production, a spawning channel may be designed to increase or enhance natural spawning habitat thorough control of such factors as water flow, substrate, sedimentation, and predation to increase the egg-to-fry survival rates. Implementation of this action requires a stable source of high quality water (usually from groundwater) that is protected from surface runoff, proper terrain, and sufficient brood stock to utilize the spawning channels (Appendix C).

Willette, et al. (1993) performed surveys for potential locations for habitat-improvement projects in the EVOS area and identified potential sites for limited applications of habitat improvement strategies for some wild stocks of pink salmon in some drainages.

Wherever fish stocks are created or increased, there may be an interference with other stocks that already are present. There may be a risk of overharvesting the existing stocks. Returning adult fish may stray into adjacent drainages, interbreed with naturally reproducing populations, and disturb the genetic makeup of those populations.

Action 6. Relocation of Hatchery Runs. This action may provide a benefit for wild stocks of pink salmon by providing an alternate location, timing, or stock for commercial fishing activities. If the locations or timing for the relocated runs are carefully selected, the commercial fishery can be displaced and proceed with little or no interception of the injured wild stocks. Combined with good fishery management practices and a redistribution of the commercial fishing fleet, fishing pressure could be diverted away from the wild stocks that need additional protection and be refocused on the relocated hatchery runs. This will remove the fishing mortality from the injured wild stocks and allow them to recover.

The ADF&G and PNP aquaculture organizations have established a modern fisheries enhancement program that began in the mid-1970's that has included the establishment of new runs; however, some locations remain that provide ideal opportunities for juvenile fish imprinting and adult fish terminal-harvest areas that are readily accessible to the fishing fleets.

Every fisheries restoration, development, or enhancement program must be carefully planned and managed to avoid risks to wild stocks, and the fish-culture program must be carefully structured and controlled to avoid or minimize potential changes in the genetic makeup and health of the wild stocks that might be caused by the program. Although restoration, development, and enhancement of wild salmon stocks with fish-cultural techniques has been widely applied in the Pacific northwest, this strategy is not fully accepted within the fisheries profession (Hilborn, 1992; Martin, Webster and Edwards, 1992). Hatchery-produced fish typically can be harvested at a higher rate than most wild stocks. Consequently, if wild stocks are harvested with hatchery-produced fish, there may be a danger that the wild stocks may be overharvested (Hilborn, 1992). A good harvest-management strategy must be developed so the hatchery-produced stocks can be harvested in a separate time or place. Every fish-culture program must be carefully structured, planned, and controlled to avoid or minimize potential risks of change in the genetic makeup and health of the wild stocks (Hindar, Ryman and Utter, 1991; ADF&G, 1983; Holland-Bartels, Burger, and Klein, 1994; Meyers et al., 1988; Davis et al., 1985). Additional state and federal permits and a site-specific NEPA compliance review may also be required before a project is implemented (Appendix C, Section 1).

Conclusions

Short-term effects.	Low. Although some benefits may be accrued, it is not reasonable to expect substantial results within one lifecycle.
Long-term effects.	High. It is expected that these actions would assist the recovery of the injured wild stocks of pink salmon. Long-term effects of some or all of these actions may be realized in 6 to 10 years (3 to 5 generations of pink salmon). Certain actions, however, may be useful only in portions of the EVOS area, and not all populations may be totally restored.

Sockeye Salmon

Alternative 5 would provide comprehensive restoration actions to assist natural recovery of wild-stock sockeye salmon populations. Actions that may be implemented to restore wild-stock sockeye salmon populations as part of Alternative 5 include habitat protection, lake fertilization, migration-corridor improvements, actions that may improve survival rates of sockeye salmon eggs by using egg incubation boxes, net-pen rearing or hatchery rearing, and other methods (EVOS Trustee Council, April; November 1993).

Habitat Protection and Acquisition

Criteria for parcels that may benefit sockeye salmon include ratings of high for parcels with sockeye salmon streams or systems known to have exceptional value, moderate for parcels with sockeye salmon streams or systems with average production, and low for parcels with few or no sockeye salmon streams or systems with low production (EVOS Restoration Team, November 1993).

Habitat protection that may benefit wild-stock sockeye salmon populations according to Alternative 5 will depend on the average cost per acre and the final budget allocation. Therefore, the maximal number of parcels that may be purchased includes all 81 available parcels, and the minimal number of parcels that may be purchased ranges between 31 and 34 (Appendix A).

If all habitat parcels are protected, approximately a low to moderate benefit for the sockeye salmon resource is expected and 21 per cent of the parcels would be rated as moderate or high value (Table 4-11) (Appendix A). If between 31 and 34 parcels can be purchased according to Alternative 5, the expected protective value will be rated as low to moderate (Appendix A.). Of the parcels that may be purchased, 38 to 42 percent of the parcels would be rated as moderate or high value (Table 4-11).

Table 4-11
Number of habitat parcels within each rating category that may be protected to benefit sockeye salmon with different purchase scenarios for Alternative 5.

	Number of Parcels with Benefit Value Rated			
Total Number of Parcels	High	Moderate	Low	None
81	9	8	48	16
34	7	6	13	8
31	7	6	12	6

Although the average value of forecasted habitat acquisition may not have a high overall rating for sockeye salmon, individual parcels may have exceptional value. In the event that some of these parcels may not be protected through acquisition, the habitat will continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

General Restoration

Action 1. Lake fertilization. This potential action may be taken to improve the rearing success of juvenile sockeye salmon during their one to three years in the lake environment and increase their survival to the smolt stage. The ADF&G began a lake limnology and lake fertilization program in the late 1970's, and a number of lake systems in the area have been treated to improve sockeye salmon production (Kyle, Koenings and Edmundson, 1994).

Within the EVOS area, new opportunities for lake-enrichment projects may be limited because of the successes that already have been achieved in the present program. Where new opportunities exist, however, this action can be expected to improve the rearing habitat and produce additional sockeye salmon.

Lake-nutrient enrichment has been used successfully to improve the freshwater survival rates of juvenile sockeye salmon and to produce more adult fish in Canada and the United States. Within the EVOS area, the magnitude of potential benefits from this action would depend primarily on the ability to identify new candidate lake systems in areas where returning adult fish may be harvested without risk of overharvesting existing wild stocks.

Wherever fish stocks are created or increased, however, there may be interference with stocks that already are present. There may be a risk of overharvesting the existing stocks. Returning adult fish may stray into adjacent drainages, interbreed with naturally reproducing populations, and disturb the genetic makeup of those populations.

Action 2. Migration Corridor Improvements. This action entails mitigation of a barrier to fish migration that may prevent access to previously unavailable habitat for spawning or rearing and typically includes installation of a fishpass or removal of a migration barrier. The construction of a fishpass (i.e., fish ladder or steep pass) is a permanent form of habitat modification to enable fish to access spawning and rearing habitat above an impassable barrier, such as a waterfall.

This technique has been widely applied throughout the EVOS area to increase populations of wild salmon stocks and to establish new self-sustaining populations by providing access to new or additional spawning habitat. However, it is only effective for sockeye salmon where the newly-produced fry have access to rearing habitat that is presently underused. The potential benefit will usually be limited by the amount of rearing habitat rather than the amount of new spawning habitat that is accessed. The installation usually is permanent, with a long lifespan. Within the EVOS area, potential benefits for sockeye salmon may be limited by the ability to identify new sites for application of this action where they will not interfere with management of other nearby wild stocks.

Action 3. Egg-Incubation Boxes. These boxes have been used highly successfully in the Copper River drainage to develop a small wild-stock population of sockeye salmon into an estimated annual total return of approximately 200,000 adult fish, with an estimated annual commercial harvest of over 100,000 fish (Roberson and Holder, 1993). Other experiments to incubate sockeye and chum salmon eggs in egg-incubation boxes in Prince William Sound were less successful (Jackson; 1974), however, when properly installed, these units control the water flow, substrate type, sedimentation, and predation to provide egg-to-fry survival rates as high as 90 percent. This compares quite favorably with an expected survival rate of 12 to 43 percent of eggs laid in redds by spawning sockeye salmon (Drucker, 1968) where survival may be affected by extremes of environmental conditions.

The potential contribution of egg-incubation boxes for the restoration of wild sockeye salmon stocks in the EVOS area would be limited to drainages with (1) limited successful reproduction, (2) spring areas with appropriate physical features and good water quality and quantity, and (3) underutilized lake rearing capacity for the sockeye salmon fry that are produced.

Although extensive surveys to locate potential sites to operate this technique have not been performed, if suitable locations can be identified within drainages that presently support small populations of sockeye salmon, this technique may be applied to help restore those populations without a major intrusion into the environment or the fish stock.

Action 4. Net-Pen Rearing. This practice has been widely applied to increase the survival rate of all salmon species. This technique, however, has only recently been applied successfully for sockeye salmon because most previous attempts have failed because sockeye salmon are particularly susceptible to the disease, infectious hematopoietic necrosis virus (IHNV) (Mr. Terry Ellison, ADF&G, oral comm.).

Although the net-pen rearing technique has been applied in both freshwater and saltwater, most success has been achieved with freshwater rearing, because the early lifestages from only a few stocks of sockeye salmon can survive in saltwater. Burke (1993), however, described a highly successful program for rearing juvenile sockeye salmon in saltwater net pens to the smolt stage, but only after they had been fed first in freshwater hatchery raceways. Consequently, although net-pen rearing of sockeye salmon in saltwater may have excellent potential for a hatchery-based application, it is of limited value for protection and restoration of wild stocks except where it may be used to create an alternate opportunity for commercial fishermen.

Juvenile sockeye salmon typically spend up to three years rearing in freshwater (Burgner, 1991). During this period, the mortality rate between the fry and smolt stages may range from 86 to 99 percent (Roberson and Holder, 1993), but fry held in net pens are largely are protected from predators and food is provided, so the mortality rate is low. Net-pen rearing of sockeye salmon fry in freshwater has not been widely applied, but Schollenberger (1993) and Zadina and Haddix (1990) have reported good success with this strategy.

Net-pen rearing of sockeye salmon fry to increase their survival rate potentially may be employed in many systems throughout the EVOS area. Only two key ingredients are necessary, a source of fry and a suitable site to anchor and service the net pens. Fry may be captured from a spawning stream or transferred from a hatchery. Careful application of the net-pen rearing technique will increase the numbers of emigrating sockeye salmon smolts and returning adults with minimal undesirable effects on the population or the lake-rearing system. The magnitude of the benefit would depend on the numbers of captive fry that can be accommodated.

Every fisheries restoration, development, or enhancement program must be carefully planned and managed to avoid risks to wild stocks, and the fish-culture program must be carefully structured and controlled to avoid or minimize potential changes in the genetic makeup and health of the wild stocks that might be caused by the program. Although restoration, development, and enhancement of wild salmon stocks with fish-cultural techniques has been widely applied in the Pacific northwest, this strategy is not fully accepted within the fisheries profession (Hilborn, 1992; Martin, Webster and Edwards, 1992). Hatchery-produced fish typically can be harvested at a higher rate than most wild stocks. Consequently, if wild stocks are harvested with hatchery-produced fish, there may be a danger that the wild stocks may be overharvested (Hilborn, 1992). A good harvest-management strategy must be developed so the hatchery-produced stocks can be harvested in a separate time or place. Every fish-culture program must be carefully structured, planned, and controlled to avoid or minimize potential risks of change in the genetic makeup and health of the wild stocks (Hindar, Ryman and Utter, 1991; ADF&G, 1983; Holland-Bartels, Burger, and Klein, 1994; Meyers et al., 1988; Davis et al., 1985). Additional state and federal permits and a site-specific NEPA compliance review may also be required before a project is implemented (Appendix C, Section 1).

Action 5. Hatchery Rearing. Hatchery rearing of sockeye salmon has had a long history in Alaska. During the last decade, however, this strategy has been improved and has produced dramatic innovations and results (Ellison, 1992). In Alaska, cultured juvenile sockeye salmon have been released as fed fry, presmolts, and smolts. Each lifestage has its own particular logistical, biological, and fish cultural constraints and advantages. Fry are less expensive to rear, transport, and release, but they require at least one year of rearing in a lake before they smoltify, and they will not survive to the adult stage as well as presmolts or smolts. Fry that are retained and fed in hatchery raceways may be released in late fall as presmolts. These young fish require few resources from the lake system during the winter and emigrate as smolts in the spring. Smolts are expensive to rear and transport, but they will survive better to the adult stage; however, they can be released as migrants without reliance on freshwater rearing.

Injured wild sockeye salmon stocks may be helped directly by a rearing and release program for that stock; or the wild stocks may be helped indirectly by creating an alternate opportunity for the commercial fishers to divert fishing pressure away from the injured wild stocks. For direct restoration, fry-rearing programs will be limited to those drainages where the forage is underutilized by the naturally produced fry. Presmolt- and smolt-rearing programs, however, can provide direct restoration with little or no effect on plankton populations.

Every fisheries restoration, development, or enhancement program must be carefully planned and managed to avoid risks to wild stocks, and the fish-culture program must be carefully structured and controlled to avoid or minimize potential changes in the genetic makeup and health of the wild stocks that might be caused by the program. Although restoration, development, and enhancement of wild salmon stocks with fish-cultural techniques has been widely applied in the Pacific northwest, this strategy is not fully accepted within the fisheries profession (Hilborn, 1992; Martin, Webster and Edwards, 1992). Hatchery-produced fish typically can be harvested at a higher rate than most wild stocks. Consequently, if wild stocks are harvested with hatchery-produced fish, there may be a danger that the wild stocks may be overharvested (Hilborn, 1992). A good harvest-management strategy must be developed so the hatchery-produced stocks can be harvested in a separate time or place. Every fish-culture program must be carefully structured, planned, and controlled to avoid or minimize potential risks of change in the genetic makeup and health of the wild stocks (Hindar, Ryman and Utter, 1991; ADF&G, 1983; Holland-Bartels, Burger, and Klein, 1994; Meyers et al., 1988; Davis et al., 1985). Additional state and federal permits and a site-specific NEPA compliance review may also be required before a project is implemented (Appendix C, Section 1).

Conclusions

Short-term effects.	Low. Some benefits in some drainages may be accrued within one lifecycle.
Long-term effects.	High. It is expected that these actions will assist the recovery of the injured wild stocks of sockeye salmon. Long-term effects of some or all of these actions may be realized in 10 to 50 years (2 to 10 generations of sockeye salmon). Certain actions, however, may be useful in only portions of the EVOS area, and all populations may not be totally restored.

Pacific Herring

Alternative 5 includes only one restoration action to assist natural recovery of Pacific herring: habitat protection and acquisition (EVOS Trustee Council, April 1993).

Habitat Protection and acquisition

The criteria for parcels that may benefit Pacific herring include ratings of high for parcels with a documented, consistent annual Pacific herring spawning along the parcel shoreline; moderate for parcels with occasional spawning along the parcel shoreline; and low for parcels with no documented Pacific herring spawning along the parcel shoreline, but a possible feeding area (EVOS Restoration Team, 1993).

Habitat protection that may benefit Pacific herring populations according to Alternative 5 would depend on the average cost per acre and the final budget allocation. Therefore, the maximal number of parcels that may be purchased includes all 81 that are available, and the minimal number of parcels that may be purchased ranges between 31 and 34. (Appendix A).

If all habitat parcels are protected, approximately a moderate benefit for the Pacific herring resource is expected and 54 per cent of the parcels would be rated as moderate or high value (Table 4-12) (Appendix A). If between 31 and 34 parcels can be purchased according to Alternative 5, the expected protective value will also be rated as moderate (Appendix A). Of the parcels that may be purchased, 68 percent are rated as moderate or high value (Table 4-12).

Table 4-12
Number of habitat parcels within each rating category that may be protected to benefit Pacific herring with different purchase scenarios for Alternative 5.

	Number of Parcels with Benefit Values Rated			
Total Number of Parcels	High	Moderate	Low	None
81	15	29	30	7
34	9	14	9	2
31	8	13	8	2

Although the average value of forecasted habitat acquisition may not have a high overall rating for Pacific herring, individual parcels may have exceptional value. In the event that some of these parcels may not be protected through acquisition, the habitat will continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

Conclusions

Short-term effects. Negligible. No benefits will be accrued within one lifecycle.

Long-term effects. Moderate. Habitat protection and acquisition actions will have a long-term value to Pacific herring stocks in the EVOS area by helping to ensure maintenance of production. Over half of the parcels that may be purchased have moderate or high value for Pacific herring.

Impacts on Social and Economic Resources

Archaeological / Cultural Resources

Habitat Protection and Acquisition

It is assumed that between 31 and 34 large parcels would be purchased under this alternative. These parcels contain low (no known or suspected cultural sites on parcel), moderate (no significant cultural sites on or adjacent to parcel), or high (documented concentration or significant cultural sites on parcel) potential for benefiting cultural resources as analyzed by the Habitat Protection Work Group (November 30, 1993). For the purpose of this analysis, benefit consists of protection of sites from further damage. If low potential benefit on a parcel is assigned a value of 1, moderate potential benefit a value of 2, and high potential benefit a value of 3, these parcels average 2.2 to 2.3 (or slightly higher than moderate). These estimates reflect known sites in the EVOS area, not all of the sites present. Not all sites have been found, so the actual protection for cultural resources may be greater than reflected in these estimates. This analysis also does not take into consideration small parcel acquisition, which is currently under evaluation.

It is possible that land prices will be lower or higher than those assumed here. That may result in the purchase of more parcels (possibly all 81 identified parcels) or fewer parcels.

Benefits from habitat acquisition would accrue primarily through (1) placing private lands under public management and application of federal and state cultural resource protection laws, and (2) reducing the likelihood of damage to cultural resources resulting from extractive economic activities such as mining and logging. Benefits would accrue slowly, with no immediate or short-term benefits. Considered without the impacts discussed below for general restoration, the long- term benefits of habitat protection and acquisition may be moderate for cultural resources.

General Restoration

General restoration actions may include activities on individual sites (site stabilization, site salvage excavations, site monitoring and stewardship), or in local communities (archaeological repositories, acquiring replacement artifacts). Often, onsite work can be combined with community activities, as is envisioned in the site stewardship program. Each of the proposed actions considered here can be implemented independently or in combination with any of the others. The most effective approach is comprehensive, tailoring combinations of actions within each community whose cultural resources were injured by the spill. Actions considered applicable for Alternative 5 are discussed below.

Stabilize Archaeological Sites. Archaeological sites affected through erosion begun or worsened by oil-spill activities may be stabilized to slow or stop the erosion. Stabilization may entail recontouring parts of the sites to cover up exposed archaeological deposits. This would reduce the visibility of artifacts and so reduce chances of looting or vandalism. This is a relatively nondestructive alternative when compared to archaeologically excavating the sites or allowing damage to continue.

Stabilization is a site-specific activity that may be accomplished through several different methods. Some sites are located along high-energy shorelines, or in high-energy intertidal areas, and may not be suited to stabilization. Also, stabilization techniques that contrast with surrounding terrain may serve as magnets for visitation rather that protection against visitation. The benefit of stabilization is to preserve the integrity of the site, a benefit that may be temporary (requiring periodic maintenance) or permanent. This may have an immediate and short term high level of benefit by reducing or stopping site degradation at specific sites. It also has the potential to preserve sites and reduce damage at a high level over the long term.

Excavate Archaeological Sites. Not all sites can be stabilized, whether for physical or economic reasons. Ongoing vandalism, looting, and erosion of archeological sites in the EVOS area can be mitigated through salvage excavation instead of stabilization. Excavation and stabilization also can be done on the same site. Scientific excavation of the sites most in danger of destruction can yield information important to understanding the history and prehistory of the EVOS area, a major element of Alaska's cultural heritage. Excavation also can remove human remains and funerary objects associated with the ancestors of contemporary people living in communities in the spill area. These remains could be moved to locations less likely to be disturbed by looters or vandal, or unearthed by ongoing erosion.

One effect of excavation is permanent destruction of the excavated portions of the sites. This destruction, however, is controlled and exactly delimited, allowing for the appropriate care and analysis of removed items and associations. Without archaeological excavation, damage to and eventual destruction of several of the sites will continue with neither the public nor the resource benefiting. The short- term and long-term benefit of salvage excavation of highly endangered sites is, therefore, high. This action both protects the sites from further looting and vandalism and mitigates the spill-related damage already incurred.

Site Monitoring and Stewardship. Archaeological site stewardship programs active in Arizona, Arkansas, and Texas have demonstrated the utility of public education and increased oversight of sites for reducing continuing vandalism. A site stewardship program for the EVOS area would combine public education and site monitoring through recruitment, training, coordination, and maintenance of a corps of local interested citizens to watch over nearby archaeological sites. Sites to be monitored by local residents would be identified by land owners and managers on the basis of past and ongoing vandalism and erosion. Law-enforcement officials may be involved as during investigations or called to sites to intercept active vandalism.

The benefits of site stewardship would be an increased knowledge and appreciation of archaeological methods of site monitoring and decreased site vandalism. These benefits may begin within the first year of implementation and continue for an indefinitely long term. The benefits of this action in the short term would be low but are potentially high in the long term, as site stewards become better trained and knowledge of the program is disseminated as a disincentive among people who do, or may be inclined to, damage sites. The action has additional importance by involving local individuals and communities in cultural resources protection.

Archaeology Repositories. Communities within the spill-affected area increasingly express a desire that archaeological materials remain in (or at least are regularly returned to) their area of origin for display and interpretation. Local preservation of artifacts and interpreting of Native heritage is proposed as a means to offset the increasing loss of artifacts and disturbance of Native graves in the spill area.

Placing artifacts in a local repository and using that repository as a base for interpreting cultural resources could help better educate residents and area visitors about practices of the past and the continuity of that past with the present and the future. These repositories may be established through modifying existing structures or by building new structures to accommodate collections. These would be located in communities within the oil-spill area and could serve as local foci for heritage-oriented activities. The short-term benefits of this action may be to restore a feeling of involvement with and oversight of the cultural heritage of which local communities are part. These benefits would be immediate but moderate. Long-term benefits are likely to be high in terms of enhanced community involvement. It is this involvement that will address spill-related injury to the sense of cultural continuity and connectedness within the local communities.

Acquisition of replacement artifacts. Museums, agencies, and other repositories outside the spill area hold collections containing artifacts originally from the spill area. An action has been identified that would acquire some of these artifacts as a means of replacing a portion of the cultural heritage lost through the oil spill and subsequent cleanup activities. Many of these artifacts were removed from the spill area through ethnographic collecting and archaeological investigations in the 19th and early 20th centuries, and many reside outside of Alaska in the lower 48 states, Europe, and Russia. Returning part of this diverse artifactual heritage to the spill area may have a low but immediate benefit in the communities within the spill area, allowing the people of the communities to more fully see the range of materials that represent a tangible part of their past. The long term benefits of this approach are potentially high. By establishing a seed of improved cultural connectedness and fostering a sense of cultural continuity, this approach could grow into a major factor in producing a sense of recovery from the effects of the spill among the residents of those communities most affected.

This action could work through partnerships with existing museums or other regional repositories, or as combined with the establishment of local artifact repositories and interpretive centers. It is likely that communities would react differently from each other to this approach. Individual consultations with each community would be required to assess the importance and effectiveness in each.

Conclusions

Short-term effects:	Moderate Benefits. The proposed actions would increase the level of protection for archaeological resources, and improve the understanding or appreciation of cultural resource values.
Long-term benefits:	Moderate to High Benefits. The proposed actions may increase protection for archaeological resources and substantially improve the understanding or appreciation of cultural resource values.

Subsistence Uses

Habitat Protection and Acquisition

It is assumed here that between 31 and 34 large parcels would be purchased. These parcels contain low (status as a subsistence-use area unknown); moderate (known historic subsistence-use area, which may be used again); or high (known current subsistence-use area) potential for benefiting subsistence as analyzed by the Habitat Protection Work Group (November 30, 1993). If low potential benefit on a parcel is assigned a value of 1, moderate potential benefit a value of 2, and high potential benefit a value of 3, these parcels average between 2.3 and 2.4 (or between moderate and high).

Protecting lands from the habitat degradation associated with extractive economic activities like mining and logging may help recovering subsistence resources recover more quickly. This is the main benefit to subsistence that may be achieved by the habitat protection and acquisition portion of Alternative 5. Short-term benefits of habitat protection and acquisition would be negligible, but the long- term benefits would likely be low to moderate.

This analysis does not take into consideration small parcel acquisition, which is currently under evaluation. It also is possible that land prices will be lower or higher than those assumed here. That may result in the purchase of more parcels (possibly all identified parcels) or fewer parcels.

General Restoration

General restoration projects may be funded that directly affect the subsistence resources and subsistence users within the EVOS area. These proposed actions could be conducted independently from each other or in combination.

Harbor Seals. The decline in subsistence harvest of harbor seals may have helped stabilize the harbor seal population. The proposed action to implement cooperative programs between subsistence users and agencies to assess the effects of subsistence harvest may help in sorting out which localities would be best utilized (or best left alone) for subsistence use to optimize natural recovery of the populations. This will be a moderate long-term benefit, taking as long as 5 to 10 years to establish a measurably significant effect. This action has the advantages of relatively low cost and spin-off value in improving communication between agency biologists and subsistence users. Cooperative programs proposed for reducing incidental take of harbor seals during fishing likewise would have low short-term benefits to harbor seal population, but may have moderate long-term benefits in 5 to 10 years. Reducing disturbance at haulout sites in the oil spill area would have a negligible benefit in the short term and may produce a moderate benefit in the long term.

Sea Otters. One of the proposed actions would establish a cooperative program between subsistence users and research scientists or agency managers. While subsistence harvests are not a significant impact on sea otter populations, agency biologists and subsistence users both would benefit from the additional interaction and information sharing that would grow from such an action. Traditional knowledge of sea otter behavior and their relation to other parts of the ecosystem may be more extensive than is presently recognized by agency biologists. Similarly, the present range and concentration of sea otters may be better understood by agency biologists than is presently recognized by many subsistence users. This type of action may have little benefit immediately or in the short term on the recovery of sea otters, but the long-term benefit on management efforts, and thus the sea otter populations and subsistence users, could be significant.

Intertidal Organisms. A project has been proposed to reduce hydrocarbon levels in oiled mussel beds by temporarily removing mussels, replacing oiled sediments, and returning the mussels. Part of this action would be to monitor treated and untreated mussel beds to document the different rates of recovery. This action may have low short-term and moderate long-term benefits on subsistence users through increasing the abundance of edible mussels. These benefits likely would be localized.

Fucus, one of the central elements in intertidal ecosystems, is important for subsistence users as food and as habitat for other subsistence resources. A pilot project has been proposed to transplant *Fucus* to increase its population in the high intertidal zone. Recovery of *Fucus* is estimated at a decade. This would have insignificant short-term benefits, but may have moderate long-term benefits to subsistence users.

The recruitment of intertidal clams on cleaned beaches will remain low until a substrate of appropriate grain size is re-established, either naturally or through restoration efforts. A project has been proposed to study the feasibility of depositing fine-grained sediments to enhance larval recruitment and population recovery. Should this prove feasible, it would be possible under this alternative to fund expansion of the technique within the spill area. The hypothesis is that population recovery could occur within 1 or 2 years. Should this hypothesis be substantiated, and if subsistence users could be assured of the safety of eating clams produced in the enhanced habitat, both long- and short-term benefit of increased availability of clams for subsistence use would be high.

Pink Salmon. Relocation of hatchery runs has been identified as a means to divert the commercial-fishing fleet away from wild stocks of pink salmon. The resultant recovery of stocks may benefit subsistence uses of pink salmon. The benefits of this action on subsistence would mirror those of the pink salmon population -- negligible in the short term but high in the long term of 5 to 10 years.

Sockeye Salmon. The use of egg-incubation boxes has been proposed to restore or enhance sockeye salmon populations in the spill area. It is estimated that short-term benefits would be moderate, drainage-specific increases in populations. Long-term benefits may be low because of scarcity of appropriate sites. If appropriate sites are found near villages, this technique has the potential for working very well locally to increase the amount of sockeye salmon available (both long and short term) for subsistence use.

Net-pen rearing of sockeye salmon fry has been proposed to increase their survival rate. Because there are many appropriate locations for net pens in the EVOS, it is estimated that this technique would have strong short- and long-term benefits on the sockeye salmon populations. The advantage to subsistence users may be a corollary benefit.

Hatchery rearing of sockeye salmon, with release possible as fed fry, presmolts, and smolts, has been proposed as another method to increase their population. A number of project types are applicable, using different combinations of biological, physical, logistical, and technological factors. The short-term benefit of this type of action is likely to be low because it will take some time to establish the populations. The long-term benefit to sockeye salmon populations is estimated to be high, as several generations of improved survival rates to the smolt stage leading to the increased numbers of returning adults. The benefit to subsistence users will increase as populations of sockeye salmon increase. Benefit to subsistence users increases if wild stocks are separated from hatchery stocks. Concentration on hatchery stocks by commercial fisheries may reduce competition for wild stocks.

Fertilizing lakes to improve sockeye rearing success within the lake and increase sockeye population also has been proposed. Sockeye salmon populations have been successfully increased through lake fertilization, but there may be few candidate lake systems for this application. The short-term benefit of this action on subsistence users may be negligible, while the long-term outlook may be substantially increased numbers of sockeye in specific stream systems, a high long- term benefit for subsistence users in some locations..

Relocation of hatchery runs has been identified as a means to divert the commercial-fishing fleet away from wild stocks of sockeye salmon. The resultant recovery of stocks may benefit subsistence uses of sockeye salmon. The benefits of this action on subsistence mirror those of the sockeye salmon population: negligible in the short term, but high in the long term of 6 to 10 years.

Subsistence Food Testing. One of the main elements in the damage to subsistence uses in the spill area is the fear that once-safe subsistence foods are no longer safe to eat. An action has been proposed to conduct tests on subsistence foods to determine the amount of contamination, if any, in various types of subsistence foods. This action would provide immediate information to subsistence users, providing short- and long-term high-level benefit to their sense of security.

Conclusions

Short-term effects:	Low Benefits. The proposed actions require some time after implementation before any changes could be expected.
Long-term effects:	Moderate to High Benefits. The proposed actions are expected to moderately increase populations of subsistence harvest species negatively affected by the EVOS and substantially increase the confidence of subsistence users in determining the healthfulness of subsistence foods.

Recreation and Tourism

Habitat Protection and Acquisition

It is assumed here that between 31 and 34 large parcels would be purchased. These parcels contain low (low to no recreation use; access may be difficult), moderate (receives occasional public use; adjacent waters used for recreational boating; adjacent area receives high public use), or high (receives regular, high, directed public use; highly visible to a large number of recreationists/tourists) potential for benefiting recreation and tourism as analyzed by the Habitat Protection Work Group (November 30, 1993). If low potential benefit on a parcel is assigned a value of 1, moderate potential benefit a value of 2, and high potential benefit a value of 3, these parcels average 2.1 (or slightly higher than moderate).

The benefits to recreation and tourism of habitat protection and acquisition would derive from protection of the scenic, wildlife, and undeveloped characteristics important for recreation values in the parcels being evaluated for acquisition. Extractive economic activities may reduce the recreational visual appeal of the landscape, shift or reduce wildlife viewing possibilities, and eliminate the relative lack of developed character, thus reducing the overall utility of these and surrounding areas for recreation purposes. These benefits may be low in the short term but moderate to high in the long term.

This analysis does not take into consideration small parcel acquisition, which is currently under evaluation. Also, it is possible that land prices may be lower or higher than those assumed here. This would result in the purchase of more parcels (possibly all identified parcels) or fewer parcels.

General Restoration

Restoration strategies for recreation and tourism are to preserve or improve the recreation and wilderness values of the EVOS area, remove or reduce residual oil if it is cost effective and less harmful than leaving it in place, and monitor recovery. Alternative 5 focuses on stabilizing and improving existing recreation opportunities. It allows for funding of projects that create new recreation opportunities or promote public land recreation use as long as the projects benefit the same user group that was injured.

Removing Residual Oil. Under this alternative, removing residual oil on beaches important for recreation use would restore these beaches to useable condition, which would have a moderate short-term benefit. The long-term benefits of this action may be high locally but are estimated to be moderate overall.

Easement Identification. Easement identification has been proposed as a means to reduce trespass and land-use conflicts between private landowners and the general public. This may improve recreation and tourism by letting people know where public land exists. The short-term benefit would be low, because dissemination of the knowledge about the existence of public land could--as a result of increased use--accumulate impact over several years. The long-term benefit may be moderate to high but might be very localized.

New Recreation Opportunities. New recreation opportunities may include new facilities, trails, recreation sites, or support for activities in new areas (like new access or supply means) which are consistent with the character and public uses of the areas. This may benefit recreation and tourism by expanding the numbers of available places to take part in activities already present in the spill area, or by expanding the range of available types of activities beyond those now present. These actions might produce immediate impacts that would be minimal in the short term but could be major in the long term.

Promoting Recreation Use. Promoting recreation use on public lands could take a variety of forms, from creating new visitor centers or building a marine environmental institute to distributing educational or interpretive information through existing marketing sources. Various education and public information projects have been proposed, including, for example, a Leave No Trace education program and a recreation information center at Portage. These actions would have to be consistent with the character and public uses of the area. They may have low benefits on the numbers or categories of recreationists or tourists in the short term but potentially could greatly increase visitation in the long term, especially if they are used to inform and educate the public concerning other spill-related restoration actions that affect recreation and tourism. The benefits of new recreation alternatives and recreation marketing potentially could greatly increase recreation use and tourism in the spill area in both the short term and the long term. This includes increased visitors to population centers and remote locations throughout the spill area. However, increasing the level of recreation and tourism use creates negative effects for ecosystems, especially if increased pressures occur to species and landscapes not recovered or still recovering from the spill. Increased numbers of people and technology (boats, planes, generators, etc.) also may change the wilderness quality of the recreation experience.

Conclusions

Short-term effects:	Low Benefits. The proposed actions may increase numbers of visitors, types of recreation opportunities available, and quality of experiences, but this is expected to occur gradually.
Long-term effects:	Moderate to High Benefits. The proposed actions may increase recreational use levels, types, and opportunities. This is expected to occur locally in some cases and throughout the spill area in other cases.

Designated Wilderness

Habitat Protection and Acquisition

It is assumed that between 31 and 34 large parcels would be purchased under Alternative 5. These parcels contain low (high/moderate evidence of human development and/or ongoing activities), moderate (area remote; evidence of human development and/or ongoing activities), or high (area remote; little or no evidence of human development) potential for benefiting wilderness character as analyzed by the Habitat Protection Work Group (November 30, 1993). If low potential benefit on a parcel is assigned a value of 1, moderate potential benefit a value of 2, and high potential benefit a value of 3, these parcels average 2.3 to 2.4 (or between moderate and high). These benefits to wilderness character are assumed to derive from protecting these lands from extractive activities, thereby maintaining their isolation, undeveloped landscape, and unmodified ecosystems.

There would be negligible short-term benefits to designated Wilderness Areas or Wilderness Study Areas, and to wilderness character of non-Wilderness public lands. Long-term benefits likely would be low, with benefits achieved by extending protection from extractive activities to areas adjacent to or near Wilderness or Wilderness Study areas, thereby increasing the viability of undisturbed ecological relationships that may exist between species in those lands. This analysis does not take into consideration small-parcel acquisition, which currently is under evaluation. Also, it is possible that land prices would be lower or higher than those assumed here. This would result in the purchase of more parcels (possibly all identified parcels) or fewer parcels.

General Restoration

General restoration actions could include any actions that assist recovery of injured resources or prevent further injury. Any of these actions may have spinoff benefits that could improve wilderness values in the EVOS area. Recovery of designated Wilderness areas hinges both on the removal of traces of oil and remaining materials from cleanup activities and the public's perception that the areas are recovered.

Projects that remove residual oil and/or residual cleanup materials still existing in isolated pockets in Wilderness areas may occur under this alternative. The short-term benefits of these projects to Wilderness recovery would be immediate, but if the public-perception aspect of recovery is not addressed these benefits may be low to moderate. In the long term, benefits would be moderate if the public-perception aspect of recovery is not addressed, even if all oil and residual cleanup materials were removed. However, if the public is made aware of continued cleanup activities and the continued pristine nature of Wilderness areas in the spill area, the benefits of cleanup activities may be magnified, creating a high level of recovery in the long term.

Conclusions

Short-term effects:	Low Benefits. All of the proposed actions require some time after implementation before any changes could be expected.
Long-term effects:	Moderate to High Benefits. The proposed actions could reduce negative impacts on designated Wilderness Areas and Wilderness

Study Areas, and extend some degree of protection to wilderness character of *de facto* wilderness lands.

Commercial Fishing

Alternative 5 would provide restoration actions to assist replacement of harvest opportunities that were lost because of fishing closures or harvest restrictions that occurred as a result of the EVOS. Actions that may be implemented as part of Alternative 5 include habitat protection and acquisition and creation of new hatchery-produced runs (EVOS Trustee Council, April and November 1993).

Habitat Protection and Acquisition

Habitat protection may benefit commercial-fishing opportunities by providing long-term protection for natural production and stability of wild stocks of pink and sockeye salmon and Pacific herring. The criteria for these parcels that may benefit commercial fisheries depends on the values assigned for those species (EVOS Restoration Team, 1993).

Habitat protection that may benefit replacement of lost opportunities for commercial fishing according to Alternative 5 will depend on the average cost per acre and the final budget allocation. Therefore, the number of parcels that may be purchased is expected to range between 31 or 34 parcels and all parcels that are available. If all available parcels were purchased, the benefit is expected to provide low to moderate value for commercial fisheries. If between 31 and 34 parcels were purchased, the benefit is expected to provide moderate value (Appendix A).

Although the average value of forecasted habitat acquisition may not have a high overall rating for commercial fisheries, individual parcels may have exceptional value. If some of these parcels were not protected through acquisition, the habitat would continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

General Restoration

Create New Hatchery Runs. For commercial fishing resources, actions considered under Alternative 5 may replace lost opportunities by creating new hatchery-produced runs of salmon. Development of new runs of pink, sockeye, and chum salmon may benefit commercial fishing by providing an alternate location, timing, or stock for commercial fishing activities and if the brood-stock selection for these new runs and the release site were carefully selected, there would be minimal interception of injured wild stocks. Good fishery management practices combined with a redistribution of the fishing fleet, would enable an intensive commercial fishery to harvest these stocks.

Specific actions that may be considered can be expected --either alone or collectively-- produce new runs of sufficiently large numbers of adult pink, sockeye or chum salmon to accommodate a reasonable portion of the fishing fleet and provide a harvest that may be separated in time or space from existing fisheries. Several potential actions that may provide these fish by development of new hatchery runs entail actions that have been described for restoration of wild stocks of pink and sockeye salmon (e.g., rear and release fry, presmolts, or smolts) or habitat manipulation to increase production of selected stocks (e.g., lake fertilization, migration corridor improvements, spawning channels, etc.) (Appendix C). The actions and methods remain the same, but the brood stock selection (e.g., source, species, timing, etc.), release strategies (e.g., age, size, location, etc.), and the harvest management (harvest rate, timing, location, etc.) may be selected to benefit commercial fishers and, perhaps, particular gear types.

ADF&G and PNP aquaculture organizations have established a modern fisheries enhancement program in the EVOS area and have developed new runs of salmon for harvest by commercial fishers. Excellent success has been achieved with most of these programs which have developed new self-sustaining or hatchery-produced runs of fish (Ellison, 1992); however, some locations that are accessible to the fishing fleets remain as opportunities for juvenile fish imprinting and adult fish terminal harvest areas.

Every fisheries restoration, development, or enhancement program must be carefully planned and managed to avoid risks to wild stocks, and the fish-culture program must be carefully structured and controlled to avoid or minimize potential changes in the genetic makeup and health of the wild stocks that might be caused by the program. Although restoration, development, and enhancement of wild salmon stocks with fish-cultural techniques has been widely applied in the Pacific northwest, this strategy is not fully accepted within the fisheries profession (Hilborn, 1992; Martin, Webster and Edwards, 1992). Hatchery-produced fish typically can be harvested at a higher rate than most wild stocks. Consequently, if wild stocks are harvested with hatchery-produced fish, there may be a danger that the wild stocks may be overharvested (Hilborn, 1992; Seeb, 1993). A good harvest-management strategy must be developed so the hatchery-produced stocks can be harvested in a separate time or place. Every fish-culture program must be carefully structured, planned, and controlled to avoid or minimize potential risks of change in the genetic makeup and health of the wild stocks (Hindar, Ryman and Utter, 1991; ADF&G, 1983; Holland-Bartels, Burger, and Klein, 1994; Meyers et al., 1988; Davis et al., 1985; Seeb, 1993). Additional state and federal permits and a site-specific NEPA compliance review may also be required before a project is implemented (Appendix C, Section 1).

Conclusions

Short-term effects.	Negligible. New runs to support new commercial fisheries probably cannot be established within one lifecycle to replace opportunities lost because of fishing closures or reduced harvests.
Long-term effects.	Moderate. These actions would assist the replacement of lost commercial fishing opportunities. However, some portions of the EVOS area would obtain greater benefits than other portions.

Sport Fishing

Sport fishing was disrupted throughout most of the EVOS area because of the oil spill, and populations of several important sport fish species were damaged. Lost sport fishing opportunities may be replaced by creating new sport fisheries for salmon or trout. Alternative 5 would provide restoration actions to assist replacement of harvest opportunities that were lost because of fishing closures or harvest restrictions that occurred as a result of the EVOS. Actions that might be implemented to as part of Alternative 5 include habitat protection and acquisition and creation of new hatchery-produced runs (EVOS Trustee Council, April and November 1993).

Habitat Protection and Acquisition

Habitat protection and acquisition may benefit sport fishing opportunities by providing long-term protection for natural production and stability of wild stocks of pink and sockeye salmon, Dolly Varden, and cutthroat trout. The criteria for these parcels that may benefit sport fisheries depends on the values assigned for these species (EVOS Restoration Team, 1993).

Under Alternative 5, the forecasted habitat protection that may benefit replacement of lost opportunities for sport fishing will depend on the average cost per acre and the final budget allocation. Therefore, the number of parcels that may be purchased is expected to range between 31 and 34 parcels and all 81 parcels that are available. If all available parcels are purchased, the benefit is expected to provide low to moderate value for sport fisheries. If between 31 and 34 parcels are purchased, the benefit is also expected to provide low to moderate value (Appendix A).

Although the average value of forecasted habitat acquisition may not have a high overall rating for sport fisheries, individual parcels may have exceptional value. If some of these parcels were not protected through acquisition, the habitat would continue to have some measure of protection through the actions of normal resource agency planning and permitting requirements (Appendix C).

General Restoration

Establish Hatchery Runs. The establishment of new hatchery-produced runs of salmon or trout would provide some benefit for all fishers by providing new opportunities with new locations and stocks that anglers may use. Typically, a run of a few thousand fish will provide tens of thousands of angler/days of recreation (Mills, 1993). Sport fisheries, however, would be successful only if they are located where they would be accessible by anglers. The ADF&G already has employed this strategy to improve sport fishing opportunities for trout and salmon in the EVOS area by stocking catchable-sized trout and salmon smolts at accessible locations, often where self-sustaining runs cannot be established. Actions are similar or identical to those described in Appendix C.

A small number of fish in a good, accessible location can provide angling to accommodate a substantial number of angler/days of recreation. Wherever large numbers of fishers concentrate to harvest a concentrated population of fish, some portions of the adjacent habitat may be affected. While new sport fisheries would readily create new recreational opportunities, these likely would be for different species in new locations.

Every fisheries restoration, development, or enhancement program must be carefully planned and managed to avoid risks to wild stocks, and the fish-culture program must be carefully structured and controlled to avoid or minimize potential changes in the genetic makeup and health of the wild stocks that might be caused by the program. Although restoration, development, and enhancement of wild salmon stocks with fish-cultural techniques has been widely applied in the Pacific northwest, this strategy is not fully accepted within the fisheries profession (Hilborn, 1992; Martin, Webster and Edwards, 1992). Hatchery-produced fish typically can be harvested at a higher rate than most wild stocks. Consequently, if wild stocks are harvested with hatchery-produced fish, there may be a danger that the wild stocks may be overharvested (Hilborn, 1992; Seeb,1992). A good harvest-management strategy must be developed so the hatchery-produced stocks can be harvested in a separate time or place. Every fish-culture program must be carefully structured, planned, and controlled to avoid or minimize potential risks of change in the genetic makeup and health of the wild stocks (Hindar, Ryman and Utter, 1991; ADF&G, 1983; Holland-Bartels, Burger, and Klein, 1994; Meyers et al., 1988; Davis et al., 1985; Seeb, 1992). Additional state and federal permits and a site-specific NEPA compliance review may also be required before a project is implemented (Appendix C, Section 1).

Conclusions

Short-term effects:	Negligible. New sport fisheries to replace lost sport fishing opportunities probably cannot be established within one lifecycle.
Long-term effects:	High. After hatchery production is expanded, newly-established sport fisheries can be expected to provide substantial recreational benefits.

Economy

Qualitative analysis indicates that Alternative 5 would result in moderate economic benefits in commercial fisheries and recreation and moderate negative effects in forestry. This analysis reflects effects resulting from habitat acquisition on forestry and other sectors but not effects on commercial fishing and recreation because data in these sectors is not available to quantify. The quantitative analysis follows.

In Alternative 5 significant timberlands will be acquaired and it is assumed that signficant timber will not be harvested. As shown in Table 4-13 Alternative 5 annual average industry output is projected to decline by $27.6 million and employment is anticipated to decline by 279 employees.

Spending of money by timberland owners has a direct effect on the construction sector as shown in Table 4-13 Alternative 5 in the amount of $6.2 million in inudstry output. soending of meony by timberland owners also has a direct effect on the services sector in the amount of $3.9 million in final demand and 321 employees.

Spending in the construction and service sectors is not enough to offset the negative effects in the forestry sector. The net effect is shown in the total line which has negative quantities for five out of the six economic measures; only employment is positive.

Alternative 5 assumes ranges of expenditures for the expenditure categories. In the quantitative economic analysis specific points within the ranges are assumed for the purpose of simplifying the analysis.

Habitat acquisition and general restoration expenditures will have economic benefits for the commercial fisheries and recreation sectors of the economy. However, these benefits are not reflected in the IMPLAN projections presented in Table 4-13 . Therefore, this table does not quantify important economic benefits in commercial fishing and recreation because these benefits are not quantified. Of the three most important economic sectors for this analysis, only forestry is quantified. The typical projects in various combinations, such as fish ladders, fish hatcheries, and preservation of habitat will economically enhance the commercial fisheries and recreation sectors of the economy. However, because studies and data are not available that quantify in terms of dollars or employment, it is not possible to quantify the economic effects for these two sectors of the economy. In Table 4-13 the quantities for the commercial fisheries and recreation sectors are reflections of the indirect effects of other sectors of the economy only; they are not reflections of the anticipated but unquantified effects on those sectors.

Short-term impacts are anticipated to be negligible.

See the introduction to Chapter 4 on economics and Appendix D of this EIS, Economics Methodology, for a more detailed discussion of methodology.

Conclusions

Short-term effects:	Negligible. Short-term impacts are anticipated to be negligible.:
Long-term effects:	Qualitative analysis indicates that Alternative 5 would result in moderate economic benefits in commercial fisheries and recreation and moderate negative effects in forestry. Quantitative analysis reflects there would be effects resulting from habitat acquisition on forestry and other sectors but not on commercial fishing and recreation. Quantitative analysis indicates that Alternative 5 would result, in annual averages for a 10-year period, in a loss of approximately $28 million in forestry industry output, an increase of $6 million in construction industry output, and $2 million in services. The corresponding changes in employment would be a loss of 279 jobs in forestry, an increase of 55 in construction, and an increase of 320 in services.

Table 4-13. Alternative 5
Average Annual Change from Base in 1990$ Millions

Economic Sector	Final Demand $	Industry Output $	Employee Comp. $	Property Income $	Value Added $	Employment #
Forestry	-22.424	-27.599	-6.110	-3.526	-10.500	-279
Commercial Fisheries	0.000	0.000	0.000	0.000	0.000	0
Mining	0.013	-0.045	-0.003	-0.020	-0.034	0
Construction	6.761	6.261	2.210	0.936	3.262	55
Manufacturing	0.012	-0.334	-0.054	-0.017	-0.080	1
Recreation Related	0.011	0.023	0.006	0.007	0.013	0
Communication & Utilities	0.022	0.030	0.006	0.019	0.026	0
Trade	0.010	-0.044	-0.036	-0.008	-0.058	0
Finance, Insurance, Real Estate	0.400	-0.026	-0.032	0.048	0.010	-1
Services	3.953	1.597	1.803	-0.241	1.578	321
Government	2.119	2.024	2.080	-0.019	2.060	38
Miscellaneous	0.000	0.000	0.000	0.000	0.000	0
Total	-9.021	-18.112	-0.028	-2.830	-3.722	135

Source: IMPLAN Economic Model. See text for methodology.

Cumulative Effects

Introduction

Actions that may affect EVOS restoration include the Whittier road access project, Whittier harbor expansion, Cordova road access, harbor dredging at Shepard Point near Cordova , tourism and recreation development at Child's Glacier on the Copper River Delta, the Trans-Alaska Gas Pipeline terminal in Port Valdez, Lower Cook Inlet oil development, and the effects of EVOS projects for Fiscal Years 1992 through 1994 (FY's 1992-94). This section discusses these actions, evaluates their effects on each injured resource, and summarizes the cumulative effects on each resource.

Whittier Road Access and Whittier Harbor Expansion

These two actions are considered together because their effects on resources would be similar. Road access to Whittier and expansion of Whittier harbor both would dramatically increase the number of people in Prince William Sound. Numbers of recreational boaters of all kinds, tourists aboard charter and tour boats, and seasonal and year-round residents of Whittier would all increase. The increase in boat traffic would be especially pronounced within 30 to 40 miles of Whittier, the normal range of weekend boaters. Even without these actions, recreational and tour boat use has steadily increased the past few years in this part of Prince William Sound, particularly in Blackstone Bay, around Esther and Culross Islands, in Port Wells, and in Harriman and College Fjords. These two actions would create even more pressure on these areas and their resources. Boat traffic between Whittier and Valdez and throughout Prince William Sound would also increase.

Cordova Road Access

Road access to Cordova would increase the number of people who use southeastern Prince William Sound. Numbers of recreational boaters and tourists aboard charter and tour boats will all increase markedly, especially within 30 to 40 miles of Cordova, the normal maximum range of weekend boaters. Boat traffic throughout eastern Prince William Sound also would increase.

Shepard Point (Nelson Bay) Dredging

Dredging near Cordova at Shepard Point in Nelson Bay is proposed to accommodate berthing of cruise ships and tour boats to enhance tourism in the Cordova area. This action would alter the natural character of the local nearshore environment and temporarily create dredge spoils and noise.

Child's Glacier Tourism Development

A lodge and related tourism and recreation facilities are planned for construction near Child's Glacier and the "Million Dollar Bridge."

Trans-Alaska Gas Pipeline Terminal

Construction of the terminal for the Trans-Alaska Gas Pipeline is planned for Anderson Bay, near the mouth of Port Valdez.

Lower Cook Inlet Oil Development

Minerals Management Service (MMS) Lease Sale 149 is proposed to be held in 1996 for the Outer Continental Shelf in Cook Inlet from the north end of Kodiak Island to the north end of the Kenai Peninsula.

The base case in a scenario formulated by MMS projects the following activity over a 30-year period:

- 3 exploration wells
- 5 delineation wells
- 3 production platforms
- 48 production/service wells
- 1 shorebase
- 125 miles of 12-inch pipeline offshore to the Nikiski industrial complex, which would self-bury because of turbid conditions
- 200 million barrels of oil produced

Additional MMS projections are that development of infrastructure and production of oil would include considerable aerial and marine support from a shorebase; oil would be used locally or sent via tanker to the West Coast of the U.S.; and an oil spill of 50,000 barrels is estimated to have a 27-percent chance of occurring at some time over the 19-year period of production.

FY's 1992 - 94 EVOS Projects

The EVOS projects funded in FY's 1992 - 94, are shown in Appendix E of this EIS. These projects were reviewed for inclusion of their potential impacts in this analysis.

Biological Resources

Intertidal Resources

Several of the actions are unlikely to impact the intertidal zone. This discussion focuses on those actions that could affect the recovery of intertidal organisms. The harbor expansion projects at Whittier and Cordova (Shepard Point) would cause a localized loss of the existing intertidal habitats. Because neither of these specific areas were directly impacted by the EVOS, these localized losses should not have a negative effect on the recovery of the injured intertidal areas.

Lower Cook Inlet oil development would increase the risk by 27 percent of another oil spill occurring in the EVOS area. Likewise, the increased tanker traffic caused by the Trans-Alaska Gas Pipeline would increase the risk of another oil spill, indirectly, through an increased potential for oil tanker collisions. Any oil spill within the EVOS area could have an enormous impact on the intertidal zone. The EIS's associated with these two actions would have to consider the potential impacts on the intertidal organisms in the event of an oil spill. If no oil spills occurred, and steps were taken to reduce disturbance, there should be little or no impacts.

Restoration actions undertaken in response to the EVOS from 1992 to 1994 include feasibility studies to develop effective techniques to clean oiled mussel beds and to accelerate the recovery of *Fucus* in the upper intertidal zone. The results of these actions, if positive, would enable the implementation of restoration projects to occur more quickly.

Conclusions

The cumulative actions that may affect EVOS restoration, combined with the proposed action, should not change the expected benefits, assuming that another oil spill does not occur.

Marine Mammals

Harbor Seals and Sea Otters

Increased potential for disturbance to harbor seals and sea otters would be the primary impact caused by most of the cumulative actions being considered. The Whittier road access, the Whittier harbor expansion, the Cordova road access, the Shepard Point dredging, and the Trans-Alaska Gas Pipeline would result in increased boat traffic, from tankers to pleasure boats and kayaks, in Prince William Sound. This increase probably would have a negligible impact on sea otters, but it could harm harbor seals. The proposed action includes an information-based program that would minimize the impacts of human-caused disturbance to harbor seals. If this program were implemented in proportion to the increase in human use, the overall effects should be negligible. A lodge at Child's Glacier should have no impact on harbor seals and/or sea otters..

The Lower Cook Inlet Oil development has the potential to create disturbance near haulout sites, but the greatest negative impact would be caused if there were another oil spill. The increased tanker traffic caused by the Trans-Alaska Gas Pipeline also might increase the risk of another oil spill, indirectly, through an increased potential for oil-tanker collisions. Any oil spill within the EVOS area could have an enormous impact on the recovery of sea otters and harbor seals. The MMS has estimated that there is a 27-percent chance of an oil spill occurring from Lower Cook Inlet oil development during the 19-year production period. The EIS's with these two actions should consider the impacts on marine mammals in the event of an oil spill. If no oil spills occur, and steps are taken to reduce disturbance, there should be little or no impact on sea otters and harbor seals.

Restoration actions undertaken in response to the EVOS in FY's 1992 through 1994 include feasibility studies to develop effective techniques for cleaning oiled mussel beds. The results of these studies, if positive, would enable the implementation of restoration projects to occur more quickly. This will reduce the risk of continuing exposure to hydrocarbons for sea otters.

Initiation of a cooperative program with subsistence users also is scheduled to begin in 1994. This would have no effect on the results of the analysis of this action; however, it would accelerate the timing of the benefits by at least 1 year.

The EVOS program also has protected uplands in Kachemak Bay and Seal Bay. These areas are adjacent to valuable habitat for sea otters and harbor seals, and this protection would help maintain these high-quality habitats.

Conclusions (Cumulative effects on harbor seals and sea otters)

The cumulative actions that may affect EVOS restoration, combined with the proposed action, should not change the expected benefits, assuming that another oil spill does not occur.

Birds

Harlequin Ducks

Increased boat traffic in Prince William Sound, especially from smaller motorboats that generally travel close to shore, would have an increasing disturbance effect on harlequin ducks, especially during late summer when molting takes place and new broods are first acclimatizing to the marine environment. Occasional hikers in riparian habitat should have a negligible disturbance effect on nesting harlequin ducks. Increased hunting pressure may affect populations, but hunting regulations could be adjusted where necessary to negate this effect. New oil development in Cook Inlet would increase the risk of a spill that might repeat the injury suffered by the Prince William Sound population. Cleaning oiled mussel beds would have a moderate to high benefit for local populations of harlequin ducks but would have little influence on their overall recovery. Other proposed actions in this alternative appear to have a negligible lasting effect on harlequin ducks.

Conclusions (Cumulative effects on harlequin ducks)

The combined effects of proposed Alternative 5 and the cumulative actions described above would be moderately beneficial to harlequin duck populations in the EVOS zone.

Common Murres

Murre populations generally are quite low in Prince William Sound, but important seabird colonies lie within the lower Cook Inlet oil-sale area, including the injured breeding population of common murres in the Barren Islands. There also are several smaller colonies in the sale area, including Gull Island in Kachemak Bay and Chisik Island at the mouth of Tuxedni Bay. An oil spill near these colonies would have a major, highly negative effect on the injured population of common murres, especially at the Barren Islands, where the population is just beginning to recover.

Conclusions (Cumulative effects on common murres)

The combined effects of the proposed alternative and the actions described above would be moderately beneficial for common murres in much of the EVOS area. However, proposed oil development in lower Cook Inlet would have an extremely high negative impact on the recovering common murre population at the Barren Islands, should a spill reach those islands during the nesting season.

Pigeon Guillemots

Increased boat traffic in Prince William Sound would create the threat of disturbance to a few colonies of pigeon guillemots. Guillemots are most susceptible to disturbance during the early stages of the breeding season, when they are highly social at their colonies. However, this social behavior mostly takes place in the early morning when most boaters are inactive, so actual disturbance is likely to be low. Predator control slated for the Shumagin Islands, downstream from the EVOS area, would allow a local increase in pigeon guillemot numbers.

Conclusions (Cumulative effects on pigeon guillemots)

The combined effects of proposed Alternative 5 and the actions described above would be highly beneficial for the pigeon guillemot populations at the colonies slated for predator removal. Benefits for the overall EVOS area would be moderate.

Marbled Murrelets

The effects of this alternative on marbled murrelets likely would result in a negligible increase in the prey base of marbled murrelets.

Conclusions (Cumulative effects on marbled murrelets)

The combined effects of proposed Alternative 5 and the cumulative actions described above would produce a high overall benefit for marbled murrelet populations.

Fish

Pink Salmon, Sockeye Salmon, Pacific Herring, and Commercial Fishing

Proposed Actions and Expected Effects. Increased road access to Whittier and Cordova and an expansion of the capacity of the Whittier boat harbor may cause an increased number of commercial fishers or increase the ease of access to commercial fisheries, so pressure on the commercial-fisheries resource could be expected to increase. However, increased effort can be expected to be offset by an increased effort to manage or to enhance the fisheries. These actions also could increase the volume of recreational users and tourism, which could have a disruptive effect on the execution of the fisheries and potentially lead to a degradation of important fish spawning and rearing habitat.

Development of a Lower Cook Inlet oil field may have a disruptive effect on fish migrations and the execution of the fishery; however, before the oil field is developed, the potential impacts should be discussed and, presumably, resolved; e.g., by seasonal operational plans or well-defined shipping lanes.

Dredging operations to expand cruise ship traffic near Cordova could have a disruptive effect on other vessel movements during both the construction and operational phases. Potential direct disruptive effects on the fish resources may be minimized by controlling activities during critical periods of fish production and migration.

Trans-Alaska Gas Pipeline construction and operation may have a similar, but lesser, effect on fish or fisheries in the EVOS area as would the Trans-Alaska Oil Pipeline. Some local effects may occur, and shipping may increase the number of tankers in the same shipping lanes, but accidental leakage of gas in the EVOS area is not expected to harm the aquatic environment. Increased tanker traffic in the shipping lanes may increase the likelihood of a tanker collision.

Recreational development near Child's Glacier would increase the number of visitors and recreational fishers, but it is unlikely to have an important effect on commercial fishing or fishes in the EVOS area.

Fisheries restoration projects that have already been funded would contribute to the recovery of commercial fish and fisheries, but these projects alone would not have a substantial effect. Fish hatchery operations in FY 1994 are a continuation of established programs that help provide stability to the operation of the fishery and habitat-restoration programs to improve protection and production of wild stocks of fish.

Discussion. Several of these potential actions might have an individual or cumulative negative impact on commercial fish and fisheries; one would be beneficial. Each, however, must be evaluated with it's own environmental review and designed to minimize or avoid potential damage during both the construction and operational phases.

Conclusions

The cumulative effects of the proposed action and these other actions should not change the expected benefits of the EVOS restoration for pink salmon, sockeye salmon, Pacific herring, and commercial fishing.

Sport Fishing, Pink Salmon, Sockeye Salmon, Cutthroat Trout, and Dolly Varden

Proposed Actions and Expected Effects. Increased road access to Whittier and Cordova and an expansion of the capacity of the Whittier boat harbor may cause an increase number of visitors, tourists, and fishers or increase the ease of access to recreational fisheries, so pressure on the fisheries resources could be expected to increase. Increased demand for the available resources could be expected to be offset by an increased effort to enhance the fisheries or manage them more conservatively. These actions also could increase the volume of other recreational and tourist activities, which could have a disruptive effect on the execution of the fisheries and potentially could lead to a degradation of important fish spawning and rearing habitat.

Development of a Lower Cook Inlet oil field may have a disruptive effect on fish migrations. However, before the oil field is developed, the potential impacts should be discussed and, presumably, resolved. (e.g., by seasonal operational plans or well-defined shipping lanes).

Dredging operations to expand cruise ship traffic near Cordova may have a disruptive effect on other vessel movements during both the construction and operational phases. Potential direct disruptive effects on the fish resource could be minimized by controlling activities during critical periods of fish production and migration.

The Trans-Alaska Gas Pipeline construction and operation may have a similar, but lesser, effect on fish or fisheries in the EVOS area than the Trans-Alaska Gas Pipeline. Some local effects may occur and shipping may increase the number of tankers in the same shipping lanes, but accidental leakage of gas is not expected to harm the aquatic environment in the EVOS area. Increased tanker traffic in the shipping lanes may increase the likelihood of a tanker collision.

Recreational development near Child's Glacier would increase the number of visitors and recreational fishers. Increased demand for the available resource could be expected to be offset by an increased effort to enhance the fisheries or manage them more conservatively. This action also could increase the volume of other recreational and tourist activities, which could have a disruptive effect on the fisheries and potentially lead to a degradation of important fish spawning and rearing habitat.

Fisheries restoration projects that already have been funded would contribute to the recovery of sport and commercial fish and fisheries, but these projects alone would not have a substantial effect. Fish-hatchery operations in FY 1994 are a continuation of established programs that help provide stability to the operation of fisheries, and habitat-restoration programs improve protection and production of wild stocks of fish.

Discussion. Several of these potential actions may have an individual or cumulative negative impact on sport fish and fisheries; one will be beneficial. Each, however, must be evaluated with its own environmental review and designed to minimize or avoid potential damage during both the construction and operational phases.

Conclusions

The cumulative effects of the proposed action and these other actions should not change the expected benefits of the EVOS restoration for sport fishing, pink salmon, sockeye salmon, cutthroat trout, and Dolly Varden.

Social and Economic Resources

Archaeological / Cultural Resources

Factors that might impact cultural resources are: (1) construction that may damage archaeological or historic sites; (2) increased access to or numbers of visitors to sites, thus allowing for activities that could damage archaeological or historic sites; or (3) changes in the levels of site monitoring and/or interpretation.

The Whittier road access would increase ease of access to Whittier, which would produce an increase in the population of visitors to Prince William Sound. This would result in increased numbers of people using small motorboats, the Alaska State Ferry, and boat charters out of Whittier. The proposed expansion of the Whittier harbor would allow more and larger pleasure boats to use the area. The increase in small- motorboat use would allow greater numbers of people to visit culturally sensitive areas, especially within the 30- to 40-mile normal maximum range for weekend boaters. Without sufficient monitoring and/or interpretation, this would increase the possibility of damage to archaeological and historic sites in the region. However, if interpretation and monitoring are increased in proportion to the visitor population, there is the potential for greatly expanded public knowledge and appreciation of the cultural resources of the region.

Cordova Road access similarly would increase the population of visitors to Prince William Sound. In addition to exposing archaeological and historical sites to increased use through boat access, the Cordova Road would allow easier access to areas alongside or near the road. Similar effects could be expected as a result of the Childs Glacier lodge/motel development proposed by Chugach Alaska Corporation and Princess Lodge. Again, site monitoring and public education/interpretation could reduce the levels of impact.

Lower Cook Inlet oil development may increase populations and coastal activities in and around Cook Inlet communities. Depending on the location and extent of these increases, archaeological and historical sites could be adversely affected. If site excavations, monitoring, and interpretation are undertaken as discussed in the proposed alternative, the negative effects of these projects may be reduced.

The proposed harbor at Shepard Point near Cordova would have no substantial impacts that would produce cumulative effects that need to be considered in this EIS. The Trans-Alaska Gas Pipeline terminal likewise would produce site-specific impacts that would not substantially impact the cultural resources of the spill area.

The projects funded by the Trustee Council between FY's 1992 - 94 are producing local benefits to archaeological and historical sites and also should produce some benefit to the understanding and appreciation of cultural resources in EVOS communities.

Conclusions (Cumulative impacts on cultural resources)

Taken into consideration in conjunction with other ongoing or planned projects in the spill area, the benefits of Alternative 5 would be somewhat reduced. The benefits of this proposed alternative would help offset the negative impacts of the cumulative actions.

Subsistence Uses

Cumulative impacts on subsistence are those that affect the populations and distributions of species that subsistence users harvest as well as those that affect the attitude subsistence users have toward harvesting those species. This includes impacts of the proposed action and other ongoing planned projects in the EVOS area.

The main impact on subsistence from other ongoing or planned projects in the spill area would be from increased competition for resources that are both subsistence and recreation species. It is anticipated that these cumulative effects would be restricted to Prince William Sound. The road projects to Whittier and Cordova, the Whittier harbor expansion, and the lodge development at Childs Glacier each may add increments of additional numbers of recreational boaters in Prince William Sound. While it is unlikely that increased numbers of recreational boaters would affect the numbers of sea mammals, it is possible that increased boat traffic could cause some disturbance of harbor seals or sea otters in localized areas. There also may be increased competition for salmon or other fish used by sport anglers. However, the primary impact may be competition for deer in Prince William Sound, especially at locations like Montague Island.

Projects funded by the Trustee Council from FY's 1992 - 94 (Subsistence Food Testing, Subsistence Planning, and efforts to increase populations of subsistence harvest species) have produced some benefits to the confidence levels of subsistence users toward the safety of consuming traditional foods.

Conclusions (Cumulative impacts on subsistence)

Increased competition for subsistence resources may result from ongoing or planned projects in the Prince William Sound region. The benefits expected from the proposed alternative, Alternative 5, will not substantially offset the impact of that competition.

Recreation and Tourism

The factors that may come into play in the cumulative effects on recreation and tourism include the numbers and types of visitors, their distribution, and the availability of suitable facilities or sites. This analysis is concerned with recreation and tourism in the entire EVOS area.

Whittier road access and Cordova road access would increase the numbers of visitors to Prince William Sound and the Copper River Delta. They also would increase the use of vehicle access to tourist facilities and businesses in Whittier as well as to recreation sites in Prince William Sound. This would allow more people to use existing campgrounds, interpretive sites, picnic areas, and so on, especially in the Cordova area. The proximity of Whittier to Anchorage would allow potentially large increases in numbers of visitors, which would allow for new tourism-based businesses. The increased access to both Cordova and Whittier also would likely increase the number of small motorboats using Prince William Sound. This would put additional stress on recreation sites, which could have damaging effects to local ecosystems and cause shifting in recreation use patterns. Recovery of recreation as discussed for the proposed alternative, Alternative 5, would help balance the shift in recreation use patterns and provide new recreational use opportunities. Habitat protection and acquisition would allow additional public access to lands that were previously privately owned, thereby providing new recreation site opportunities. Recreation projects developed for general restoration may provide additional facilities or enhance existing facilities or sites in a way that would reduce the impact of increased numbers of visitors.

The proposed lodge/motel at Childs Glacier also would increase the numbers of visitors along the Cordova road system, and there is additional potential for airplane and boat charter operations in connection with this development. Again, the recovery of recreation as discussed for Alternative 5 would help balance the shift in recreation use patterns and provide new recreational use opportunities.

Should a deep-water harbor be constructed at Shepard Point, Cordova could become a focus for cruise ship-based tourism. A harbor of that type potentially would be a major positive impact to tourism in Cordova, primarily affecting retail sales. Some additional charter business (bus, small boat, and airplane) is expected as a result of this development; however, little effect is expected on dispersed or remote recreation in the area.

The proposed Lower Cook Inlet oil development would result in the development of infrastructure, which would entail both short-term and long-term population increases in some communities. It also would entail considerable aerial and marine support from a shore base. This could have a substantial local impact on demand for recreation opportunities in the Lower Cook Inlet region. During the construction phase, the additional air and marine traffic could disrupt the recreation quality in the area and along the transportation routes. Acquisition of lands through the EVOS restoration process may make more lands available for public recreation, and public education/ information availability may help distribute recreational activities to decrease impact from overuse of a few areas. The presence of 48 production/service wells and 3 production platforms would impact the visual character of the landscape, which would change the recreational experience in the region.

The Trans-Alaska Gas Pipeline is anticipated to have little impact on recreation and tourism in the EVOS area.

Projects funded for recreation and tourism by the Trustee Council for FY's 1992-94 have been directed toward gaining information on the quantity and types of impacts to those services. While this information is expected to have considerable benefits to the Trustee Council's ability to appropriately plan restoration activities, no projects have yet been funded that would directly benefit these services.

Conclusions (Cumulative effects on recreation and tourism)

In combination with the effects of the proposed alternative, the cumulative effects of these projects would be increased pressure on facilities and undeveloped sites and a change in recreation experience for visitors to Prince William Sound.

Wilderness

Conclusions

None of the developments considered would, in combination with actions under the proposed alternative, have a cumulative effect on Wilderness.

Economy

The actions described in the cumulative case would have an economic impact of increasing employment and output by 1 percent per year over a 10-year period. An increase in employment of 1 percent per year is projected in a report by the Institute for Social and Economic Research (ISER) (1992). These employment projections in the ISER report assume approximately the same range of projects and factors affecting the economy as described in this cumulative case. The 1-percent annual increase in employment and output as a result of cumulative-case activity plus the economic impact from Alternative 5 would result in moderate economic effects.

Unavoidable Adverse Impacts

Impacts on Biological Resources

No unavoidable adverse impacts on biological resources are expected from the Proposed Action (Alternative 5). In fact, the opposite is estimated to be true. The proposed action should result in benefits of varying degrees for all the biological resources analyzed.

Impacts on Social and Cultural Resources

There are no projected unavoidable adverse impacts on the social and cultural resources expected from the Proposed Action.

Impacts on the Economy

The proposed action (Alternative 5) would have a moderate adverse impact on the forestry sector of the economy because a certain amount of timberlands would not be available for harvesting. Forestry output and employment would be less to a moderate degree.

Relationship Between Local Short-Term Uses and Enhancement of Long-Term Productivity

In this section, the short-term impacts and uses of various components of the environment are related to long-term impacts and the maintenance and enhancement of long-term productivity.

Impacts on Biological Resources

The nature of the Proposed Action (Alternative 5) is--that like the other action alternatives in this EIS--it does not adversely impact the biological resources. Details of the short and long-term impacts are discussed in the description of the environmental consequences of each alternative earlier in this chapter. The short-term impacts are beneficial to all the resources, although usually to a negligible degree. The long-term aim of all the alternatives, including the Proposed Action, is recovery from the EVOS injury. Long-term productivity is benefited or enhanced by the action pattern contained in the Proposed Action.

Impacts on Social and Cultural Resources

Similarly to the biological resources, the social and cultural resources are benefited by the Proposed Action. The actions proposed would restore the resources and thereby the services they provide injured by the EVOS and thus benefit the lives of those who use them.

Impacts on the Economy

The protection of habitat necessarily would adversely impact the timber-related economy of the EVOS area. This is in the form of reducing or eliminating into the future the potential for commercial timber operations on private lands. This will also have a long-term beneficial effect on biological resources such as commercial fish species, that may offset this adverse impact. The impacts associated with the Proposed Action are discussed in detail earlier in this chapter.

Irreversible and Irretrievable Impacts

Impacts on Biological Resources

There would be no irreversible or irretrievable impacts on the biological resources. The Proposed Action would benefit the biological resources through actions proposed to restore the resources injured as a result of the EVOS.

Impacts on Social and Cultural Resources

There would be no irreversible or irretrievable impacts on the social and cultural resources.

Impacts on the Economy

There would be no irreversible or irretrievable impacts on the economy.

ANILCA Section 810(a) Evaluation and Finding

Introduction

Section 810 of the Alaska National Interest Lands Conservation Act (ANILCA) requires Federal agencies having jurisdiction over lands in Alaska to evaluate the potential impacts of proposed actions on subsistence uses and needs. Section 810 of ANILCA states:

> In determining whether to withdraw, reserve, lease, or otherwise permit the use, occupancy, or disposition of public lands under any provision of law authorizing such actions, the head of the Federal agency having primary jurisdiction over such lands or his designee shall evaluate the effect of such use, occupancy, or disposition on subsistence uses and needs, the availability of other lands for the purposes sought to be achieved, and other alternatives which would reduce or eliminate the use, occupancy, or disposition of public lands needed for subsistence purposes. No such withdrawal, reservation, lease, permit, or other use, occupancy or disposition of such lands which would significantly restrict subsistence uses shall be effected until the head of such Federal agency—
>
> > (1) gives notice to the appropriate State agency and the appropriate local committees and regional councils established pursuant to section 805;
> > (2) gives notice of, and holds, a hearing in the vicinity of the area involved; and
> > (3) determines that (A) such a significant restriction of subsistence uses is necessary, consistent with sound management principles for the utilization of the public lands, (B) the proposed activity will involve the minimal amount of public lands necessary to accomplish the purposes of such use, occupancy, or other disposition, and (C) reasonable steps will be taken to minimize adverse impacts upon subsistence uses and resources resulting from such actions.

In 1984, the Alaska Land Use Council adopted guidelines for complying with the requirements of Section 810. These guidelines provide the framework for this ANILCA Section 810(a) evaluation and finding.

The Section 810 evaluation consists of three components: (1) the impacts of the program on subsistence uses and needs; (2) the availability of other lands to fulfill the purposes of the program; and (3) alternatives to reduce or eliminate the proposed program from lands needed for subsistence purposes.

Evaluation

Impacts on Subsistence Uses and Needs

In accordance with the guidelines adopted by the Alaska Land Use Council, three criteria were used to evaluate the impact of the alternatives on subsistence uses and needs: (1) a reduction in subsistence uses due to factors such as direct impacts on the resource, adverse impacts on habitat, or increased competition for the resources; (2) a reduction in subsistence uses due to changes in availability of subsistence resources caused by an alteration in their distribution, migration, or location; and (3) a limitation on the access of subsistence users to harvestable resources.

Biological Resources

This assessment examines the reduction in subsistence uses due to factors such as direct impacts on the resource, adverse impacts on habitat, or increased competition for the resources. All alternatives consider all of the shoreline oiled by the spill, severely affected communities, and uplands adjacent to the watershed divide. None of the alternatives would change subsistence laws or regulations.

Impacts on the Availability of Subsistence Resources

This assessment examines the reduction in subsistence uses due to changes in the availability of subsistence resources caused by an alteration in their distribution, migration, or location. None of the alternatives contain provisions that would modify habitat or otherwise alter the distribution, migration, or location of wildlife populations in a way that would produce negative impacts on the availability of subsistence resources.

Impacts on the Access to Subsistence Resources

This assessment examines the limitation on the access of subsistence users to harvestable resources. None of the alternatives contain provisions that would alter subsistence-user access to harvestable resources. Decisions and regulations concerning access generally would continue to be the responsibility of the respective land manager.

Availability of Other Lands to Fulfill the Purpose of the Program

All alternatives consider all of the shoreline oiled by the spill, severely affected communities, and uplands adjacent to the watershed divide. In addition, Alternative 4 would allow restoration actions to occur anywhere there is a link to injured resources or services. Alternative 5 would allow restoration actions outside the spill area under certain conditions, but all actions must be within Alaska.

Other Alternatives That Would Reduce or Eliminate the Proposed Action from Lands Needed for Subsistence Purposes

No other alternatives have been identified that would reduce or eliminate the proposed action from lands needed for subsistence purposes.

Finding

The intent of the above evaluation is to find if implementation of any of the proposed alternatives might present a significant restriction of subsistence uses on public lands. In accordance with the Alaska Land Use Council guidelines, a potential restriction to subsistence is considered significant if--after any modification warranted by consideration of alternatives, conditions, or stipulations it can be expected to result in a substantial reduction in the opportunity to continue subsistence uses of renewable resources. Reductions in the opportunity to continue subsistence uses generally are caused by reductions in the abundance, or major redistributions, of harvestable resources; substantial interference with access; or major increases in the use of those resources.

Alternative 1 Finding

This evaluation concludes that this alternative would have no impacts on harvestable resources or on subsistence use.

Alternative 2 Finding

Under Alternative 2, there would be better long-term protection of harvestable resources than under Alternative 1. Any effects on harvestable resource populations should be positive. No effects are anticipated either on subsistence uses, availability of subsistence resources caused by an alteration in their distribution, or substantial interference with access of subsistence users to harvestable resources.

Alternative 3 Finding

Under Alternative 3, there would be better long-term protection of harvestable resources than under Alternative 1 and protection at a level comparable to that under Alternative 2, so any effects on harvestable resource populations should be positive.. There would be no substantial effect on redistributions, though some proposed actions might cause some beneficial redistribution of some harvestable resources. There would be no substantial interference with access or major increases in the use of harvestable resources.

Alternative 4 Finding

Under Alternative 4, there would be better long-term protection of harvestable resources than under Alternative 1, but at a somewhat reduced level than under Alternatives 2 and 3. Any effects on harvestable resource populations should be positive. There would be no substantial effect on redistributions, though some proposed actions might cause some beneficial redistribution of some harvestable resources. There would be no substantial interference with access or major increases in the use of harvestable resources.

Alternative 5 Finding

Under Alternative 5, there would be better long-term protection of harvestable resources than under Alternative 1, at a somewhat reduced level than under Alternatives 2 and 3, and at a level comparable to that under Alternative 4. Any effects on harvestable resource populations should be positive. There would be no substantial effect on redistributions, though some proposed actions might cause some beneficial redistribution of some harvestable resources. There would be no substantial interference with access or major increases in the use of harvestable resources.

4 Environmental Consequences

Notice and Hearings

The public notice and hearing requirements contained in Section 810(a)(1-3) must be met if it is found that the proposed action may present a significant restriction on subsistence uses. Because of the lack of potential for impacts resulting from implementation of the alternatives considered for adoption, no public notice and hearings were required or took place.

Preliminary Determinations

The following determinations have been made in accordance with Section 810(a)(3): (1) whether such a significant restriction of subsistence uses is necessary, consistent with sound management principles for the utilization of the public lands; (2) whether the proposed activity will involve the minimal amount of public lands necessary to accomplish the purposes of such use, occupancy, or other disposition; and (3) whether reasonable steps will be taken to minimize adverse impacts on subsistence uses and resources resulting from such actions.

Necessity and Consistency with Sound Management of Public Lands

The alternatives proposed have been examined to determine whether they are necessary and consistent with sound management of public lands to maintain subsistence resources and lifestyles. The Federal Water Pollution Control Act, 33 USC 1321 (f)(5), provides the authority for the civil settlement. The civil settlement includes two documents. The first is a Consent Decree between Exxon and the State of Alaska and the United States that requires Exxon to pay the United States and the State of Alaska $900 million over a period of 10 years. The second is the Memorandum of Agreement between the State of Alaska and the United States. Both were approved by the U.S. District Court.

Based on the analysis of the information presented in this document, Alternatives 2, 3, 4 and 5 may have significant positive impact on subsistence uses. Under these alternatives, significant amounts of habitat important for harvestable resources will be better protected from potential degradation than in the existing condition or Alternative 1. Additionally, Alternatives 3, 4, and 5 would provide for a variety of general restoration actions that are designed to stabilize or enhance harvestable resources. This would result in increased local subsistence resource harvest potential in ways that are consistent with sound management of public lands.

Amount of Public Land Necessary to Accomplish the Proposed Action

All alternatives consider all of the shoreline oiled by the spill, severely affected communities, and uplands adjacent to the watershed divide. None of the alternatives would change subsistence laws or regulations.

Reasonable Measures to Minimize Adverse Impacts on Subsistence Uses and Resources

None of the alternatives would have adverse impacts on subsistence uses and resources. Therefore, no measures are required to minimize adverse impacts on subsistence uses and resources.

Final Determination

The Record of Decision for the final EIS will include a final determination about whether the selected alternative might present a significant restriction on subsistence uses. The final determination will re-list the above criteria and make a final determination on each of the categories considering further information obtained from hearings, public comments, and other sources incorporated in the preparation of the final EIS. The summary evaluation, findings, and determinations will be contained in the Record of Decision.

Chapter 5

Response to Comments

Response to Comments 5

This chapter will contain the responses to public comments in the Final Environmental Impact Statement.

Chapter 6

Consultation and Coordination

Chapter 6

Consultation and Coordination

Development of the Proposed Action

As a direct result of the litigation and settlement discussed below, the Federal and State governments, acting as members of the Trustee Council are responsible for taking actions necessary for the restoration of injured resources and services from the EVOS. The Federal Water Pollution Control Act (Clean Water Act) (33 U.S.C. § 1321[f]) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. § 9607[f]) provide the legal basis for these responsibilities.

The EVOS contaminated thousands of miles of Alaska's coastline. It killed birds, mammals, and fish, and disrupted the ecosystem in the path of the oil. In 1991, Exxon agreed to pay the United States and the State of Alaska $900 million over ten years to restore the resources injured by the spill, and the reduced or lost services (human uses) they provide. Of that amount, approximately $620 million remains available to fund restoration activities.

The *Exxon Valdez* Restoration Plan will provide long-term guidance to the Trustee Council for using these funds in restoring the resources and services injured by the oil spill.

The Trustees began developing a restoration plan in 1990. Most of the effort at that time was focused on identifying and developing possible restoration techniques. Following the settlement between the Exxon companies and the United States and the State of Alaska on October 9, 1991, the Trustees decided to continue development of a restoration plan and to allow for meaningful public participation. Following public review and comment on the brochure in April 1993, the Trustees developed the draft Restoration Plan in November 1993 as the proposed action for this EIS. The final Restoration Plan will assist the decisionmaking process by establishing management direction for identifying and selecting of activities to restore injured resources and services. Program-level guidelines will assist in evaluating and implementing future proposed restoration activities. These activities will be developed as part of the Trustees' Annual Work Program and will be evaluated by the policies set forth in the Restoration Plan. Each Annual Work Program will contain descriptions of the restoration activities to be funded that year, based on the policies and spending guidelines of the Restoration Plan, public comments, and changing restoration needs.

The brochure described five alternative courses of action, including the no action alternative; explained the evaluation criteria used; and outlined the differences among each of the alternatives. It also discussed an approach to implementing the alternatives; and it covered administration, funding allocation guidelines and mechanisms, monitoring, and public participation.

Based on public comment on the alternatives presented in the brochure, the Trustees have modified and designated Alternative 5 as the proposed action for this EIS and have published this modified alternative as the draft Restoration Plan. This EIS is intended to assist decisionmakers and the public in assessing the merits of the various alternatives and determining which of the possible alternatives should be selected as the final Restoration Plan.

The MOA between the Federal and State governments requires meaningful public involvement. Toward that end, all decisions made by the Trustees have been made in an open public forum with opportunity for public comment. Public comments received on the Restoration Framework document also were used to identify significant issues related to implementing a restoration program. A Summary of Alternatives for Public Comment on the Draft Restoration Plan was released in April 1993. Public comments on the Summary of Alternatives, the draft Restoration Plan, and the DEIS will be used to refine the final Restoration Plan.

To ensure that the public had the opportunity to identify issues related to the proposed action to be addressed, the Trustees had five periods for public comment. The first was in January and February 1992, to solicit input for the formation of a Public Advisory Group. In May 1992, the public was invited to comment on the Restoration Framework at meetings in Seldovia (teleconferenced to Port Graham), Homer, Kodiak, Juneau, Tatitlek, Valdez, Seward, Whittier, Chenega Bay, Anchorage, Cordova, and Fairbanks. These comments were used to identify issues related to implementing a restoration program. In November 1992, agencies and individuals were invited to an "open house" held in Anchorage to discuss input for the DEIS. A fourth round of meetings was held in April 1993 to collect public comments on the Summary of Alternatives for Public Comment, released in April 1993. These meetings were held in Chignik Lagoon, Chignik Lake, Chenega Bay, Kodiak, Port Graham, Ouzinkie, Port Lions, Seldovia, Larsen Bay, Homer, Akhiok, Old Harbor, Nanwalek (English Bay), Anchorage, Valdez, Seward, Tatitlek, Juneau, Cordova, Fairbanks, and Whittier. A fifth period for public comment was held in late January and early February 1994 after the publication of the draft Restoration Plan and the Revised Notice of Intent to prepare an EIS. A public meeting was held in Anchorage at that time.

The DEIS and the draft Restoration Plan will be available for public comment for 45 days. The comments received from the public will be used to create the final EIS.

In addition, a Public Advisory Group, formed in October 1992, was established to provide input to the Trustees on all matters relating to planning, evaluating, and allocating funds, as well as planning, evaluating, and conducting injury assessments and restoration activities. This group is made up of 15 members who represent a cross-section of the interest groups and the public affected by and concerned about the spill. Additionally there are two ex officio members representing the Alaska Legislature.

Development of the EIS

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The Trustees have sought public input on the following questions in regard to the draft Restoration Plan:

- Which resources and services should be targeted for restoration efforts?

  Should restoration actions address all injured resources and services, or should they address only those biological resources whose populations declined measurably as a result of the spill?

- How long should restoration actions last?

  Should they be undertaken until a resource or service has recovered, then stopped? Or should they continue beyond the point of restoration to prespill levels?

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- Which restoration actions should be undertaken?

  Should the plan include only those actions that are expected to produce substantial improvement over the rate of natural (unaided) recovery? Or should actions believed to produce at least some improvement over the rate of unaided recovery be included as well?

- In what geographic area should restoration actions be taken?

  Should actions be limited to the spill area, or should they be taken in any area where there is a link to injured resources or services?

- To what extent, if any, should restoration actions create opportunities for human use?

  Should human use of, and access to, the spill area be decreased? Protected? Increased? Or should new opportunities for human use be considered?

Issues

The interdisciplinary team (IDT) of federal and state scientists assigned to write the EIS reviewed and analyzed the concerns and ideas expressed in the public involvement and interagency scoping. The following issue statements describe those concerns and ideas in general terms. The issue statements were evaluated to decide which issues were significant and should be addressed in the EIS.

The public, agencies, community leaders, and other knowledgeable individuals and organizations raised many issues during the scoping process. The agencies identified the significant issues based on "reviews of similar actions, knowledge of the area or areas involved, discussions with community leaders, and/or consultations with experts and other agencies familiar with such actions and their effects" (Forest Service Handbook 1909.15 [11.5]). These issues are addressed in this document.

Public meetings were held in the following communities during one or more of the public comment periods held in the development and preparation of this EIS. A Summary of Public Comment on Alternarives (EVOS Trustee Council, September 1993) was published summarizing the results of the most extensive public involvement effort during the preparation of the proposed action and alternatives for this EIS. Approximately 2,000 people gave written or oral comments at that time.

Akhiok	Fairbanks	Nanwalek	Seward
Anchorage	Homer	Old Harbor	Tatitlek
Chenega Bay	Juneau	Ouzinkie	Valdez
Chignik Lake	Karluk	Port Graham	Whittier
Chignik Lagoon	Kodiak	Port Lions	
Cordova	Larsen Bay	Seldovia	

The comments received addressed the planning alternatives which were included in the brochure, Draft *Exxon Valdez* Oil Spill Restoration Plan Summary of Alternatives for Public Comment (EVOS Trustee Council, April 1993) and the issues and injured resources and services.

The EIS was developed by considering the No Action Alternative, the proposed action and the planning alternatives 2 through 4 as presented in the brochure. The reasonably foreseeable actions that were consistent with the policies contained in each alternative were then estimated and evaluated in Chapter 4 of this EIS.

List of Contacts for Preparation and Review of the EIS

Federal, State, and local government agencies, academic institutions, special-interest groups, Native groups, and private citizens consulted prior to and during the preparation of this EIS are listed below.

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- Forest Service
- Office of General Counsel

Department of Commerce
- National Marine Fisheries Service
- National Oceanic and Atmospheric Administratoin

Department of Interior
- Bureau of Indian Affairs
- Fish and Wildlife Service
- Minerals Management
- National Biological Survey
- National Park Service

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Glossary

Acronyms

ACMP	Alaska Coastal Management Program
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
AMSA	Area Meriting Special Attention
ANILCA	Alaska National Interest Lands Conservation Act
ANCSA	Alaska Native Claims Settlement Act
AOU	American Ornithological Union
AVSP	Alaska Visitors Statistics Program II
DEIS	Draft Environmental Impact Statement
DNR	Department of Natural Resources
DOI	Department of the Interior
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EVOS	*Exxon Valdez* Oil Spill
FEIS	Final Environmental Impact Statement
FRED Division	Division of Fisheries Rehabilitation, Enhancement and Development (State, ADF&G)
IDT	Interdisciplinary Team
KANA	Kodiak Area Native Association
MMPA	Marine Mammal Protection Act of 1972
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration

NPFMC	North Pacific Fishery Management Council
NPS	National Park Service
NWR	National Wildlife Refuge
PNP	private nonprofit
PWS	Prince William Sound
PWSRWG	Prince William Sound Recreation Work Group
ROD	Record of Decision
USDA	U.S. Department of Agriculture
USDOI	U.S. Department of the Interior
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
VHS	viral hemorrhagic septicemia

Glossary

Alevin	first lifestage of a salmonid after hatching; alevins burrow into the gravel and absorb their yolk-sac before they emerge and become free-swimming
Amphipod	small crustacean that is often common in both freshwater and saltwater
Anadromous	fish behavior that includes migrations for spawning in freshwater and growth and development in saltwater
Create a new run or fishery	to develop or establish a new stock or population of fish where none had previously existed
Egg incubation boxes	insulated chambers that are installed in a streamside location and loaded with fertilized fish eggs for incubation and hatching in a flow of high-quality water.
Emergence	movement of an alevin from the redd to a free-swimming stage after their yolk sac has been absorbed
Enhance existing run	manipulate a stock or population of fish to increase the numbers of returning adult fish
Escapement	anadromous fish that escape from being harvested to migrate into a drainage to spawn and sustain the reproductive process
Eyed-egg planting	fish eggs, at the eyed-egg lifestage, are buried or injected into non-utilized spawning gravel to complete the incubation process
Eyed-egg	stage of development of a fish egg in which the pigmented eyes of the embryo are visible
Fair market value	the amount in cash, or on terms reasonably equivalent to cash, for which in all probability the property would be sold by a knowledgeable owner willing but not obligated to sell to a knowledgeable purchaser willing but not obligated to buy. In ascertaining that figure, consideration should be given to all matters that might be brought forward and reasonably be given substantial weight in bargaining by persons of ordinary prudence, but no consideration whatever should be given to matters not affecting market value
Final demand	regional purchases of goods and services
Fishery	harvest of a fish stock or of fish stocks
Fry (or "fingerling")	juvenile lifestage of a fish; for a salmon, this stage occurs between an alevin and a smolt
Habitat improvement	a required habitat is improved to benefit a particular lifestage of a particular species to increase the overall survival rate of that population
Hatchery rearing	juvenile fish are held and fed in rearing chambers (usually, raceways) until they reach a proper size or age for release or transport to a stocking site

Hatching	stage of development in which the embryo breaks through the egg membrane or shell
Haulout areas	rocks, ice floes, sand, and mud bars that are used by harbor seals or sea otters for resting, pupping, or molting
Homing	migratory process of returning to the natal (or "home") stream where an adult anadromous fish had been hatched from an egg; accurate homing depends on proper imprinting
IMPLAN	an economic model used for economic analysis
Imprinting	process of creating a long-term memory of the spawning stream in a juvenile anadromous fish
Industry output	regional supply of goods and services
Lake nutrient enrichment	addition of particular amounts of selected chemicals into a lake to stimulate or fertilize the production of microscopic plants that are the base of the food chain (or pyramid) that results in sockeye salmon smolt production
Limiting factor	a particular parameter or need in the life cycle of an organism that will limit, reduce or constrain the survival from one lifestage to the next
Long-term effects	changes that occur during the approximate timeframe required for natural recovery of an injured resource or service (EVOS Trustee Council, April 1993); usually, ten or more years; specific definition may vary slightly among the resources or services
Migration corridor improvement	methods to remove or mitigate a barrier to fish migration,that may include installation of a fish ladder, construction of resting pools, or removal of a barrier by hand labor or blasting
Net pen rearing	juvenile fish are held in floating net pens in estuaries or lakes where they are fed until they reach a desirable size or age for release or transport
Overescapement	spawning anadromous fish that escape from harvest and into a drainage in excess of the number that is required to sustain the population reproductive process
Parcel	unit of measure of an upland area that is being considered for purchase by the EVOS Trustee Council as part of the comprehensive habitat protection process; the sizes of individual parcels are highly variable
Presmolt	juvenile lifestage of an anadromous fish that precedes the smolt stage; a presmolt is approximately as large as a smolt, but it is not yet physiologically transformed
Redd	pit or nest that is excavated by a female salmonid where the eggs are laid, fertilized, buried and incubated
Rehabilitate a fishery	rebuild a stock or population of fish that has been depressed

Relocation of hatchery runs	large numbers of hatchery-produced fish are transported to a location for imprinting and homing so returning adults can be harvested efficiently with little risk of over-harvesting wild stocks
Sac-roe fishery	fishery that is designed to harvest Pacific herring to obtain the ovary of mature females for sale as a specialty dish for the Japanese market
Salmonid	member of the trout and salmon family of fish
Short-term effects	changes that may occur during the approximate timeframe required for completion of one life cycle or recruitment period of an injured resource or during the timeframe between implementation of an action and one to three years
Smolt	juvenile migratory lifestage of an anadromous fish; smolts are transformed physiologically to survive and grow in saltwater and are emigrating from freshwater
Spawning channel	new spawning habitat created by developing a source of upwelling groundwater and good, high-quality spawning gravel
Value-added	costs added within the region to produce industry output composed of employee compensation and property income

Bibliography

BIBLIOGRAPHY

Ainley, D. G., and R. J. Boekelheide. 1990. Seabirds of the Farallon Islands. Stanford University Press, Stanford, CA.

Alaska Department of Community and Regional Affairs, Municipal and Regional Assistance Division. 1994. Electronic data files. Juneau, AK.

Alaska Department of Education. 1994. Alaska Blue Book 1993-94, 369 pp.

Alaska Department of Environmental Conservation. 1993. The *Exxon Valdez* Oil Spill: Final Report, State of Alaska Response. Anchorage, AK.

Alaska Department of Fish and Game. 1985a. Alaska Habitat Management Guide; Life Histories and Habitat Requirements of Fish and Wildlife. Juneau, AK.

Alaska Department of Fish and Game. 1985b. Harbor Seal Life History and Habitat Requirements, Southwest and Southcentral Regions. *In*: Alaska Habitat Management Guide; Life Histories and Habitat Requirements of Fish and Wildlife. Juneau, AK pp. 55-61.

Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development. 1994. Alaska Fisheries Enhancement Program 1993 Annual Report. M. McNair and J. Holland, eds. 43 pp.

Alaska Department of Fish and Game. 1985. Pink Salmon Life History and Habitat Requirements Southwest and Southcentral, Arctic, Western and Interior Regions. *In*: Alaska Habitat Management Guide. Life Histories and Habitat Requirements of Fish and Wildlife. Juneau, AK, pp. 519-536.

Alaska Department of Fish and Game. 1983. Fish Culture Manual. Alaska Department of Fish and Game. Division of Fisheries Rehabilitation, Enhancement and Development. 90 pp.

Alaska Department of Fish and Game. 1990. Prince William Sound Area Annual finfish Management Report 1998. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2C90-02. 162 pp.

Alaska State Libraries. 1992. Alaska Blue Book. Juneau, AK: State of Alaska, Department of Education, Division of State Libraries, Archives and Museums.

Allen, S.G., D.G. Ainley, G.W. Page, and C.A. Ribic. 1984. The Effect of Disturbance on Harbor Seal Haulout Patterns at Bolinas Lagoon, California. Fish. Bull. 82(3):493-500.

American Ornithologists Union. 1983. Checklist of North American Birds, 6th ed. Lawrence, KS: Allen Press, 877 pp.

Anonymous. 1993. In Brief...Major Impacts. Alaska's Wildlife. January-February 1993, pp. 24-25.

Babcock, M.M., J.F. Karinen, J.W. Short, and C.C. Brodersen. 1993. Pre-Spill and Post-Spill Concentrations of Hydrocarbons in Sediments and Mussels in Prince William Sound. *In*: *Exxon Valdez* Oil Spill Symposium Abstracts, February 1993, Anchorage, AK, pp. 322-323.

Barrett, B.M. 1990. An Estimate of the 1989 Chignik Management Area Salmon Catch and Escapement Numbers Had There Been a Normal Fishery without the *Exxon Valdez* Oil Spill. Regional Information Report 4K90-28. Division of Commercial Fisheries, 51 pp.

Barrett, B.M., C.O. Swanton, and P.A. Roche. 1990. An Estimate of the 1989 Kodiak Management Area Salmon Catch, Escapement, and Run Numbers Had There Been a Normal Fishery without the *Exxon Valdez* Oil Spill. Regional Information Report 4K90-35. Division of Commercial Fisheries, 150 pp.

Bechtol, W. 1994. Review of 1993 Groundfish Fisheries in Prince William Sound. Report to the Board of Fisheries. Alaska Department of Fish and Game. Division of Commercial Fisheries Management and Development. Regional Information Report No. 2A 94-08, 21 pp.

Bellrose, F. C. 1982. Ducks, Geese and Swans of North America, 3rd ed. Stackpole Books, Harrisburg, PA, 544 pp.

Bengtson, S.-A. 1966. Field Studies on the Harlequin Duck in Iceland. Wildfowl Trust, 17th, pp. 79-94.

Bengtson, S.-A. 1972. Breeding Ecology of the Harlequin Duck *Histrionocus histrionocus* (L.) in Iceland. Ornis Scand. 3:1-19.

Biggs, E., T. Baker, L. Brannian, and S. Fried. 1993. Prince William Sound Herring - What Does Their Future Hold? Alaska's Wildlife. January-February 1993, pp. 37-39.

Biggs, E.D., and T.T. Baker. 1993. Summary of Known Effects of the *Exxon Valdez* Oil Spill on Herring in Prince William Sound, and Recommendations for Future Inquiries. *EVOS* Symposium. Abstract Book, pp. 264-267.

Birkhead, T.R. 1974. The Movement and Mortality Rates of British Guillemots. Bird Study 21: 245-254.

Birkhead, T.R. 1977. The Effect of Habitat and Density on Breeding Success in the Common Murre *Uria aalge*. J. Animal Ecol., 46:751-764.

Brady, J., S. Morstad, E. Simpson, E. Biggs. 1991. Prince William Sound Area Annual Finfish Management Report. 1989. Regional Information Report No. 2C90-07. Division of Commercial Fisheries, 186 pp.

Brennan, K., D. Prokopowich, and D. Gretsch. 1993. Kodiak Management Area Commercial Salmon Annual Management Report. 1992. Regional Information Report No. 4K93-28. Alaska Department of Fish and Game, Division of Commercial Fisheries, 278 pp.

Bucher, W.A., and L. Hammarstrom. 1993. 1992 Lower Cook Inlet Area Annual Finfish Management Report. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 2A 93-11, 133 pp.

Bue, B.G., S. Sharr, S.D. Moffitt, and A. Craig. 1993. Assessment of Injury to Pink Salmon Eggs and Fry. *EVOS* Symposium. Abstract Book, pp. 101-103.

Burgner, R.L. 1991. Life History of the Sockeye Salmon (*Oncorhyncus nerka*). *In:* Pacific Salmon Life Histories. C. Groot and L. Margolis, eds. University of British Columbia Press. Vancouver, B.C., pp. 1-119.

Burke, J. 1993. Some conclusions from Sockeye Smolt Experiments at Main Bay Hatchery (1987 through 1990; Adult Returns through 1993). 1993 Sockeye Culture Workshop. Alaska Department of Fish and Game. Division of Commercial Fisheries Management and Development. In press.

Campbell, McKie, 1991. Proposed Legislation Defines What Subsistence Is, Where It Happens, Who Participates. Arctic Issues Digest, October 1991, pp. 8-11.

Campbell, R.W. 1977. Use of Man-Made Structures as Nest Sites by Pigeon Guillemots. Canadian Field Naturalist 91:193-194.

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.

Carson, R., and W.M. Hanemann. 1992. A Preliminary Economic Analysis of Recreational Fishing Losses Related to the *Exxon Valdez* Oil Spill. A report to the Attorney General of the State of Alaska. 14 pp.

Carter, H.R., and M.L. Morrison, eds. 1992. Status and Conservation of the Marbled Murrelet in North America. Proc. Western Foundation Vert. Zool. 5(1):1-133.

Case, D.S. 1991. Subsistence and Self-Determination: Can Alaska Natives Have a More "Effective Voice?" Arctic Issues Digest, October 1991:26-39.

Cody, M.B., J. Fadely, and T. Gehrlach. 1993. Pigeon Guillemot Colony Locations along the Northern and Southwestern Coast of Afognak Island, Alaska. Unpubl. Rept., USDOI, Fish and Wildlife Service, Division of Realty, Anchorage, AK.

Cohen, M.J. 1993. The Economic Impacts of the *Exxon Valdez* Oil Spill on Southcentral Alaska's Commercial Fishing Industry. *EVOS* Symposium. Abstract Book, pp. 227-230.

Collier, T.K., M.M. Krahn, C.A. Krone, L.L. Johnson, M.S. Myers, S.L. Chan, and U. Varanasi. 1993. Survey of Oil Exposure and Effects in Subtidal Fish Following the *Exxon Valdez* Oil Spill: 1989-1991. *EVOS* Symposium. Abstract Book, pp. 235-238.

Cook Inlet Regional Planning Team. 1981. Cook Inlet Regional Salmon Enhancement Plan 1981-2000. 72 pp.

Cooney, R.T. 1986. Zooplankton. *In*: the Gulf of Alaska; Physical Environment and Biological Resources, D.W. Hood and S.T. Zimmerman, eds. OCS MMS 86-0095. USDOC, National Oceanic and Atmospheric Administration, and USDOI, Minerals Management Service, pp. 285-304.

Corbett, D.G., and D. Reger, 1993. Development of the Alaska Heritage Stewardship Program for Protection of Cultural Resources at Increased Risk Due to the *Exxon Valdez* Oil Spill Restoration Study Number R104A, Draft Final Report. Prepared for *Exxon Valdez* Oil Spill Trustee Council. Anchorage, AK.

Davis, B., B. Allee, D. Amend, B. Bachen, B. Davidson, T. Gharrett, S. Marshall, and A. Wertheimer. 1985. Alaska Department of Fish and Game Genetic Policy. Genetic Policy Review Team. Alaska Department of Fish and Game. Division of Fisheries Rehabilitation Enhancement and Development. 25 pp.

DeGange, A.R. and G.A. Sanger. 1986. Marine birds, Chapter 16. *In* the Gulf of Alaska: Physical Environment And Biological Resources. D. W. Hood and S.T. Zimmerman ,eds., USDOI, Minerals Management Service, MMS 86-0095, pp.479-524.

DeGange, A.R., D.C. Douglas, D.H. Monson, and C. Robbins. 1993. Surveys of Sea Otters in the Gulf of Alaska in Response to the *Exxon Valdez* Oil Spill. Marine Mammal Study 6. Draft Final Report, USDOI, Fish and Wildlife Service. Anchorage, AK.

Dekin, A.A., Jr., M.S. Cassell, J.I. Ebert, E. Camili, J.M. Kerley, M.R. Yarborough, P.A. Stahl, and B.L. Turcy. 1993. *Exxon Valdez* Oil Spill Archaeological Damage Assessment, Final Report. L. Green, ed. Binghamton University, NY: Prepared for the U.S. Department of Agriculture, Forest Service, Juneau, AK.

Delacour, J. 1959. The Waterfowl of the World, Vol. III. Arco Publ., Inc., NY, pp. 163-170.

Donaldson, W., S. Morstad, E. Simpson, J. Wilcock, and S. Sharr. 1993. Prince William Sound Management Area 1992 Annual Finfish Management Report. Regional Information Report No. 2A93-12 .Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, 158 pp.

Doroff, A.M., and J.L. Bodkin. 1993. Sea Otter Foraging Behavior and Hydrocarbon Levels in Prey Following the *Exxon Valdez* Oil Spill in Prince William Sound, Alaska. Marine Mammals Study No. 6., USDOI, Fish and Wildlife Service, Anchorage, AK.

Drent, R., G.F. Van Tets, F. Tompa, and K. Vermeer. 1964. The Breeding Birds of Mandarte Island, British Columbia. Can. Field Naturalist 78:208-263.

Drent, R. 1965. Breeding Biology of the Pigeon Guillemot, *Cepphus columba*. Ardea 53:99-160

Drucker, B. 1968. Red Salmon Studies at Karluk Lake, 1967. U.S. Fish and Wildlife Service. Bureau of Commercial Fisheries. Auke Bay, Alaska.

Dzinbal, K.A. and R.L. Jarvis. 1984. Coastal Feeding Ecology of Harlequin Ducks in Prince William Sound, Alaska, During Summer. *In:* Marine birds: Their feeding ecology and commercial fisheries relationships. D.N. Nettleship, G.A. Sanger, and P.F. Springer, eds., Canadian Wildlife Service, Special Publ., Ottawa. pp. 6-10.

Ellison, T. 1992. Development of Public and Private Hatcheries in Alaska. Alaska Department of Fish and Game. Division of Fisheries Rehabilitation, Enhancement and Development. Presented at the Ninth Annual Meeting of the Aquaculture Association of Canada. Vancouver, British Columbia.

Emms, S.K., and K.H. Morgan. 1989. The Breeding Biology and Distribution of the Pigeon Guillemot *Cepphus columba* in the Strait of Georgia. *In:* Ecology and status of marine birds in the Strait of Georgia, British Columbia. K. Vermeer and R.W. Butler, eds., Canadian Wildlife Service, Special Publ., Ottawa, pp. 100-106.

Eppley, E.A., and M.A. Rubega. 1990. Indirect effects of an oil spill: reproductive failure in population of South Polar skuas following the 'Bahia Paradiso' oil spill in Antarctica. Marine Ecology Prog. Ser. 67:1-6.

Esipenko, A.G. 1986. Influence of Anthropogenic Factors on Behaviour and Distribution of the Baltic Pinnipeds. International Council for the Exploration of the Sea, No. 3.

Estes, J.A. 1990. Growth and Equilibrium in Sea Otter Populations. Journal of Animal Ecology 59:385-401.

Ewins, P.J., H.R. Carter, and Y.V. Shibaev. 1993. The Status, Distribution and Ecology of Inshore Fish-Feeding Alcids (*Cepphus* Guillemots and *Brachyramphus* Murrelets). *In:* The status, ecology, and conservation of marine birds of the North Pacific. Canadian Wildlife Service, Special Publ., Ottawa, pp. 164-175.

Ewins, P.J. 1993. Pigeon Guillemot (*Cepphus columba*). *In:* The Birds of North America, No. 49, A. Poole and F. Gill, eds. The Academy of Natural Sciences, Philadelphia. Washington, D.C.

Exxon Valdez Oil Spill Restoration Team Habitat Protection Work Group. November 1993. Comprehensive Habitat Protection Process: Large Parcel Evaluation and Ranking, Vols. I and II. Anchorage, AK: *Exxon Valdez* Oil Spill Trustee Council.

Exxon Valdez Oil Spill Trustee Council. April 1992. Restoration Framework, Vol. I. Anchorage, AK, 52 pp.

Exxon Valdez Oil Spill Trustee Council. April 1992. 1992 Draft Work Plan, Vol. II. Anchorage, AK.

Exxon Valdez Oil Spill Trustee Council. October 1992. 1993 Draft Work Plan. Anchorage, AK.

Exxon Valdez Oil Spill Trustee Council. April 1993. Draft *Exxon Valdez* Oil Spill Restoration Plan Summary of Alternatives for Public Comment. Anchorage, AK.

Exxon Valdez Oil Spill Trustee Council. September 1993. Summary of Public Comment on Alternatives. Anchorage, AK.

Exxon Valdez Oil Spill Trustee Council. November 1993. Draft *Exxon Valdez* Oil Spill Restoration Plan. Anchorage, AK.

Exxon Valdez Oil Spill Trustee Council. December 1993. Draft 1994 Work Plan. Anchorage, AK.

Fall, J.A. 1993. Subsistence Uses of Fish and Wildlife. Alaska's Wildlife 25(1):4-6.

Fall, J.A. 1991a. Subsistence Uses of Fish and Wildlife in 15 Alutiiq Villages after the *Exxon Valdez* Oil Spill. Paper presented at the 18th annual meeting of the Alaska Anthropological Association, March 23, 1991, Anchorage, AK.

Fall, J.A. 1991b. Subsistence Uses of Fish and Wildlife and the *Exxon Valdez* Oil Spill. Arctic Anthropology 27(2):68-92.

Federal Subsistence Board. 1992. Subsistence Management for Federal Public Lands in Alaska, Final EIS Summary. Anchorage, AK. USDOI, Fish and Wildlife Service, p. iii.

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, OR. 153 pp.

Forsell, D. and P.J. Gould. 1981. Distribution and Abundance of Marine Birds and Mammals Wintering in the Kodiak Area of Alaska. FWS/OBS-81/13. USDOI, Fish and Wildlife Service, 72 pp.

Frost, K.F., and L.F. Lowry. 1993. Assessment of Injury to Harbor Seals in Prince William Sound, Alaska, and Adjacent Areas Following the *Exxon Valdez* Oil Spill. State-Federal Natural Resource Damage Assessment, Marine Mammals Study No. 5, Draft Final Report, 94 pp.

Frost, K.F., L.F. Lowry, E. Sinclair, J. VerHoef, and D.C. McAllister. In press. Impacts on Distribution, Abundance, and Productivity of Harbor Seals. *In:* Impacts of the *Exxon Valdez* Oil Spill on marine mammals, T.R. Loughlin, ed. Academic Press.

Fry, D.M. and L.A. Addiego. 1988. Effects of Oil Exposure and Stress on Seabird Endocrine Systems. Proceedings 1988 International Association of Aquatic Animal Medicine. 19:60-67.

Garrott, R.A., L.L. Eberhardt, and D.M. Burn. 1993. Mortality of Sea Otters in Prince William Sound Following the *Exxon Valdez* Oil Spill. Marine Mammal Science 9(4):343-359.

Gould, P.J., D.J. Forsell, and C.J. Lensink. 1982. Pelagic Distribution and Abundance of Seabirds in the Gulf of Alaska and Eastern Bering Sea. USDOI Fish and Wildlife Service, FWS/OBS-82/48, 294 pp.

Haggarty, J.C., C.B. Wooley, J.M. Erlandson, and A. Crowell. 1991. The Exxon Cultural Resource Program: Site Protection and Maritime Cultural Ecology in Prince William Sound and the Gulf of Alaska. Anchorage, AK. Exxon Shipping Company and Exxon Company.

Hart, J.L. 1973. Pacific Fishes of Canada. Fisheries Research Board of Canada, Bulletin 180, 740 pp.

Harvey, J.T., R.F. Brown, and B.R. Mate. 1990. Abundance and Distribution of Harbor Seals (*Phoca vitulina*) in Oregon, 1975-1983. Northwestern Naturalist 71:65-71.

Heard, W.R. 1991. Life History of the Pink Salmon (*Oncorhyncus gorbuscha*). *In*: Pacific Salmon Life Histories, C. Groot and L. Margolis, eds. Vancouver: UBC Press, pp. 119-231.

Hedgren, S. 1976. Reproductive Success of Guillemots, *Uria aalge,* on the Island of Stora Karlso. Ornis Fennica 57:49-57.

Hepler, K.R., P.A. Hansen, and D.R. Bernard. 1993. Impact of Oil Spilled from the *Exxon Valdez* on Survival and Growth of Dolly Varden and Cutthroat Trout in Prince William Sound, Alaska. *EVOS* Symposium. Abstract Book, pp. 239-240.

Highsmith, R.C., A.J. Hooten, M.S. Stekoll, and P. van Tamelen. 1993. Herring Bay Experimental and Monitoring Studies. Draft Final Report, Restoration Project No. 102.

Highsmith R.C., M.S. Stekoll, and W.E. Barber. 1993. Comprehensive Assessment of Coastal Habitat; Final Status Report, Vol. I. Coastal Habitat Study No. 1A. Draft Final Report.

Hilborn, R. 1992. Hatcheries and the Future of Salmon in the Northwest. Fisheries. 17(1):5-8.

Hindbar, K., N. Ryman, and F. Utter. 1991. Genetic Effects of Cultured Fish and Natural Fish Populations. Canadian Journal of Fisheries and Aquatic Sciences. 48:945-957.

Hoffman, A.G., K.R. Hepler, and P.A. Hansen. 1993. Assessment of Damage to Demersal Rockfish in Prince William Sound Following the *Exxon Valdez* Oil Spill. *EVOS* Symposium. Abstract Book, pp. 241-242.

Holland-Bartels, L., C. Burger, and S. Klein. 1994. Studies of Alaska's wild salmon stocks: Some insights for hatchery supplementation. Presented at the North American Wildlife and Natural Resources Conference. Anchorage, Alaska.

Holsten, E.H. 1990. Spruce bark beetle activity in Alaska: 1920-1989. Forest Pest Management Report, Alaska Region, R10-90-18, 28 pp.

Houghton, J.P., D.C. Lees, and W.B. Driskall. 1993. Evaluation of the Condition of Prince William Sound Shorelines Following the *Exxon Valdez* Oil Spill and Subsequent Shoreline Treatment, Vol. II. 1992 Biological Monitoring Survey. USDOC, NOAA Technical Memorandum NOS ORCA 73. Seattle, WA.

ICF Technology Incorporated. 1993. An Overview of the Ecosystem and Damage to Subsistence Resources in the Area Impacted by the *Exxon Valdez* Oil Spill, Final Report. Prepared for Chugachmiut by Fortier and Mikko; and Cohen, Milstein, Hausfeld & Toll, Richland, WA.

Impact Assessment, Inc. 1990. Economic, Social, and Psychological Impact Assessment of the *Exxon Valdez* Oil Spill Final Report. prepared for the Oiled Mayors Subcommittee, Alaska Conference of Mayors. La Jolla, CA, and Anchorage, AK: Impact Assessment, Inc.

Islieb, M.E., and B. Kessel. 1973. Birds of the North Gulf Coast - Prince William Sound Region, Alaska. Biol Papers, University of Alaska, No. 14:1-149.

Jacobsen, J.A. 1977. Alaska Voyage 1881-1883: An Expedition to the Northwest Coast of America. Translated by Erna Gunther. Chicago, IL: University of Chicago Press.

Jameson, R.J. 1989. Movements, Home Range, and Territories of Male Sea Otters off Central California. Marine Mammal Science 5:159-172.

Jesperson, M.M., and K. Griffin. 1992. An Evaluation of Archaeological Injury Documentation, *Exxon Valdez* Oil Spill. CERCLA Archaeological Steering Committee, May 14,1992. Anchorage, AK.

Johnson, B.W. 1977. The Effects of Human Disturbance on a Population of Harbor Seals. *In:* Environmental Assessment of the Alaskan Continental Shelf, Vol. 1., Annual Report of Principal Investigators, USDOC, BLS NOAA, OCSEAP. Juneau, AK.

Johnson, S.R., J.J. Burns, C.I. Malme, and R.A. Davis. 1989. Synthesis of Information on the Effects of Noise and Disturbance on Major Haulout Concentrations of Bering Sea Pinnepeds. Prepared by LGL, Inc., for USDOI, Minerals Management Service, Anchorage, AK. Contract No. 14-12-000130361, 267 pp.

Jones and Stokes Associates, Inc. 1987. Southcentral Alaska Sport Fishing Economic Study.

Kessel, B., and D.D. Gibson. 1978. Status and Distribution of Alaska Birds. Studies in Avian Biol. 1:1-100.

King, J.G. and G.A. Sanger. 1979. Oil Vulnerability Index for Marine Oriented Birds. *In:* Conservation of Marine Birds in Northern North America. Wildlife Research Report 11: 227-240.

Knapp, G. 1993. Employment and Income Impacts of Alaska Commercial Fisheries: Some Rules of Thumb. Presentation Summary at Alaska Chapter of the American Fisheries Society, Fairbanks, AK, November 1993. 3 pp.

Koenings, J., D. Schmidt, S. Fried, K. Tarbox, and L. Brannian. 1993. Kenai River Sockeye Salmon - the Problem with Too Many Fish. Alaska's Wildlife. January-February 1993, pp. 43-45.

Krasnow, L.D., and G.A. Sanger. 1986. Feeding Ecology of Marine Birds in the Nearshore Waters of Kodiak Island. U.S. Department of Commerce, OCSEAP Final Report. 45: 505-630.

Kuletz, K.J. 1983. Mechanisms and Consequences of Foraging Behavior in a Population of Breeding Pigeon Guillemots. M.S. Thesis, University of California, Irvine, 79 pp.

Kuletz, K.J. 1993. Effects of the *Exxon Valdez* Oil Spill on Marbled Murrelets, *In*: *Exxon Valdez* Oil Spill Symposium, Anchorage, AK, February 2-5, 1993. EVOS Trustee Council, University of Alaska Sea Grant College Program, Amer. Fish. Soc., Ak. Chap. Abstract Book, pp. 148-150.

Kvitek, R.G., D. Shull, D. Conestro, E.C. Bowlby, and B.L. Troutman. 1989. Sea Otters and Benthic Prey Communities in Washington State. Marine Mammal Science 5(3):266-280.

Kyle, G., J. Koenings, and J. Edmundson. 1994. An Overview of Alaska Lake-rearing Salmon Enhancement Strategy: Nutrient Enrichment and Juvenile Stocking. *In:* Alaska Freshwaters. Springer-Verlag. In press.

Lentfer, J.W. 1988. Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations. Marine Mammal Commission, 275 pp.

Levkovitz, T., ed. The Day the Water Died: A Compilation of the November 1989 Citizens Commission Hearings on the *Exxon Valdez* Oil Spill. Anchorage, AK: National Wildlife Federation, Natural Resources Defense Council, Wildlife Federation of Alaska, and the Windstar Foundation.

Loughlin, T.R. 1992. Abundance and Distribution of Harbor Seals (*Phoca vitulina richardsi*) in Bristol Bay, Prince William Sound, and Copper River Delta During 1991. Unpubl. Rep., USDOC, NOAA, NMFS, NMML, Seattle, WA, 26 pp.

Martin, J., J. Webster, and G. Edwards. 1992. Hatcheries and Wild Stocks: Are They Compatible? Fisheries 17(1):4.

Marty, G.D., M.S. Okihiro, and D.E. Hinton. 1993. Histopathologic Analysis of Chronic Effects of the *Exxon Valdez* Oil Spill on Alaska Fisheries. *EVOS* Symposium. Abstract Book, pp. 243-246.

Mcallister, M.E. 1992. Generating Damage Restoration Costs for Archaeological Injuries of the *Exxon Valdez* Oil Spill. *In*: *Exxon Valdez* Oil Spill Symposium Abstracts. Anchorage, AK: *Exxon Valdez* Oil Spill Trustee Council

McDowell Group. 1989. Alaska Seafood Industry Study. A Summary. Alaska Seafood Industry Study Commission. 22 pp.

McDowell Group. 1989. Alaska Visitor Statistics Program II: Patterns, Opinions, and Planning, Summer 1989. Juneau, AK: State of Alaska, Department of Commerce and Economic development, Division of Tourism.

McDowell Group. 1990. An Assessment of the Impact of the EVOS on the Alaska Tourism Industry. Juneau, AK: McDowell Group.

McGurk, M., and E.G. Biggs. 1993. Egg-Larval Mortality of Pacific Herring in Prince William Sound, Alaska, after the *Exxon Valdez* Oil Spill. *EVOS* Symposium. Abstract Book, pp. 254-255.

Mendenhall, V. 1992. Distribution, Breeding Records, and Conservation Problems of the Marbled Murrelet in Alaska. *In*: Status and Conservation of the Marbled Murrelet in North America. H.R. Carter and M.L. Morrison, eds. Proc. Western Foundation of Vert. Zool. 5 (1):5-16.

Meyers, T., P. Krasnowski, D. Amend, B. Bachen, J. Cochran, K. Hauck, K. Rawson, and R. Saft. 1988. Regulation Changes, Policies and Guidelines for Alaska Fish and Shellfish Health and Disease Control. Alaska Department of Fish and Game. Division of Fisheries Rehabilitation, Enhancement and Development. 72 pp.

Mickelson, P.G. 1989. Natural History of Alaska's Prince William Sound and How to Enjoy it. Alaska Wild Wings, 209 pp.

Mifflin and Associates. 1991. *Exxon Valdez* Oil Spill Damage Assessment Contamination of Archeological Materials, Chugach National Forest: Radiocarbon Experiments and Related Analyses, Final Report. U.S. Forest Service Contract No. 53-0109-1-00305. Anchorage, AK: U.S. Department of Agriculture, Forest Service.

Mills, M. 1993. Harvest, Catch, and Participation in Alaska Sport Fisheries During 1992. Fishery Data Series No. 93-42. Alaska Department of Fish and Game, Sport Fish Division, 228 pp.

Mobley, C., J.C. Haggarty, C.J. Utermohle, M. Eldridge, R.E. Reanier, A. Crowell, B.A. Ream, D.R. Yesner, J.M. Erlandson, and P.E. Buck, 1990. The 1989 *Exxon Valdez* Cultural Resource Program. Anchorage, AK: Exxon Shipping Company and Exxon Company, USA.

Monnett, C., and L.M. Rotterman. 1992. Movements of Weanling and Adult Female Sea Otters in Prince William Sound, Alaska, after the T/V *Exxon Valdez* Oil Spill. Marine Mammal Study No. 6, Draft Final Report. Enhydra Research, Homer, AK. Draft Final Report.

Morrow, J.E. 1980. The Freshwater Fishes of Alaska. Alaska Northwest Publishing Co., Anchorage, AK, 248 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. USDOI, Fish and Wildlife Service, Biological Report. 82(11.26), U.S. Army Corps of Engineers TR EL-82-4, 18 pp.

Nelson, D. A. 1991. Demography of the Pigeon Guillemot on Southeast Farallon Island, California. Condor 93:765-768.

Nettleship, D.N., and T.R. Birkhead. 1985. The Atlantic Alcidae. Academic Press. 574 pp.

Nysewander, D.R., C.H. Dippel, G.V. Byrd, and E.P. Knudtson. 1993. Effects of the T/V *Exxon Valdez* Oil Spill on Murres: A Perspective from Observations at Breeding Colonies. Final Report, EVOS Bird Study No. 3, USDOI, Fish and Wildlife Service, Migratory Bird Management, Anchorage, AK. 40 pp.

O'Clair, C.E., and S.T. Zimmerman. 1986. Biogeography and Ecology of the Intertidal and Shallow Subtidal Communities. *In*: The Gulf of Alaska; physical environment and biological resources. D.W. Hood and S.T. Zimmerman, eds. OCS MMS 86-0095. USDOC, National Oceanic and Atmospheric Administration, and USDOI, Minerals Management Service, pp. 305-346.

Oakley, K. 1981. Determinants of the Population Size and Distribution of the Pigeon Guillemot (*Cepphus columba*) at Naked Island, Prince William Sound, Alaska. M.S. Thesis, University of Alaska, Fairbanks, 65 pp.

Olesiuk, P.F., M.A., Bigg and G.M. Ellis. 1990. Recent Trends in Abundance of Harbor Seals, *Phoca vitulina*, in British Columbia. Can. J. of Fish. Aquat. Sci. 47:992-1003.

Palinkas, L.A., M.A. Downs, J.S. Petterson, and J. Russell. 1993. Social, Cultural, and Psychological Impacts of the *Exxon Valdez* Oil Spill. Human Organization 52(1):1-13.

Patten, S. 1991. Injury Assessment of Hydrocarbon Uptake by Sea Ducks in Prince William Sound and the Kodiak Archipelago, Alaska. EVOS Status report, Bird Study 11, 41 pp.

Piatt, J.F., and R.G. Ford. 1993. Distribution and Abundance of Marbled Murrelets in Alaska. Condor 95:662-669.

Piatt, J.F., C.J. Lensink, W. Butler, M. Kendziorek, and D.R. Nysewander. 1990. Immediate Impact of the *Exxon Valdez* Oil Spill on Marine Birds. Auk 107:387-397.

Pitcher, K.W. 1980. Food of the Harbor Seal, *Phoca viulina richardsi*, in the Gulf of Alaska. Fishery Bulletin 78:544-549.

Pitcher, K.W. 1990. Major Decline in Number of Harbor Seals, *Phoca vitulina richardsi*, in the Gulf of Alaska. Mar. Mamm. Sci. 6:121-134.

Prince William Sound Planning Team. 1983. Prince William Sound-Copper River Comprehensive Salmon Plan. Phase I-20 Year Plan (1983-2002). 176 pp.

Prince William Sound Planning Team. 1986. Prince William Sound-Copper River Comprehensive Salmon Plan. Phase II-5 Year Plan (1986-1991). 151 pp.

Prince William Sound Recreation Project Work Group. 1993. Summary of Comments from the Draft Restoration Plan Questionnaire. Anchorage, AK: *Exxon Valdez* Oil Spill Trustee Council.

Prince William Sound Recreation Working Group. 1994. Prince William Sound Recreation Project Nos. 93065 and 94217. Draft Report. Prepared for the *Exxon Valdez* Oil Spill Trustee Council. Anchorage, Alaska.

Quimby, A., and D.L. Owen. 1994. Chignik Management Area Annual Finfish Management Report 1992. Regional Information Report 4K94-2. Alaska Department of Fish and Game, Division of Commercial Fisheries, 225 pp.

Reed, R.K., and J.D. Schumacher. 1986. Physical Oceanography. *In*: The Gulf of Alaska; Physical Environment and Biological resources, D.W. Hood and S.T. Zimmerman, eds. OCS MMS 86-0095. USDOC, National Oceanic and Atmospheric Administration, and USDOI, Minerals Management Service, pp. 57-74.

Reger, D.R., J.D. McMahan, and C.E. Holmes. 1992. Effect of Crude Oil Contamination on Some Archaeological Sites in the Gulf of Alaska, 1991 Investigations. Office of History and Archaeology Report Number 30. Anchorage, AK: State of Alaska, Department of Natural Resources.

Reidman, M.L., and J.A. Estes. 1990. The Sea Otter (*Enhydra Lutris*): Behavior, Ecology, and Natural History. Biological report 90(14). USDOI, Fish and Wildlife Service.

Rounds, P., S. Rice, M.M. Babcock, and C.C. Brodersen. 1993. Variability of *Exxon Valdez* Hydrocarbon Concentrations in Mussel Bed Sediments. *In*: *Exxon Valdez* Oil Spill Symposium, February 1993, Anchorage, AK, Abstracts, pp. 182-183

Royce, W.F., T.R. Schroeder, A.A. Olsen, and W.J. Allender. 1991. Alaskan Fisheries. Cook Inlet Fisheries Consultants, 35 pp.

Ruesch, P.H. 1990. Upper Cook Inlet Commercial Fisheries Annual Management Report, 1989. Regional Information Report No. 2S90-3. Alaska Department of Fish and Game, Division of Commercial Fisheries, 72 pp.

Ruesch, P.H., and J. Fox. 1993. Upper Cook Inlet Commercial Fisheries Annual Management Report, 1992. Regional Information Report 2A93-17. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, 63 pp.

Sambrotto, R.N., and C.J. Lorenzen. 1986. Phytoplankton and Primary Production. *In*: The Gulf of Alaska; Physical Environment and Biological Resources. D.W. Hood and S.T. Zimmerman, eds. OCS MMS 86-0095. USDOC, National Oceanic and Atmospheric Administration, and USDOI, Minerals Management Service, pp. 249-284.

Sanger, G.A. 1987a. Trophic Levels and Trophic Relationships of Seabirds in the Gulf of Alaska, *In*: Seabirds: Feeding ecology and role in marine ecosystems, J. Croxall, ed. Cambridge University Press, Cambridge, NY, and Melbourne: pp. 229-257

Sanger, G.A. 1987b. Winter Diets of Common Murres and Marbled Murrelets in Kachemak Bay, Alaska. Condor 89:426-430.

Sanger, G.A. 1986. Diets and Food Web Relationships of Seabirds in the Gulf of Alaska and Adjacent Marine Regions. USDOC., OCSEAP Final Report. 45, pp. 631-771.

Schmidt, D.C., K. Tarbox, G. Kyle, B. King, L. Brannian, and J. Koenings. 1993. Overescapement Impacts of Kenai River Sockeye Salmon. *EVOS* Symposium. Abstract Book, pp. 132-133.

Schroeder, T.R., and R. Morrison. 1990. 1989 Lower Cook Inlet Area Annual Finfish Management Report. Regional Information Report No. 2H90-03. Alaska Department of Fish and Game, Division of Commercial Fisheries, 96 pp.

Scott, C.L., A.W. Paige, G. Jennings, and L. Brown. 1992. Community Profile Database Catalogue. Juneau, AK: Alaska Department of Fish and Game, Division of Subsistence.

Scott, C.L., A.W. Paige, G. Jennings, and L. Brown. 1993. Subsistence Household Survey 1993. Anchorage, AK: State of Alaska, Department of Fish and Game, Division of Subsistence.

Scott, J.M. 1973. Resource Allocation among Four Syntopic Species of Marine Diving Birds. Unpubl. Ph D thesis, Oregon State University, Corvallis, OR, 97 pp.

Seeb, J. 1993. Wild Stocks: Why Do We Want to Save Them? Alaska's Wildlife 25(2):5-7.

Sharr, S., G. Peckham, and G. Carpenter. 1988. Catch and Escapement Statistics for Copper River, Bering River, and Prince William Sound Salmon, 1986. Alaska Department of Fish and Game. Technical Fishery Report 88-17.

Sowls, A., S.A. Hatch, and C.J. Lensink. 1978. Catalog of Alaskan Seabird Colonies. USDOI, Fish and Wildlife Service, Office of Biological Services, FWS/OBS-78-78.

Stacey, P.J., R.W. Baird, and A.B. Hubbard-Morton. 1990. Transient Killer Whale (*Orcinus Orca*) Harassment and "Surplus Killing" of Marine Birds in British Columbia. Pacific Seabird Group Bulletin 17:38.

Stewart, B.S., P.K. Yochem, and J.R. Jehl, Jr. 1992. Review and Critical Synthesis of the Literature on Recovery of Ecosystems Following Man-Induced and Natural-Phenomena-Related Disturbances: harbor seals and killer whales. Hubb-Sea World Research Institute, CA, 81 pp.

Stewart, B.S., G.A. Antonelis, Jr., and R.L. DeLong. 1988. Abundance of Harbor Seals on San Miguel Island, California, 1927 Through 1986. Bulletin Southern California Academy of Science, 87:39-43.

Thompson, F., and J. Fox. 1990. Chignik Management Area Annual Finfish Management Report, 1989. Regional Information Report 4k 90-14. Alaska Department of Fish and Game, Commercial Fisheries Division, 193 pp.

Thoreson, A.C., and E.S. Booth. 1958. Breeding Activities of the Pigeon Guillemot *Cepphus columba columba* (Pallas). Walla Walla College, Publ. Dept., Sci. 23:1-36.

Tuck, L.M. 1960. The Murres: Their Distribution, Populations and Biology, a Study of the Genus *Uria*. Canadian Wildlife Service, Canadian Wildlife Series 1, 260 pp.

USDA, Forest Service, Alaska Region. 1994. An Evaluation of the Chugach National Forest Land and Resource Management Plan Direction in Relation to *Exxon Valdez* Oil Spill Restoration Archives. R10-MB-235. May 1994.

USDOI, Fish and Wildlife Service. 1993. Alaska Seabird Colony Catalog: Computer Database and Colony Data Archives. Marine Coastal Bird Project, Anchorage, AK.

USDOI, Fish and Wildlife Service, Region 7. 1983. Kenai National Wildlife Refuge Draft Comprehensive Conservation Plan, Environmental Impact Statement and Wilderness Review.

Van Zee, B., H. Makarka, F.P. Clark, P.C. Reed, and L.S. Ziemann. Subsistence in Alaska Wilderness. Tomso, Norway: Paper prepared for the 5th World Wilderness Congress.

Vermeer, K., K.H. Morgan, R.W. Butler, and G.E.J. Smith. 1989. Population, Nesting Habitat, and Food of Bald Eagles in the Gulf Islands. *In:* Ecology and status of marine birds in the Strait of Georgia, British Columbia. K. Vermeer and R.W. Butler, eds. Canadian Wildlife service, Special Publ., Ottawa, pp. 123-130.

Vermeer, K., K.H. Morgan, and G.E.J. Smith. 1993. Colony Attendance of Pigeon Guillemots as Related to Tide Height and Time of Day. Colonial Waterbirds 16:1-8

Webster, J.D. 1941. Feeding habitats of the black oystercatcher. Condor 43:141-156.

Weidmer, M., M.J. Fink, and J.J. Stegeman. 1993. Cytochrome P450 Induction and Histopathology in Pre-Emergent Pink Salmon from Oiled Streams in Prince William Sound, Alaska. *EVOS* Symposium. Abstract Book, pp. 104-107.

Wertheimer, A.C., A.G. Celewycz, M.G. Carls, and M.V. Surdevant. 1993. The Impact of the *Exxon Valdez* Oil Spill on Juvenile Pink and Chum Salmon and Their Prey in Nearshore Marine Habitats. *EVOS* Symposium, Abstract Book, pp. 115-117.

Willette, M. 1993. Impacts of the *Exxon Valdez* Oil Spill on the Migration, Growth, and Survival of Juvenile Pink Salmon in Prince William Sound. *EVOS* Symposium, Abstract Book, pp. 112-114.

Wolfe, R.J., and R.J. Walker. 1987. Subsistence Economies in Alaska: Productivity, Geography, and Developmental Impacts. Arctic Anthropology 24(2):56-81.

Wolfe, R.J. 1983. Understanding Resource Uses in Alaskan Socioeconomic Systems. *In*: Resource Use and Socioeconomic Systems: Case Studies of Fishing and Hunting in Alaska Communities. Division of Subsistence Technical Paper No. 61:248-274, R.J. Wolfe, and L.J. Ellana, eds. Juneau, AK: State of Alaska, Department of Fish and Game.

Workman, W. 1980. Continuity and Change in the Prehistoric Record from Southern Alaska. *In:* Alaska Native Culture and History, Y. Kotani and W.B. Workman, eds. Senri Ethnological Studies 4:49-101. Osaka, Japan: National Museum of Ethnology.

Wynne, K.M., D.L. Hicks, and N.R. Munro. 1992. 1991 Marine Mammal Observer Program for the Salmon Driftnet Fishery of Prince William Sound, Alaska. Saltwater, Inc., for USDOC, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Juneau, AK.

Yarborough, M.R., and L.F. Yarborough. 1993. Regional Overview of Prince William Sound and the Pacific Coast of the Kenai Peninsula. Paper presented at the International Seminar on the Origins, Development, and Spread of Prehistoric North Pacific-Bering Sea Maritime Cultures, Honolulu, HI, June 1993.

Zadina, T., and M. Haddix. 1990. Net-pen Rearing of Juvenile Sockeye Salmon (Oncorynchus nerka) in Hugh Smith Lake, Southeast Alaska. Alaska Department of Fish and Game. Division of Fisheries Rehabilitation and Development. No. 10. 26 pp.

PERSONAL COMMUNICATIONS

Agler, B., P. Seiser, S. Kendall, and D. Irons. 1993. Written communication.

Babcock, M. 1994. Oral communication.

Ballachey, B. 1994. Oral communication.

Bodkin, J. 1994. Oral communication.

Brown, E. 1994. Oral communication.

Byrd, V. 1994. Oral communication.

Frey, C. 1994. Written communication.

Kendall, S. 1994. Written communication.

Klosiewski, S., and K. Laing. 1993. Written communication.

Kuletz, K.J., D.K. Marks and N.L. Naslund. 1993. Written communication.

Kuletz, K.J. 1994. Oral communication.

Mendenhall, V. 1994. Oral communication.

Monson, D.H. 1993. Written communication.

Oakley, K., and K. Kuletz. 1994. Written communication.

Patten, S. 1992. Oral communication.

Patten, S. 1994. Written communication.

Rice, B. 1994. Oral communication.

Roseneau, D. 1994. Oral communication.

Sanger, G., and M. Cody. 1994. Written communication.

Stekoll, M. 1994. Oral communication.

White, Lorne. 1994. Oral communication.

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Appendix A

Habitat Protection

Table A-1.

Summary of Data from Large Parcel Evaluation and Ranking

Potential for Benefit → / Parcel #	Acres	Pink Smn.	Sock-eye Smn.	Cut-throat Trout	Dolly Var-den	Her-ring	Bald Eagle	Black Oys-ter-cat-cher	Com-mon Murre	Har-bor Seal	Har-le-quin Duck	Inter-tidal/ Sub-tidal Biota	Mar-bled Mur-relet	Pigeon Guil-lemot	Riv. Otter	Sea Otter	Rec-rea-tion/ Tour-ism	Wil-der-ness	Cul-tural Re-sources	Subsis-tence
AJV 03	13,400	H	M	-	L	M	H	H	L	H	H	H	H	H	M	H	M	H	H	L
EYA 02	9,100	H	L	L	M	M	H	H	L	H	H	H	M	L	M	H	H	M	H	H
CHE 02	12,100	H	H	M	H	L	M	L	L	M	H	M	M	H	M	M	H	H	M	H
TAT 01	8,800	L	L	L	L	H	H	H	L	M	H	H	M	H	H	M	M	M	H	H
AKI 06	16,900	H	H	-	H	H	H	L	L	H	H	H	M	H	H	L	H	M	M	H
CHE 01	7,900	M	H	H	H	L	H	M	L	M	M	M	M	L	H	M	H	M	L	H
AJV 01	27,100	H	L	-	H	H	M	H	L	H	H	H	H	H	M	H	L	H	H	L
AKI 04	34,300	H	-	-	H	M	M	H	H	H	H	H	H	H	H	L	L	H	M	M
EYA 03	7,100	H	L	H	M	M	H	M	L	M	L	M	M	L	M	H	H	H	L	H

Table A-1.

Summary of Data from Large Parcel Evaluation and Ranking

Potential for Benefit → Parcel #	Acres	Pink Smn.	Sockeye Smn.	Cutthroat Trout	Dolly Varden	Herring	Bald Eagle	Black Oystercatcher	Common Murre	Harbor Seal	Harlequin Duck	Intertidal/ Subtidal Biota	Marbled Murrelet	Pigeon Guillemot	Riv. Otter	Sea Otter	Recreation/ Tourism	Wilderness	Cultural Resources	Subsistence
KIB 01	27,900	M	L	-	H	M	L	M	L	M	M	H	M	H	H	H	M	H	H	L
AKI 08	15,600	L	H	-	H	H	H	M	L	H	M	L	L	L	H	L	M	M	H	H
KON 01	9,900	H	-	-	L	H	H	H	M	H	H	H	H	H	H	H	H	L	H	H
KON 04	28,200	H	H	-	H	-	H	-	-	-	H	-	L	-	H	-	H	M	H	H
ENB 06	3,800	H	L	L	M	L	H	H	L	L	H	H	H	H	H	H	M	H	L	L
EYA 01	3,400	M	L	L	L	M	H	L	L	M	H	M	M	L	H	M	M	H	M	H
KON 02	7,000	L	-	-	L	M	H	M	M	H	H	H	H	H	H	H	H	H	H	H
PTG 05	11,500	H	H	-	M	M	L	H	L	L	H	H	H	M	H	H	M	M	L	L

Total Acres Ranked as "High" in the Largel Parcel Evaluation Process = 244,000

Table A-1.

Summary of Data from Large Parcel Evaluation and Ranking

Potential for Benefit → Parcel #	Acres	Pink Smn.	Sockeye Smn.	Cutthroat Trout	Dolly Varden	Herring	Bald Eagle	Black Oystercatcher	Common Murre	Harbor Seal	Harlequin Duck	Intertidal/ Subtidal Biota	Marbled Murrelet	Pigeon Guillemot	Riv. Otter	Sea Otter	Recreation/ Tourism	Wilderness	Cultural Resources	Subsistence
AKI 05	8,200	M	-	-	L	H	M	M	L	H	H	H	H	H	H	L	L	H	M	L
AJV 04	56,700	M	M	-	M	H	M	M	L	H	H	M	M	H	M	H	M	H	M	H
ENB 02	6,200	L	L	-	L	M	L	M	L	L	M	M	H	M	H	M	H	H	H	L
PTG 01	4,300	M	M	L	M	M	M	H	L	M	M	M	M	M	H	M	H	M	M	L
AJV 06	27,300	M	M	-	L	H	M	M	L	L	H	L	M	H	M	H	M	M	L	H
AKI 01	4,900	M	-	-	M	M	M	L	L	H	H	H	H	H	M	L	L	H	M	L
CHE 09	6,200	M	L	L	L	L	H	M	L	H	M	M	H	L	M	H	L	H	M	H
ENB 08	15,700	H	M	-	L	M	H	M	M	M	M	H	M	M	L	M	M	L	H	H

Table A-1.

Summary of Data from Large Parcel Evaluation and Ranking

Potential for Benefit ➜ Parcel #	Acres	Pink Smn.	Sock-eye Smn.	Cut-throat Trout	Dolly Var-den	Her-ring	Bald Eagle	Black Oys-ter-cat-cher	Com-mon Murre	Har-bor Seal	Har-le-quin Duck	Inter-tidal/ Sub-tidal Biota	Mar-bled Mur-relet	Pigeon Guil-lemot	Riv. Otter	Sea Otter	Rec-rea-tion/ Tour-ism	Wil-der-ness	Cul-tural Re-sources	Subsis-tence
PTG 02	3,500	L	L	L	L	M	M	H	L	L	M	H	H	H	M	H	M	H	M	L
PTG 11	3,300	L	L	L	L	L	L	H	L	H	L	H	M	L	L	M	L	H	M	H
AKI 09	15,900	L	-	-	L	L	M	M	L	H	H	H	H	M	H	L	L	L	H	H
CAC 02	10,800	L	M	M	L	L	M	L	L	H	M	M	M	M	L	L	L	M	H	H
CAC 05	800	M	L	L	L	L	M	H	L	H	L	H	L	L	L	H	L	L	H	H
EYA 11	13,700	L	H	H	H	-	H	-	-	L	L	L	L	-	H	L	H	L	L	H
KON 03	22,400	L	-	-	L	M	M	H	M	M	H	H	H	H	H	M	H	L	L	H
KON 05	21,900	M	-	-	M	L	M	M	L	H	M	L	L	L	H	L	L	H	M	H
AJV 05	12,700	M	L	-	M	H	H	M	L	L	L	M	M	M	M	M	M	M	L	H

Table A-1.

Summary of Data from Large Parcel Evaluation and Ranking

Potential for Benefit ➜ / Parcel #	Acres	Pink Smn.	Sock-eye Smn.	Cut-throat Trout	Dolly Var-den	Her-ring	Bald Eagle	Black Oys-ter-cat-cher	Com-mon Murre	Har-bor Seal	Har-le-quin Duck	Inter-tidal/ Sub-tidal Biota	Mar-bled Mur-relet	Pigeon Guil-lemot	Riv. Otter	Sea Otter	Rec-rea-tion/ Tour-ism	Wil-der-ness	Cul-tural Re-sources	Subsis-tence
PTG 07	10,500	L	L	L	L	M	M	H	L	L	L	M	H	M	M	L	L	M	H	L
CHE 04	7,300	L	L	L	L	L	H	H	L	H	H	M	M	L	M	H	L	H	H	H
OLD 05	5,300	L	-	-	L	L	H	M	M	M	M	M	M	M	M	L	M	M	M	H
KON 06	22,400	M	-	-	M	-	M	-	-	L	H	-	L	-	H	-	L	H	M	H
OLD 04	4,600	H	-	-	L	H	M	L	M	L	M	M	L	L	M	L	M	M	M	H
CHE 03	15,000	H	L	M	L	L	H	M	L	L	L	M	M	L	M	H	M	H	M	H
OLD 01	9,500	H	-	-	L	H	H	L	M	M	M	L	L	M	M	L	M	M	H	H

Total Acres Ranked as "Moderate" in the Largel Parcel Evaluation Process = 309,100

Table A-1.
Summary of Data from Large Parcel Evaluation and Ranking

Potential for Benefit → Parcel #	Acres	Pink Smn.	Sock-eye Smn.	Cut-throat Trout	Dolly Var-den	Her-ring	Bald Eagle	Black Oys-ter-cat-cher	Com-mon Murre	Har-bor Seal	Har-le-quin Duck	Inter-tidal/ Sub-tidal Biota	Mar-bled Mur-relet	Pigeon Guil-lemot	Riv. Otter	Sea Otter	Rec-rea-tion/ Tour-ism	Wil-der-ness	Cul-tural Re-sources	Subsis-tence
EYA 04	3,700	H	L	M	M	M	H	M	L	H	L	M	M	L	M	M	H	M	M	H
PTG 08	16,200	H	L	L	M	H	H	M	L	H	L	H	M	L	M	M	L	L	M	H
AKI 02	4,200	L	-	-	L	M	M	L	L	L	M	H	M	M	M	L	L	H	H	L
AKI 03	12,400	M	-	-	L	L	M	M	L	M	M	M	L	M	M	L	L	H	M	M
CAC 04	1,600	L	L	L	L	L	L	M	L	H	L	H	M	L	L	H	L	H	L	H
CHE 08	1,700	L	L	L	L	L	H	M	L	H	M	L	M	M	L	L	L	H	L	H
ENB 01	1,400	L	L	L	L	M	M	L	L	L	L	M	H	M	H	L	H	H	L	L
ENB 05	7,600	L	L	L	L	M	L	M	L	L	L	M	H	L	L	L	M	H	H	L
ENB 07	8,900	L	L	L	M	M	M	L	L	M	L	M	H	L	L	L	M	M	M	L

Table A-1.

Summary of Data from Large Parcel Evaluation and Ranking

Potential for Benefit ➜ / Parcel #	Acres	Pink Smn.	Sock-eye Smn.	Cut-throat Trout	Dolly Var-den	Her-ring	Bald Eagle	Black Oys-ter-cat-cher	Com-mon Murre	Har-bor Seal	Har-le-quin Duck	Inter-tidal/ Sub-tidal Biota	Mar-bled Mur-relet	Pigeon Guil-lemot	Riv. Otter	Sea Otter	Rec-rea-tion/ Tour-ism	Wil-der-ness	Cul-tural Re-sources	Subsis-tence
EYA 05	7,600	L	L	L	L	H	H	L	L	L	L	L	M	L	M	L	L	H	L	H
OLD 02	8,000	L	-	-	L	H	M	M	L	H	M	M	L	M	M	L	L	H	M	H
SEL 02	10,100	M	L	-	L	M	H	L	L	L	M	H	M	L	M	L	H	M	M	H
EYA 07	3,300	M	L	M	L	L	H	L	L	M	L	M	M	L	L	H	H	M	L	H
OLD 03	7,300	M	-	-	L	M	H	L	L	L	H	H	L	M	M	L	M	L	M	H
ENB 03	4,600	L	L	-	L	M	M	M	L	M	M	M	M	M	M	L	L	H	L	L
CAC 01	3,200	M	L	L	L	L	L	L	L	L	L	M	M	H	L	L	L	H	L	H
CHE 06	5,400	M	L	L	L	L	M	L	L	L	L	L	M	L	L	L	L	H	H	H
EYA 06	4,000	L	L	L	L	L	H	L	L	M	M	M	M	L	L	H	H	M	L	H

Table A-1.
Summary of Data from Large Parcel Evaluation and Ranking

Potential for Benefit ➜ Parcel #	Acres	Pink Smn.	Sockeye Smn.	Cutthroat Trout	Dolly Varden	Herring	Bald Eagle	Black Oystercatcher	Common Murre	Harbor Seal	Harlequin Duck	Intertidal/ Subtidal Biota	Marbled Murrelet	Pigeon Guillemot	Riv. Otter	Sea Otter	Recreation/ Tourism	Wilderness	Cultural Resources	Subsistence
AKI 07	15,200	L	L	-	L	L	L	M	L	M	H	M	L	M	M	L	L	L	M	H
PTG 06	12,400	L	L	L	L	M	L	L	L	M	L	L	H	H	L	M	M	M	M	L
SEL 01	18,600	M	L	-	L	M	L	M	L	L	M	M	M	L	M	L	H	M	H	H
CAC 03	12,900	L	L	L	L	L	H	M	L	H	L	M	M	M	L	L	L	M	L	H
PTG 09	15,300	H	L	L	L	L	H	M	L	H	L	M	M	L	M	M	L	L	H	H
PTG 03	3,400	L	L	L	L	M	L	M	L	L	H	L	H	M	L	L	L	H	L	L
CHE 05	8,300	M	L	L	L	L	H	L	L	L	L	L	M	H	L	L	L	M	H	H
SEL 03	13,100	L	L	-	M	M	M	L	L	L	M	L	M	L	M	L	H	L	M	H
EYA 08	4,800	L	H	H	H	-	H	-	-	-	L	-	L	-	H	-	H	L	L	H

Table A-1.

Summary of Data from Large Parcel Evaluation and Ranking

Potential for Benefit → / Parcel #	Acres	Pink Smn.	Sockeye Smn.	Cutthroat Trout	Dolly Varden	Herring	Bald Eagle	Black Oystercatcher	Common Murre	Harbor Seal	Harlequin Duck	Intertidal/ Subtidal Biota	Marbled Murrelet	Pigeon Guillemot	Riv. Otter	Sea Otter	Recreation/ Tourism	Wilderness	Cultural Resources	Subsistence
EYA 09	5,100	L	H	H	H	-	H	-	-	L	L	-	L	-	H	L	H	L	L	H
ENB 09	14,700	M	L	-	L	L	M	M	L	L	L	H	M	L	L	M	L	L	M	H
AJV 02	2,100	L	L	-	L	H	H	L	L	L	M	M	M	H	M	H	L	M	L	L
ENB 04	5,900	L	L	L	L	M	L	M	L	L	M	M	M	M	L	L	L	H	M	L
EYA 10	3,800	L	M	M	H	-	H	-	-	L	L	M	L	-	M	L	H	L	L	H
EYA 13	4,600	L	L	L	L	L	M	L	-	L	L	L	H	L	L	M	H	M	L	H
CHE 11*	400	L	L	L	L	L	L	L	L	M	L	L	L	H	L	L	L	H	L	H
CHE 10	3,700	L	L	L	L	L	H	L	L	L	L	M	M	L	L	L	L	L	H	H
CHE 07	1,500	L	L	L	L	L	M	L	L	L	L	L	M	M	L	L	L	H	L	M

Table A-1.

Summary of Data from Large Parcel Evaluation and Ranking

Potential for Benefit → Parcel #	Acres	Pink Smn.	Sock-eye Smn.	Cut-throat Trout	Dolly Var-den	Her-ring	Bald Eagle	Black Oys-ter-cat-cher	Com-mon Murre	Har-bor Seal	Har-le-quin Duck	Inter-tidal/ Sub-tidal Biota	Mar-bled Mur-relet	Pigeon Guil-lemot	Riv. Otter	Sea Otter	Rec-rea-tion/ Tour-ism	Wil-der-ness	Cul-tural Re-sources	Subsis-tence
PTG 04	2,300	L	L	L	L	M	L	M	L	L	L	L	M	M	L	L	L	H	L	L
EYA 12	6,900	M	L	L	L	-	L	-	-	L	M	L	M	L	H	L	L	H	L	H
ENB 10	15,400	M	M	-	H	L	L	L	L	L	L	L	L	L	M	L	M	L	L	H
PTG 10	28,400	M	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	H

Total Acres Ranked as "Low" in the Largel Parcel Evaluation Process = 310,000

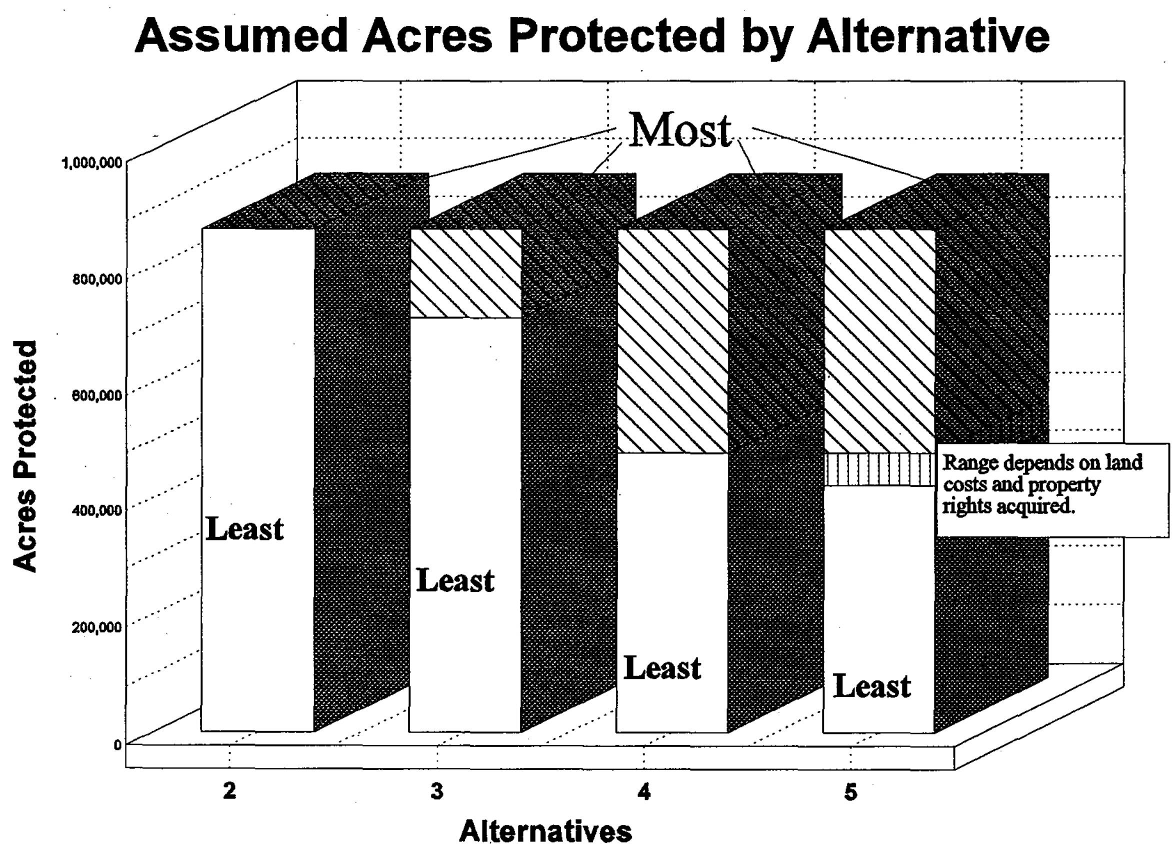
Grand Total All Parcels = 863,100

* Listing says 400, parcel sheet says 422.

For comparison purposes, Figure A-1 displays the number of acres assumed protected for each of the action alternatives. The assumption made was that funds would be sufficient to protect all of the parcels shown in Chapter 2, Figures 2-1 through 2-3 if land or easement prices are low. It is also assumed that since prices and rights negotiated will vary widely that a smaller portion of the parcels shown could still be protected. These ranges of parcels are shown in Figure A-1.

The "Most" label represents the most acres assumed protected by each alternative if the unit price for the parcels is relatively low. The "Least" label represents the least acres protected assuming the unit price is higher. In Alternative 5 the funds estimated available for Habitat Protection is a range of 45 to 50 percent. This range affects the assumed least acreage and is represented by a band between the most and least acres.

Figure A-1



Appendix B

Species Names

Appendix B
Common and Scientific Names

Common Name	Scientific Name
Arctic fox	*Alopex lagopus*
Arctic tern	*Sterna paridisaea*
Arctic skua	*Catharacta skua*
bald eagle	*Haliaeetus leucocephalus*
barnacle	*Chthamalus dalli*
black-legged kittiwake	*Rissa tridactyla*
black oystercatchers	*Haematopus bachmani*
blennies	*Clinidae, Blennidae, or Stichaeidae*
Bonaparte's gull	*Larus philadelphia*
brant	*Branta bernicla*
brook trout	*Salvelinus fontinalis*
Canada goose	*Branta canadensis*
chinook salmon (king salmon)	*Onchorhynchus tschawytscha*
chum salmon (dog salmon)	*Onchorhynchus keta*
clams	*Tellina sp., Spisula sp., Siliqua sp.*
coho salmon (silver salmon)	*Onchorhynchus kisutch*
common raven	*Corvus corax*
common murre	*Uria aalge*
copper rockfish	*Sebastes caurinus*
cormorant	*Phalacrocorax* spp.
cutthroat trout	*Onchorhynchus clarki*
Dolly Varden	*Salvelinus malma*
Dungeness crab	*Cancer magister*
eider duck	*Somateria mollisima*
eulachon (candlefish)	*Thaleichthys pacificus*
flounder (starry)	*Platichthys stellatus*
glaucous-winged gulls	*Larus glaucescens*
grebe	*Podiceps* spp.
harbor seal	*Phoca vitulina richardsi*
harlequin duck	*Histrionicus histrionicus*
humpback whale	*Megaptera novaengliae*
killer whale	*Orcinus orca*
king crab	*Paralithodes spp. and Lithodes aquispina*
limpet	*Tectura persona*
loon	*Gavia* spp.
Lutz spruce	*Picea X Lutzii*
marbled murrelet	*Brachyramphus marmotatum*
mink	*Mustela vison*
mussels	*Mytilus trossulus*

Common Name	Scientific Name
mysids	mysidaceae "oppossum shrimp"
northwestern crow	*Corvus caurinus*
other ducks	family Anatidae, subfamily Anatinae
Pacific cod	*Gadus macrocephalus*
Pacific halibut	*Hippoglossus stenolepis*
Pacific herring	*Clupea harengus pallasi*
Pacific Ocean perch	*Sebastes alutus*
Pacific tomcod	*Microgadus proximus*
Pacific hake	*Merluccius productus*
pandalid shrimp	family Pandalidae (genera *Pandalus* and *Pandalopsis*)
peregrine falcon	*Falco peregrinus*
pigeon guillemot	*Cepphus columba*
pink salmon (humpy)	*Onchorhynchus gorbuscha*
quillback rockfish	*Sebastes maliger*
rainbow trout	*Onchorhynchus mykiss*
river otters	*Lutra canadensis*
rockfish	Scorpaenidae
rockweed or popweed	*Fucus gardneri*
sablefish	*Anoplopoma fimbria*
scallops	*Pecten caurinus, Chlamys rubida and Chlamys hastata hericia*
sea otter	*Enhydra lutris*
shrimp	primarily *Pandalus spp.*
Sitka spruce	*Picea sitchensis*
sockeye salmon (red salmon)	*Onchorhynchus nerka*
sole (yellowfin)	*Limanda aspera*
spruce bark beetle	*Dendroctonus rufipennis*
Steller sea lion	*Eumetopias jubatus*
sticklebacks	*Gasterosteus aculeatus* or *Pungitius pungitius*
swan	*Cygnus* spp.
Tanner crab	*Chionoecetes bairdi and C. opilio*
thick-billed murre	*Uria lomvia*
tufted puffin	*Fratercula cirrhata*
walleye pollock	*Theragra chalcogramma*
western hemlock	*Tsuga heterophylla*
white spruce	*Picea glauca*
yelloweye rockfish	*Sebastes ruberrimus*

Appendix C

Fish

APPENDIX C
FISH

Section 1. Procedures for Project Planning and Permitting

Any new fisheries project, regardless of the funding source, must undergo the scrutiny of one or more standard review processes before it can be implemented. A project that will entail any form of stock manipulation -- including a hatchery operation, stock introduction, egg incubation box, or eyed-egg planting -- is required by regulation 5 AAC 41.005 to first have a Fish Transport Permit (FTP) (ADF&G,1990). This regulation makes it unlawful to transport, possess, export from the State, or release into the waters of the State any live fish (or fish eggs) without an FTP, which is issued for a fixed term and authorizes only that operation specified in the permit. Any change of species, brood stock, or location requires a new permit. Each applicant for an FTP submits the following information to the Alaska Department of Fish and Game (ADF&G) (5 AAC 41.010): species and stock; incubation, rearing, and release site(s); number and life history stage; disease history of the stock and inspection and certification; isolation measures planned to control disease; source of water for rearing and means of effluent discharge; identification and status of native stocks involved; method and time of transport or release; purpose and expected benefits of the proposed project; evaluation plans; and other information.

The ADF&G reviews each FTP application and issues an FTP only if it is determined that the proposed transport, possession, or release of fish will not adversely affect the continued health and perpetuation of other native, wild, or hatchery stocks. Terms and conditions may be attached if necessary to protect the continued health and perpetuation of native, wild, or hatchery stocks of fish (5 AAC 1.030).

In addition to these regulations, certain Departmental policies also apply to fish-stocking programs in Alaska. The ADF&G Genetic Policy (Davis et al., 1985) addresses stock transports, protection of wild stocks, and maintenance of genetic variability. The ADF&G policy relating to fish health and disease control (Meyers et al., 1988) is intended to prevent dissemination of infectious finfish and shellfish diseases within or outside the borders of Alaska without introducing impractical constraints for aquaculture and necessary stock-renewal programs. These policies are reviewed as part of the FTP application process. Another policy, the (draft) Wild Stock Protection Policy, also influences sport fish stocking programs in Alaska. Accordingly, the Sport Fish Division will not accept stocking hatchery fish in locations where wild stocks of sport fish presently occur unless:

> (a) the indigenous wild stock(s) is (are) incapable of supporting a recreational fishery; or (b) the indigenous wild stock(s) is (are) important to sport anglers and is (are) found to be depressed; or (c) adequate evaluation can be dedicated to the stocking project to maintain historical levels of natural production, run timing, and spawning distribution (Peltz, 1994).

Further, proposed projects that are intended to provide benefits for a sport fishery receive more detailed review. Each project is reviewed to ensure that hatchery production matches fish production demands according to fishery management plans. These management plans, which address fish stocking, are reviewed every 4 to 5 years and are incorporated into a Statewide Stocking Plan for Recreational Fisheries. This plan contains specific information about each stocking location; region of the State, Division of Sport Fish Management Area; and reference to a sport fishery management plan that covers the stocking location, release site, species to be released, whether the location is anadromous or landlocked, size of fish to be stocked, and number of fish to be stocked each year. Time is allowed for public viewing of the draft plan as part of a separate NEPA review process before it is approved by the Commissioner of ADF&G (Peltz, 1994).

Any proposed project that may entail any form of aquatic habitat alteration (such as migration corridor improvements or stream habitat improvement) must be reviewed and approved through a multiagency process. This process is coordinated by the State of Alaska Division of Governmental Coordination and called the "project consistency review" based on the Alaska Coastal Management Program (ACMP) described in State of Alaska Regulations (Title 6, Chapter 50). This review is designed to improve management of Alaska's coastal land and water uses. Project proposals are reviewed to identify permits required by the State of Alaska Departments of Environmental Conservation, Fish and Game, and Natural Resources and to determine the project's consistency with the standards of the ACMP and enforceable policies of approved district coastal management programs. The purpose of this permitting and review process is to allow reasonable developmental activities while protecting the aquatic habitats.

In addition, several Federal Agency permits may be required. Because these projects typically occur on wetlands, a permit from the U.S. Army Corps of Engineers also is required. If the proposed project location is on federally owned lands (e.g., National Forest or National Wildlife Refuge), a special-use permit may also be required. Where an effluent will be discharged; e.g., with a hatchery operation, a U.S. Environmental Protection Agency National Pollution Discharge Elimination System (NPDES) Permit and approval by the State of Alaska Department of Environmental Conservation are required.

Finally, Regional Planning Teams (RPT's) have been established by State of Alaska Statutes Title 16 within each of the commercial fisheries management areas to develop coordinated plans for fisheries rehabilitation, enhancement and development projects (AS 16.10375-470). Voting members of the RPT include three members from ADF&G, and three representatives from the appropriate Regional Aquaculture Association. These planning teams review proposals to assure that potential projects are compatible with the existing fisheries and to confirm that the projects will provide the expected benefits to the intended fishers. The RPT also reviews the Annual Hatchery Management Plan that is required from each fish hatchery that may be located in that region. These annual plans include detailed information about the origin, numbers, and release strategy, evaluation plan, and short and long-range harvest management plan for each stock of fish in the hatchery.

Consequently, before any proposed fisheries project can become operational, in addition to preimplementation biological monitoring, a substantial amount of time and effort must be expended to assure that it will comply with all of the required permitting and planning. These requirements have been established to allow orderly development of new projects that are compatible with existing biological resources and fisheries within each region.

Section 2. Restoration Activities

Description of Actions: Various restoration actions may be implemented to assist natural recovery of wild-stock pink and sockeye salmon populations and commercial and sport fishing activities, but it is also assumed that the responsible resource management agencies will maintain the historic levels of their activities.

Pink Salmon. Actions that may be implemented, in addition to habitat acquisition, to restore wild-stock pink salmon populations may include: (1) migration corridor improvements, (2) egg incubation boxes, (3) net pen rearing, (4) hatchery rearing, (5) habitat improvement, and (6) relocation of hatchery-produced runs (EVOS Trustee Council, April and November 1993).

Fisheries restoration actions provide a means to restore wild stocks and fisheries. Before they are implemented, however, it is important to allow a sufficient amount of time for adequate planning and permitting procedures. At least 1 year (but 2 years are better) is required for good preimplementation studies and design, and at least 1 year of "shakedown" operational activities is needed before most projects can be considered fully operational.

1. Migration corridor improvements entail mitigation of a barrier to fish migration that may prevent access to critical habitat for fish spawning or rearing. This typically involves installing of a fishpass or removing of a migration barrier. The construction of a fishpass (i.e., fish ladder or steep pass) is a permanent form of habitat modification to enable fish to access spawning and rearing habitat above an impassable barrier such as a steep or long waterfall.

Description: Migration corridor improvements may be either a constructed fish ladder (i.e., made from concrete, steel, or aluminum) to bypass a barrier or simply an alteration of the barrier itself (e.g., through explosives to provide a series of ascending resting pools); however, their success will depend on adequate preconstruction studies, design, and evaluation, including estimates of high- and low-water flows as well as the species and number of fish using the system. Several agencies, including USFS and ADF&G, have had experience throughout the EVOS area in these techniques over a broad range of conditions. Although these changes to the barrier are permanent, inspection and maintenance of the structures are required at regular intervals.

If a migration barrier is present upstream from a spawning population of pink salmon, after the barrier has been mitigated, the returning spawners may colonize the newly available habitat. However, full utilization of the entire area of new habitat may require several generations. Where a barrier may be present without a spawning population, a stock may be introduced by any of several methods that may include transplanting mature adult fish, eggs (e.g., in the gravel or in incubation boxes), or emergent fry.

Potential Applications: This technique has been widely applied throughout the EVOS area, especially in Prince William Sound, to increase populations of wild-stock pink salmon and to establish new populations by providing access to new or additional spawning habitat (Wedemeyer, 1993, oral comm.; Blackett, 1979, 1987). Because pink salmon migrate directly to saltwater after they emerge from the spawning gravel, they do not require freshwater rearing habitat; consequently, population benefits will be accrued for pink salmon wherever access can be provided to new or underutilized spawning habitat.

Potential Benefits: Providing migration corridor improvements that create access to good quality spawning habitat for pink salmon is a proven technique to improve pink salmon populations. The potential benefit is in direct proportion to the amount of new spawning habitat that is accessed. Properly installed, the structures usually are permanent, with a long lifespan.

Potential Drawbacks: Installation costs may be high. Routine annual inspection and maintenance are required.

2. Egg incubation boxes have been used highly successfully in the Copper River drainage to develop a small wild-stock population of sockeye salmon into an estimated annual total return of approximately 200,000 adult fish with an estimated annual commercial harvest of over 100,000 fish (Roberson and Holder, 1993).

Although early experimental efforts to incubate sockeye and chum salmon eggs in egg incubation boxes in Prince William Sound were less successful (Jackson, 1974), Pete Velsko (1993, oral comm.) has reported that egg incubation boxes have been used successfully in several drainages in the Nome area to incubate chum salmon eggs. These and other results demonstrate the importance of proper site selection, installation, and operational techniques. Egg incubation boxes have not been used widely to incubate pink salmon eggs; however, Terry Ellison (ADF&G, 1994, oral comm.) reports that egg incubation boxes were used effectively for several years to increase the numbers of pink salmon brood stock returning to Cannery Creek in Prince William Sound.

Description. The technique of egg incubation boxes involves use of a large box (e.g., from 2x2x2 ft. to 4x4x8 ft.) in which fertilized eggs and selected gravel or artificial substrate are placed in alternating layers. Cool, oxygen-rich water is fed by gravity from an intake box, through a plumbing system, and up through the gravel and eggs in the incubation box. When properly installed, these units control the water flow, substrate type, sedimentation, and predation to provide egg-to-fry survival rates of over 80 percent (Roberson and Holder, 1993). This compares quite favorably with an expected survival rate of 12 to 43 percent in redds of naturally spawned sockeye salmon (Drucker, 1968) or 4 to 23 percent for pink salmon (Heard, 1991).

In-stream egg incubation boxes provide a low-cost restoration or enhancement technique that is ideally suited for small-scale, low-technology operations at remote sites. After the brood stock is spawned and the eggs are placed in the unit, minimal care is required. When they are used for enhancement of indigenous stocks, these units can minimize the genetic and pathology concerns associated with transport of eggs or fry.

To successfully apply this technique, the following prerequisites are necessary: (1) high-quality, free-flowing (i.e., throughout the winter) spring water source; (2) adequate hydraulic head differential to obtain sufficient gravity flow without installing an excessive length of piping; (3) suitable stream bottom; and (4) a protected area for the incubation units.

Potential Applications: The potential contribution of egg incubation boxes for the restoration or improvement of wild pink salmon stocks in the EVOS area will be very good in drainages which have reasonably accessible spring areas or free-flowing water in winter, appropriate physical features, good water quality and quantity, and potential capacity to achieve a satisfactory benefit:cost ratio.

Extensive surveys to locate potential sites to implement this technique in the EVOS area have not been performed, however, large-scale potential sites have not been identified during routine surveys and monitoring for fisheries management activities or fish hatchery site identification. However, potential sites for application of this action are believed to exist in some drainages.

Potential Benefits: Where an optimal location can be used, dramatic results can be attained (Roberson and Holder, 1993). Where suitable locations can be identified, this action may be applied to help restore or improve pink salmon populations without a major intrusion into the environment or the wild fish stocks. Within the EVOS area, there may be a number of drainages where this technique may be applied.

Potential Drawbacks: This method will require substantial development to achieve dramatic results with pink salmon. While it can be used to benefit individual stocks within individual drainages, logistical costs may constrain widespread small-scale development.

3. Net pen rearing is a practice that has been widely applied to increase the survival rate of all salmon species. This is a common technique that has been used in ADF&G and PNP programs in the EVOS area and throughout the State of Alaska to improve the survival rate of juvenile pink salmon. It has not been commonly applied, however, for wild stocks of pink salmon.

Description: Net pen rearing to improve the survival rate for wild-stock juvenile pink salmon will entail capturing the fry as they emigrate from a spawning stream and placing them in a rearing pen, or emergent fry may be collected from eggs that are incubated in a hatchery and transported to the rearing site. On-site personnel will feed the fry, protect them against predators and physical damage, and monitor fish health to maximize the survival rate of the fry until they are released. The increased survival rate and larger size of the young fish contribute to a greater number of returning adult fish.

Potential Applications: Net pen rearing of wild-stock pink salmon fry to increase their survival rate potentially may be employed in many systems throughout the EVOS area. Only two key ingredients are necessary: a source of fry and a suitable site to anchor and service the net pens. The wild-stock fry may be captured as they emigrate from a spawning stream, or they may be transferred through a hatchery operation. Although this action has not been widely applied for wild-stock pink salmon, the techniques of capturing emigrating fry and net pen rearing are standard practices. Successful application will depend primarily upon appropriate site selection, and Willette et al. (1993) already have identified a number of candidate locations in the EVOS area.

Potential Benefits: Careful application of the net pen rearing technique can be expected to increase the survival rate of juvenile pink salmon by 50 to over 150 percent and, consequently, returning adults (Martin, Heard and Wertheimer, 1981; Leon, 1987). The magnitude of the benefit will depend on the numbers of captive fry that can be accommodated.

Potential Drawbacks: Whenever any organisms are held captive in high density, they become more susceptible to disease or other catastrophic loss; however, this risk can be reduced by adjusting the loading density (Schollenberger, 1993) and by applying good fish-cultural techniques (ADF&G, 1983). Any fish-cultural activity may have some genetic consequence on the natural population (e.g., because of selective egg-take practices), but this introgression is reduced by using the indigenous stock and minimal manipulation activities (Davis et al., 1985).

4. Hatchery rearing of pink salmon fry to increase the survival rate to the adult stage has had a long history in Alaska. Typically, these operations have been based on a large, established hatchery brood stock that was derived from a donor wild stock; however, eggs may be taken annually from individual wild stocks to supply the eggs. As the fry emerge, they must be transported to an estuarine rearing site at the stream mouth where they can be held until they become imprinted to this stream and until the environmental conditions are satisfactory.

Description: Eggs are taken from the appropriate brood stock and incubated. As fry emerge from the incubators, they are transferred to floating net pens that are anchored in a sheltered location in the estuary where they are fed. The release timing is determined by either the appropriate growth and size of the fry or when the natural rearing conditions in nearshore nursery areas are optimal. If the rearing and release location is not adjacent to the hatchery, it must be in the freshwater plume of the target drainage to achieve proper imprinting and homing.

Potential Applications: Hatchery rearing for pink salmon fry may be a useful technique to restore pink salmon populations in many drainages in the EVOS area; however, the wild stocks must be selected for egg takes, and the fry rearing pens must be operated at the mouth of the systems that are selected. Candidate locations must have enough spawners to supply the eggs, and the physical features of the stream mouths must accommodate the net pens. Willette et al. (1993) may serve as a guide for site selection.

Potential Benefits: Damaged wild stocks may be helped directly by a rearing and release program for that stock, or the wild stocks may be helped indirectly by creating an alternate opportunity for the commercial fishers to divert fishing pressure away from the damaged wild stocks. For direct restoration, fry-rearing programs will be limited to those drainages that can provide brood stock and accommodate a rearing program. Typically, the survival rate from fry to adult may be increased by 50 to over 150 percent (Martin, Heard, and Wertheimer, 1981; Leon, 1987).

Potential Drawbacks: Whenever any organism is held captive in high density, it becomes more susceptible to disease or other catastrophic loss; however, this risk can be reduced by adjusting the loading density (Schollenberger, 1993) and application of good fish-cultural techniques (ADF&G, 1983). Any fish-cultural activity may have some genetic consequence on the natural population (e.g., selective egg-take practices), but this introgression is reduced by using the indigenous stock and minimal manipulation activities (Davis et al., 1985).

The success of this action depends on a combination of biological, physical, logistical, and technological factors; and no project application can be expected to become fully operational without appropriate site selection, testing, and evaluation.

5. Habitat improvement techniques are employed to overcome a factor in the fishes environment that may limit the full potential production for that species from that system (Zemke, Casipit, and Richel, 1987). Consequently, it is important to determine which aspect of the life history is the limiting factor and what must be done to improve conditions for increased production. Because pink salmon use the freshwater environment only for spawning, habitat improvement opportunities are limited primarily to improving migration corridors and creating new spawning habitat.

Description: Before any habitat improvement method should be applied, at least 1 year of monitoring and evaluation with a systematic approach should be scheduled. Seasonal visits will be most critical during low-flow periods and the coldest season. The most important parameters to evaluate include water temperature, water volume and velocity, and dissolved oxygen. If a fish population is not present, other water quality parameters also must be evaluated. A map of existing and improved habitat should be drawn, and engineering plans may be necessary to design a fishpass or spawning channel. If new spawning areas are to be developed, it is crucial to know the amount of water and to verify that the water is well oxygenated and that it does not freeze in winter. In addition, after habitat improvement has been completed, it must be monitored on a regular basis both to assure that it is operating as designed and to perform periodic maintenance.

If migration corridor habitat is poor, a fishpass may be installed to mitigate a migration barrier to provide access for pink salmon spawning habitat. Migration corridors also may be improved with techniques such as stabilizing stream banks or installing structures (e.g., boulders or wood debris) to maintain riffles and pools in a stream to create resting areas for spawning adults, but these factors rarely substantially limit pink salmon production. Selective removal of a portion of a barrier sufficient to allow passage of fish upstream without substantially altering the flow of water or downstream conditions may also improve access to spawning habitat.

If lack of adequate spawning habitat limits production, a spawning channel may be designed to increase and enhance natural spawning habitat thorough control of such factors as water flow, substrate, sedimentation, and predation to increase the egg-to-fry survival rates. While the average egg-to-fry survival rates in a natural stream average between 4 and 23 percent, spawning channels can increase those survival rates to nearly 60 percent (Heard, 1991). Implementation of this action requires a stable source of high- quality water (usually from groundwater) that is protected from surface runoff, proper terrain, and sufficient brood stock to use the spawning channels. Although numerous spawning channels have been constructed in other parts of the United States for various species of salmon (Bell, 1986; Bonnell, 1991; Marshall, 1985), few have been installed in Alaska, and these usually have not been designed to intentionally benefit pink salmon (Mattson, 1980; Garrison, 1993, oral comm.).

Potential Applications: Surveys have been performed to identify potential locations for habitat improvement projects in the EVOS area, and several potential sites have been discovered (Willette et al., 1993).

Potential Benefits: Pink salmon will benefit directly from access or development of any new good-quality spawning habitat because they rely on the freshwater environment only for spawning.

Potential Drawbacks: Wherever fish stocks are created or increased, there may be an interference with other stocks that already are present. There may be a risk of overharvesting the existing stocks. Returning adult fish may stray into adjacent drainages, interbreed with naturally reproducing populations, and disturb the genetic makeup of those populations.

6. Relocation of hatchery runs will provide a benefit for wild-stock pink salmon by providing an alternate location, timing, or stock for commercial fishing activities. If the locations to establish these new runs are carefully selected, there will be little or no interception of the wild stocks. Combined with good fishery management practices and a redistribution of the commercial-fishing fleet, fishing pressure can be diverted away from the wild stocks that need additional protection and refocused on the relocated hatchery runs that will allow the wild stocks to recover. This type of action has been employed already in portions of the EVOS area by ADF&G and PNP programs (Ellison, 1992; ADF&G, 1994). Fish hatcheries provide a valuable tool to relocate or establish fish runs; however, as with any tool, it must be used properly. First, the release location must be selected carefully. Juvenile fish must be transferred from the hatchery to the release site and, at the time of release, provisions must be made to assure that the young fish are imprinted properly to the release site to minimize straying by returning adult fish. After the adult fish return, the site for the terminal harvest must contain the fish (and the fishers) until the fish have been harvested with little or no impact on the wild stocks. Second, the donor brood stock must be appropriate for the need (i.e., species, stock, size, age, run timing, etc.), and the escapement of that stock must be sufficient to provide enough eggs for the new project. Third, guidelines established in the ADF&G Genetics Policy (Davis et al., 1985) and the Fish Health and Disease Control Policy (Meyers et al., 1988) must be followed. Finally, any proposed action must be consistent with permitting, planning, and review procedures for all fishery projects (Appendix C, Section 1). These procedures assure that new fishery projects will not interfere with wild-stock management practices and that a fishery management plan is established before the first fishery is allowed.

Potential Applications: The ADF&G and PNP aquaculture organizations have established a modern fisheries enhancement program that began in the mid-1970's. This program has included the establishment of salmon runs in new areas by relocating hatchery runs; however, some locations are available that will provide good opportunities for juvenile fish imprinting and adult fish terminal harvest areas that are readily accessible to the fishing fleets.

Potential Benefits: Fish hatcheries have been used in Alaska to relocate runs or establish runs of salmon for harvest by commercial fishers. Excellent success has been achieved with transplanting pink salmon into new locations, and other new runs at new locations can be developed as well.

Potential Drawbacks: Hatchery-produced fish typically can be harvested at a higher rate than most wild stocks. Consequently, the release site must be chosen carefully to minimize the potential mixture of wild and hatchery-produced fish in the harvest area. Where commercial fishing effort can be concentrated on the hatchery-produced stocks, however, the impacts of harvests of wild stocks can be reduced. Every fish-culture program must be carefully structured and controlled to avoid or minimize potential changes in the genetics makeup and health of the wild stocks that may be caused by the fish- cultural program (Martin, Webster, and Edwards, 1992; Holland-Bartels, Burger, and Klein, 1994; Hilborn, 1992. See b, 1993).

Sockeye Salmon

Restoration actions in addition to habitat protection that may be implemented to habitat protection, to assist natural recovery of wild-stock sockeye salmon populations include lake fertilization; migration-corridor improvements; and actions that may improve survival rates of sockeye salmon eggs by using egg incubation boxes, net pen rearing, or hatchery rearing (EVOS Trustee Council, April and November 1993).

1. Lake fertilization is a potential action that may be taken to improve the rearing success of juvenile sockeye salmon during their 1 to 3 years in the lake environment and to increase their survival to the smolt stage. The ADF&G began a lake limnology and lake fertilization program that has included 16 lakes since 1979 and, since 1974, 43 lake systems have been stocked with nearly 600 million juvenile sockeye salmon to improve production (Kyle, Koenings, and Edmundson, 1994).

Description: ADF&G has an established Lake Limnology and Lake Enrichment Policy (Koenings et al., 1979) that presently is being revised and updated (Kyle, 1994, oral comm.). According to this policy, a candidate lake system requires at least 2 years of study and evaluation before a project can be implemented. Because each lake system has unique characteristics, these research studies are designed to evaluate the status of the sockeye salmon fry populations, to determine if these populations will benefit from nutrient enrichment and to prescribe the appropriate mixture and amount of chemicals that are needed to stimulate the food chain. Some systems, such as Leisure Lake, on the lower Kenai Peninsula, have barrier falls on their outlet streams that prevent immigration of adult salmon but allow successful emigration of smolts. Fry must be stocked annually to replace the spawning adults and fertilizer must be added annually to replace the nutrients usually provided by the carcasses of spawners (Bechtol and Dudiak, 1988).

Potential Applications: The technology of lake nutrient enrichment to fertilize lakes to improve the rearing, growth, and survival of wild stocks of sockeye salmon has been developed in Alaskan waters and in other areas. Within the EVOS area, good success already has been achieved in the present lake enrichment program (Kyle, Koenings, and Edmundson, 1994); and where new opportunities exist, this action can be expected to improve the rearing habitat and produce additional sockeye salmon.

Potential Benefits: Lake nutrient enrichment has been used successfully in Canada and the United States to improve the freshwater survival rates of juvenile sockeye salmon and to produce more adult fish. Within the EVOS area, the magnitude of potential benefits from this action will depend primarily on the ability to identify new candidate lake systems in areas where returning adult fish may be harvested without risk of overharvesting existing wild stocks.

Potential Drawbacks: Wherever fish stocks are created or increased, there may be an interference with stocks that already are present. There may be a risk of overharvesting the existing stocks. Returning adult fish may stray into adjacent drainages, interbreed with naturally reproducing populations, and disturb the genetic makeup of those populations. Proper planning will reduce these risks (Appendix C, Section 1).

2: Migration corridor improvements entail mitigation of a barrier to fish migration that may prevent access to critical habitat for spawning or rearing and typically include installation of a fishpass or removal of a migration barrier. The construction of a fishpass (i.e., fish ladder or steep pass) is a permanent form of habitat modification to enable fish to access spawning and rearing habitat above an impassable barrier such as a waterfall.

Description: This technique can be applied either as a constructed fish ladder (i.e., made from concrete, steel, or aluminum) to bypass a barrier or as an alteration of the barrier itself (e.g., through explosives to provide a series of ascending resting pools); however, successful design, installation, and operation will depend on adequate preconstruction studies and evaluation, including estimates of high- and low-water flows and the geology of the area. Several agencies, including the USFS and ADF&G, have had experience throughout the EVOS area in these techniques over a broad range of conditions. Although these changes to the barrier are permanent, inspection and maintenance of the structures are required at regular intervals.

After a migration barrier that is located upstream from an established population of salmon is mitigated, the returning spawners may colonize the newly available habitat. However, it may require several generations before it is fully utilized. If there is no spawning population, a new spawning stock may be introduced by any of several methods that may include transplanting mature adult fish, eggs (e.g., in the gravel or in incubation boxes), or juvenile fish.

For sockeye salmon, a fishpass to access new spawning habitat will be of no value unless rearing habitat that is presently underutilized will be available for the fry that will be produced. If a spawning population must be introduced to colonize a newly accessible spawning area, that brood stock must be carefully chosen for the proper size, run timing, and behavior. Blackett (1979, 1984) described the installation and operation of a fishpass to establish chinook and sockeye salmon runs into the Frazer Lake system on Kodiak Island. This system, which had been blocked to anadromous salmon runs by a 10-meter- high falls, required four 64-meter-long runs of fishpass to maintain the new runs of fish.

Potential Applications: This technique to improve migration corridors has been widely applied throughout the EVOS area, especially in Prince William Sound, to increase populations of wild-stock pink salmon and to establish new populations by providing access to new or additional spawning habitat. It has been less widely applied for sockeye salmon because the juvenile sockeye salmon require the lake-rearing habitat, and it is more difficult to find a drainage system that both lacks access to spawning habitat and contains underutilized fry rearing habitat. Because this technique has been widely applied, in the EVOS area, many ideal locations already have been utilized (Willette et al., 1993).

Potential Benefits: Migration corridor improvements that create access to good quality spawning habitat is a proven technique to improve salmon populations; however, it will be effective for sockeye salmon only if the newly produced fry have access to rearing habitat that is presently underutilized. The potential benefit usually will be limited by the amount of available rearing habitat rather than the amount of new spawning habitat that is accessed. The installation usually is permanent, with a long lifespan.

Potential Drawbacks: Installation costs may be high. Routine inspection and minor maintenance are required. If substantial new populations are created, a harvest-management plan must be developed to minimize interference with management of other nearby stocks.

3. Egg incubation boxes have been used highly successfully in the Copper River drainage to develop a small wild-stock population of sockeye salmon into an estimated annual total return of approximately 200,000 adult fish with an estimated annual commercial harvest of over 100,000 fish (Roberson and Holder, 1993). Other early experiments to incubate sockeye and chum salmon eggs in egg incubation boxes in Prince William Sound were less successful (Jackson, 1974), but Pete Velsko (1993, oral comm.) has reported that egg incubation boxes have been used successfully to incubate chum salmon eggs in several drainages in the Nome area.

Description. The technique of egg incubation boxes involves use of large box (e.g., from 2x2x2 ft. to 4x4x8 ft.) in which fertilized eggs and selected gravel or artificial substrate are placed in alternating layers. Cool, oxygen-rich water is fed by gravity from an intake box, through a plumbing system, and up through the gravel and eggs in the incubation box. When properly installed, these units control the water flow, substrate type, sedimentation, and predation to provide egg-to-fry survival rates of over 80 percent (Roberson and Holder, 1993). This compares quite favorably with an expected survival rate of 12 to 43 percent for eggs laid and incubated in redds of naturally spawned sockeye salmon (Drucker, 1968) where egg survival may be affected either by washout in high-water conditions or desiccation in low-water conditions.

In-stream egg incubation boxes provide a low-cost restoration or enhancement technique that is ideally suited for small-scale, low-technology operations at remote sites. After the brood stock is spawned artificially and the eggs are placed in the unit, minimal care is required. When they are used for enhancement of indigenous stocks, these units can minimize the fish genetic and pathology concerns associated with transport of eggs or fry.

To successfully apply this technique, the following prerequisites are needed: (1) a high-quality, free-flowing (i.e., throughout the winter) spring water source; (2) adequate head differential to obtain sufficient gravity flow without installing excessive length of piping; (3) suitable stream bottom; and (4) a protected area for the incubation units. This technique will be successful for sockeye salmon, however, only if the fry that are produced can migrate into an underutilized lake rearing system with an adequate supply of zooplankton for forage.

Potential Applications: The potential contribution of egg incubation boxes for the restoration of sockeye salmon stocks in the EVOS area will be limited to drainages with (1) limited successful reproduction, (2) spring areas with appropriate physical features and water quality and quantity, and (3) underutilized rearing capacity for the sockeye salmon fry that are produced.

Although extensive surveys to locate potential sites to operate this technique have not been performed, good candidate sites are believed to exist in some drainagesfor application within the EVOS area.

Potential Benefits: Where an optimal location can be utilized, dramatic results can be attained (Roberson and Holder, 1993). Where suitable locations can be identified within drainages that presently support small populations of sockeye salmon, this technique may be applied to help restore those populations without a major intrusion into the environment or the fish stock.

Potential Drawbacks: This method requires substantial development to achieve dramatic results. Within individual drainages, however, it may be used to benefit individual stocks if underutilized rearing habitat also is available.

4. Net pen rearing is a practice that has been widely applied as a means to increase the survival rate of all salmon species. This technique, however, has been applied successfully only recently for sockeye salmon. This is because sockeye salmon are particularly susceptible to the disease "infectious hematopoietic necrosis virus" (IHNV). (Terry Ellison, 1993, oral comm.).

Although the net pen rearing technique has been applied in both freshwater and in saltwater, most success has been achieved with freshwater rearing because the early lifestages from only a few stocks of sockeye salmon can survive in saltwater. Burke (1993), however, described a highly successful program for rearing juvenile sockeye salmon to the smolt stage in saltwater net pens, but only after they first had been fed in freshwater hatchery raceways. Consequently, although net pen rearing of sockeye salmon in saltwater may have excellent potential for a hatchery-based application, it is of limited value for protection and restoration of wild stocks except where it may be used to create an alternate opportunity for commercial fishermen.

Juvenile sockeye salmon typically rear and grow in freshwater lakes for up to 3 years (Burgner, 1991). During this period, the mortality rate between the fry and smolt stages may range from 86 to 99 percent (Roberson and Holder, 1993), but fry held in net pens are largely protected from predators and food is provided, so the mortality rate is low while they are in the pens. Net pen rearing of sockeye salmon fry in freshwater lakes has not been widely applied; however, Schollenberger (1993) and Zadina and Haddix (1990) have reported good success with this strategy.

Description: Net pen rearing to improve the survival rate for juvenile wild-stock sockeye salmon first requires a source of captive fry. Fry may be captured as they emigrate from a spawning stream and placed in the rearing pen, or emergent fry may be collected from eggs incubated in a hatchery and transported to the rearing site. On-site personnel feed the fry, protect against predators and physical damage, and monitor the fish health. The objective of net pen rearing is to increase the survival rate of the fry to the smolt stage by providing protection and food to increase their growth and survival rates. With a faster growth rate, fry are expected to achieve a threshold size for smoltification during their first year of life (Zadina and Haddix, 1990). The increased survival rate contributes to a larger smolt population and, consequently, an increased return of adult fish. After the fry attain sufficient size, they are released--usually in the fall so they can overwinter naturally, smoltify, and emigrate to the ocean.

Schollenberger (1992, 1993) reported encouraging results from a net pen rearing project to restore a sockeye salmon run in English Bay Lakes in lower Cook Inlet. The English Bay Lakes sockeye salmon run had fluctuated widely and had declined since the mid-1970's, and lake rearing conditions were poor. After the implementation of the net pen rearing projects, the estimated percentage of age-1 smolts increased from 63 to 97 percent and the average size of age-1 smolts increased 10 percent in length and 31 percent in weight.

Zadina and Haddix (1990) reported that growth rates of pen-reared sockeye salmon fry were two to three times greater than those of free-ranging fry, and the estimated survival rate of the pen-reared fry was 92 percent compared with 34 percent for the free-ranging fry.

Potential Applications: Net pen rearing of sockeye salmon fry to increase their survival rate potentially may be employed in many systems throughout the EVOS area. Only two key ingredients are necessary: a source of fry and a suitable site to anchor and service the net pens. Fry may be captured from a spawning stream or transferred from a hatchery.

Potential Benefits: Careful application of the net pen rearing technique will increase the numbers of emigrating sockeye salmon smolts and returning adults with minimal undesirable effects on the population or the lake rearing system. The magnitude of the benefit will depend on the numbers of captive fry that can be accommodated.

Potential Drawbacks: Whenever any organisms are held captive in high density, they become more susceptible to disease or other catastrophic loss; however, this risk can be reduced by adjusting the loading density and application of good fish-cultural practices (ADF&G, 1983; Meyers et al., 1988; Schollenberger, 1993). Any fish-cultural activity may have some genetic consequence on the natural population (e.g., selective egg-take practices), but this introgression is reduced by using the indigenous stock and minimal manipulation activities (Davis et al., 1985).

5. Hatchery rearing of sockeye salmon has had a long history in Alaska, and this strategy has been improved during the last decade. It has produced dramatic innovations and results (Ellison, 1992). In Alaska, cultured juvenile sockeye salmon have been released as fed fry, presmolts, and smolts. Each lifestage has its own particular logistical, biological, and fish-cultural constraints and advantages. Fry are comparatively inexpensive to rear, transport, and release, but they require at least 1 year of rearing in a natural lake system before they smoltify, and they dol not survive to the adult stage as well as presmolts or smolts. Fry that are retained and fed in hatchery raceways may be released in late fall as presmolts. These young fish require few resources from the lake system during the winter and emigrate as smolts in the spring. Smolts are more expensive to rear and transport, but they survive to the adult stage at a higher rate, and they can be released as migrants without reliance on freshwater rearing.

Description: The hatchery rearing technique requires a source of fry from eggs taken from a spawning stock. After the eggs are incubated, the fry are held and fed in freshwater raceways until they are ready to release as fry, presmolts, or smolts (Burke, 1993). Emergent fry or short-term-reared fry may be released into a nursery lake if that the naturally-spawning population cannot fully stock the system. Fry that are released as presmolts are reared longer, nearly to the size of a smolt.

If the carrying capacity for sockeye salmon in nursery lakes is achieved by natural spawning, additional production cannot be achieved by releasing additional fry, but more adult fish can be produced by rearing and releasing sockeye salmon at the presmolt or smolt stages. Fish released as presmolts late in the growing season (immediately before freezeup) have a low metabolism, and they place little demand on the rearing environment in the lake (Carpenter, 1991). In spring, the fish feed and grow only slightly before they emigrate as smolts. Carpenter (1991) reported that sockeye salmon stocked as fry into Prince William Sound lakes had survival rates to age-1 smolts of 8.5 and 12.2 percent and that presmolts survived to age-1 smolts at a rate of 63.3 percent.

Sockeye salmon can be reared successfully to the smolt stage in hatcheries in approximately 1 year after they are hatched (Burke, 1993). Smolts are released at a larger size than presmolts, so they are more difficult and expensive to transport. They begin their migration immediately, however, so they will not compete with fry that may be in the nursery system. Care must be taken, in all cases, to ensure that the smolts are properly imprinted for good homing of returning adults.

Each hatchery-rearing strategy will improve the survival of sockeye salmon fry compared with fry that are naturally produced. Each strategy, however, relies on different intensities of human intervention, cost, and logistical constraints.

Potential Applications: Hatchery rearing sockeye salmon fry may be a useful technique to restore sockeye salmon populations in many drainages in the EVOS area, but fry can be stocked only into those systems that presently are underutilized by juvenile sockeye salmon.

Potential Benefits: Damaged wild stocks may be helped directly by a rearing and release program for that stock, or the wild stocks may be helped indirectly by creating an alternate opportunity--spatially or temporally--for the commercial fishers to divert fishing pressure away from the damaged stocks. For direct restoration, fry-rearing programs will be limited to those drainages where the forage is underutilized by naturally produced fry. Presmolt- and smolt-rearing programs, however, can provide direct restoration with little or no effect on plankton populations.

Potential Drawbacks: Whenever any organism is held captive in high density, it becomes more susceptible to disease or other catastrophic loss; however, this risk can be reduced by adjusting the loading density and application of good fish-cultural practices (ADF&G, 1983; Meyers et al., 1988; Schollenberger, 1993). Any fish-cultural activity may have some genetic consequence on the natural population (e.g., selective egg-take practices), but this introgression is reduced by using the indigenous stock and minimal manipulation activities (Davis et al., 1985).

6. Eyed-egg planting (i.e., burying salmon eggs in a stream bed after they have been incubated to the eyed stage) has been used successfully in Alaska to rehabilitate the early-run population of sockeye salmon in the Karluk River drainage (White, 1988). Historically, the Karluk River sockeye salmon run ranged from 1,000,000 to 5,000,000 fish, but from 1978 and 1987, escapements declined to an average of 323,000 fish. During recent years, however, sockeye salmon escapements into the Karluk River drainage have ranged from 440,000 to 996,000 fish after a total of 85,000,000 eyed sockeye salmon eggs were planted between 1978 and 1987 (White, 1988). This program, became the largest eyed-egg planting project ever conducted in the north Pacific (White, 1988), and it demonstrates the effectiveness of this technique.

The principle for this strategy is to improve the survival rate of the eggs that are delivered by the spawning female salmon. Fertilized sockeye salmon eggs, spawned and buried naturally in the stream bed, survive to the eyed stage at a rate of about 14 percent (Drucker, 1970), compared with a survival rate of 84 percent, for those that are incubated in a controlled system (White, 1988). Eggs survived from the eyed stage to emergent fry at an average rate of 42 percent after planting by hand compared with 30 percent of those spawned naturally (White, 1988). A higher survival rate from the egg to fry stage can be achieved by hatchery-rearing methods; however, the technique of eyed-egg planting is a more natural method, and it avoids the need for costly transport of the young fish from the hatchery to the stocking site.

Description: The technique of planting eyed salmon eggs in an acceptable stream substrate involves two steps. First, eggs are collected from the brood stock and incubated to the eyed stage. Second, the eyed eggs are introduced into a good-quality stream-gravel substrate after the gravel has been cleaned of fine materials. Bams (1985) and Harshbarger and Porter (1982) discuss several methods, including the most conventional method of digging with a shovel, but White (1980) described a simple but highly effective device to plant large numbers of eyed eggs quickly and efficiently with a high survival rate. This device injects a jet of water into the substrate to cleanse the gravel before the eggs are delivered.

Eyed-egg planting of salmon eggs may be a simple, low-cost restoration or enhancement technique that is ideally suited for small-scale operations at remote sites. After the brood stock is spawned and the eyed eggs are delivered, no other care is required. When it is used with indigenous stocks, this technique can minimize the genetic and pathology concerns associated with transport of eggs or fry. To successfully apply this technique for sockeye salmon, however, underutilized rearing habitat must be available for the fry that will be produced.

Potential Applications: The potential contribution of eyed-egg planting for the restoration or improvement of wild sockeye salmon stocks in the EVOS area will be very good in drainages that have spawning-type habitat that is reasonably accessible for egg planting and, for sockeye salmon, rearing habitat for the fry that are produced.

Although extensive surveys to locate potential sites to operate this technique have not been performed, potential sites are believed to exist in some drainages for the application of this technique for pink or sockeye salmon.

Potential Benefits: Where an optimal location can be utilized, dramatic results can be attained and, where suitable locations can be identified, this action may be applied to help restore or improve pink or sockeye salmon populations without a major intrusion into the environment or the wild-fish stocks. Within the EVOS area, there may be a number drainages where this technique may be applied to benefit individual stocks.

Potential Drawbacks: This method will require a substantial program to achieve dramatic, cost-effective results with sockeye salmon; and it cannot be successful for sockeye salmon unless the fry that are produced have access to underutilized rearing habitat.

Commercial Fishing

For commercial-fishing resources, the primary restoration action that is being considered will replace lost harvest opportunities by creating new runs of salmon. Other actions that may be considered should either alone, or collectively, produce sufficiently large numbers of wild stocks of adult pink, sockeye, or chum salmon to accommodate a reasonable portion of the fishing fleet by providing a harvest that is separated in time or space from existing harvests. These may include relocating hatchery runs, developing new hatchery runs (e.g., for stock fry, presmolts, or smolts), or manipulating habitat to increase production of selected stocks (e.g., lake fertilization, egg incubation boxes, etc.). Actions that are designed to increase pink and sockeye salmon production by habitat manipulation are described for those species.

Development of new runs of hatchery-produced salmon will provide a benefit for commercial fish by providing an alternate location, species, timing, or stock of salmon for harvest. If the brood stock selection for these new runs and the release site are carefully selected, there also will be minimal risk of interception of damaged wild stocks. Combined with good fishery management practices and a redistribution of the fishing fleet, an intensive commercial fishery can harvest these new runs.

This type of action has been employed already in the EVOS area (Ellison, 1992; ADF&G, 1994). Fish hatcheries may provide a tool to establish new fish runs; however, as with any tool, it must be used properly. First, the release location must be selected carefully. Juvenile fish must be transferred from the hatchery to the release site and, at the time of release, provisions must be made to assure that the young fish are imprinted properly to the release site to minimize straying by returning adult fish. After the adult fish return, the site for the terminal harvest must contain the fish (and the fishers) until the fish have been harvested. Second, the donor brood stock must be appropriate for the need (i.e., species, size, age, run timing, etc.), and the escapement of that stock must be sufficient to provide enough eggs for the new project. Third, guidelines established in the ADF&G Genetics Policy (Davis et al., 1985) and the Fish Health and Disease Control Policy (Meyers et al., 1988) must be followed. Finally, any proposed action must be consistent with permitting, planning, and review procedures for all fishery projects (Appendix C, Section 1). These procedures assure that new fishery projects will not interfere with wild-stock-management practices and that a fishery management plan is established before the first fishery is allowed.

Potential Applications: Potential new opportunities to relocate or establish hatchery runs in the EVOS area may be limited because ADF&G and PNP aquaculture organizations have established a modern fisheries enhancement program that began in the mid-1970's that has included the establishment of new runs. Few locations remain that provide ideal opportunities for large-scale juvenile fish imprinting and adult fish terminal-harvest areas that are readily accessible to the fishing fleets. Similarly, many systems that may have underutilized rearing lakes for potential sockeye salmon production already have been incorporated into an enhancement program (Kyle, 1994).

Potential Benefits: Fish hatcheries have been used successfully in Alaska to rehabilitate, enhance, or establish runs of salmon for harvest by commercial fishers. Excellent success has been achieved with sockeye (Ellison, 1992), pink, and chum salmon, although survival of the small pink and chum salmon fry is dependent on annual differences in nearshore water temperatures, food availability, and predator abundance (Heard, 1991; Salo, 1991). Other new runs at new locations or additional fish production at existing facilities or locations can be developed as well.

Potential Drawbacks: Hatchery-produced fish typically can be harvested at a higher rate than most wild stocks. Consequently, if wild stocks are mixed with hatchery-produced fish, there is a danger that the wild stocks may be overharvested (Hilborn, 1992; Seeb, 1993) unless a good harvest-management strategy is developed. The wild stocks may become depleted unless the hatchery-produced stocks can be harvested in a time or place that is separated from the wild stocks. Every fish-culture program must be carefully structured, planned, and controlled to avoid or minimize potential changes in the genetic makeup and health of the wild stocks that may be caused by the fish-cultural program (Hindar, Ryman, and Utter, 1991; Hilborn, 1992; Martin, Webster, and Edwards, 1992; Seeb, 1993; Holland-Bartels, Burger, and Klein, 1994; Appendix C, Section 1).

Sport Fishing

Sport fishing was disrupted throughout most of the EVOS area because of the oil spill, and damage was sustained by several important sport fish species. Lost sport fishing opportunities may be replaced by creating new sport fish fisheries for salmon or trout.

Establishment of hatchery runs will provide some benefit for all fishers by providing new opportunities with new locations, stocks, or timing; however, the greatest benefits to sport fishermen will accrue from new fisheries that are designed specifically for anglers. Typically, a run of a few thousand fish will provide tens of thousands of angler/days of recreation (Mills, 1993), compared with a commercial fishery, which often requires hundreds of thousands of salmon for a successful fishery. Sport fisheries, however, will be successful only if they are located where they can be accessible by anglers.

This type of action has been employed already by ADF&G to improve sport fishing opportunities for trout and salmon in the EVOS area. Hatchery-produced salmon and trout are released in locations with public access that are selected to minimize or avoid interactions with wild stocks. New anadromous salmon runs typically depend on releases of coho or chinook salmon smolts. Land-locked lakes usually are stocked with fry or catchable-sized rainbow trout, but coho and chinook salmon, Arctic char, Arctic grayling, and lake trout also are stocked to provide recreational angling.

Fish hatcheries may provide an excellent tool to establish new runs of fish; however, as with any tool, it must be used properly. First, the release location must be selected carefully. Juvenile fish must be transferred from the hatchery to the release site and, at the time of release, provisions must be made to assure that the young fish are imprinted properly to the release site to minimize straying by returning adult fish. After the adult fish return, the harvest site must contain the fish and accommodate the fishers with little or no impact on the wild stocks. Second, the donor brood stock must be appropriate for the need (i.e., species, stock, size, age, run timing, etc.), and the escapement of that stock must be sufficient to provide enough eggs for the new project. Third, guidelines established in the ADF&G Genetics Policy, Wild-Stock Policy, and the Fish Health and Disease Control Policy must be followed; and any proposed action must be consistent with permitting, planning, and review procedures for all fishery projects (Appendix C, Section 1). These policies and procedures assure that new fishery projects will not interfere with wild-stock management practices and that a fishery management plan is established before the first fishery is allowed.

Potential Applications: The existing sport fisheries enhancement program already has incorporated many good locations. Some barren lakes (e.g., in Prince William Sound) may be candidates for establishment of new sport fisheries, but, these also would require simultaneous development of an access trail from tidewater and an educational program to alert anglers about the new opportunities. The hatchery program can be expanded, and the production of catchable-sized fish can be increased to supply more fish and recreation in lakes that already are included in the existing ADF&G sport fishery enhancement program.

Potential Benefits: A small number of fish in a good location can provide angling to accommodate a substantial number of angler-days of recreation.

Potential Drawbacks: Wherever large number of fishers concentrate to harvest a concentrated population of fish, the riparian zone habitat may be damaged by the heavy foot traffic, and access trails will become established. Pristine areas may become disturbed by increased numbers of people. It is also unlikely that the lost sport fishing opportunities will be replaced directly by new opportunities. New sport fisheries will create new opportunities, but most likely for different species in new locations. A number of years will be required to expand hatchery production and refine transport, release, and management strategies; and several years also may be required for anglers to learn about and take advantage of the new opportunities provided by the establishment of new runs.

Literature Cited (Appendix C)

ADF&G. 1983. Fish Culture Manual. Alaska Department of Fish and Game. Division of Fisheries Rehabilitation, Enhancement and Development, 90 pp.

ADF&G. 1988. Prince William Sound Management Area Shellfish Management Report to the Alaska Board of Fisheries 1987/1988. Alaska Department of Fish and Game, Division of Commercial Fisheries, Cordova, 57 pp.

ADF&G. 1989. Prince William Sound Area Annual Shellfish Management Report 1988. Alaska Department of Fish and Game, Division of Commercial Fisheries, Cordova, 54 pp.

ADF&G. 1990. Fish Transport Permit. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement and Development, 12 pp.

ADF&G. 1990. Prince William Sound Area Annual Finfish Management Report 1998. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2C90-02, 162 pp.

Bams, R. 1985. Comparison of Three In Stream Incubation Techniques for Coho Salmon. North American Journal of Fisheries Management 5:159-172.

Bechtol, W. and N. Dudiak. 1988. The Development of the Leisure Lake Sockeye Salmon: Smolt and Adult Production Summary, 1977 to 1984. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation and Development, Report No. 83, 43 pp.

Bell, M. 1986. Fisheries Handbook of Engineering Requirements and Biological Criteria. U.S. Army Corps of Engineers, AD/A167 877, 290 pp.

Blackett, R. 1979. Establishment of Sockeye (*Oncorhynchus nerka*) and Chinook (*O. tshawytscha*) Salmon Runs at Frazer Lake, Kodiak Island, Alaska. Journal of the Fisheries Research Board of Canada 36(10):1265-1277.

Blackett, R. 1984. Progress Report - Frazer Lake Sockeye and Chinook Salmon Enhancement, 1978 and 1979. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement and Development, No. 36, 33 pp.

Blackett, R. 1987. Development and Performance of an Alaska Steeppass for Sockeye salmon (*Oncorhynchus nerka*). Canadian Journal of Fisheries and Aquatic Sciences 44(1):66-76.

Bonnell, G. 1991. Construction, Operation, and Evaluation of Groundwater-Fed Side Channels for Chum Salmon in British Columbia. Fisheries Bioengineering Symposium, American Fisheries Society Symposium 10:109-124.

Burgner, R.L. 1991. Life History of the sockeye salmon (*Oncorhyncus nerka*), pp. 1-119. *In*: Pacific Salmon Life Histories, C. Groot and L. Margolis, eds. Vancouver: UBC Press, 564 pp.

Burke, J. 1993. Some Conclusions from Sockeye Smolt Experimints at Main Bay Hatchery (1987 through 1990; Adult Returns through 1993). 1993 Sockeye Culture Workshop. Alaska Department of Fish and Game. Division of Commercial Fisheries Management and Development, in press.

Carpenter, G. 1991. Sockeye Salmon Fry and Pre-smolt Stocking at Pass and Esther Pass Lake in Prince William Sound. 1991 Sockeye Culture Workshop. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement and Development.

Davis, B., B. Allee, D. Amend, B. Bachen, B. Davidson, T. Gharrett, S. Marshall, and A. Wertheimer. 1985. Alaska Department of Fish and Game Genetic Policy. Genetic Policy Review Team, Alaska Department of Fish and Game, Division of Fisheries Rehabilitation Enhancement and Development, 25 pp.

Drucker, B. 1968. Red Salmon Studies at Karluk Lake, 1967. U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries. Auke Bay, Alaska.

Ellison, T. 1992. Development of Public and Private Hatcheries in Alaska. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement and Development. Presented at the Ninth Annual Meeting of the Aquaculture Association of Canada. Vancouver, British Columbia.

EVOS Trustee Council. April 1993. Draft EVOS Restoration Plan. Summary of Alternatives for Public Comment. 10 pp.

EVOS Trustee Council. November 1993. Draft *Exxon Valdez* Oil Spill Restoration Plan. 36 pp.

Harshbarger, T. and P. Porter. 1982. Embryo Survival and Fry Emergence from Two Methods of Planting Brown Trout Eggs. North American Journal of Fisheries Management 2:84-89.

Heard, W.R. 1991. Life History of the Pink Salmon (*Oncorhyncus gorbuscha*), pp. 119-231. *In*: Pacific Salmon Life Histories, C. Groot and L. Margolis, eds. UBC Press. Vancouver: 564 pp.

Hilborn, R. 1992. Hatcheries and the Future of Salmon in the Northwest. Fisheries 17(1):5-8.

Hindar, K., N. Ryman, and F. Utter. 1991. Genetic Effects of Cultured Fish and Natural Fish Populations. Canadian Journal of Fisheries and Aquatic Sciences 48:945-957.

Holland-Bartels, L., C. Burger, and S. Klein. 1994. Studies of Alaska's Wild Salmon Stocks: Some Insights for Hatchery Supplementation. Presented at the North American Wildlife and Natural Resources Conference. Anchorage, Alaska.

Jackson, J. 1974. Results of Gravel Incubator Experiments in Prince William Sound. Alaska Department of Fish and Game, Division of Commercial Fisheries, Prince William Sound Management Area, Data Report No. 6, 15 pp.

Koenings, J., M. Kaill, J. Clark, L. Engel, M. Haddix, and P. Novak. 1979. Policy and Guidelines for Lake Fertilization. Alaska Department of Fish and Game, 27 pp.

Kyle, G., J. Koenings, and J. Edmundson. In press. An Overview of Alaska Lake-Rearing Salmon Enhancement Strategy: Nutrient Enrichment and Juvenile Stocking. *In*: Alaska Freshwaters. Springer-Verlag.

Leon, K. 1987. Benefit-Cost Differences Caused by the Effects of Rearing and Time of Release of Hatchery-Produced Pink and Chum Salmon. *In*: Proceedings of the 1987 Northeast Pacific Pink and Chum Salmon Workshop, pp. 157-161. P. Rigby, ed. Anchorage, Alaska. February 1987. Alaska Department of Fish and Game, 223 pp.

Marshall, D. 1985. Development and Assessment of Groundwater-Fed Side Channels. Proceedings of the 1985 Pink and Chum Salmon Workshop. Department of Fisheries and Oceans, Canada: 107-110.

Martin, J., J. Webster, and G. Edwards. 1992. Hatcheries and Wild Stocks: Are They Compatible? Fisheries 17(1):4.

Martin, R., W. Heard, and A. Wertheimer. 1981. Short-term Rearing of Pink Salmon (*Oncorhynchus gorbuscha*) fry: Effect on Survival and Biomass of Returning Adults. Canadian Journal of Fisheries and Aquatic Sciences 38: 554-558

Mattson, C. 1980. Innovations and Guidelines for Alaskan Salmon and Enhancement Channels. Proceedings of the 1980 Pink and Chum Salmon Workshop. Alaska Department of Fish and Game :154-261.

Meyers, T., P. Krasnowski, D. Amend, B. Bachen, J. Cochran, K. Hauck, K. Rawson, and R. Saft. 1988. Regulation Changes, Policies and Guidelines for Alaska Fish and Shellfish Health and Disease Control. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement and Development, 72 pp.

Mills, M. 1993. Harvest, Catch, and Participation in Alaska Sport Fisheries During 1992. Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series No. 93-42, 228 pp.

Peltz, L. 1994. The Role of Fish Hatcheries in the Sport Fisheries of the State of Alaska. Presented at the North American Wildlife and Natural Resources Conference. Anchorage, Alaska.

Roberson, K. and R. Holder. 1993. Gulkana Hatchery Sockeye Salmon Enhancement Project Historical Data Summary, 1973-1993. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Regional Information Report No. 2A93-30, 107 pp.

Salo, E. 1991. Life History of Chum Salmon (*Oncorhynchus keta*), pp. 231-309. *In*: Pacific Salmon Life Histories. Groot, C. and L. Margolis, eds. Vancouver: UBC Press, 564 pp.

Schollenberger, M. 1992. English Bay Sockeye Enhancement Project. Draft Progress Report, unpublished, 43 pp.

Schollenberger, M. *In*: English Bay Sockeye Salmon Freshwater Net Pen Rearing and Smolt Production, 1991-1993. 1993 Sockeye Culture Workshop. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development.

Seeb, J. 1993. Wild Stocks: Why Do We Want to Save Them? Alaska's Wildlife 25(2):5-7.

White, L. 1988. Karluk Lake Sockeye Salmon Investigations. Section C, Successful Rehabilitation of Upper Thumb River Sockeye Salmon Stock. Federal Aid in Anadromous Fish Conservation, AFS 52-3, 28 pp.

White, L. 1980. Evaluation of a New Planting Device for Salmon Eggs. The Progressive Fish-Culturist 42(3):177-180.

Willette, M., N. Dudiak, L. White, and K. Wedemeyer. 1993. Survey and Evaluation of Instream Habitat and Stock Restoration Techniques for Wild Pink and Chum Salmon. EVOS Trustee Council, Restoration Implementation Project No. R105, 1992 Draft Status Report.

Zadina, T. and M. Haddix. 1990. Net Pen Rearing of Juvenile Sockeye Salmon (*Oncorhynchus nerka*) in Hugh Smith Lake, Southeast Alaska. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation and Development, No. 10, 26 pp.

Zemke, S., C. Casipit, and B. Rickel. 1987. Fish Habitat and Enhancement Program for Pink and Chum Salmon on the Ketchikan Area, Tongass National Forest. Proceedings of the 1987 Pink and Chum Salmon Workshop. Alaska Department of Fish and Game :177-182.

Appendix D

Economic Analysis

Appendix D
Economics Methodology

The Forest Service's IMPLAN (Impact PLANning) econoic computer model was used in the quantitative analysis of the economic impacts of the proposed Restoration Plan alternatives. In preparing data for use as input in the IMPLAN economic model, several factors that are unique to the *EVOS* area have been considered. The first factor involves Section 7(i) of ANCSA that requires the sharing of proceeds from timber sales by one Native Corporation with the other Native Corporations. Accordingly, spending the proceeds of timber sale monies within the *EVOS* area would be less than the amount spent from monies received from habitat purchase (i.e., some of the money from the proceeds of timber sales would be distributed and spent by Native Corporations outside the oil spill area). Another factor considered involves an assumption that most habitat purchases are from stocks of commercial timberland. This assumption is based on the criteria used for determining potential parcels available for acquisition under the habitat protection option presented in the Draft Restoration Plan. Timberland purchases reduce economic activity more than purchases of non-commercial land because timberland provides regional employment, non-commercial land does not. On the other hand, proceeds from non-commercial land are not shared and are more likely to remain in the regional economy, thus creating jobs within the region. With regard to the funds received from the sale of timber, the sharing requirements of ANCSA represent a significant expenditure outside the regional economy, or as economists describe this phenomenon, there is a "strong leakage" from the regional economy.

By inputing the various allocation of expenditures into the IMPLAN model, different measures of economic performance (output) are produced. For the purposes of this economic impact analysis, six measures of economic performance are used in the economic analysis. These measures are presented numerically in tables of economic analysis for each of the alternatives.

The dollar value change is determined by: the lump sum amount of the remaining funds; the percent allocation each category receives of the remaining funds; a deflator to turn the settlement's 1993 dollars into IMPLAN's 1990 dollars; and a factor that turns the lump sum amount into an annual amount. For the purpose of this analysis, spending occurs over the ten year period during which restoration funds are being received.

The results of the IMPLAN economic impact analysis for allocating (spending) the remaining $620 million of the civil settlement funds in five alternatives spending scenarios were analyzed. The spending represents annual average amounts continuing for ten years. The results are given for the six economic indicators described previously, and by sector.

Table 3-3 in Chapter 3 depicts the regional economy as it currently exists with no consideration of restoration fund spending. Analysis of the spending alternatives identify absolute change from the baseline year of 1990.

In recent decades in the EVOS area the timber industry has shown cyclical fluctuations while the recreation industry has shown a relatively steady increase. The economic analysis of alternatives is of annual averages over a ten-year period. These different trends for the timber and recreation industries are averaged out also.

The analysis considers direct, indirect and induced spending for each alternative. Direct spending is spending for the demand change. Indirect spending is spending in the industries linked to the direct spending. Induced spending is caused by the changes in income that were generated by the direct and indirect spending. For example, the purchase of commercial timberland for habitat decreases output and employment in the forest product industry (direct effect) and in the industries that supply the forest product industry (indirect effects). These decreases cause regional income and employment to fall and further reduce spending in the economy (induced effects). However, habitat purchases increase the income of landowners. The spending of this income increases demand for the products they buy (direct effects) and for the industries that supply the directly affected industries (indirect effects). The increase in demand increases employment and income and stimulates the economy (induced effects). The impact analysis models these spending flows and reports the results in total and by sector.

IMPLAN's data is from the 1990 U.S. Census, the U.S. Department of Labor and the Bureau of Economic Analysis of the U.S. Department of Commerce. Although the data comes from sampling, the results approximate the characteristics of the population. Probability theory shows that the results of the repeated sampling vary around the population value in a normal distribution. For example, under a normal distribution, 95 percent of the sampled estimates are within (plus or minus) 1.96 standard deviations of the population characteristic. In other words, a value greater than plus or minus 1.96 standard deviations is not the result of a random event.

These considerations suggest assessing the significance of the modeling results by reference to the standard deviation of the underlying data. The impact procedure: first, samples baseline regional employment; then, spends the civil settlement; then, calculates regional employment. A statistically significant change occurs if, for example, two employment estimates differ by roughly two standard deviations. Alternatively, assume employment changes are assessed by sampling employment before and after the spending of the civil settlement. The two estimates do not differ significantly if they are within two standard deviations. Any change in sampled employment could be attributed to a random factor such as sampling error.

For comparison purposes, the standard deviation for 1990 employment in the boroughs of Anchorage, Kenai, Kodiak and Valdez-Cordova is 684. A significant change in regional employment is an increase or decrease of 1368. Any change between zero and 1368 could be the result of sampling and not attributable to settlement spending according to this statistical analysis.

For the regional economy as a whole, each alternative leaves the baseline unchanged. The employment changes are not more than twice the standard error for the underlying employment data.

Since total employment changes are insignificant and since employment changes are the largest relative changes, then, a first conclusion is that the performance of the regional economy is left unchanged by each of the five spending alternatives.

There are sector changes that may be statistically significant. However, information is unavailable to assess quantitatively the statistical significance of these results. The sectoral changes, however, are larger in relative terms than the total changes. Accordingly, it is likely that the sectoral shifts cannot be attributed to chance. The sectoral changes reflect (1) the purchase of commercial timberland for habitat preservation, (2) the spending of the sale proceeds, and (3) the spending of the remainder of the settlement for other goods and services. Thus, a second conclusion is that the spending alternatives may change the economy's reliance on specific sectors.

A limitation of these results and those from any economic analysis is that only market commodities are included and they are valued at market prices. Non-market activities such as barter, subsistence fishing/hunting, experiences whose price is essentially zero, or the willingness-to-pay for the simple existence of wilderness, are not addressed. The implication of this is simply that economic analysis should be supplemented with other, non-market analyses.

The category "Respending of Habitat Protection" is part of the modeling exercise but does not appear in the tables for the Alternatives. However it should be noted that habitat purchases put dollars in the hands of resource owners. This category specifies a spending pattern for these funds that saves/invests part (securities, construction) and consumes part (social services).

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