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Chapter I: Purpose and Need for Action

Introduction

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 oil spill in U.S. history. Approximately 11 million gallons of North Slope crude oil 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 I-1 shows the extent of surface oiling as recorded by satellite observation at the time of the spill.

The weather for the first 3 days following the spill was calm and did not move the oil 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 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. Seventy-two 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.

Litigation and Settlement

After the spill, both President George Bush and Alaska Governor Steve Cowper declared their intent to restore both the affected ecosystem and 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 were also filed. The Federal Government brought criminal charges under the Clean Water Act (33 U.S.C. 1251 *et seq.*), the Migratory Bird

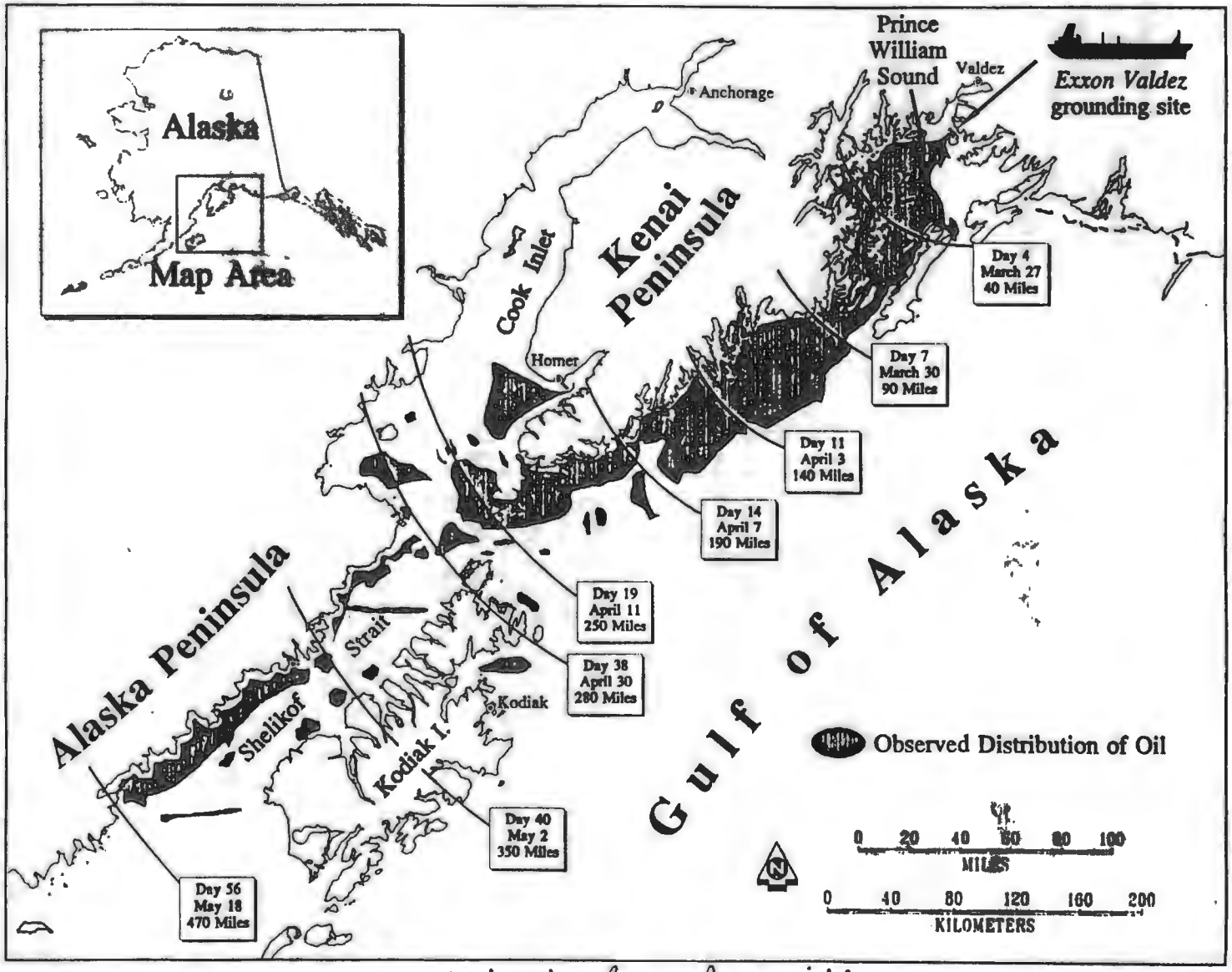

Figure I-1. Extent of surface oiling

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Treaty Act (16 U.S.C. § 703 *et seq.*). Private citizens also made claims for damages against Exxon, many of which are still pending.

Terms for a settlement between the Exxon companies and the United States and the State of Alaska were approved 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. These payments are deposited in the registry of the Federal District Court in Alaska and invested Federal Court Registry Investment System. As funding needs for restoration projects are identified, the Trustees apply for disbursement of funds from the court 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 this agreement, 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 Memorandum of Agreement (MOA) also provides for the reimbursement of certain spill-related expenses such as litigation costs, cleanup, and damage assessment.

To date, the Trustees have authorized approximately $200.2 million in expenditures from the restoration fund. The Trustees released $107.5 million to reimburse the Federal and State governments for the cost of past damage assessment, cleanup, litigation, response, and restoration expenses. A total of $39.9 million was credited to Exxon for cleanup costs incurred after January 1, 1991. A total of approximately $19.5 million was spent on developing and implementing the 1992 Annual Work Plan. The 1993 Annual Work Plan was allocated $33.3 million, including $7.5 million for the purchase of Kachemak Bay. In May 1993, the Trustees entered negotiations to buy property at Seal Bay for approximately $38 million. Final negotiations were pending at the time of writing. It is estimated that an additional $70–$90 million will be required to reimburse the Federal and State governments for past expenditures on cleanup and litigation.

The MOA provides that the Trustees are responsible for making all decisions regarding funding, injury assessment, and restoration. Six organizations have been designated to serve as Trustees, three representing the State of Alaska and three representing 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 (DOI), the Secretary of the U.S. Department of Agriculture (USDA), and the Administrator of the National Oceanic and Atmospheric Administration (NOAA). Each of the Federal Trustees appointed a representative to the Alaska-based

Trustee Council, which oversees restoration planning and implementation activities. The Regional Forester of the Forest Service represents USDA, the Special Assistant to the Secretary of the Interior represents DOI, and the Regional Director of the National Marine Fisheries Service represents NOAA. The planning, evaluation, and conduct of restoration activities must be made by the unanimous agreement of the Trustees.

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 regulations. 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, had already 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 are therefore 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. These funds are not controlled by the Trustees, but 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.

Proposed Action

The proposed action is to restore the injured natural resources and services by implementing a Restoration Plan. The Draft Restoration Plan issued in conjunction with this Draft Environmental Impact Statement (DEIS) presents five general approaches to restoration. The final restoration approach will be decided by the Trustees, and the effects analysis in the DEIS will be considered in their decision. The Final Restoration Plan will provide broad, long-term guidance for the use of the funds from the civil settlement to implement restoration projects for the Exxon Valdez oil spill (EVOS). To assist in the management of these funds, the Trustee Council has identified the oil spill area as shown in Figure I-2. The EVOS 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.

A Draft Restoration Plan has been prepared for public review and comment. As indicated above, it presents five alternative approaches to restoring the injured resources and human uses those resources support. Each of the alternatives sets priorities for funding allocations, and provides decisionmaking parameters. Each of the alternatives is made up of varying proportions of the four restoration categories of administration, monitoring, habitat protection, and general restoration. Within the category of general restoration, there are 25 options. The term "option" refers to a general category of actions designed to achieve a

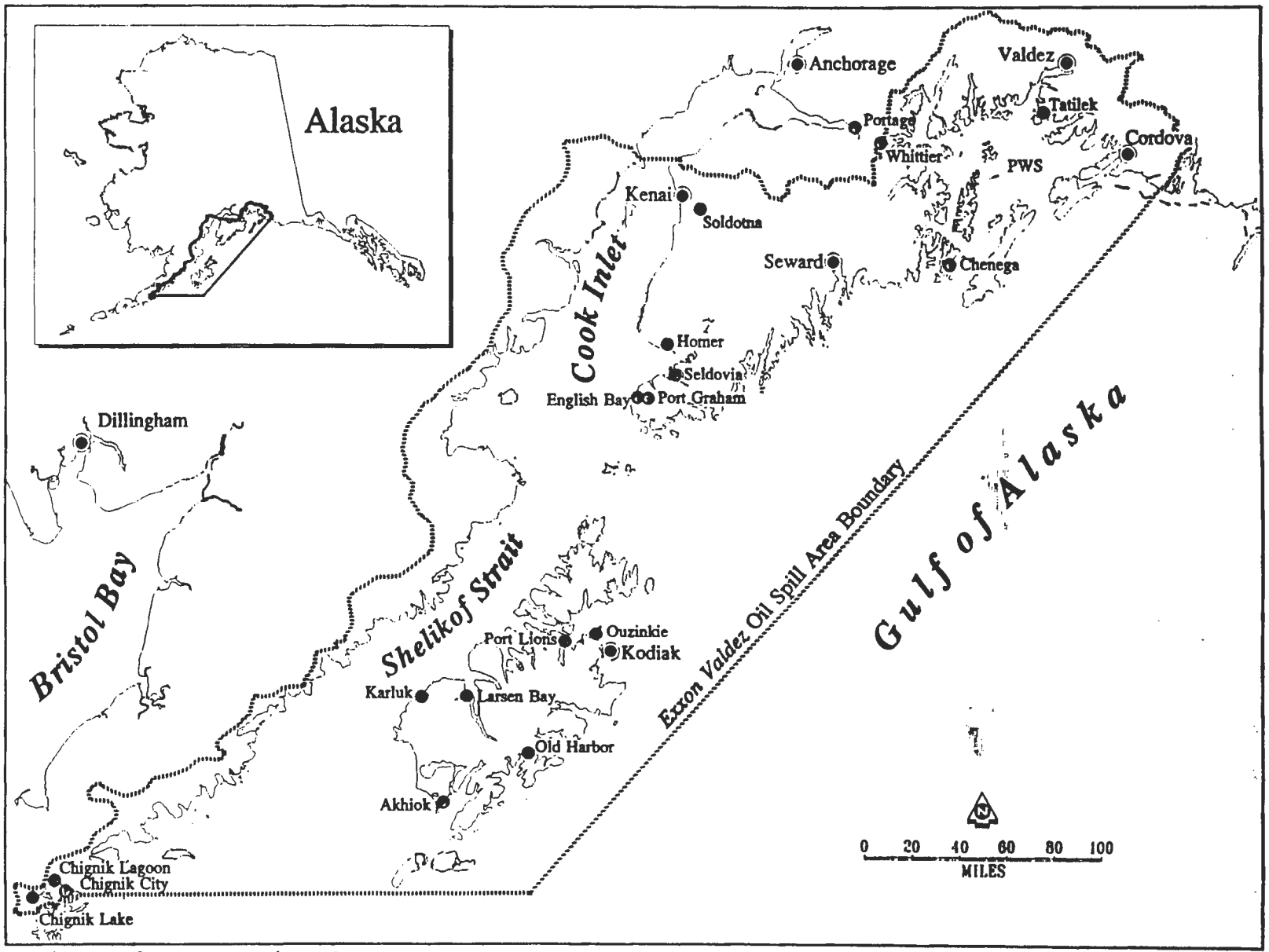

Figure I-2 Location Map.

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particular objective. Actions is the term used to refer to site-specific projects to be implemented to achieve the option goals. The analysis contained in this DEIS pertains to the alternatives and the options, but does not consider individual actions. Appropriate site-specific environmental documents will be written by the appropriate agencies for all future actions that require additional analysis.

Purpose and Need for Action

Following public review and comment on the Draft Restoration Plan, the Trustees will select a preferred alternative for implementation. This alternative will be the focus of the Final Restoration Plan. The Final Restoration Plan will assist the decisionmaking process by establishing management direction for the identification and selection of activities for restoring injured resources and services. Program-level guidelines will assist in the evaluation and implementation of future proposed restoration activities. These activities will be developed as part of an Annual Work Program and will be evaluated by the criteria 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 Draft Restoration Plan describes the five alternative courses of action, including the no action alternative, explains the evaluation criteria used, and outlines the differences among each of the alternatives. It discusses an approach to implementing the alternatives. The Restoration Plan also covers administration, funding allocation guidelines and mechanisms, monitoring, and public participation. 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.

Each restoration alternative is made up of four types of activities, and the alternatives place different emphasis on each category:

- 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 rights to privately held land, or changing the management of publicly held land.

- General restoration.

  This activity includes options that manipulate resources directly, such as building new fish passes. It also includes options that manage human use of affected areas, such as a plan to reduce human disturbance near seabird nesting areas.

- Monitoring and research.

This activity is designed to determine whether the environment is recovering and what can be done to accelerate the recovery process. Monitoring falls into three subcategories: recovery monitoring, restoration monitoring, and ecosystem monitoring. Restoration research could clarify the causes of poor or slowed recovery, and design, develop, and implement new technologies and approaches to help restore resources and services not recovering or recovering at lower than expected rates.

- Administration and public information activities.

  Funding ~~levels~~ for these 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 increases. This category also includes providing information to the public about restoration activities and the progress of recovery.

Public Participation Process

Roles of the Agencies

The Trustees selected the USDA Forest Service to act as the lead agency in developing the Environmental Impact Statement for the Restoration Plan (see 40 CFR 1501.5–7, 1503.1, and 1508.16). In this capacity, the Forest Service has used its implementing regulations, policies, and procedures for ensuring compliance with NEPA regulations. The Forest Service selected and supervised third-party contractors to produce the analyses and public scoping documents, including this DEIS. Contractors provided impartial analysis and input, as well as an independent evaluation of the Draft Restoration Plan. The Department of Interior, the National Marine Fisheries Service, the Alaska Department of Natural Resources, the Alaska Department of Environmental Conservation, and the Alaska Department of Fish and Game are cooperative agencies with the Forest Service in the NEPA process and scoping of the action.

The lead agency is responsible for coordinating the public scoping process, which is required by 40 CFR 1501.7. The scoping process is defined as "an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action." During the scoping process, the Forest Service coordinated with affected Federal, State, 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 EIS. As required by Forest Service policy, the planning record for the Restoration Plan EIS 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 Memorandum of Agreement between the Federal and State governments requires meaningful public involvement. Toward that end, 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 were also 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 opportunity to provide identify issues to be addressed related to the proposed action, the Trustee Council held four sets of public meetings. The first set, held in January - February 1992, was 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 as input 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 Draft EIS. A third round of meetings was held in April 1993 to collect public comments on the Summary of Alternatives for Public Comment, released in April 1993. 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. 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 Trustee Council on all matters relating to the planning, evaluation, and allocation of funds, as well as the planning, evaluation, and conduct of injury assessments and restoration activities. This group is made up of 15 members and 2 *ex-officio* members who represent a cross-section of the interest groups and the public affected by and concerned about the spill.

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?

- For 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 pre-spill levels?

- 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 action be limited to the spill area, or should actions 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 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. The public also raised many issues that are relevant to developing the Restoration Plan, but not relevant to analyzing the effects of the alternatives. Those issues are identified in the Restoration Framework document published in April 1992 and in the Draft Restoration Plan.

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 has expressed interest 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, acreage or sites protected from development or other physical encroachment, changes in human use or management, or changes in aesthetic quality could also affect the rate and degree of recovery.

Issue 2: How would activities directed at injured resources and services affect non-target resources and services?

Each of the proposed restoration options aims to aid a particular resource or service; 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 could also indirectly affect non-target resources and services. Potential impacts include changes in the number or structure of non-target species populations as a result of restoration-associated changes in the amount or quality of available habitat or food sources.

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

Ecological change 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. Many of the proposed activities aim to change ecosystem diversity and species abundance. Specific ecological changes include structural changes in habitat and changes in species populations.

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. The number and kinds of new jobs, as well as the income associated with them, are of interest to the public. There is also concern that employment could be reduced in some resource development industries that may be adversely affected by some restoration options. Additionally, the effect of increased or decreased employment on the economy and services of the local communities 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 or enhancement 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 land management 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 will be considered in this analysis.

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. Restoration activities may focus on increasing the abundance of natural resources used for subsistence in the area or increasing access to resources not previously available for subsistence harvest. Subsistence use may also 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 and publicizing research to determine the level of persistent contamination, if any, in harvested resources.

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. Full public participation would be sought before any changes would be made to the Restoration Plan.

Draft Environmental Impact Statement Organization

An Environmental Impact Statement serves as a decision-aiding tool to ensure that Federal agency actions take into consideration the policies and goals of NEPA. An EIS is prepared by integrating as many of the natural and social sciences as may be warranted based on the potential effects of the proposed action. The direct, indirect, and cumulative impacts of the proposed action are analyzed. This document is a program-level EIS; it addresses only the

alternatives proposed for the Restoration Plan. Specific actions and/or projects to be implemented in the future would require additional environmental assessment.

Chapter I of this Draft EIS document has presented the purpose and need for action by describing the background circumstances, the proposed action, and the management process involved. Chapter II presents the five alternatives being considered for implementation as the final Restoration Plan. It briefly describes each of the alternatives and highlights the differences among them. In Chapter III, an overview of the affected environment is presented. This chapter describes the physical, biological, and socioeconomic environment and conditions of the EVOS area. Chapter IV contains the results of the environmental impact analysis and presents the projected effects of each of the proposed alternatives. Supplementary information, including a glossary, list of preparers, species list, and reference list, is included in the latter portions of this document.

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Chapter II: Alternatives Considered

Introduction

The *Exxon Valdez* Restoration Plan contains five potential alternatives for restoration. These alternatives, including the required "no action" alternative, are briefly described in this chapter. 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. For more detailed information about the alternatives, please refer to the Restoration Plan.

Each of the alternatives is made up of several 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 25 options, i.e., general types of actions designed to achieve a particular objective in relation to an injured resource or service. The Trustees are seeking public input on five policy questions in regard to the Draft Restoration Plan:

- Which resources and services should be targeted?
- How long should restoration actions last?
- Which restoration actions should be undertaken?
- In what geographic area should actions be taken?
- To what extent, if any, should restoration actions create or enhance opportunities for human use?

Alternative 1: No Action

The "no action" alternative required by 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 their responsibilities would remain unchanged. None of the funds from the civil settlement would be spent if this alternative were implemented.

The following paragraphs briefly summarize 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 primary 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 maintaining wild stock habitat.

The *National Oceanic and Atmospheric Administration*'s 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 whales and pinnipeds in Alaska; 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* 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, 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 *Alaska Department of Environmental Conservation* is a regulatory agency that oversees activities that could directly affect resources by pollution or environmental damage. It formulates regulations limiting the amount, kind, and location or other restrictions necessary to limit pollution and issues discharge permits. The Department of Environmental Conservation is involved in education efforts and technology transfer directed at reducing pollution.

The *Alaska Department of Natural Resources* manages State land and resources and regulates timber harvest on private and State land under the Alaska Forest Practices Act. In the spill area, the Department of Natural Resources 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* is charged with managing and protecting the fish, game, and aquatic plant resources of the State. Functions include managing harvests to ensure sustained yields of fish and game, granting permits for activities in fish-bearing and anadromous streams, administering ADF&G Special Areas, overseeing 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. ADF&G also makes management recommendations to the State Board of Fisheries and Game, which are responsible for establishing harvest regulations. ADF&G has the authority to order emergency harvest openings and closures.

Alternative 2: Habitat Protection

The goal of Alternative 2 is to protect strategic lands and habitats important to the long-term recovery of injured resources and services from further damage. 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.

Figure II-2 displays the potential allocation of funds for this alternative. The majority of the funds would be used to acquire and protect lands within the spill area. The potential allocations are illustrative only and do not represent a commitment of actual resources.

Alternative 3: Limited Restoration

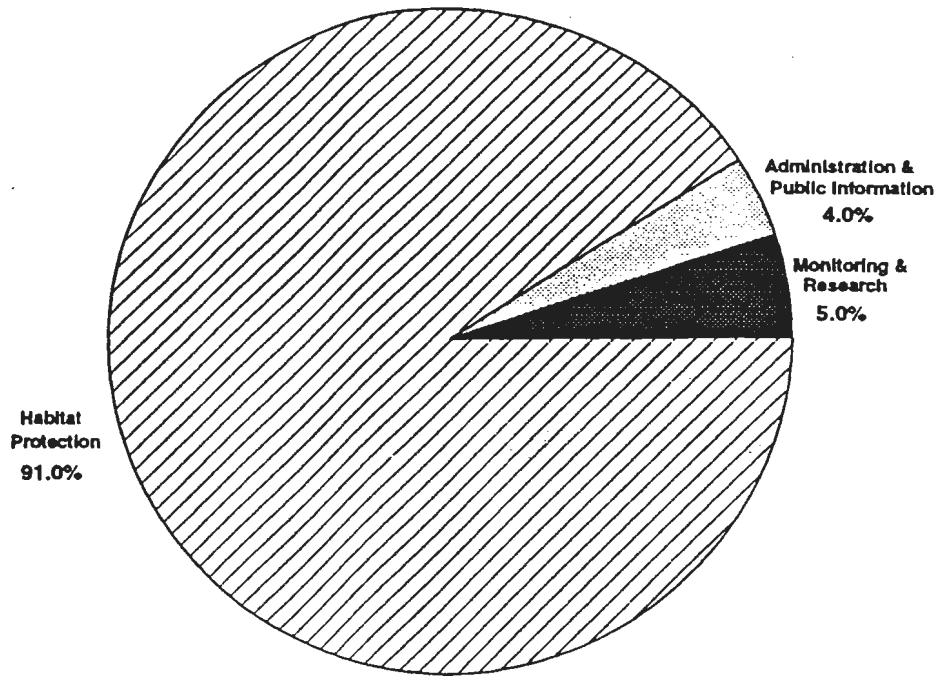

Figure II-2. Potential Allocation of Funding for Alternative 2: Habitat Protection

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 would 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.

Figure II-3 displays the potential allocation of funds for Alternative 3. Although the majority of the funds would be used to acquire and protect lands within the spill area, this alternative also includes funding for general restoration activities. The potential allocations are illustrative only and do not represent a commitment of actual expenditures.

Alternative 4: Moderate Restoration

This alternative is broader than Alternative 3 in that it aims to aid recovery of all injured resources and services, not only the most injured. 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 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 would increase opportunities for human use to a limited extent. Monitoring and research would be conducted.

Figure II-4 displays the potential allocation of funds for Alternative 4. 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. The potential allocations are illustrative only and do not represent a commitment of actual expenditures.

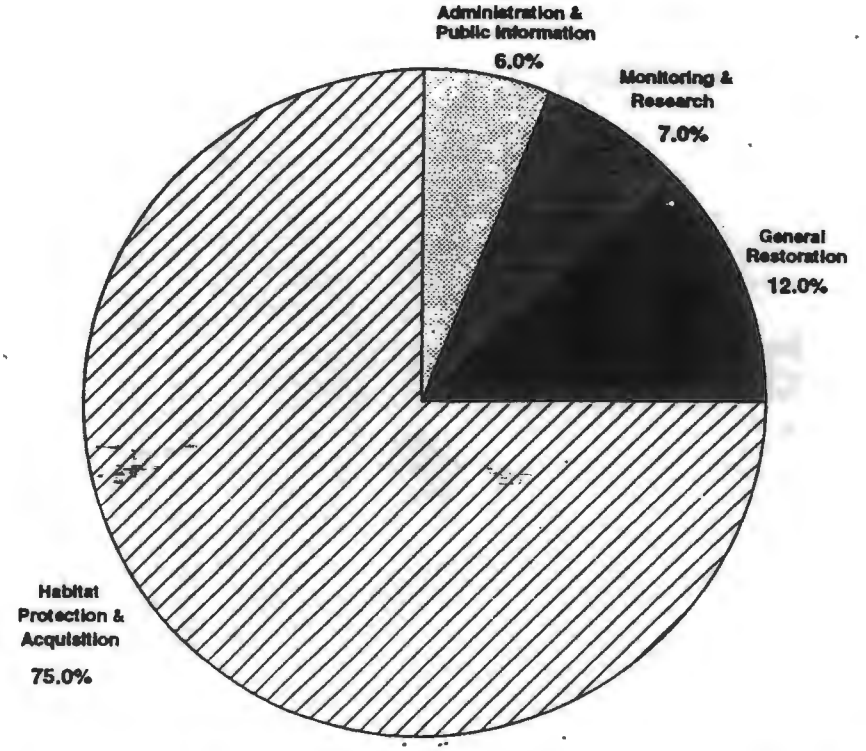

Figure II-3. Potential Allocation of Funding for Alternative 3: Limited Restoration

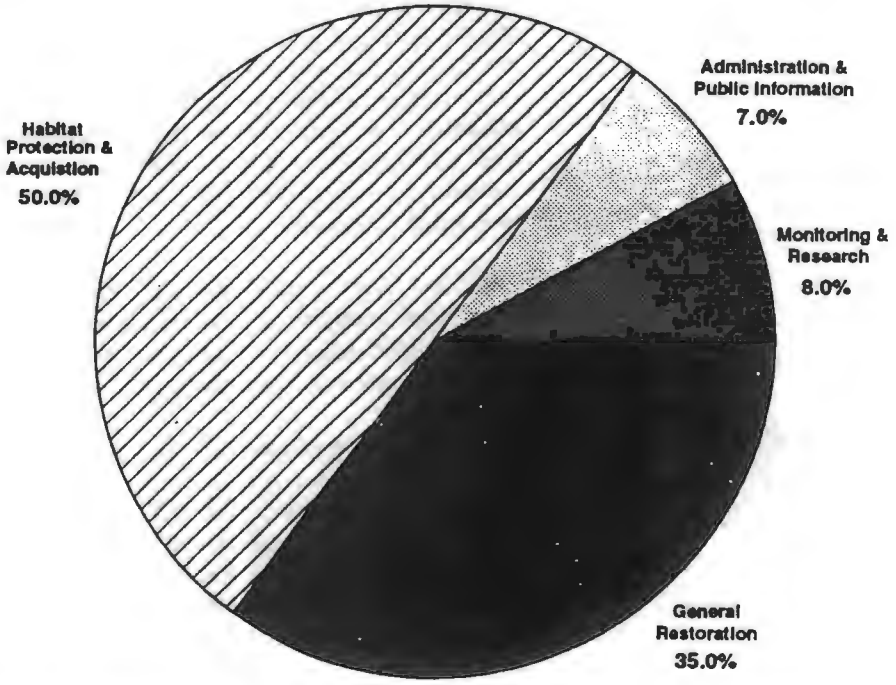

Figure II-4. Potential Allocation of Funding for Alternative 4: Moderate Restoration

Alternative 5: Comprehensive Restoration

Alternative 5 is the broadest in scope of the proposed alternatives. It would help all injured resources and services, both within the spill area and in other parts of Alaska. Unlike Alternatives 3 and 4, this alternative includes actions to aid resources and services that have already recovered, as well as those that have not. Actions likely to produce some improvement over unaided recovery would be allowable under this alternative. Habitat protection is a smaller part of this alternative. Alternative 5 also allows for expansion of current human use and encourages appropriate new uses. Monitoring and research would also be included.

Figure II-5 displays the potential allocation of funds for Alternative 5. As the pie chart shows, funding percentages under this alternative are projected to be more evenly distributed among the action categories. The potential allocations are illustrative only and do not represent a commitment of actual expenditures. In this alternative, the majority of funds would be used for general restoration activities. The percentage allotted to habitat protection and acquisition is the least of all the alternatives except the "no action" alternative.

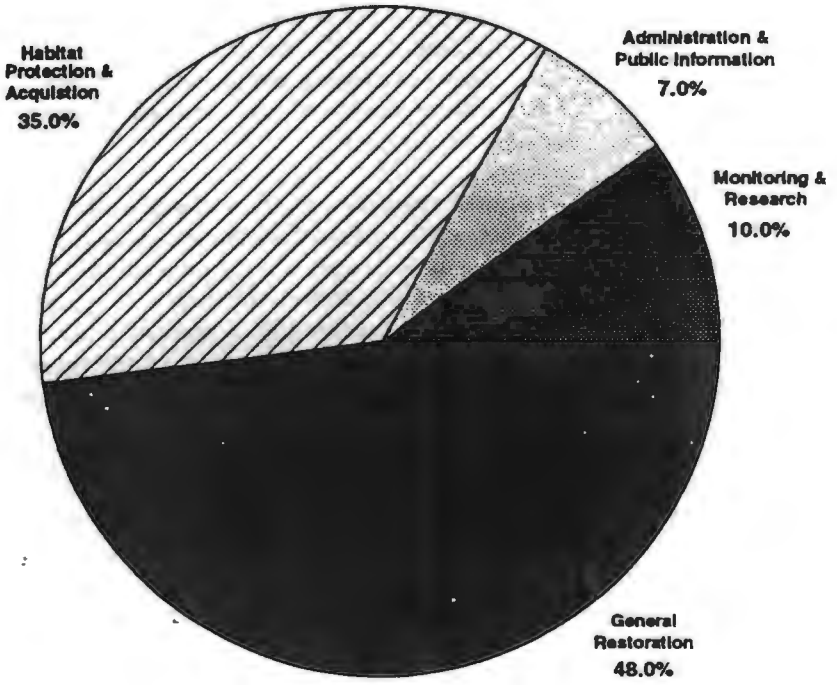

Figure II-5. Potential Allocation of *Funding for Alternative 5: Comprehensive Restoration*

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.

An alternative was developed with a theme and policy direction that fell between Alternatives 4 and 5. However, this alternative was dropped from detailed consideration because it was not significantly different from the other alternatives.

Comparison of the Alternatives

Each alternative in the Draft Restoration Plan is structured to give varying degrees of emphasis among the four categories of habitat protection and acquisition, general restoration, monitoring and research, and administration and public information. The no action alternative, (Alternative 1) does not contemplate any activities in these categories above and beyond normal agency management actions.

The comparative emphasis on categories of actions for Alternatives 2 through 5 is illustrated in Figure II-6. The essential variation among the alternatives has to do with the balance between habitat protection and restoration activities. Alternative 2 is principally habitat protection with no restoration activities, whereas Alternative 5 proposes roughly identical emphasis for these two categories.

The restoration category of actions includes 25 options. Table II-1 provides a brief description of these, indicates which alternative(s) contain each option, and identifies what the targeted resource or service is for each alternative/option combination. As noted under the alternative descriptions above, Alternatives 3, 4, and 5 vary in terms of the scope of restoration activities proposed. Alternative 3 restoration 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. As shown in the table, only the most severely injured species and services are targeted.

Alternative 4 envisions actions that would aid recovery of all injured resources and services, not just the most injured as summarized in Table II-1. 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 encourage new uses would be taken. Accordingly, Table II-1 shows the most extensive list of targets for this alternative than for any of the others.

The focus of this DEIS is to identify and compare how each of the proposed alternatives addresses the five restoration issues posed in Chapter I. Table II-2 summarizes the impacts of Alternatives 2 through 5 on each of the issues. Alternative I is not included because it would have 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. Public input is needed to inform the Trustee Council as to what these values should be.

Table II-1. List of alternatives and associated options.

Option	Alternative 3 Targets	Alternative 4 Targets	Alternative 5 Targets
Option 1: Implement cooperative programs between fishermen and agencies to reduce incidental take of harbor seals.	harbor seals	harbor seals	harbor seals
Option 2: Implement cooperative programs between subsistence users and agencies to assess the effects of subsistence harvest on sea otters and harbor seals.	harbor seals, sea otters	harbor seals, sea otters	harbor seals, sea otters
Option 3: Study techniques for changing black cod fishery gear to avoid conflicts between fishermen and killer whales.		killer whales	killer whales
Option 4: Intensify fisheries management to protect injured stocks.	sockeye salmon	cutthroat trout, Dolly Varden, pink salmon, rockfish, pacific herring, sockeye salmon	cutthroat trout, Dolly Varden, pink salmon, rockfish, pacific herring, sockeye salmon
Option 5: Improve freshwater wild salmon spawning and rearing habitats.			pink salmon, sockeye salmon
Option 6: Improve survival rates of salmon eggs to fry by using egg boxes, net pens, or hatchery rearing.	sockeye salmon	sockeye salmon	pink salmon, sockeye salmon
Option 7: Relocate hatchery runs of pink salmon to reduce the interception rate of wild stocks of pink salmon.		pink salmon	pink salmon
Option 8: Update the Alaska Anadromous Streams Catalog to ensure that the necessary protection and regulation is provided for all listed salmon streams in the spill area.			pink salmon, cutthroat trout
Option 9: Remove predators at injured colonies or remove predators from islands that supported murres, black oystercatchers, or pigeon guillemots before the spill.	common murre, pigeon guillemot	common murre, pigeon guillemot, black oystercatcher	common murre, pigeon guillemot, black oystercatcher
Option 10: Study use of artificial stimuli (decoys, vocalizations) to encourage recovery at affected murre colonies and accelerate recolonization of historic colonies.	common murre	common murre	common murre
Option 11: Study changes in fishing gear or timing as a way of minimizing incidental capture of marbled murrelets.	marbled murrelet	marbled murrelet	marbled murrelet

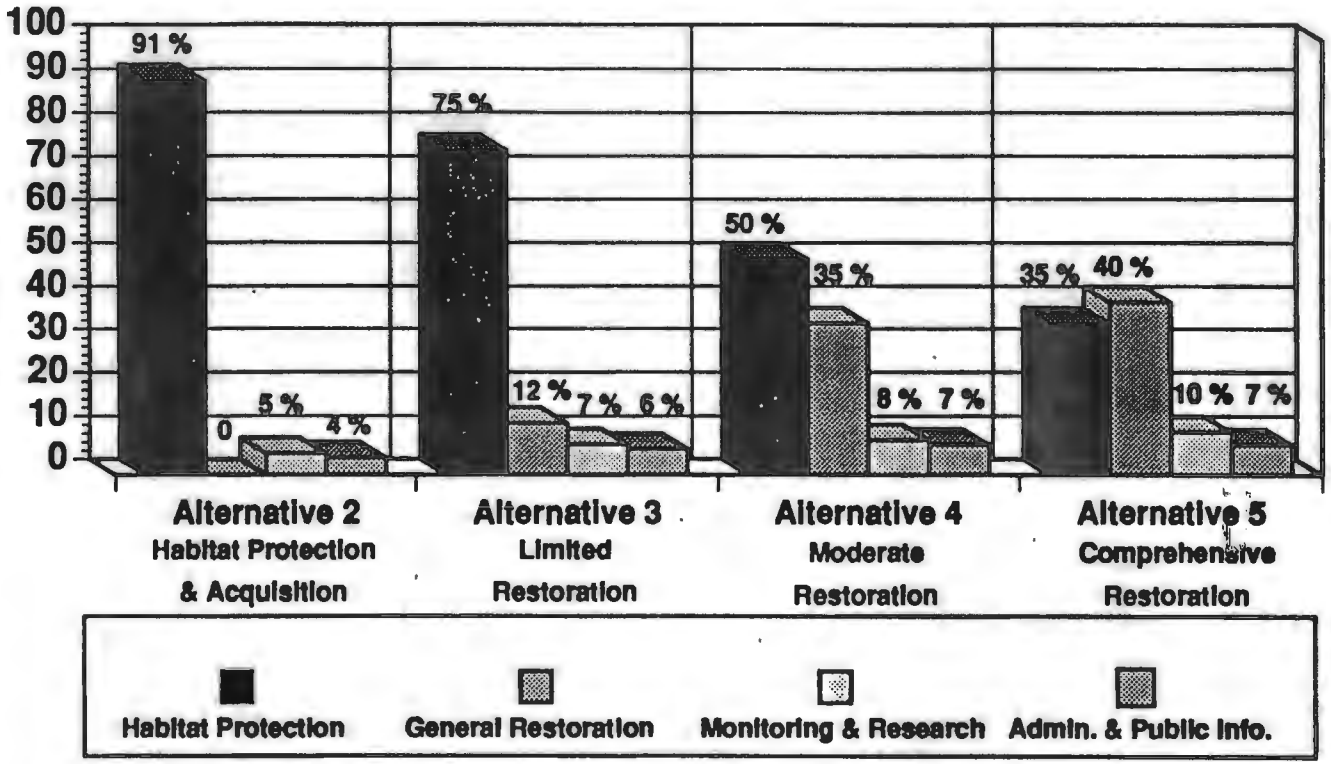

Figure II- 6
Comparative Emphasis on Categories of Actions Among Alternatives

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Option	Alternative 3 Targets	Alternative 4 Targets	Alternative 5 Targets
Option 12: Accelerate recovery of upper intertidal zone.	intertidal organisms	intertidal organisms	intertidal organisms, black oystercatcher
Option 13: Study the effects of disturbance in marine birds and mammals.	sea otter	sea otter, common murre, harbor seal	sea otter, common murre, harbor seal
Option 14: Study extent of oiling of mussel beds and techniques for removing oil from mussel beds.	harlequin duck, sea otter	harlequin duck, sea otter	harlequin duck, sea otter
Option 15: Propose modifications of sport and trapping harvest guidelines of injured river otter and harlequin duck populations to speed the rate of recovery.			river otter, harlequin duck
Option 16: Develop a site stewardship program to monitor archaeological sites.	archaeological sites	archaeological sites	archaeological sites
Option 17: Preserve archaeological sites and artifacts within the spill area.	archaeological sites	archaeological sites	archaeological sites
Option 18: Acquire replacements for artifacts removed from the oil spill area.	archaeological artifacts	archaeological artifacts	archaeological artifacts
Option 19: Develop new public recreation activities.	protect existing recreation opportunities	protect or increase existing recreation opportunities	protect or increase existing recreation opportunities, encourage new use
Option 20: Test subsistence foods for continued contamination.	subsistence foods	subsistence foods	subsistence foods
Option 21: Provide new access to traditional subsistence foods in areas outside the spill area to replace lost use.	subsistence foods	subsistence foods	subsistence foods
Option 22: Develop subsistence mariculture sites, shellfish hatcheries, and a technical research center.			subsistence foods
Option 23: Replace lost sport, commercial, and subsistence fishing opportunities by creating new fisheries for salmon or trout.	commercial and sport fishing, commercial tourism	commercial and sport fishing, commercial tourism	commercial and sport fishing, commercial tourism, subsistence fishing
Option 24: Develop and conduct public information programs through visitors' centers.			recreation and commercial tourism

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Option	Alternative 3 Targets	Alternative 4 Targets	Alternative 5 Targets
Option 25: Establish a marine environmental institute and research foundation.			education

Table II-2. 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 and acquisition of all alternatives, could enhance natural rate of recovery.	Second highest allocation of restoration funding for habitat protection and acquisition. Only high rate of recovery options selected under this alternative.	Third highest allocation of restoration funding for habitat protection and acquisition. Would include options that address only those resources and services that have not recovered from *EVOS* ~~are included~~.	Least amount allocated to habitat protection and acquisition. Would include all injured resources and services. Largest amount allocated to general restoration.
2. How would activities directed at injured resources and services affect non-target resources and services?	Habitat acquisition could greatly enhance ecosystem management and the consideration nontarget species.	Habitat acquisition could greatly enhance ecosystem management and the consideration nontarget species.	Habitat acquisition could moderately enhance ecosystem management and the consideration nontarget species.	Habitat acquisition could moderately enhance consideration nontarget species. Intensive stocking may reduce natural populations.
3. What ecological change would occur in the spill area as a result of restoration activities?	Habitat protection could greatly enhance the ecological integrity of the *EVOS* area and therefore promote only beneficial ecological change.	Habitat protection could greatly enhance the ecological integrity of the *EVOS* area and general restoration could enhance recovery of natural ecological conditions for selected species.	Habitat protection could enhance the ecological integrity of the *EVOS* area and general restoration could enhance recovery of natural ecological conditions for selected species.	Habitat protection could enhance the ecological integrity of the *EVOS* area and general restoration could enhance recovery of natural ecological conditions for selected species.
4. How would restoration activities affect land uses, local economies, and communities?	Habitat acquisition could preclude areas from resource exploitation, principally logging. Tourism and fishing economies may benefit.	Habitat acquisition may preclude areas from resource exploitation, principally logging. Tourism and fishing economies could benefit. Short-term disruption of fishing.	Habitat acquisition may preclude areas from resource exploitation, principally logging. Tourism and fishing economies could benefit. Short-term disruption of fishing.	Habitat acquisition may preclude areas from resource exploitation, principally logging. Tourism and fishing economies may benefit. Short-term disruption of fishing.

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5. What changes to subsistence uses would occur as a result of restoration activities?	Habitat protection might restrict subsistence uses on certain lands, or increase competition for resources.	Habitat protection might restrict subsistence uses on certain lands. General restoration could enhance opportunities for subsistence use.	Habitat protection might restrict subsistence uses on certain lands. General restoration could substantially enhance opportunities for subsistence use.	Habitat protection might restrict subsistence uses on certain lands. General restoration could substantially enhance opportunities for subsistence use.

Chapter III. Affected Environment

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 section of this chapter covers the physical and biological environment including the physical setting, marine, coastal, and terrestrial ecosystems, and individual biological resources. In addition to describing the fish and wildlife of the EVOS area, this section summarizes injury to the biota including results of the natural resource damage assessment studies. The second part of the chapter covers the social and economic environment in the affected area before and after the spill. This section 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 and Biological Environment

Figure III-A shows the location of the area oiled by the *Exxon Valdez* spill in relation to the rest of the State of Alaska. Within this area, Prince William Sound and the Gulf of Alaska were the areas most severely affected.

Physical Setting

The *Exxon Valdez* Oil Spill (EVOS) area is located in southcentral Alaska, north of the Gulf of Alaska, encompassing a surface area of approximately 75,000 square miles. At the northeastern edge of the EVOS region is Prince William Sound, an area about the size of Maryland's Chesapeake Bay or Washington State's Puget Sound (Mickelson, 1988). Southwest of Prince William 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, including Montague, Kodiak, and Afognak; 19 minor islands; and 150 lesser islands.

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 shook Prince William Sound for approximately 5 minutes destroying the towns of Valdez, Whittier, and Chenega. Winter winds in the Gulf of Alaska are generally easterly or southeasterly and interact with currents to push waters into Prince William Sound. This produces complex flow patterns resulting in strong downwelling and an outflow of surface waters to the southwest. The majority of the EVOS area has a maritime climate with heavy precipitation, averaging 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, 1988).

Greater EVOS Ecosystem

The EVOS region contains diverse marine, coastal, and terrestrial ecosystems that together constitute one of the largest and least developed regional ecosystems in the United States.

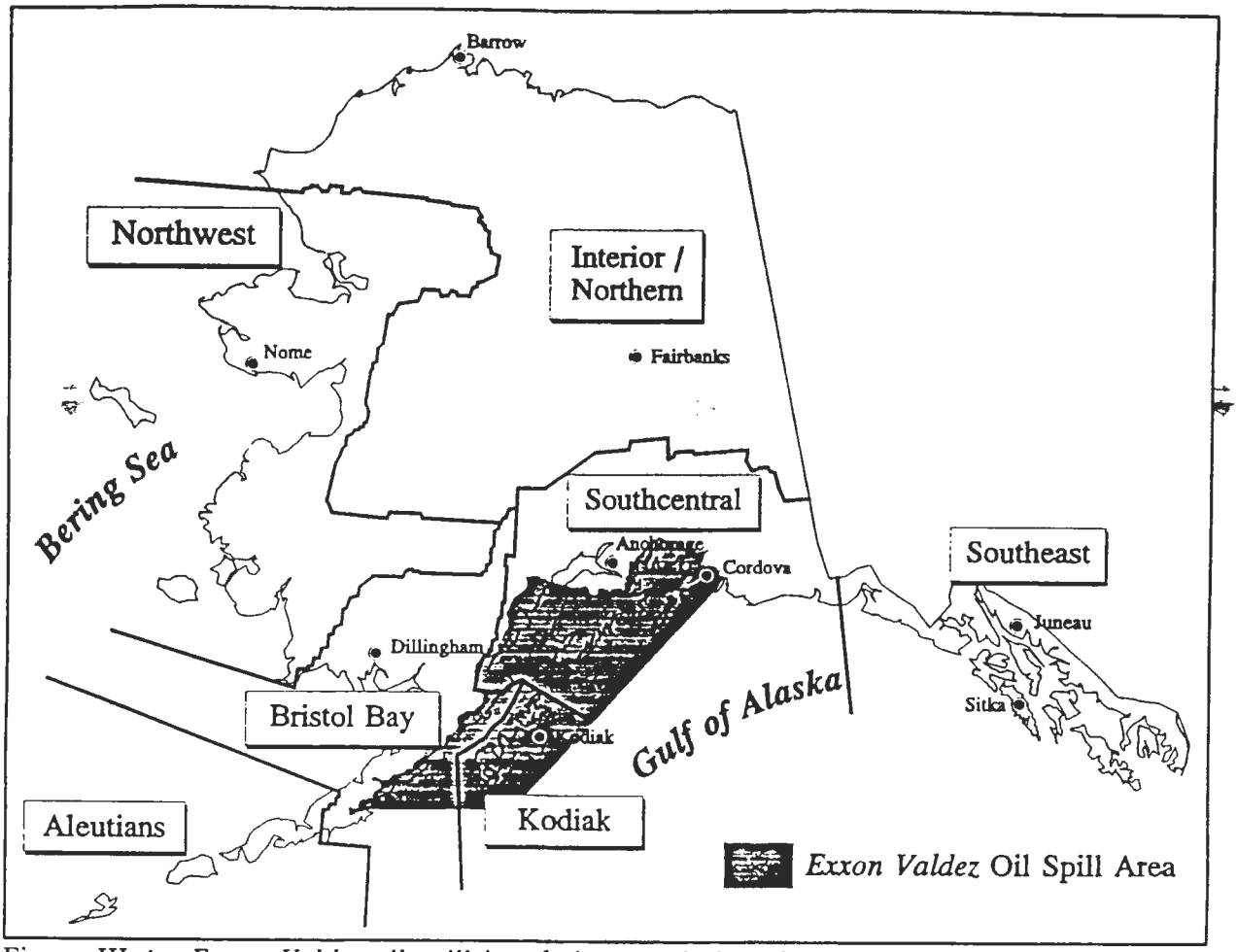


Figure III-A. *Exxon Valdez* oil spill in relation to Alaskan Census Regions.

the region. Abundant saltwater finfish include halibut, sole, flounder, sablefish, pollock, mackerel, and Pacific ocean perch. King, tanner, and Dungeness crabs are abundant and move to shallower water in summer months for spawning. Shrimp, clams, and scallops are also important shellfish in the region.

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 EVOS area contain unusually 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 supratidal zone is important for marine mammal haulout areas and many terrestrial species. The intertidal and subtidal zones contain diverse communities of their own and are critically important for maintaining a food source for both marine and terrestrial organisms.

The intertidal zone is reaches from low to high tide and is intermittently inundated. Inhabitants of the intertidal zone include algae (e.g., *Fucus*), mussels, clams, barnacles, limpets, amphipods, isopods, marine worms, and fish. The intertidal zone is used as a spawning area by many species of fish and as a feeding ground for a variety of marine organisms (e.g., sea otters, Dungeness crabs, juvenile shrimps, rockfish, cod, and juvenile fishes), terrestrial organisms (e.g., bears and river otters), and birds (e.g., black oystercatchers, harlequin ducks, numerous other species of ducks, and shorebirds) (Peterson, 1993). 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 (*Exxon Valdez* Oil Spill Trustees, 1992).

The subtidal zone extends from the low tide boundary of the intertidal zone into the open water area. Because the near coastal subtidal community is similar in many respects to the intertidal community, it is considered separately from the marine ecosystem. Inhabitants of the shallow subtidal zone include amphipods, clams, eelgrass, crabs, juvenile cod, *Laminaria* plants, spot shrimp, and many other organisms. Like the intertidal zone, the subtidal zone is especially vulnerable to oil spills.

Terrestrial Ecosystem

The *Exxon Valdez* Oil Spill area falls almost entirely within the Oceanic Forest-Tundra Province of Bailey's (1989) ecoregional classification. This Province is part of the Marine Regime Mountains Division and Humid Temperate Domain. Within the EVOS area, three more specific biogeographic regions can be identified—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 are still present at high elevations in all three regions.

At lower elevations, ecological conditions vary between 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, devilsclub, 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 yrs plus), mature forest (70-200 years), intermediate stage forest (40-70 years), early stage forest (0-20 years), lowland shrub, mud flats/gravel/rock, subalpine shrub, alpine shrub-lichen tundra, cliffs, islands in lakes, and snow/ice/glaciers (USFWS, 1983). Inland aquatic habitats include anadromous fish streams, anadromous fish lakes, resident fish streams, and resident fish lakes.

A wide range of bird and mammal species inhabit the terrestrial ecosystem of the EVOS area and many are more abundant there than anywhere else throughout their range. More than 200 species of birds occur in the EVOS area, including more than 100 shorebirds and seabirds. Approximately 100 species of these birds are year-round residents. Important nesting and breeding areas include the Copper River Delta, Kenai Peninsula, lower Cook Inlet, and the Kodiak and Afognak Island coasts. Moderate populations of bald eagle and peregrine falcon occur and the endangered Aleutian Canada goose and short-tailed albatross may be seasonal visitors to the area. The EVOS region contains 33 species of terrestrial mammals including brown and black bear, moose, Sitka blacktail deer, mink, and river otter. In addition to the five species of anadromous Pacific salmon (chinook, coho, pink, chum, and sockeye), many other fish contribute to the area's diverse inland aquatic communities including Dolly Varden char, rainbow and cutthroat trouts, lake trout, arctic grayling, whitefish, and turbot.

Of the 15 million acres within the oil-spill area, 1.8 million are private lands (Figure III-B). 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 (ANSCA). Lands chosen for conversion to private uses were primarily 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-1970s, and no harvests are currently planned. Nine other large Federal land management areas are contained wholly or partially within the EVOS area. The National Park Service 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 and Katmai 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 millions of acres in the Kenai National Wildlife Refuge (NWR), Kodiak NWR, Becharof NWR, Alaska Peninsula NWR, and Alaska Maritime NWR. 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.

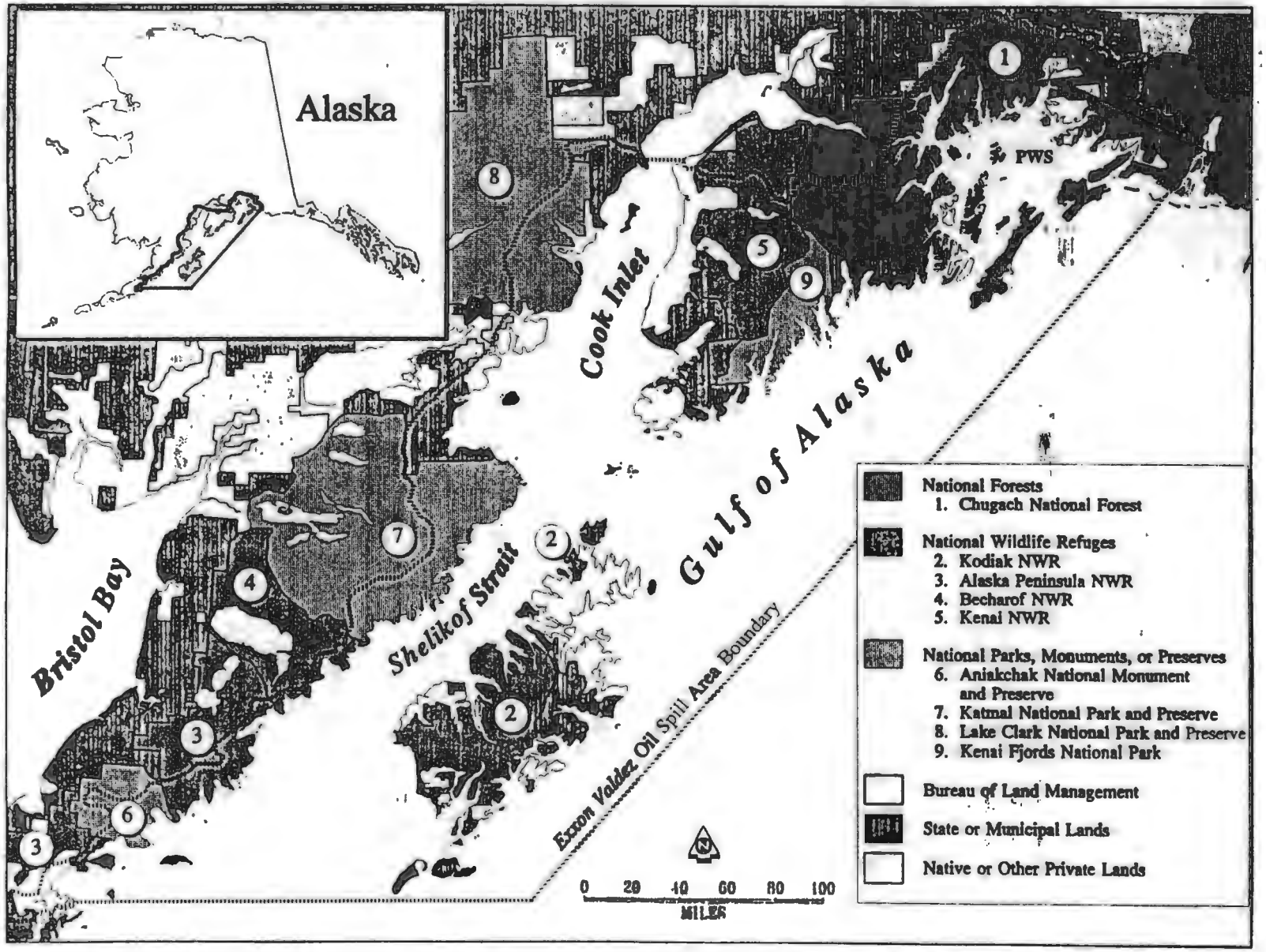
Land management activities, especially those that involve timber harvesting (either clear-cut logging or selective cutting), have important consequences for the recovery of injured resources in the EVOS area. Although timber harvesting is allowed on some Federal and State lands, it is the primary activity planned for the majority of forested private lands. Therefore, the proportion of sensitive EVOS area lands in private ownership can be used to estimate future adverse impacts to the ecosystem that may slow the natural recovery of injured resources.

Another issue in forest land management is the prevalence and impact of infestations of bark beetles and other insects on forest health and survival. At present, these pests are not expected to be a major factor affecting forest management or limiting habitat acquisition options designed to protect ecosystems in the oil spill area. The spruce beetle (*Dendroctonus rufipennis)* is an endemic pest affecting older conifer stands in southcentral Alaska. Although this species can effectively kill all trees over large areas (the natural 100-150 year cycle of these infestations may have been shortened with the suppression of fire), 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, but serious infestations are not expected within Sitka spruce stands (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 5,000 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 may also 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. Some species (e.g., invertebrates such as clams and barnacles) have never been inventoried, while others, such as the brown bear and the bald eagle, are counted annually for management purposes. Much 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 the oil spill area. It will be used in evaluating the potential impacts, either direct or indirect, of the various restoration options.


Alaska
PWS
Cook Inlet
Gulf of Alaska
Bristol Bay
Shelikof Strait
Exxon Valdez Oil Spill Area Boundary
0 20 40 60 80 100
MILES
National Forests
1. Chugach National Forest
National Wildlife Refuges
2. Kodiak NWR
3. Alaska Peninsula NWR
4. Becharof NWR
5. Kenai NWR
National Parks, Monuments, or Preserves
6. Aniakchak National Monument and Preserve
7. Katmai National Park and Preserve
8. Lake Clark National Park and Preserve
9. Kenai Fjords National Park
Bureau of Land Management
State or Municipal Lands
Native or Other Private Lands

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Marine Mammals

The following section discusses the relevant population status, life cycle requirements, and oil spill injuries including relevant information for harbor seals, sea lions, sea otters, and killer whales.

Harbor Seals

The harbor seal (*Phoca vitulina richardsi*) is a protected species under the Marine Mammal Protection Act of 1972, which placed a moratorium on the taking of harbor seals except for subsistence use by Native Alaskans. The harbor seal is under the management of the National Marine Fisheries Service.

Harbor seal pre-spill populations in Prince William Sound Alaska have been estimated to be between 2,000 and 5,000 individuals. The harbor seal population has been declining by approximately 11-14 percent annually for unknown reasons (Frost and Lowry, 1993). In portions of its geographic range, the harbor seal was and is now in direct competition with human subsistence, recreational, and commercial resource users for fish. Bycatch of harbor seals from commercial fishing activity has been estimated to cause 2,800 seal deaths a year (Lentfer, 1988). The harbor seal is also harvested by Native Alaskans for subsistence use. Natural predators of harbor seals include killer whales and sharks.

Life cycle requirements of the harbor seal include sources of fish, octopus, squid and shrimp for food, and protected haulout sites for pupping and molting. 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). Factors influencing the population recovery for harbor seals include high mortality in first year of life; the seal's annual reproductive rate (1 pup); and age to reproductive maturity (2-6 years).

The oil spill caused population declines and sublethal injuries to harbor seals in Prince William Sound. While some dead seals were recovered from the Kenai Peninsula, the extent of injury outside Prince William Sound is unknown. Many were directly oiled and an estimated 345 seals died. The pre-spill population of harbor seals in Prince William Sound was estimated to be between 2,000 to 5,000 animals.

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 post-spill spring (April) survey were extensively oiled and 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.

Steller Sea Lions

The Steller sea lion (*Eumetopias jubatus*) has been classified as "threatened" under the Endangered Species Act of 1973. The sea lion is a protected species under the Marine Mammal Protection Act of

1972, which placed a moratorium on the taking of sea lions except for subsistence use by Native Alaskans. The sea lion is under the management of the National Marine Fisheries Service.

Pre-spill sea lion populations for the Gulf of Alaska have been estimated at 136,000 (Calkins and Pitcher, 1982). Approximately 70 percent of the world population of sea lions is located in Alaska (Johnson et al., 1989). The sea lion population has been in decline since 1980 (Johnson et al., 1989). In Alaska, the sea lion population declined 56 percent from 1985 to 1990 (Alaska Fisheries Science Center, 1991). The sea lion is in direct competition with human subsistence, recreational, and commercial resource users for fish. Natural predators of sea lions include killer whales and sharks.

Life cycle requirements for the sea lion include their age to reproductive maturity (4-7 years) and their annual reproductive rate (1 pup). Other causes of mortality are disturbance and stampeding during breeding season (August being the most critical period), and deaths incidental to commercial fishing (Johnson et al., 1989).

Results from sea lion studies were inconclusive about the effects of the spill. Several sea lions were observed with oiled pelts, and oil was found in some tissues. Sea lions have experienced a severe decline over the past 30 years in the north Pacific Ocean--as great as 93 percent. This decline combined with seasonal movements, which are significant but not well understood, hindered determining if the seal lion population in the Gulf of Alaska had been affected by the spill. Sea lions were counted at eight haulout sites, located mainly in the Gulf of Alaska. Some of these sites were oiled, although oiling was patchy and generally short-lived, but away from these sites, sea lions were observed swimming through oil. Ten sea lions were found dead in oiled areas, mainly on rocky beaches, but it is not known how many of these deaths were attributable to natural mortality, or if any were due to oiling.

Sea Otters

The sea otter (*Enhydra lutris*) has been classified as "threatened" under the Endangered Species Act of 1973. The sea otter is a protected species under the Marine Mammal Protection Act of 1972, which placed a moratorium on the taking of sea otters except for subsistence use by Native Alaskans. The sea otter is under the management of the State of Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service. Pre-spill and post-spill management of sea otters by these agencies has focused on population monitoring through surveys and monitoring of Native harvest.

Sea otter pre-spill population for the entire State of Alaska was estimated at 150,000 animals (*Exxon Valdez* Oil Spill Trustees, 1992). The population in Prince William Sound prior to the oil spill was estimated at 10,000 animals (*Exxon Valdez* Oil Spill Trustees, 1992). The sea otter population within the oil spill zone 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 was and is now in direct competition with human subsistence, recreational, and commercial resource users for crabs, clams, and other benthic organisms. Natural predation of sea otters is limited.

Life cycle requirements of the sea otter appear to be intertidal and subtidal invertebrates as food sources and protected areas for use as haulouts. An adequate food supply is critical for sea otters because they must eat large quantities in order to maintain the high metabolic rate necessary to survive in cold waters (Chapman, 1981). The importance of haulouts for sea otters is not fully understood. Sea otters appear to need haulouts for grooming to maintain their fur's insulating

capabilities (Van Gelder, 1982) and also may use haulouts for pup rearing and weaning. Factors influencing the population recovery for sea otters are age to reproductive maturity (3-5 years); annual reproductive rate (1 pup); and low juvenile survivorship (Calkins and Pitcher, 1979). Adult sea otter survivorship is generally high in absence of outside mortality events (e.g., oil spills, disease, or harvest). There are limited management opportunities to increase sea otter populations. Population management is restricted to protecting habitat and monitoring Native harvest.

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. It also is estimated that there are 150,000 animals in state waters.

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 were still 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.

One possible cause of the relatively higher mortalities of weaning and prime-age animals is the ingestion of oil-contaminated prey. During 1992 surveys, fresh (unweathered) oil was found in beds of mussels on protected (low energy) beaches. Sea otters, particularly young sea otters, feed on mussels and other invertebrates and may still be exposed to oil persisting in intertidal habitats.

Killer Whales

The killer whale (*Orcinus orca*) is protected under the Marine Mammal Protection Act of 1972, under which a moratorium was placed on harvesting killer whales. Killer whales are managed by the National Marine Fisheries Service (NMFS).

The largest members of the dolphin family, killer whales live and migrate in groups of up to 50 individuals. There are two types of these groups, called pods: resident pods and transient pods. Because transient pods travel great distances throughout the year, resident pods were more likely to have suffered injuries from the EVOS. Resident pods have a more defined social structure, including a home range that may cover an area up to several hundred square miles (Matkin et al., 1993). Another factor that may affect the ability of killer whales to recover is their low reproduction rate. The birthing rate of killer whales varies, with 5 years being the average time between calves. The gestation period is about 16 to 17 months and the cow gives birth to a single calf. Killer whales reach sexual maturity at approximately 7 years and have a life span of approximately 25 years. Analysts estimate that recovery of the AB pod to pre-spill numbers could take one to two decades.

Thirteen killer whales disappeared from one pod (extended family group) between 1988 and 1990, and are presumed to have died. Approximately 140 killer whales forming nine distinct pods regularly use Prince William Sound, and are considered resident pods. There are also transient pods and other resident pods with wider ranges that enter the Sound occasionally. The rate of natural mortality in

killer whales in the North Pacific is about 2 percent per year, so it would be unusual for more than 3 to 4 individuals to be missing annually from Prince William Sound's resident pods.

In the summer of 1989, there were more than nine whales missing from resident pods. The AB pod, which had 36 individuals, when last seen in the Sound in the fall of 1988, was missing 7 animals, for an unprecedented 19.4 percent mortality rate. In 1990, an additional 6 individuals were found missing from AB pod, resulting in an annual mortality rate of 20.7 percent (prespill mortality for the resident AB pod typically ranged from 3.1 to 9.1 percent from 1984 to 1988). All of the missing whales were either females or immature animals, and in several cases calves were orphaned. No births were recorded in 1989 or 1990. Due to the fidelity of killer whales to the pod, and the bonds observed between mothers and calves, the missing whales are presumed to have died. However, no dead individuals were ever recovered.

The cause of death is uncertain. Some experts think that the circumstantial evidence points to the spill. Other experts acknowledge that something very unusual happened to AB pod in 1989 and 1990, but that based on current knowledge of the spill and the toxicity of crude oil, it is unlikely that these deaths were due to contact with oil spilled by the *Exxon Valdez*.

Humpback Whales

Humpback whales (*Megaptera novaeangliae*) are currently listed under the U.S. Endangered Species Act of 1973. They are also protected under the Marine Mammal Protection Act of 1972. Humpback whales are managed by the National Marine Fisheries Service (NMFS).

The estimated worldwide population of humpback whales is 10,000, with approximately 1,500 occurring in the North Pacific (Ziegesar and Dahlheim 1993). The humpback whale is a large whale (up to 48 feet and 50 tons) and eats vast amounts of krill and schooling fishes such as herring, anchovies, and sardines (Grzimek, 1990). Their preferred habitat is along shallow shelves and bank areas, rather than deeper ocean waters. During spring migration, the humpback whale travels well defined routes along the continental coastline to high latitude waters for feeding. In the Northern Hemisphere, the mating and calving season is October to March (Walker, 1983). During the breeding season, humpback whales migrate to tropical waters. Like the killer whale, humpback whales have a low reproduction rate, reaching sexual maturity in 7 to 10 years and giving birth every 1 to 3 years.

The only apparent effect of the spill on humpback whales was a temporary displacement from preferred habitat in Lower Knight Island Passage during the summer of 1989. There is no evidence that any humpbacks were killed by the spill, nor has the reproduction been affected. Photodocumentation studies confirmed that normal use of lower Knight Island Passage was resumed in late 1989.

Terrestrial Mammals

Sitka Black-tailed Deer

The Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) is an introduced game species under the management of the State of Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service.

Sitka black-tailed deer were introduced into Prince William Sound and the Kodiak Archipelago in the 1930s (Wallmo, 1978). The present population of deer in Alaska is approximately 350,000 to 400,000. Deer are hunted for sport and for subsistence use by Native Alaskans. Life cycle requirements of the Sitka black-tailed deer include old-forest habitat, herbaceous vegetation in the forest understory as food, and coastal vegetation during winter when uplands are snow covered.

Deer often forage in the intertidal zone on seaweed. Since seaweeds were extensively contaminated on oiled shores, deer were probably exposed to oil. In fact, tissues from deer taken by subsistence hunters and chemically analyzed were found in some cases to contain slightly elevated concentrations of hydrocarbons. The deer were, however, determined to be safe to eat. No evidence was found that populations of Sitka black-tailed deer were injured by the spill. Most deer carcasses found in 1989 on islands in Prince William Sound were probably the result of winter kill.

Black Bear

The black bear (*Ursus americanus*) has been classified as threatened under the Endangered Species Act of 1973 in the states of Mississippi, Louisiana, and Texas. The black bear is under the management of the State of Alaska Department of Fish and Game. Life cycle requirements of the black bear include use of foraging habitat in coastline intertidal regions, riparian regions, and upland areas. Black bears are omnivorous; their main diet consists of grasses, berries, and assorted plant foods, but they also eat fish during salmon runs in Alaska. Factors influencing population growth of black bears include age to reproductive maturity (3-5 years) (Pelton, 1982); 2-year intervals between offspring production (Jonkel, 1978); and availability of large habitat as range areas.

There was an initial attempt to study the potential effects of the spill on black bears, but due to the difficulty of finding, tagging, or observing this species in dense vegetation, the effort was quickly abandoned. No carcasses or other indications of oil spill-related injuries were ever reported.

Brown Bear

The brown bear (*Ursus arctos*) has been classified as "threatened" in the lower 48 states under the Endangered Species Act of 1973. The brown bear is under the management of the State of Alaska Department of Fish and Game.

The population of brown bears in Alaska is approximately 32,000 to 43,000. The brown bear competes with human subsistence, recreational, and commercial resource users for fish and clams. The opportunity to observe and photograph brown bears draws thousands of tourists to Katmai National Park and McNeil River State Park annually. In Alaska, brown bears are hunted for sport. On the Alaska Peninsula, approximately 250 bears are harvested annually by residents and non-residents (NRDA, 1990).

Brown

Life cycle requirements of the brown bear include use of foraging habitat in coastline regions in the spring, riparian regions in the summer, and upland areas in the fall and winter (*Exxon Valdez* Oil Spill Trustees, 1992). Black bears are omnivorous. Their main diet consists of grasses, berries, and assorted plant foods. They also eat fish during salmon runs in Alaska. Factors influencing population growth of brown bears include high cub mortality; 2- to 3-year intervals between offspring production (Craighead and Mitchell, 1982); and availability of large range areas.

In the Kodiak Archipelago and in the Alaska Peninsula, brown bears forage in the intertidal zone, where clams are a favorite food. Brown bears also apparently scavenged the carcasses of sea otters and birds that washed ashore after the spill. Analyses of fecal material and samples of bile indicated that some brown bears had been exposed to oil. High concentrations of oil were found in the bile of one yearling brown bear dead in 1989. Since the mortality rate for cubs is close to 50 percent for the first two years, it is uncertain whether this death was associated with oil exposure.

River Otters

The river otter (*Lutra canadensis*) has been found throughout North America except in the extreme southwest (Trustee, 1992). The river otter is one of the largest members of the weasel family. Found in marshes, wooded stream banks, and all types of inland waterways, river otters are almost completely aquatic, although they sometimes travel overland great distances to reach another stream (Forsyth, 1985).

The primary diet of the river otter is fish. They also eat crabs, mussels, clams, snails, and aquatic invertebrates (Walker, 1983), and occasionally birds and small land mammals such as rodents and rabbits. River otters are more prolific reproducers than bears, with a gestation period of 60 to 63 days (Toweill and Tabor, 1982) and females breeding more than once a year at age 2. Predators include bobcat, lynx, coyote, wolves, bald eagle and great horned owl when they are young.

Following the oil spill, eleven river otter carcasses were found on beaches. It is estimated that as many as 50 animals could have been killed if it is assumed that the recovery rate of carcasses is similar to that for sea otters. The bile from two river otters collected from oiled areas in 1989 was analyzed and found to contain elevated concentrations of hydrocarbons. This indicates that surviving river otters could have ingested contaminated food.

There are indications that chronic oil exposure may affect river otters in Prince William Sound, although there is uncertainty about the evidence. First, river otters captured in oiled areas after the winter of 1989-1990 weighed less than those captured in oiled areas, while they were of the same overall length. Since the oiled population is an island population (Knight Island) and the unoiled population is from a mainland location (Ester Passage), and there are no comparative prespill length and weight data from the two areas, it is difficult to determine whether this represents an effect of the spill. Second, chemical factors in the blood show slight differences between study areas: in the oiled population, haptoglobin concentrations and some amino transferase enzyme activities are slightly elevated. These differences could be caused by oil exposure, but they could also be caused by disease, handling stress, and parasitism.

A reduction in the number of prey species was noted in the diets of river otters in the oiled areas between 1989 and 1990; this reduction was not seen in the unoiled study areas. This reduction was probably due to the severe impact of the spill on the intertidal and shallow subtidal fauna in the oiled portions of Knight Island. Also, on Knight Island the average size of territories of river otters were larger than on the mainland, potentially a result of having to forage over a larger area to find sufficient food. Because of the lack of pre-spill data and follow-up study, however, there again is uncertainty.

Finally, data from an analysis of river otter droppings in latrine sites suggested that estimated populations sizes were not different between the study areas, although this conclusion also can be questioned because of the relatively small sample sizes employed.

Birds

Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) lives only in North America, ranging from south of the arctic tundra in Alaska and Canada to the southern United States and Baja California in Mexico. In all States where it occurs, except Alaska, the bald eagle is classified as an endangered or threatened species and receives Federal protection under the Endangered Species Act (16 U.S.C. §1543 [1976 & Supp. V 1981]). Although the bald eagle in Alaska is classified as neither threatened nor endangered, the species is protected under the Bald Eagle Protection Act of 1940 (16 U.S.C. §§668-668d [1976 & Supp. V 1981]) and the Migratory Bird Treaty Act (16 U.S.C. §§703-711 [1976 & Supp. V 1981]).

Water is the feature common to bald eagle nesting habitat. Nearly all bald eagle nests are within two miles, and the vast majority are within a half mile, of a coastal area, bay, river, lake, or other body of water (Grubb, 1976; Lehman, 1979). Proximity to water reflects the dependence of bald eagles on fish, waterfowl, and seabirds as primary food sources. On National Forests in Alaska, protection measures for bald eagles and their nesting habitats are prescribed in the Memorandum of Understanding between the USDA Forest Service and the U.S. Fish and Wildlife Service. The Memorandum provides for the exclusion of all land-use activities within a buffer zone of 100 meters around all active and inactive bald eagle nests.

Abundant, readily available food resources are a primary characteristic of bald eagle wintering habitat. Most wintering areas are associated with open water, where eagles feed on fish or waterfowl, often taking dead or injured animals that are easy to find. Wintering bald eagles also use habitats with little or no open water if other food resources, such as carrion, are regularly present (Spencer, 1976).

There are estimated to be 27,000 adult bald eagles in Alaska. About 2,000 of these are in Prince William Sound and about 6,000 are found along the northern coast of the Gulf of Alaska. Bald eagles encountered floating oil while preying on fish and oil- contaminated carcasses, and heavy oiling of the plumage led to loss of flight and probably also loss of body heat. Preening also exposed eagles to oil by ingestion. While 151 eagles were found dead after the spill, an estimated 200 to 300 may have been killed.

There is considerable uncertainty as to the total number of eagles killed by the spill. Seventy-four percent of radio-tagged eagles that died of natural causes in a post-spill study were found in forest and other inland areas. If this carcass deposition pattern is representative of eagles dying from acute oil exposure, then total mortality based mainly on the recovery of carcasses during beach searches would be about 430 individuals. However, it seems unlikely that acutely oiled birds would die in similar locations as those that died of natural causes.

Most aerial surveys to estimate population size and productivity were conducted in Prince William Sound. Population estimates made in 1989, 1990 and 1991 indicate that there may have been an

increase in the bald eagle population since the previous survey conducted in 1984, although considerable variability was associated with this data. Estimates for the three post-spill years were not significantly different.

Estimates of productivity indicate that in 1989, 85% of nests in moderately and heavily oiled areas failed, compared to 55% in lightly oiled and unoiled areas. In 1990, there were no differences between these areas. It is estimated that the loss of production in 1989 was equivalent to 133 chicks.

Peale's Peregrine Falcon

Peale's peregrine falcon (*Falco peregrinus pealei*) is a very large, dark western form, or subspecies, of the peregrine falcon. In North America it nests from the Aleutians, occasionally the Pribilofs, south to Queen Charlotte Island. In winter it migrates to California (Brown and Amadon, 1968). Though some of the subspecies of peregrine falcon are on the Endangered Species List, the race *pealei* has been considered stable and is apparently maintaining its population. This species is protected under the Migratory Bird Treaty Act (16 U.S.C. §§703-711 [1976 & Supp. V 1981]).

During the breeding season, peregrines frequently inhabit offshore islands where bluffs provide suitable undisturbed nest sites and an abundance of food from nearby colonies of nesting seabirds. At all seasons, open country is preferred, particularly shores and marshes frequented by shorebirds and waterfowl.

Common Murre

The subspecies of common murre found in Alaska (*Uria aalge inornata* Salomonsen) breeds from the Commander Islands, Saint Matthew Island, and northwestern Alaska to Kamchatka, the Kurile Islands, southern Sakhalin, eastern Korea, and Hokkaido, and through the Aleutian and Pribilof Islands to southern British Columbia (Johnsgard, 1987). This species is protected under the Migratory Bird Treaty Act (16 U.S.C. §§703-711 [1976 & Supp. V 1981]).

Breeding colonies of common murres are largely restricted to subarctic and temperate coastlines on rocky coasts that usually have steep seaward cliffs, though low-lying coasts may also be used if they are remote and predator-free. Stratified rock layers providing nesting ledges, or weathered pinnacles and similar promontories, are important habitat components (Tuck, 1961). Murres normally nest in dense colonies and breeding is synchronized so that all young hatch at the same time. Synchronized breeding helps satiate predators such as gulls and ravens. Murres are highly social birds on the breeding areas, with maximum densities of 28 to 34 birds per square meter reported by Tuck (1960), with some birds occupying no more than 500 cm^2 (about 0.5 square feet) of ledge. No nest is built, though a few pebbles or other materials may be dropped at the nest site, perhaps to reduce rolling of eggs early in incubation before the egg has become cemented to the substrate by excrement and sediment (Johnsgard, 1987). Only one large pyriform (pear-shaped) egg is laid. If disturbed, the egg usually rolls in a small circle around its pointed end. There is often a fairly high loss of chicks to exposure or falls during the first 6 days after hatching, after which their clinging, hiding, and thermoregulation abilities have become better developed (Johnsgard, 1987).

Breeding success has been reported to be between 70 to 80 percent of young fledged per breeding pair (Birkhead, 1977; Hedgren, 1980). Birkhead (1974) estimated a 6-percent annual adult mortality rate and stated that most birds probably do not begin breeding until their fifth year. A 6-percent mortality

rate results in an average life expectancy for adults of 16 years. Banded birds have been known to survive as long as 32 years, however.

Non-breeding habitats are coastal and pelagic areas. Typically, they are found in the offshore zone (at least 8 kilometers out to sea), and no more than a few hundred kilometers offshore at their southernmost breeding limits (Tuck, 1961). The common murre feeds predominantly on fish throughout the year. Prey are captured by extended dives, mostly at depths of 4-5 meters, but sometimes by bottom feeding at 8 meters (Madsen, 1957). Foraging tends to occur in flocks early in the breeding season, but as the year progresses, murres begin to forage individually.

The oil spill caused population declines and sublethal injuries at murre colonies in the Gulf of Alaska. Including both common murres and thick-billed murres, there are about 12 million murres in Alaska, and 1.4 million in the Gulf of Alaska region. About 1.2 million of the total population in the Gulf of Alaska nest on the Semidi Islands, which were not directly impacted by the oil. Murres are particularly vulnerable to floating oil and have been killed in large numbers by oil spills elsewhere in the world.

At the major breeding colonies studied (Chiswell Islands, Barren Islands, Puale Bay, and the Triplets), an estimated 120,000 - 134,000 adult breeders were killed by contact with oil. The oil arrived in early April just as birds were beginning to congregate at the colonies in anticipation of breeding. If the rate of mortality is adjusted for birds not counted on the colonies, but feeding at sea, it is estimated that 170,000 to 190,000 breeding birds were killed. In general, it is estimated that between 35 percent and 70 percent of the breeding adults at the above colonies were killed by the spill. It is not known where pre-breeding juveniles were at the time of the spill, or if many were killed.

The timing of reproduction also changed at oil-impacted colonies following the spill. At the Barren Islands and at Puale Bay, egg laying was about a month late in 1989, 1990 and 1991. In 1992 there were some indications that breeding was returning to normal at places in the Barren Islands colony. At the Chiswell Islands, laying was not observed in 1989, and laying was late in 1990. Due also to fewer birds occupying these colonies, it is likely that the rate of predation was much greater than normal, since these colonies rely on sheer numbers of birds to discourage predation by gulls and eagles. Furthermore, the delay in egg-laying (estimated to be one month) that has been seen in the Barren Islands, at Puale Bay and in the Chiswell Islands since the spill, may produce chicks that cannot survive the first autumn storms in the Gulf of Alaska. Conservatively, the estimate of lost production associated with delayed reproduction could exceed 300,000 chicks.

Marbled Murrelet

The marbled murrelet (*Brachyramphus marmoratum marmoratum*) breeds on islands and in coastal areas from southeastern Alaska to northwestern California. In Alaska, it is probably a common to abundant breeder in southeastern and south-coastal areas, a resident and probable local breeder in the Alaska Peninsula and also the Aleutians, and a casual summer visitor in western areas (Kessel and Gibson, 1976). The marbled murrelet is a species of concern in Alaska and is listed as threatened under the Endangered Species Act (16 U.S.C. §1543 [1976 & Supp. V 1981]) in Washington, Oregon, and California. This species is also protected under the Migratory Bird Treaty Act (16 U.S.C. §§703-711 [1976 & Supp. V 1981]).

The total breeding distribution of this species is poorly understood, but it apparently is limited to fairly warm waters of the west coast of North America. It is most closely associated with the humid coastal areas supporting wet-temperate coniferous forests with redwood, Douglas fir, and other ecologically similar species, but it also inhabits coastlines along tundra-covered uplands along the Alaska Peninsula and in the Aleutian Islands. In winter the birds move farther south, sometimes as far as southern California, but some wintering occurs on protected waters as far north as the Kodiak area of Alaska and as far west as the Aleutians (Forsell and Gould, 1981). For most of the year the birds seem to prefer semiprotected waters of bays and inlets, making only limited use of rock coastlines (Hatler, Campbell, and Dorst, 1978).

The murrelet eats small fishes it catches by diving in tide rips and other places where small fishes swim in schools. The major fish prey, sand lance (*Ammodytes*), belongs to a group of fish in which the young of the previous fall and winter tend to migrate to surface waters and move inshore in late spring, when they would become available to the murrelets. The murrelet's fall and winter diet is essentially unknown, but samples from a few birds suggest that sea perch (*Cymatogaster*) may be an important food item, and possibly also mysid and schizopod crustaceans (Sealy, 1975). Nearly all foraging is done in fairly shallow water close to shorelines. During the course of a study involving fishermen who salvaged dead birds for inspection, Carter and Sealy (1984) found that the marbled murrelet was the most frequently killed alcid. Marbled murrelets were killed almost exclusively at night and within 2 meters of the surface. They estimated that this accounted for 7.8 percent of the potential fall population, or 6.2 percent of the breeding birds. They also reported 600 to 800 murrelets killed annually in Prince William Sound.

Approximately 612 marbled murrelets were recovered from beaches following the spill. Based on other carcass recovery studies, this suggested that between 8,000 and 12,000 birds may have been killed by the oil spill, which appears to be about 5 - 10% of the current population in the affected area. The available post-spill data indicated that marbled murrelets population have declined since the last census conducted in the middle 1980s. The oil spill probably increased the rate of decline for this species in the spill area, although the magnitude of incremental injury is difficult to estimate.

Storm Petrels

Storm petrels are among the smallest of the seabirds, measuring between 7½ and 9 inches in length and having a wingspan of 18 to 19 inches. With the exception of the breeding and nesting period, these birds spend their entire lives on the ocean. Two species of storm petrels are known to occur in Alaska. Those species are the fork-tailed storm petrel (*Oceanodroma furcata*), and Leach's storm petrel (*Oceanodroma leucorhoa*). The fork-tailed storm petrel occurs in the northern Pacific from the Bering Sea to southern California (Terres, 1980). The breeding range includes the Kurile, Komandorskie, and Aleutian Islands, southward along the North American Pacific coast to northern California. Leach's storm petrel occurs throughout the oceanic portion of the northern hemisphere. This species' breeding and nesting range includes coastal islands in the northern Pacific and northern Atlantic. In the Pacific, breeding occurs on the Kurile and Aleutian Islands, Alaska, and southeast along the Pacific Coast to Baja California (Godfrey, 1979; Terres, 1980). Storm petrels are protected under the Migratory Bird Treaty Act (16 U.S.C. §§703-711 [1976 & Supp. V 1981]).

The petrel's primary food sources are small fishes, crustaceans, mollusks, small squids, and oily materials gleaned from the ocean (Terres, 1980). Habitat requirements for storm petrels include the open ocean and coastal islands for nesting purposes. For breeding purposes, storm petrels prefer

offshore islands. The preferred breeding and nesting habitats are burrows or rock crevices on marine islands and islets, although they have been known to nest up to 1 mile inland (Terres, 1980). The burrow is usually approximately 3 feet long, somewhat angled, and is excavated by the petrel. Some plant debris may accumulate at the nest site. Banding has shown that older breeding birds are the first to return to the nesting site in spring, and that pairs often return to the same nest burrow each year. It is thought that the species mates for life (Terres, 1980). As this species nests in burrows, primary predators in the oil-spill area included foxes that have been introduced to the islands.

The breeding season begins in late May for Leach's storm petrel and in June for the fork-tailed storm petrel. A single clutch consisting of one egg is produced. If that clutch is destroyed, storm petrels do not produce a second egg (Harrison, 1978). Incubation begins when the first egg is laid, usually in late May or early June for Leach's storm petrel and June to July for the fork-tailed storm petrel. Incubation lasts from 5½ to 7 weeks (Terres, 1980). The fledglings are usually deserted by the parents after 40 days. The young remain in the nest, living on fat reserves, and emerge at night to exercise as their feathers grow. The fledglings leave the nest for the sea 63 to 70 days after hatching (Harrison, 1978).

Data from the U.S. Fish and Wildlife Service's seabird colony catalog (Sowls *et al*, 1978) indicate that approximately 150,000 storm petrels colonized the Barren Islands for breeding and nesting prior to the oil spill. Post oil-spill studies (Fry, 1993) indicated that storm petrels were not directly impacted by the oil spill because they did not return to their breeding colonies until most of the oil had drifted away from the Barren Islands. However, 363 storm petrel carcasses were recovered after the spill, indicating that a number of individuals of this species were killed at sea. Injury assessments indicated that storm petrel reproduction was normal in 1989, although petrels had reportedly ingested oil and transferred that oil to their eggs. There has been no documented change in the current storm petrel population status, and no decline in population following the oil spill.

Black-legged Kittiwake

The black-legged kittiwake (*Rissa tridactyla*) is a marine bird occurring throughout the northern part of the northern hemisphere. With the exception of the breeding season, this species occurs almost exclusively in offshore waters. The nesting range includes islands and shores of the Arctic Ocean south to the Aleutian Islands and southern Alaska, southern Newfoundland, France, the Kurile Islands, and Sakhalin. The winter habitat range extends south to Baja California, southern New Jersey, northwestern Africa, and Japan (Godfrey, 1979). This species is protected under the Migratory Bird Treaty Act (16 U.S.C. §§703-711 [1976 & Supp. V 1981]). The kittiwake's primary food sources are small fishes and small mollusks, crustaceans, and other plankton (Terres, 1980).

Black-legged kittiwakes were among the most abundant colonially nesting seabirds in Prince William Sound (Irons, 1993). Additionally, the U.S. Fish and Wildlife Service's seabird colony catalog (Sowls *et al*, 1978) documented 46,600 kittiwakes utilizing the Barren Islands for breeding and nesting. Ten of the 27 colonies within Prince William Sound were subjected to the oil spill. In 1989, 1,225 carcasses were recovered from beaches after the oil spill. Post-spill monitoring has shown that overall, the number of breeding pairs did not substantially decline subsequent to the oil spill. However, the reproductive success of the kittiwakes at the oiled colonies was lower than expected in 1990, 1991, and 1992 when compared to previous years' reproductive success (Irons, 1993). In 1989, kittiwakes built their nests using contaminated seaweed (i.e., *Fucus*). It is possible that reproductive

failure of some kittiwake colonies may have been related to this oil exposure (Fry, 1993). Additionally, the brood size of fledglings decreased, suggesting less available food (Irons, 1993).

In 1989, contaminant analyses indicated that one out of 10 kittiwakes from oiled colonies contained hydrocarbon contaminated tissues. A follow-on study carried out in 1990 indicated that none of the birds collected in the oil-spill area had contaminated tissues, but two out of five kittiwakes examined had ingested hydrocarbon contaminated material suggesting that oil may have persisted in the food chain (Irons, 1993).

Black-legged kittiwakes often nest in dense colonies, usually on high cliffs overlooking the sea, and in sea caves. Their nest sites may be associated with murres and other seabirds. Their breeding season begins in May. Nests are deeply cupped and constructed of grass, mud, moss, and seaweed (Terres, 1980). Nests are often built on small projections or irregularities in the rock face. On the average, a single clutch consisting of two eggs is produced. Incubation lasts from 25 to 30 days (Harrison, 1978). Although black-legged kittiwakes are a single-brooded species, lost clutches are often replaced. The nestlings are tended by both adults, and are fledged between 38 and 48 days of hatching (Terres, 1980).

Pigeon Guillemot

Pigeon guillemots (*Cepphus columba*) have been documented as year-round residents of the Gulf of Alaska and the Aleutians. They are generally dispersed as single birds or small colonies of fewer than 1,000 individuals. In the winter, they move from exposed coastlines to sheltered bays and inlets. The winter range encompasses the Pribilof and Aleutian islands to the Kamchatka and the Kurile Islands, and south to California. During the nonbreeding season, the birds are nonpelagic and fairly sedentary. They rarely move into water more than 50 meters deep, and they tend to spread out thinly along coastlines in winter. Their breeding range extends from Chukotski Peninsula and Diomede Islands to southern Kamchatka, and from Saint Lawrence and Saint Matthew islands and the Aleutians west to the Attu, Bogoslof, and Shumagin Islands, Kodiak, and southeastern Alaska south to Santa Barbara Island, California. The pigeon guillemot is protected under the Migratory Bird Treaty Act (16 U.S.C. §§703-711 [1976 & Supp. V 1981]).

The pigeon guillemot is a diving bird that feeds on bottom dwelling small fishes (e.g., blennies, sculpins, cods), schooling fish (e.g., sand lance, herring), mollusks, crustaceans, and marine worms (Oakley and Kuletz, 1993; Terres, 1980). This species is heavily dependent upon the nearshore and intertidal environments. Most of the guillemot's prey are found on or over rocky bottoms within the subtidal zone (Johnsgard, 1987). Dietary preferences may vary between individuals of this species.

The pigeon guillemot breeding season begins in mid-May to mid-June, depending on latitude. The pigeon guillemot nests either solitarily or in small colonies (Terres, 1980). Nesting distribution may be dictated by the availability of nesting sites rather than by any colonial tendency, and is thought to be related to the use of inshore feeding areas. Breeding densities have been documented to range from 5 to 110 pair per colony (Johnsgard, 1987). Nests are often located in crevices or cavities under rocks, in crevices, or in similar cavity sites (Harrison, 1978). This species is also known to nest under railroad ties, use abandoned puffin and rabbit burrows, and nest on bridges and beneath wooden piers (Terres, 1980). In rocky habitats, the nests are usually close to water, often near the high-tide line. Throughout the breeding season, pigeon guillemots use the supratidal and intertidal areas in front of the nest sites for feeding and social activities (Johnsgard, 1987). Eggs are typically

deposited on the bare cavity floor of the nest site, as no nest-lining materials are ever brought into the cavity. The female produces one clutch consisting of two eggs. This species is thought to be single-brooded, as the incidence of renesting after the loss of the initial clutch is still unproven (Johnsgard, 1987). Both sexes incubate, with incubation lasting from 30 to 32 days (Terres, 1980). Losses of eggs before hatching are sometimes fairly high. Causes of egg failure are diverse and include human disturbance, heavy rainfall causing nest desertion or chilling, and predation (Johnsgard, 1987). Egg survival may be affected by crow and gull predators. The northwestern crow (*Corvus caurinus*) has been identified as a serious guillemot egg predator (Bent, 1919).

The young are able to fly 29 to 39 days after hatching (Terres, 1980). At fledging time, the chicks are led from the nest to the water or, if necessary, fly or glide down from higher sites. The adults then either cease to tend the chicks, leaving them to feed in nearby kelp beds (Thoreson and Booth, 1958), or convoy the chicks to deeper water where they are tended by adults for about a month after leaving the nest (Johnsgard, 1987). It is thought that pigeon guillemots do not begin breeding until they are 3 to 5 years of age.

Because these birds forage nearshore and often congregate on rocky beaches, they were vulnerable to the spilled oil. Five hundred and sixteen guillemot carcasses were recovered after the spill. Total mortality is estimated to be between 1,500 to 3,000 individuals, and may be as much as 10 - 15% of the pigeon guillemot population in the Gulf of Alaska. The results of boat surveys in Prince William Sound indicate that the population of this species was 14,600 in 1973. After the spill, the populations were 4,000 in 1989; 3,000 in 1990; and 6,600 in 1991. The population in Prince William Sound was probably declining prior to the spill, but the survey data indicate that the decline in oiled areas was greater than in unoiled areas. For the Naked Island group, results of post-spill surveys indicated a 40% decline in abundance compared to the latest pre-spill surveys in the mid-1980s. The decline showed a correlation with degree of shoreline oiling. The oil spill probably increased the rate of decline for this species in the spill area, although the magnitude of incremental injury is difficult to estimate.

There are limited management opportunities to increase pigeon guillemot populations. Identification, restoration, and protection of important nesting and feeding areas would facilitate population restoration.

Glaucous-winged Gull

The glaucous-winged gull (*Larus glaucescens*) occurs primarily along the Pacific coast of North America. The summer range extends from Alaska and St. Lawrence Island, the Pribilofs, and the Aleutians south to northwestern Washington. The winter range extends from southeastern Alaska along the Pacific coast to Baja California (Terres, 1980). This species is protected under the Migratory Bird Treaty Act (U.S.C. §§703-711 [1976 & Supp. V 1981]).

The glaucous-winged gull is oceanic in its habits, is most often found in the vicinity of salt and brackish water along the northern Pacific coast, and is rarely found more than a few miles offshore. This species is omnivorous, scavenging for garbage on docks, dumps, and shores near coastal cities. Glaucous-winged gulls follow boats and ships up and down the coast in search of food, and will eat carrion and fishes at sea. From the nearshore areas, this species gathers barnacles, mollusks, and sea urchins for food (Terres, 1980; Godfrey, 1979).

Glaucous-winged gulls breed on steep coastal cliffs and rocky islands offshore. They often nest colonially, usually on flat, low islands, rock ledges of higher islands, or on rock outcroppings. Nests are well-made bulky cups of grasses, seaweeds, feathers, fish-bones, and other debris built among tufts of plant life or left in the open on rocky ledges. The breeding season begins in late May. The female produces a single clutch of two to three eggs that are incubated for 26 to 28 days. The young are tended by both adults and leave the nest between 35 and 54 days. Glaucous-winged gulls are single-brooded, but usually replace lost clutches (Harrison, 1978; Terres, 1980).

Harlequin Duck

The harlequin duck (*Histrionicus histrionicus*) is a diving duck common to the northern coastal areas of North America, specifically along the coasts of the Aleutian Islands and Alaska. The harlequin duck occupies both an eastern and western range in the Northern Hemisphere. The western range includes northeastern Siberia north to the Arctic Circle, across the Bering Sea to the Aleutian Islands, much of the Alaskan interior, and south to northwest Wyoming and central California. The western population is much more abundant than the eastern population, with the main western stronghold located in Alaska. The greatest abundance of harlequin ducks is in the Alexander Archipelago, the Alaska Peninsula, and the Aleutian Islands (Bellrose, 1980; Johnsgard, 1978; Terres, 1980). This species is protected under the Migratory Bird Treaty Act (U.S.C. §§703-711 [1976 & Supp. V 1981]).

Fall and spring migration patterns consist of lateral movements from interior breeding grounds to coastal habitat. A number of ducks migrate from the Alaskan interior to the Aleutians each fall. Additionally, the harlequin duck population in the oil spill area consists of both resident and migratory birds. The migratory ducks spend the winter in Prince William Sound, leaving for their nesting areas in May. In the late 1960s, the May to August population estimates for the Aleutian Islands National Wildlife Refuge ranged from 100,000 to 150,000. Population estimates for this wildlife refuge peak during the winter season (September to April) and range from 600,000 to 1 million individuals (Bellrose, 1980).

During the summer breeding season, the preferred habitat of the harlequin duck is cold, turbulent mountain streams, or ponds and lakes along rocky arctic shores in remote areas. The species favors forested mountain streams over non-forested streams. Patten and Crowley (1991) found that harlequin duck nesting sites in Prince William Sound were within 25 meters of streams or small tributaries to streams. Cassirer and Groves (1990) observed harlequin broods more often on undisturbed streams, away from human activity. Streams with adjacent logging activity within 50 meters would be unsuitable for harlequin duck breeding activity for more than 20 years after the initial logging cut. This species is sensitive to human disturbance (logging, near shore boating, research activities). Reduced disturbance at breeding and molting sites may increase productivity by allowing paired ducks to maintain their pair-bonds during the pre-nesting and nesting seasons. In winter, the harlequin duck's preferred habitat is heavy surf adjacent to a rocky coastline with shelves, reefs, and sunken rocks in remote areas (Terres, 1980).

Harlequin ducks are not known to breed until their second year. After reaching maturity, adults breed annually. Their breeding season begins in mid-May of each year. Adults congregate at the mouths of anadromous fish streams in spring, and most are paired by the time they leave the coastal wintering area for their interior breeding grounds. Harlequin ducks are primarily surface nesters and may use the same nest site each year. The nests are always well concealed by dense vegetation and

are located along the rocky shores of turbulent mountain streams, often adjacent to rapids, in mature forests. Nests are composed of thin layers of grass, twigs, and leaves and are lined with white down (Bellrose, 1980).

The female produces one clutch consisting of three to seven eggs, laid at a rate of one every two days. The male leaves the breeding ground shortly after incubation begins, in preparation for the molt. The incubation period lasts from 27 to 33 days, although the time period has not been firmly established. The ducklings are tended by the female only, and are capable of flying in about 40 days (Johnsgard, 1978; Harrison, 1978; Terres, 1980). The female remains with the brood in the freshwater stream until late summer when they migrate to the coastal habitat.

Harlequin ducks feed by day, usually by themselves, and roost on rocks at night. They prefer waters rich in aquatic life. The harlequin is a diving duck, and is well adapted to swimming in torrential currents. They often emerge at their points of entry, indicating an ability to walk along the bottom of the stream against the current. At times they feed by immersing their heads or upending like dabbling ducks (Terres, 1980; Bellrose, 1980).

The harlequin duck feeds primarily on crustaceans, mollusks, insects, echinoderms, and fishes. In the mountain streams during summer, the harlequin will prey on mayfly nymphs, stone flies, caddis fly larvae, and black flies. During the winter months, the duck will feed about sunken wrecks and rock breakwaters, and rocky underwater places. The primary prey in the coastal habitat are crustaceans (crabs, amphipods, isopods) and mollusks (barnacles, limpets, snails, chitons, blue mussels) that are dislodged from rocks (Bellrose, 1980; Johnsgard, 1978; Terres, 1980).

During the fall, harlequin ducks can be legally harvested in Alaska. Management opportunities to increase harlequin duck populations include temporary restrictions on sport and subsistence harvesting of this species. Additionally, restoration of oiled mussel beds and adjacent anadromous streams; and identification, restoration, and protection of important nesting and feeding areas would facilitate population restoration.

The oil spill caused population declines and appears to have caused sublethal injuries in harlequin ducks. Of the six species of sea ducks studied, harlequin ducks feed highest in the intertidal zone where most of the stranded oil was initially deposited and in some cases still persists. An estimated 600 harlequin ducks were killed by the spill. The resident pre-spill population of harlequin ducks in western Prince William Sound was estimated to be approximately 2000. Wintering migrants increase this population in the western Sound annually by 10,000. With few exceptions since 1989, neither breeding adults nor fledglings have been located in the heavily oiled areas of western Prince William Sound. Evidence of breeding activity in the unoiled eastern Prince William Sound appears to be normal.

Elevated concentrations of hydrocarbons and their metabolites were found in the bile of harlequin ducks collected in western Prince William Sound in 1989. If residual oil in the diet is affecting reproduction, then the effect should begin to diminish once the threshold for toxicity is reached and the levels of persistent oil decrease in the environment. Unfortunately, we have no information after 1989 that determined exposure levels in bile for harlequin ducks in western Sound. Also, there is so little known about how oil may affect reproduction and what physiological changes can be induced by feeding on oiled prey. For these reasons, the possible causes of breeding failure have not been established.

Black Oystercatcher

The black oystercatcher (*Haemotapus bachmani*) is a large shorebird easily distinguishable by its long red bill used to open bivalves. The oystercatcher is often seen on rocky ledges along outer beaches where it preys on attached shellfish exposed by retreating tides. The black oystercatcher's range extends along the Pacific coast from Kiska Island, the Aleutians, Alaska, and south to Baja, California. The species is casual in winter on Pribilof Island and Yukon. The black oystercatcher does not migrate, and winter flocks seldom wander more than 30 miles from their nesting places (Terres, 1980). Observations from Alaska, however, indicate that some birds may disperse in the winter. The black oystercatcher prefers a rocky habitat. Outer saltwater shores and islands are most suitable (Godfrey, 1979). This species feeds in the intertidal zone, primarily on limpets, mussels, clams, and chitons (Terres, 1980). The black oystercatcher is protected under the Migratory Bird Treaty Act (U.S.C. §§703-711 [1976 & Supp. V 1981]).

Black oystercatchers may take two to three years to reach sexual maturity. The oystercatcher breeds on coastal sites, preferring rocky shores, promontories, and islands. The highest breeding densities occur on low elevation, gravel shorelines with little wave action. Nests consist of hollows on gravel beaches above the tide line, or hollows of a rocky islet or reef. Nests are often unlined, or lined with a variable amount of small pebbles or bits of stone and shell chips. Nesting begins in late May or early June. This species is single-brooded, but renests to replace lost clutches. The female produces a single clutch of two to three eggs. Both sexes incubate the eggs for a period of 26 to 27 days. The chicks are usually fledged after 30 days but may continue to be fed by the adults. The young are very active, drawing attention to their location, and are thus vulnerable to predation. Known predators include the river otter, mink, and gulls (Terres, 1980; Harrison 1978; Godfrey, 1979).

The spill caused population declines and sublethal injuries to black oystercatchers. Nine black oystercatcher carcasses were recovered from beaches after the spill. It is unknown how many additional oystercatchers were killed by the spill, but were not recovered. Pre-spill (1972-1973, 1984) and post-spill population surveys suggest that within Prince William Sound, an estimated 120 - 150 black oystercatchers representing 12% - 15% of the total estimated population, died as a result of the spill. Mortality outside of Prince William Sound is unknown, but the total spill-area population is thought to be approximately 2,000 birds.

In addition to mortality caused directly by the spill, oiling also affected their reproductive success. Egg volume and the weight of chicks raised in oiled areas were lower compared to those raised in unoiled areas; however, there are no pre-spill data and it is not known if those conditions existed before the spill. Other measures such as hatching success, fledgling success, and chick production were not different between oiled and unoiled areas. It is quite possible that in 1989 and 1990, disturbance associated with clean-up activities of oiled study areas, e.g., Green Island, contributed to these differences.

Fish

Pink Salmon

Pink salmon (Oncorhyncus gorbuscha), both hatchery reared fish and wild stocks are managed by the Alaskan Department of Fish & Game (ADF&G) in freshwaters and within a three mile limit in marine waters. The North Pacific Fishery Management Council prepares management plans, which

become Federal law, and applies them to marine waters for the 3-mile limit to the 200-mile limit. The International North Pacific Fisheries Commission (INPFC) provides conservation measures that limit location, time, and number of fishing days beyond the 200-mile limit.

Pink salmon have the simplest and least variable life cycle of all salmon. Adults mature after 2 years and die after their first spawning. Because of this simple life cycle, populations spawning on odd number calendar years are effectively isolated from populations spawning on even number years; therefore, no gene flow occurs between the populations (Bonar et al., 1989). As adults, pink salmon return to their natal spawning grounds in the fall to reproduce, traveling several miles up their natal streams (Scott and Crossman, 1973). However, as much as 75 percent of Prince William Sound populations spawn in the intertidal zone (ADF&G, 1985a). Spawning generally occurs between June and mid-September, and hatching occurs between October and January.

The diet of pink salmon fry consists primarily of invertebrate eggs, amphipods, and copepods. Juveniles feed primarily on larger invertebrates and small fishes, and adults feed mostly on euphausiids, squid, other invertebrates, and small fishes (Bonar et al., 1989 and ADFG, 1985a). Eggs, alevins, and fry are preyed upon by Dolly Varden, cutthroat trout, coho salmon, other fishes, and aquatic birds. During spawning migrations, juveniles and adults are consumed by terrestrial mammals such as bears and otters, and by marine mammals, predatory birds, and other fishes while at sea (ADF&G, 1985a).

The oil spill caused sublethal injuries to wild populations of pink salmon, but there is continuing debate on whether the wild stock population has been affected. Seventy-five percent of the wild pink salmon spawn intertidally at the mouth of streams in Prince William Sound. There was no apparent change in the use of this habitat in the summer of 1989, and many salmon deposited their eggs in the intertidal portion of oiled streams. In the autumn of 1989, egg mortality in oiled streams averaged about 15%, compared to about 9% in unoiled streams. Since 1989, egg mortality has generally increased, until in 1991, there was an approximate 40 - 50% egg mortality in oiled streams, and 18% mortality in unoiled streams.

Although the differences between egg mortality in oiled and unoiled streams over the first two years are likely attributable to the effects of oil, the persistence of these differences three years after the spill was entirely unexpected and is not understood. In this regard, natural factors that vary between oiled and unoiled streams, e.g., the degree of wave exposure, have not been eliminated as possible causes of persistent differences. Also, the studies of pink salmon carried out after the spill have documented that adults released as fry from nearby hatcheries are wandering into streams and spawning with wild stocks. The potential effect of this phenomenon on egg survival has not been investigated. Some scientists suggest that the longer the differences in egg mortality persist, the less likely it will be that oil is the cause or a contributing cause.

Pink salmon fry released from hatcheries as well as wild pink salmon fry leaving their natal streams in the spring of 1989 were also exposed to oil in the open water. Both pink salmon and chum salmon larvae were exposed to sufficient amounts of oil to induce 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 is dependent on conditions during the larval stage; and lower food supply, temperature and growth will result in a lower return of adults the following year.

Despite the differences in egg mortality and larval growth, tagging data do not show that pink salmon populations were affected by the oil spill. For example, fry that were tagged as they left their streams in 1990, and were recaptured as returning adults in 1992, did not show differences in survival between oiled and unoiled streams. Fisheries experts disagree whether or not the increased egg mortality seen in the oiled streams is affecting the adult populations.

Seventy-five percent of the wild pink salmon spawn intertidally at the mouth of streams in Prince William Sound. There was no apparent change in the use of this habitat in the summer of 1989, and many salmon deposited their eggs in the intertidal portion of oiled streams. In the autumn of 1989, egg mortality in oiled streams averaged about 15%, compared to about 9% in unoiled streams. Since 1989, egg mortality has generally increased, until in 1991, there was an approximate 40 - 50% egg mortality in oiled streams, and 18% mortality in unoiled streams.

Sockeye Salmon

Both hatchery reared and wild stocks of sockeye salmon (*Oncorhyncus nerka)* are managed in freshwaters and within a 3-mile limit in marine waters by the North Pacific Fishery Management Council prepares management plans, which become Federal law, and applies them to marine waters from the 3-mile limit to the 200 mile limit. The International North Pacific Fisheries Commission (INPFC) provides conservation measures that limit location, time, and number of fishing days beyond the 200-mile limit.

Spawning usually occurs between July and October. The female builds several redds in sand or graveled areas that will provide sufficient oxygenation for the eggs and alevins. Egg survival is dependent on chemical and physical characteristics of the gravel in which they are laid. One of the most critical life stages of sockeye salmon are the egg-to-juvenile stages. Several environmental requirements must be met for successful reproduction. The optimum temperature range for spawning is 10.6 to 12.2°C. Lower mortality and faster growth rates during incubation occur when water temperatures are between 8.9 and 10.0°C. Water temperatures higher than 23.0°C and lower than 7.2°C cause increased mortality and poor growth. Sockeye salmon require a minimum of 5.0 mg/l of DO for successful spawning. Low DO can disrupt swimming efficiency during migration and stunt the growth of alevins and juveniles (Pauley et al., 1989; ADFG 1985b). Egg mortality usually results from oxygen deprivation, freezing, flow fluctuations, dewatering, predation, or microbial infestation (Bonar et al., 1989). Changes in velocity can effect developing eggs and alevin through mechanical damage, temperatures changes, or reduced DO concentrations (Pauley et al., 1989; ADFG 1985b). The alevins leave the gravel as fry in April or May (Pauley et al., 1989).

The fry move into their nursery lakes and remain for 1 to 2 years, 3 years in some Alaskan lakes, as smolts. This is a critical stage in their life cycle. Mortality is generally high as a result of predation from Dolly Varden, rainbow trout, and coho salmon. During this time, the sockeye salmon are pelagic schooling fish that feed primarily on zooplankton during the afternoon and avoid predators at other times. Migration as smolts from the nursery lakes to the sea is usually temperature dependent. They migrate to the ocean and remain in the inshore areas for the first few months before moving out to the Gulf of Alaska. Adults generally remain in the marine environment for 2 to 4 years before returning to freshwater to spawn (ADFG, 1985b, Pauley et al., 1989).

Adults feed primarily on euphausiids, amphipods, copepods, and young fishes. When returning to fresh water, the adults generally do not feed. Juveniles in streams feed primarily on small insects and

insect larvae, and eat zooplankton in lakes. In the marine environment, they feed on small crustaceans, plankton, and fish larvae. Juveniles are important prey species for birds and other anadromous fish species such as Dolly Varden, coho salmon, cutthroat trout, arctic char, and sculpin. Adults are preyed on by marine mammals and predatory fishes (Pauley et al., 1989; ADFG 1985b).

Kenai River and Red Lake-Kodiak sockeye salmon stocks may have suffered population declines as well as sublethal injuries. This potential injury is unique, since 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 (overescapement) of spawning fish to the Kenai and Red Lake systems in 1989, although this was the third consecutive year of overescapement to the Kenai River system.

For the Kenai system, more than 900,000 spawning fish returned each year from 1987 through 1989, when the system was managed for a return of only 600,000 fish a year. The cumulative effect of too many spawning adults in the Kenai River system has been a decline in smolt production. Although the exact mechanism by which this occurred is not clear, it is believed that concentrations of food (planktonic crustacea) are insufficient to meet the needs of the greater number of fry produced. Fewer fry surviving their first winter in rearing lakes result in fewer outmigrant smolt in the spring. Smolt production in the Kenai River system has declined as follows: 1987, 30 million; 1988, 6 million; 1989, 2.5 million; and 1990, less than 1 million. Outmigrations of smolt from the system have been on the decline since 1990 and the forecasted returns in 1994 are below escapement goals.

Pacific Herring

Pacific herring (*Clupea harengus pallasi*) are managed in freshwaters and within a three-mile limit in marine waters by the Alaskan Department of Fish & Game (ADF&G). The North Pacific Fishery Management Council prepares management plans, which become Federal law, and applies them to marine waters from the 3-mile limit to the 200-mile limit. The International North Pacific Fisheries Commission (INPFC) provides conservation measures that limit location, time, and number of fishing days beyond the 200-mile limit.

At the time of the oil spill Pacific herring were spawning in the shallow eelgrass and algal beds. As a result, a large percentage of abnormal embryos and larvae were found in the oiled areas in Prince William Sound. There was also evidence of hydrocarbon metabolites in the bile of adult fish. It is unclear whether or not the adult population was affected by the oil spill; only when the cohorts from 1989 and 1990 return to spawn in 1992 and 1993 will determination of effect be possible.

Pacific herring mature between 2 and 4 years of age and spawn annually. They live offshore, but spawn in nearshore coastal waters. Their greatest mortality occurs during the egg-to-juvenile stages, when mortality is 99 percent. Adults have a lifespan of approximately 19 years (Pauley et al., 1988). Juvenile herring feed on crustaceans, mollusks, and fish larvae, and adults feed on euphausiids, planktonic crustaceans, and fish larvae (Pauley et al., 1988). Herring eggs are preyed on by shorebirds, diving birds, gulls, invertebrates, and fish. Herring larvae are eaten by jellyfish, amphipods, and fish. Adults are a prey base for large finfish, sharks, and marine mammals and birds (Pauley et al., 1988).

The oil spill caused sublethal injuries to Pacific herring in Prince William Sound, but scientists do not know whether these injuries will result in a population decline. Pacific herring spawned in intertidal and subtidal portions of Prince William Sound shortly after the spill. Although none of the herring

spawning areas were heavily oiled, over 40% of areas used by herring to stage, spawn, or deposit eggs and 90% of the areas used for summer rearing and feeding were lightly or moderately oiled. Oiled spawning areas included portions of Naked and Montague islands.

Studies conducted in 1989 and 1990 showed a slight but statistically significant higher rate of egg mortality in oiled areas, compared to unoiled areas. In 1989, rates of larval mortality, lethal and sublethal genetic damage, and physical deformities also were greater in oiled areas. There also is some evidence of differences in histopathological condition and reproductive success in oiled areas in 1989. However, all differences between oiled and unoiled study sites were less pronounced in 1990, and were not observed in 1991.
Three-year-old herring exposed as eggs or larvae in 1989 were under represented in the 1992 spawning migration. In 1993, the 1989 year class represented only 5 - 10% of the spawning migration, and although contributing a relatively low number of potential spawners, this number is within the natural variation for individual year class size. There also was an outbreak of viral hemorrhagic septicemia (VHS) in herring returning to Prince William Sound in 1993 but it is not known if the disease is linked to the oil spill.

Rockfish

The North Pacific Fishery Management Council prepares management plans, which become Federal law, and applies them to marine waters for the 3-mile limit to the 200-mile limit. The International North Pacific Fisheries Commission (INPFC) provides conservation measures that limit location, time, and number of fishing days beyond the 200-mile limit.

There are more than 50 species of rockfish (*Sebastes* spp. and *Sebastolobes* spp.), including yellow 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. Their life histories are variable and not well understood. The following life history information is for the yellow rockfish. Yellow 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.

Yellow rockfish are opportunistic feeders. They feed primarily on a variety of crabs, shrimp, snails, and fish. Small yellow 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 whether or not population declines also occurred. There is little pre-spill 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 incidences of organ lesions in 1989, 1990 and 1991, although there is some uncertainty associated with causes of these pathological changes. In 1990 and 1991, oil exposure was documented in oiled but also unoiled sites.

An additional unknown is the degree to which post-spill increases in fishing pressure may be impacting rockfish. Partially due to numerous spill-related commercial fishing closures (salmon,

Oil Spill Impacts on Subsistence Income

Community	Income per capita	Average persons per household	Income per household of 3 persons	Adjustment factor for household of 3	Adjusted income for family of 3	Difference % from Valdez baseline
Kenai Peninsula						
English Bay	12,615	3.76	47,432.40	0.79	37,471.59	-0.54
Homer	19,182	2.54	48,722.28	1.81	88,187.32	+0.09
Kenai	17,877	2.70	48,267.90	1.11	53,577.36	-0.34
Port Graham	17,265	2.77	47,824.05	1.08	51,649.97	-0.36
Seldovia	14,052	2.45	34,427.40	1.27	41,312.88	-0.49
Seward	16,615	2.47	41,039.05	1.21	49,657.25	-0.39
Soldotna	15,800	2.69	42,502.00	1.11	47,177.22	-0.42
Kodiak Island						
Akhiok	14,793	4.05	59,911.65	0.74	44,334.62	-0.45
Karluk	8,052	3.94	31,724.88	0.76	24,110.90	-0.71
Kodiak	22,951	2.92	67,016.92	1.02	68,357.25	-0.16
Larsen Bay	19,222	3.34	64,201.48	0.89	57,139.31	-0.30
Old Harbor	8,008	3.26	26,106.08	0.92	24,017.59	-0.71
Ouzinkie	16,530	3.07	50,747.10	0.97	49,224.68	-0.39

subsistence economy, the concept suggests a means of suggesting the contribution of subsistence activities to overall household income.

This approach is a concept only, and should not be considered the definitive approach for valuing the portion of total income represented by subsistence harvesting. Degrees of error are introduced by the averaging, extrapolation and ration assumptions which may not be valid or accurate given the current lack of precise information. The concept is offered only as a potential means of identifying the contribution of subsistence harvesting to total incomes of EVOS residents.

per capita income data and average household size were drawn from the 1990 Census for EVOS communities. Per capita income figures and average household size numbers were multiplied to produce an average household income. Household sizes ranged from 2.16 to 4.05. A standardized household size value needed to be established to provide a meaningful comparison across EVOS communities. Valdez was selected as the baseline community because it showed more diversity in its economic base, and less dependence on subsistence harvests. All other EVOS communities were compared for their deviation from the Valdez standard. A percentage value relative to Valdez was developed for each community, and adjusted household income values were established for an average household of 3.

Per capita subsistence harvest information was available for selected EVOS communities for recent years prior to the oil spill and the oil spill year (Fall 1990). For purposes of this study, a value for a pound of protein was developed using data from a market survey of Cordova. Based on the Cordova study information, values were extrapolated for other EVOS communities to facilitate the development of a cash economy replacement value. Costs for commodities varied from community to community.

The resulting amount (subsistence pound harvest X value/pound) was multiplied by 3 to represent the cash value of subsistence for the 3-person average household. This amount was added to the cash per capita household figure to create the total cash plus subsistence income for households of 3 persons.

The subsistence cash value was divided by the total cash-subsistence income to provide a percent of total household income from subsistence for the years before the oil spill and the year of the oil spill. The percentage difference between the years before the oil spill, and the year of the oil spill was established.

For the purpose of developing a scenario portraying the importance of subsistence resources to EVOS households, many assumptions were made which may not reflect the true value of subsistence harvesting in mixed cash-subsistence incomes. Valdez was selected as the baseline community because of its apparent non-subsistence dependency. Its location within the EVOS area suggested that a more reasonable comparison could be made between Valdez and other EVOS communities, ~~and~~ than between Anchorage and EVOS communities. In addition, it is acknowledged that the average household size identified in the 1990 Census may not reflect the true composition of households, particularly in largely Native communities. Nevertheless, in the absence of a standardized methodology address the value of subsistence in a mixed cash-

products are important institutions in Prince William Sound and in Alaska. 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. (The Day the Water Died, 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. Among Alaska Natives, reliance on subsistence foods is greater still, with subsistence resources providing 80 to 100 percent of Natives' total protein intake, at an average of 500 pounds per person per year as depicted on the chart for Post Spill Change. Subsistence foods provide a large portion of the diet—a portion that families can ill afford to replace with imported substitutes.

Valuing Subsistence

There is not standardized formula for establishing the cash value of subsistence harvests (Fall 1991; Pederson 1990; Wolfe 19--). The economies of the EVOS area are mixed cash-subsistence economies (Wolfe 19--). Cash income received from employment is supplemented by subsistence harvesting. The percentage of total income represented by subsistence in the EVOS communities is not known. The dependency on subsistence supplementation varies from community to community throughout the EVOS area. Nevertheless, understanding the contributions made by subsistence resources to EVOS resident incomes is important the impacts of the oil spill and the Restoration Plan. As a result, the following concept has been developed to attempt to identify the portion of overall household income represented by subsistence resource contributions, and is depicted on the Potential Oil Spill Impacts on Subsistence tables.

In an effort to provide insight into the importance of subsistence resources to EVOS households,

of clan divisions, to norms governing the distribution of wealth, to reinforcement of basic values of respect for the earth and its resources (Glass, Muth, and Flewelling, in press; Muth and Glass, 1989).

The harvest of fish and game plays important sociocultural roles in non-Native communities as well. It contributes to self-reliance, independence, and ability to provide for oneself; values that social surveys indicate 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.

Prior to the oil spill, the EVOS was considered a relatively pristine wilderness with bountiful environmental resources that made the area particularly valuable to Alaskans, both Native and non-Native. The relatively unpolluted environment enriched individual lives by simply existing. This perspective is some what 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.

Economic Implications

The economic aspects of the subsistence system are dependent upon 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 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 as depicted on the Per Capita Subsistence Harvest chart. For some residents, subsistence is the primary source of food and supplies. For others, subsistence supplements resources available from other sources.

The communities affected by the oil spill are small, relatively isolated, and economically dependent on local fish and wildlife. The noncommercial transfer and exchange of wildlife

Subsistence systems are characterized by four 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. The form of settlement and the pace of life in Alaskan communities depend upon the season.

- 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, the division of the catch or harvest, and the assignment of responsibilities are determined by tradition. Communities that share the overlapping territories for hunting and fishing occupy their individual niche and adhere to the rights and responsibilities traditionally assigned to them.

- 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.

Historically, government, the socioeconomic environment of the EVOS 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. EVOS residents working in the resource and tourist industries often experience levels of unemployment higher than the national average during periods of recession.

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.

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

Method	Where used	Technique	Potential Impacts
Relocation to surf zone (Experimental)	Shoreline, beach	Manually or mechanically removed sediments and placement in surf zone to allow natural wave action to clean sediments.	As above; potential for severe disturbance of cultural resources in the removal zone.

Subsistence

Subsistence Law

Alaska is the only State in which a significant proportion of the population lives off the land or practices a subsistence life style. Subsistence is critical to supporting the incomes and cultural values of many Alaska residents. While there are a variety of cultural, popular, and sociological definitions and interpretations of subsistence, Congress addressed 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.

ANILCA provides for "the continuation of the opportunity for subsistence uses by rural residents of Alaska, including both Natives and non-Natives, on the public lands." It also legislates that "customary and traditional" subsistence uses of renewable resources "shall be the priority consumptive uses of all such resources on the public lands of Alaska." 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. In July 1990, the State of Alaska initiated action to insure compliance of its fish and game regulations with the Federal Subsistence Board, and implemented Temporary Subsistence Management Regulations for Public Lands in Alaska with institutions of these regulations, all Alaskans residents became eligible for subsistence priority on State public lands.

Subsistence in Practice

The term "subsistence" refers to a particular pattern of harvesting and using of naturally occurring renewable resources. Subsistence hunting, fishing, trapping, and gathering activities represent a major focus of life for many EVOS communities. Individuals 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.

Treatment Methods and Potential Impacts

Method	Where used	Technique	Potential Impacts
Cold-water deluge	Crevices, interstices on rocky shores	Large volumes of ambient seawater at low pressure are used to wash surface oil to the water's edge.	Limited; comparable to normal wave action.
Cold-water, low-pressure washing	Rock surfaces, oil buried in shallow layers in sand and gravel-sized sediments	Low pressure (<50 psi) spray used to remove lightly adhering oil; also used to gently agitate substrate, expose buried oil, and move it downslope to a boomed area.	Limited; comparable to normal wave action. Improper application may drive oil farther into substrate.
Cold-water, high-pressure washing	Rock surfaces, buried oil in substrate, loose oil in tide pools and crevices	High-pressure ambient spray used to remove adhering oil and flush out loose oil.	Potentially destructive; severely agitated near-surface deposits. May drive oil deeper into substrate.
Warm-water, high-pressure washing	Heavily oiled boulder, cobble, and rock shoreline	High-pressure (up to 100 psi), heated seawater spray used to mobilize weathered oil.	As above; warm water may facilitate oil penetration to deeper levels of sediment.
Hot flush with hand wands	Inaccessible locations (e.g., narrow crevices)	Hand wands with pressurized water used to dislodge trapped oil.	Little sediment agitation lessens threat to artifacts; warm water may facilitate oil penetration.
Vacuum system	Shoreline surface	Vacuum pumps used to remove free oil.	Limited if used properly (i.e., little substrate removed).
Hot water injection	Shoreline sediments	Forces hot water below the sediment surface and flushes oil out through well points driven into the substrate.	Well point insertion may damage or displace buried artifacts; warm water may facilitate oil penetration.
Burying of oiled surfaces	Oiled logs and other materials	Used to remove oiled objects from areas of high recreational use.	Digging may damage existing buried artifacts.
Disking (Experimental)	Lightly oiled sand beaches	Used to break up oiled layers and mix throughout the upper sediment profile.	High potential for damaging surface and near-surface artifacts.
Sediment removal (Experimental)	Oiled beaches	Manual or mechanical removal of oiled sediment, then disposal.	All features in the direct work area may be affected; buried features may be compressed or displaced by heavy equipment.
Shoreline removal, cleaning, and replacement (Experimental)	Oiled shoreline	Oiled sediments are removed, treated, and replaced.	Cultural materials in the removed sediment zone may be destroyed or crushed.

Injuries included vandalism, erosion of beachfront sites, removal of artifacts, and oiled sites. With regard to the oil spill, the three major sources of potential impact were direct impacts resulting from oil in direct contact with artifacts or features; treatment methods employed to remove oil; and human activities incidental to the response actions.

The types and locations of archaeological and architectural sites made them particularly vulnerable to disturbances related to the oil spill. 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 were 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 physical materials incorporated into these sites includes stone, bone, shell, various metals, wood, textiles, leather, and other organic items.

The major potential physical impact of oiling is the obscuring of intertidal artifacts from observation, with the secondary 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 not known. Some scientists have raised questions about whether contaminated organic items can still be dated using radiocarbon techniques, but others believe that the oil can be removed from crucial samples so that they may be successfully dated. (CRS, 1989:103).

Several of the cleaning methods used on the beaches were particularly damaging to archaeological resources. Archaeological and architectural sites located in the uplands adjacent to treated shorelines were at risk only 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. In addition, a variety of pedestrian upland crossings 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.

Eight methods of treatment were routinely combined and employed to remove oil from shorelines in the EVOS, and affected archaeology sites and artifacts to varying degrees. Four more were developed and applied experimentally. The potential impacts to cultural resources varied depending on the type of application. These treatment methods and their potential impacts are outlined in the table below.

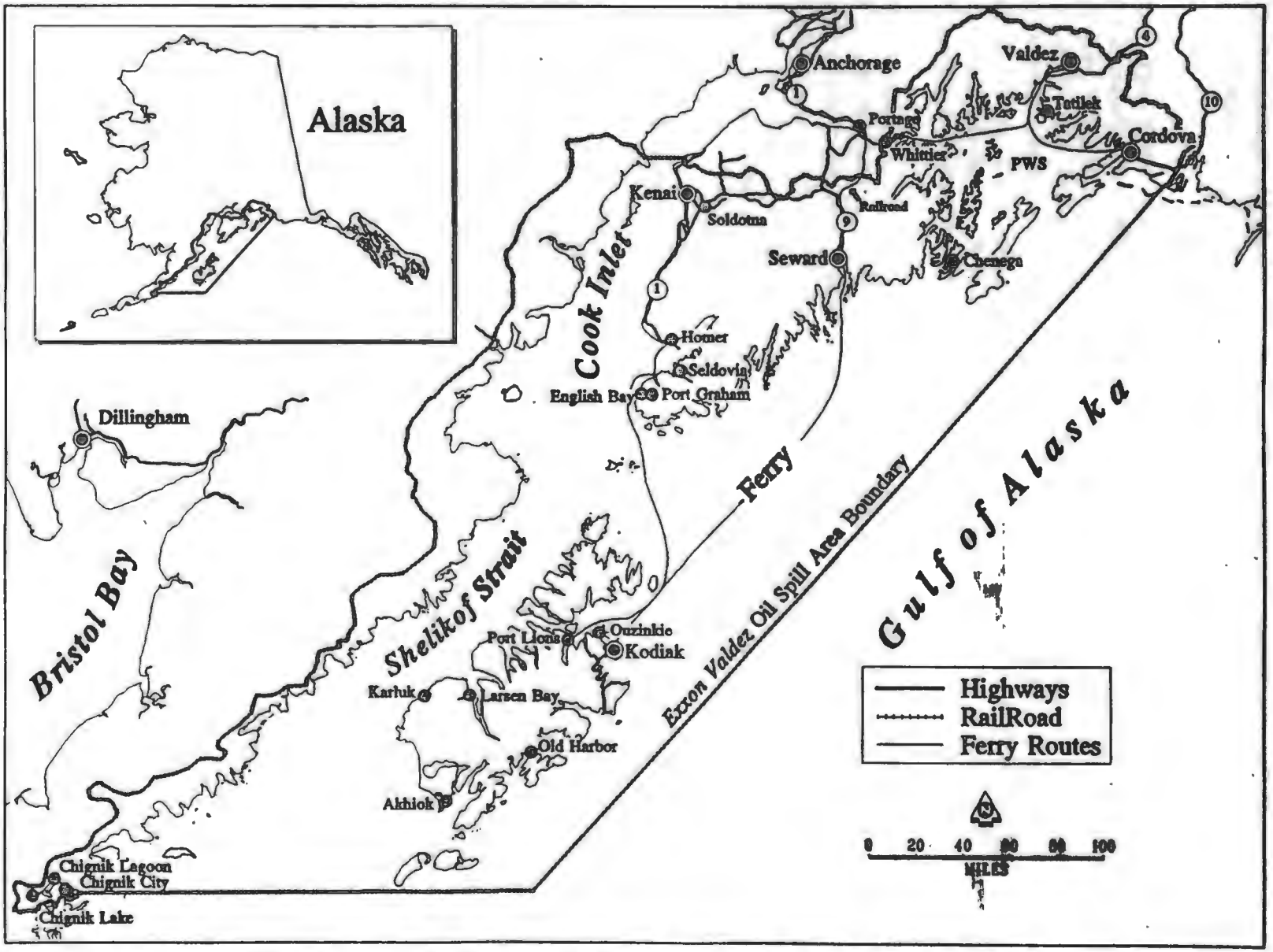

Figure III-C. Major land and water transporation paths in the *Exxon Valdez* oil spill area.

and by changes in the local economy caused by the influx of visitors and cash.

Lake and Peninsula Borough

The Lake and Peninsula Borough contains three communities—Chignik Bay, Chignik Lagoon, and Chignik Lake—which were exposed to oil in the form of tar balls and oil sheen. Some remote beaches were also oiled. Residents of all three communities are Aleut, Russian, and Scandinavian. The economies of the communities are mixed cash-subsistence.

Valdez-Cordova Census Area

The Valdez-Cordova Census Area covers an area of about 20,000 square miles of water, ice, and land in Prince William Sound. For the purpose of this study, the region includes five communities: Valdez, Cordova, Whittier, Chenega Bay, and Tatitlek. Each is accessible by air or water, and all have dock or harbor facilities. Only Valdez is accessible by road.

The region has an abundant supply of fish, shellfish, and marine mammals. These and the other natural resources of *EVOS* play an important part in the lives of area residents. In addition, the area offers significant opportunities for outdoor recreation and commercial tourism.

The 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 are also important to the local economy. Whittier residents work as government employees, longshoremen, commercial fishermen, and service providers to tourists. The Alaska Native people of Chenega Bay and Tatitlek, by contrast, rely on subsistence fishing, hunting, and gathering for their livelihood.

Transportation

Transportation resources 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. Road access is available from Anchorage to Homer and Seward on the Kenai Peninsula, and to Valdez and Cordova 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. Figure III-C summarizes the transportation resources in the Exxon Valdez oil spill area.

italics

Cultural and anthropological resources

Sites important to the Alaskan culture were injured by the oil spill and by the cleanup response, mainly by increasing human activity in and around Prince William Sound. At least 24 archaeological sites, including burial grounds and home sites, were injured to various degrees.

Region	Community	Government Type	Total Population	Non-Native Population (%)	Native Population (%)	Subsistence Prevalence	Industry and Employment	Per Capita Income	Access
Valdez-Cordova Census Area	Chenega Bay	Unincorporated village	94	29 (30.9)	65 (69.1)	High	Fishery	$9,211	Air, water
	Cordova	Home-rule city	2,110	1,873 (88.8)	237 (11.2)	Moderate	Fishery, aquaculture, fish processing	$23,408	Air, boat, N/A
	Tatitlek	Unincorporated village	119	16 (13.4)	103 (86.6)	High	Fishery	$8,674	Air, water
	Valdez	Home-rule city	4,068	3,829 (94.1)	239 (5.9)	Low	Oil, fishery, fish processing, government, transportation	$26,968	Air, water, roadway
	Whittier	Second-class city	243	213 (87.7)	30 (12.3)	Low	Fishery, tourism, transportation	$17,032	Air, water, railway

SOURCE: Alaska Department of Labor Research & Analysis, 1990 Census.

Affected Environment
Baseline Socioeconomic Description

Region	Community	Government Type	Total Population	Non-Native Population (%)	Native Population (%)	Subsistence Prevalence	Industry and Employment	Per Capita Income	Access
Kenai Peninsula Borough	Nanwalek	Unincorporated village	158	14 (8.9)	144 (91.1)	High	Fish	$12,615	Air, water
	Homer	First-class city	3,660	3,530 (96.4)	130 (3.6)	Low	Fishery, tourism, recreation, agriculture	$19,182	Air, water, roadway
	Kenai	Home-rule city	6,327	5,792 (91.5)	535 (8.5)	Low	Fishery, fish processing, oil and gas development	$17,877	Air, water, roadway
	Port Graham	Unincorporated village	166	16 (9.6)	150 (90.4)	High	Fishery, fish processing	$17,265	Air, water
	Seldovia	First-class city	316	268 (84.8)	48 (15.2)	High	Fishery, fish processing, logging, tourism	$14,052	Air, water
	Seward	Home-rule city	2,699	2,289 (84.8)	410 (15.2)	Low	Fishery, logging, coal, tourism, local government	$16,615	Air, water, roadway
	Soldotna	First-class city	3,482	3,324 (95.5)	158 (4.5)	Low	Sport fishery, tourism, recreation	$15,800	Air, water, roadway
Kodiak Island Borough	Akhiok	Second-class city	77	5 (6.5)	72 (93.5)	High	Fishery, local government	$14,793	Air (infrequent), water
	Karluk	Unincorporated village	71	6 (8.5)	65 (91.5)	High	Subsistence, fishery	$8,052	Air, water
	Kodiak	Home-rule city	6,365	5,554 (87.3)	811 (12.7)	Moderate	Fishery, fish processing, tourism, logging/timber, government	$22,951	Air, water
	Larsen Bay	Second-class city	147	23 (15.6)	124 (84.4)	High	Fishery, fish processing, tourism	$19,222	Air, water
	Old Harbor	Second-class city	284	32 (11.3)	252 (88.7)	High	Fishery	$8,008	Air, water
	Ouzinkie	Second-class city	209	31 (14.8)	178 (85.2)	High	Fishery	$16,530	Air, water
	Port Lions	Second-class city	222	72 (32.4)	150 (67.6)	High	Fishery	$14,960	Air, water
Lake and Peninsula Borough	Chignik	Second-class city	188	103 (54.8)	85 (45.2)	High	Fishery	$13,188	Air, water
	Chignik Lagoon	Unincorporated village	53	23 (43.4)	30 (56.6)	High	Fishery	$19,604	Air, water
	Chignik Lake	Unincorporated village	133	11 (8.3)	122 (91.7)	High	Fishery	$7,765	Air, water

Affected Communities

The communities affected by the *Exxon Valdez* spill are grouped into four regions: the Kenai Peninsula Borough (KPB), the Kodiak Island Borough (KIB), the Lake and Peninsula Borough, and the Valdez–Cordova Census Area. The effects of the spill differ for each region and its communities. In general, the communities that experienced the most disruption were the small villages with larger Native populations, which are mixed cash-subsistence hunting- and fishing-based economies. Figure III- presents a summary of the baseline descriptive socioeconomic data for the *EVOS* communities.

Kenai Peninsula Borough

The Kenai Peninsula Borough, which is located south of Anchorage, 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 holds 99 percent of the borough's population and most of the area's development because it is linked by roads to Anchorage. Sixty-three percent of the borough's population lives in Kenai and Soldotna. The area is economically dependent on the oil and gas industry, as well as fishing and tourism. Communities within the central Kenai Peninsula region are the cities of Kenai, Soldotna, and Seward.

The southern Kenai Peninsula contains the cities of Homer and Seldovia and the Native villages of Port Graham and English Bay. Homer is the economic and population hub of the region, with revenues from commercial fishing, tourism, government and commercial offices, and agriculture. In contrast, the Native villages are largely dependent upon subsistence hunting and fishing. Residents of these communities who relied upon subsistence were adversely affected by actual contamination or perceived contamination of subsistence foods.

Kodiak Island Borough

The Kodiak Island Borough (KIB) includes the city of Kodiak and the six Native villages of Port Lions, Ouzinkie, Larsen Bay, Karluk, Old Harbor, and Akhiok. The KIB population is between 13,000 and 15,000 and includes Natives of Aleutic background and immigrants from the Philippines and from Central and Meso-America. As in other parts of Alaska, Kodiak Island's population grows significantly in the summer. The KIB provides some social, cultural, and economic services to villages, and the Kodiak Area Native Association (KANA) provides medical and social services through the tribal governments in each village.

Nearly two-thirds of the Kodiak Island shoreline was oiled. Oil in varying forms spread from the northern end of the island along the west coast and through the many passages, coves, and small islands that make up the Kodiak Island group. In addition to the physical effects of the oil on these communities' land, social effects were associated with the cleanup activities that followed the spill. Daily life in many Native villages was disrupted by the presence of outsiders

Social and Economic Environment

This section describes the social, cultural, and economic conditions of the EVOS region. Included are descriptions of the communities affected by the spill; a discussion of the impact of the spill on traditional Native and non-Native subsistence hunting and fishing; information about spill-related injury to cultural and anthropological resources; and a description of the economic base of the area.

Relevant State History

The Alaska Statehood Act (48 U.S.C.) admitted Alaska to the Union in January 1959. The act allowed the State to select 400,000 acres of National Forest and unreserved land for community use. In addition, the State was also empowered to choose 102.55 million acres of public lands from other unreserved U.S. lands.

The Alaska Native Claims Settlement Act of 1971 (33 U.S.C. § 1601-1624) settled aboriginal rights and established the legal claims for Alaska Natives. It also authorized formation of the Regional Native Corporations. 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.

Oil exploration and development grew after statehood was declared. In 1968, a discovery well at Prudhoe Bay on the North Slope uncovered the largest known oil field in the United States. The North Slope oil lease, completed in 1969, granted oil rights to an oil consortium and brought more than $900 million in bonuses to Alaskans. To provide for transporting the oil from the North Slope to a shipping point, Congress passed the Trans-Alaska Pipeline Authorization Act in 1973. Construction of the pipeline was completed in 1977. Today, the pipeline moves almost 2 million barrels (84,000,000 gallons, or 317,940,000 liters) from Prudhoe Bay to Valdez every day. Since 1977, the Port of Valdez has shipped the bulk of crude oil taken from Prudhoe Bay (*Alaska Blue Book*, 1991).

In 1976, the first of USDOI's Minerals Management Service lease sales for outer continental shelf (OCS) oil and gas were completed in the eastern Gulf of Alaska. Sales followed in Lower Cook Inlet (1977 and 1981), the northeastern Gulf of Alaska (1980), and east of Kodiak Island (1980). Although Valdez and Prince William Sound have little or no known oil or gas potential, the area is part of Lease Sale 88.

The Alaska National Interest Lands and Conservation Act of 1980 (ANILCA, 16 U.S.C. 3111 *et seq.*) in part implemented provisions of the Alaska Native Claims Settlement Act and the Statehood Act. In ANILCA Congress recognized 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.

Pacific Razor Clam. The Pacific razor clam species is found on open sandy beaches from Pismo Beach, California to the Aleutian Islands, Alaska. Large razor clams tend to inhabit the lower intertidal zone, and razor clams found in the subtidal zone tend to be juveniles. The razor clam filters its food from the water it inhabits, and serves as prey for seagulls, sea ducks, and Dungeness crabs. This species supports an active sport fishery and limited commercial harvest. It has been suggested in the past that artificial propagation of razor clams is not feasible; however, the State of Washington has maintained a razor clam hatchery since 1980 (Lassuy and Simons, 1989).

The razor clam has been subject to disease in the past. Paralytic shellfish poisoning in razor clams was found in Alaskan razor clam populations between 1985 and 1987 (Lassuy and Simons, 1989).

Subtidal Organisms

The subtidal zone is the environment below the low tide. The shallow subtidal zone differs in community composition from deeper marine habitats and is especially vulnerable to oil spills. Inhabitants of the shallow subtidal zone consist of amphipods, clams, eelgrass, crabs, juvenile cod, *Laminaria* plants, spot shrimp, and many other organisms. As with the intertidal zone, oil-contaminated areas in the subtidal zone suffered declines in the populations of many of the organisms that inhabited them.

The oil spill caused population declines and sublethal injuries in the communities of plants and animals found below low tide. Several kinds of subtidal environments were studied after the spill: eelgrass beds, *Laminaria* (kelp) beds, fjords and the deep bottom (40 to 100 meters). All these studies relied on comparisons between oiled and unoiled environments. Study sites also were matched for conditions (sediment grain size, depth., etc.) likely to affect the distribution and abundance of organisms.

The greatest differences were seen for small organisms living in the sandy sea bottom below eelgrass beds--they were less abundant in oiled environments. Among affected groups were amphipods, known from previous studies to be highly sensitive to oil. In addition, there were larger organisms that showed differences in abundance, most notably the crab *Telemesus* was less abundant in oiled areas. Two separate studies found that eelgrass in oiled areas did not bloom as well after the spill as in unoiled areas. Other organisms, however, were more abundant in oiled areas--some small mussels that live on eel grass and juvenile cod. Even greater differences were observed in the abundance of fauna at depths from 6-20 meters below the oiled eelgrass beds, where there were far fewer individuals in oiled areas.

The results of other subtidal studies were more equivocal. Chemical analyses show that Exxon Valdez oil apparently did not reach deeper than 20 to 40 meters, although elevated activities of hydrocarbon-degrading bacteria were seen somewhat deeper in some cases. Reduced abundances in fauna were encountered in several oiled bays at 100 m, but the causes of these differences are not clear. Some flatfish had elevated amounts of hydrocarbons in their bile in 1989 and 1990, and slightly elevated prevalences of gill damage.

Because of their ability to quickly take up petroleum hydrocarbons, and their inability to quickly metabolize the hydrocarbons, clams accumulate high concentrations of hydrocarbons. Therefore, clams inhabiting the shallow subtidal zone present an ongoing source of contamination to the many organisms that feed upon them (*Exxon Valdez* Oil Spill Trustees, 1992).

little neck clams and, to a lesser extent, butter clam also were significantly affected by the spill. Also, in 1990, comparisons of abundance of intertidal fishes indicated fewer fish in oiled areas, but such differences were not found in 1991.

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 duck, 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.

Profiles of the following intertidal inhabitants are presented in subsequent paragraphs: blue mussel (*Mytilus edulis*), common littleneck clam (*Protothaca staminea*), and Pacific razor clam (*Siliqua patula*). These organisms play important ecological and commercial roles within the EVOS area (e.g., mussels provide a source of food for many other organisms, and clams are harvested both recreationally and commercially).

Blue Mussel. Within the United States, the subspecies of blue mussel called *Mytilus trossulus* is distributed from Oregon to Alaska (Moore, personal communication, 1993). It is found along rocky coastlines, in bays, and in estuaries. Blue mussels are harvested commercially for bait and for food. Blue mussels are suspension feeders and feed on dinoflagellates, organic particles, small diatoms, zoospores, ova and spermatozoa, flagellates, unicellular algae, and detritus. There is limited culturing of these mussels for food. These mussels are preyed upon by sea stars, gastropods, crabs, sea otters, black oystercatchers, and ducks (Shaw *et al.*, 1988).

Blue mussels are subject to pollution and paralytic shellfish poisoning. Commercial harvest of another subspecies of the blue mussel in California has decreased immensely over the years, primarily due to the repercussions of paralytic shellfish poisoning. These mussels can also accumulate hydrocarbons in their tissues by taking hydrocarbons up through the gill tissues. Although oil is only slightly toxic to mussels, it may prevent mussels from being marketed as food, as well as cause them to be toxic to predators (Shaw *et al.*, 1988).

Common Littleneck Clam. The common littleneck clam species is widely distributed along the coast of the Northwest region, but can be found from Mexico to the Aleutian Islands, Alaska. It serves as an important sport and subsistence species. This species is found in both intertidal and subtidal zones. Common littleneck clams are farmed in the intertidal zone in Puget Sound. It is a filter-feeder, feeding primarily on diatoms. Predators of the common littleneck clam in Prince William Sound include the sea star and the sea otter (Chew and Ma, 1987).

Studies show that the quantity of common littleneck clams landed in the U.S. Pacific Northwest have been decreasing yearly (these statistics did not include Alaska). Little recruitment of common littleneck clams occurred in Prince William Sound in 1967 to 1971 due to poor spawning and recruitment conditions. Harvest of abundant clams along the coast of Alaska is limited because of paralytic shellfish poisoning (i.e., toxic phytoplankton is filtered in and accumulated by shellfish and is fatal to humans, but not to the shellfish). It has been shown that common littleneck clams grow at a slower rate in oil-treated sediments, and they tend to burrow to a shallower depth, making them more accessible to predators (Chew and Ma, 1987).

Coastal Communities

Coastal communities are protected under the Coastal Zone Management Act of 1972 (16 U.S.C. 1451-1464), the Alaska Coastal Management Act of 1977 (A6 46.40), and the Coastal Resource District Management Plans (6AAC 80 and 85). For the purposes of this document, coastal communities include the organisms living in the intertidal and subtidal zones, as described below.

Intertidal Organisms

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 dependent upon the slope of the shore and the extent of the rise and fall of the tides (Newell, 1979). 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 area by many species of fish (*Exxon Valdez* Oil Spill Trustees, 1992). The intertidal zone serves as a feeding grounds 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) (Peterson, 1993). 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 clean-up operations (Exxon Valdez Oil Spill Trustees, 1992).

The oil spill caused population declines and sublethal injuries to the community of plants and animals living in the intertidal zone. Portions of 1200 miles of coastline were oiled (350 miles heavily oiled) resulting in significant impacts to intertidal habitats, particularly the upper intertidal zone. With tidal action, 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, 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 pre-spill data, these studies have relied on comparisons of oiled and unoiled sites. Because of our ability to measure effects on common organisms, these have been emphasized in the injury studies.

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 seaweed *Fucus gardneri* (rockweed or popweed), barnacles, limpets, periwinkles, clams, amphipods, isopods and marine worms were less abundant at oiled than unoiled sites. Although there were increased densities of mussels in oiled area, they were significantly smaller than mussels in the unoiled 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 magnitude of measured differences 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

While survival of Dolly Varden returning to oiled streams in 1990 was 32% less than those returning to unoiled streams, and survival appeared to be 57% less for cutthroat trout returning to oiled streams in 1990, these differences are not statistically different. There also are not pre-spill data with which to compare these results. However, it was determined that larger cutthroat trout grew significantly less in oiled areas in 1989, 1990 and 1991.

Cutthroat Trout

Cutthroat trout (*Salmo clarki*) are managed in freshwaters and within a three-mile limit in marine waters by the Alaskan Department of Fish & Game (ADF&G). The Alaskan Board of Fisheries develops regulations governing sport harvest of fish in Alaska.

Cutthroat trout range from northern California, Oregon, British Columbia to Prince William Sound, Alaska at the very northern edge of their range (Pauley et al., 1989). There are both anadromous and nonanadromous populations in Alaska.

The oil spill caused some injury to the anadromous populations of cutthroat in Prince William Sound. Large cutthroat trout had a higher mortality rate in oiled areas than in unoiled areas. There was a 57% greater mortality rate in oiled streams in 1989-1990 and a 65% 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.

Male sea-run cutthroat trout mature at 2 to 3 years, and females mature at 3 to 6 years. Unlike salmon they can spawn annually for up to ten years. 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 return to the sea between March and July. They remain in the vicinity of the natal stream to feed along its shores, and they return to freshwater lakes to overwinter. Cutthroat trout have a high survival rate between spawnings (Pauley et al., 1989).

Cutthroat trout are sensitive to high turbidity and its associated problems. They cease migration in streams with turbidity greater than 4,000 mg/l and may stop feeding and move to cover when turbidities exceed 35 mg/l. Excessive silt loads can affect DO concentrations, causing increased egg mortality in the redds, and can disrupt the emerging fry. The preferred water velocity for successful spawning is 11 to 90 cm/s. Fry are generally found in water velocities of less than 30 cm/s, with an optimum velocity of 8 cm/s. Changes in flow can effect developing eggs and alevin in several ways, including mechanical damage, temperature changes, or reduced DO (Pauley et al., 1989).

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 gammarid amphipods, sphaeromid isopods, callianassid shrimp, immature crabs, and other salmonid fishes (Pauley et al., 1989). Fry and juveniles are preyed on by rainbow trout, brook trout, Dolly Varden, short head 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).

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. While harvests decreased since 1990, harvests are still higher than the historic average. 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. The yellow rockfish range extends from Cook Inlet in Alaska south to Baja California (Hart, 1973). Rockfish grow very slowly and sexual maturity between 14 and 19 years of age and breeds annually thereafter. They grow slowly and produce few offspring. They can live up to 114 years. If is not known whether or how rockfish migrate, but older fish tend to move to deeper water (Carlson and Straty, 1981).

Dolly Varden

Dolly Varden (*Salvelinus malma*) are managed in freshwaters and within a three-mile limit in marine waters by the ADF&G. The Alaska Board of Fisheries develops regulations governing sport harvest of fish in Alaska

Dolly Varden are found in fresh and salt water in western North America and eastern Asia. Their range extends from northern California to the arctic coast of Alaska (Scott and Crossman, 1973). There are both anadromous and nonanadromous populations in Alaska.

Dolly Varden 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 and spawn each year from age 6 to 10 years. The young remain in their natal streams for 3 to 4 years. The average life span of the Dolly Varden is 12 years (Scott and Crossman, 1973; ADF&G, 1985c).

Spawning occurs in the fall between September and December. The female builds the redd and is usually attended by 4 to 5 males during spawning. Fecundity is positively correlated with female size with females generally producing between 1,300 and 3,400 eggs. The eggs hatch in approximately 4 to 5 months. The alevin remain in the redd for approximately 18 days and then emerge as fry. 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 fresh water for 3 to 4 years before moving seaward. They are found near logs and undercut banks, where they seek protection from predation. Post-spawning mortality is usually high in adults (Scott and Crossman, 1973; ADF&G, 1985c).

The primary diet for marine adult Dolly Varden consists of smelt, herring, juvenile salmonids, and other small fishes. In the freshwater habitat, juvenile salmonids, invertebrates, and other small fishes are the main diet. Juvenile Dolly Varden feed near the bottom and prey on aquatic insects, insect larvae, and fish eggs (Scott and Crossman 1973, ADFG 1985c).

Both Dolly Varden char 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. Both species were captured at weirs on five stream 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.

Community	Income per capita	Average persons per household	Income per household of 3 persons	Adjustment factor for household of 3	Adjusted income for family of 3	Difference % from Valdez baseline
Port Lions	14,960	3.04	45,478.40	0.98	44,568.83	-0.45
Lake and Peninsula Borough						
Chignik	13,188	3.48	45,894.24	0.86	39,469.04	-0.52
Chignik Lagoon	19,604	3.12	61,164.48	0.96	58,717.90	-0.28
Chignik Lake	7,765	3.91	30,361.15	0.76	23,074.47	-0.72

Community	Income per capita	Average persons per household	Income per household of 3 persons	Adjustment factor for household of 3	Adjusted income for family of 3	Difference % from Valdez baseline
Valdez-Cordova Census Area						
Chenega Bay	9,211	3.03	27,909.33	0.99	27,630.23	-0.66
Cordova	23,408	2.61	61,094.88	1.49	91,103.37	+0.13
Tatitlek	8,674	3.61	31,313.14	0.83	25,989.90	-0.68
Valdez	26,968	2.90	78,207.20	1.03	80,553.41	n/a
Whittier	17,032	2.16	36,789.12	1.38	50,768.98	-0.37

Per capita income and average household data from 1990 Census.
Subsistence harvest figures are drawn from Fall 1990.
Protein cost information from Stratton 1992, Cordova Market Survey, February 1989.
Protein consumption factors were based on the USDA consumption estimates of 222 pounds of protein per capita (Wolfe 1990).

Community	Adjusted income for family of 3	Per capita subsistence harvest/year (in lbs.)	Per capita cash equivalent	Subsistence cash value for family of 3	Total income for family of 3 (cash + subsistence)
Kenai Peninsula					
English Bay	12,615	288.8 [3.93]	$1,134.98	$3,404.95	$40,876.54

Community	Adjusted income for family of 3	Per capita subsistence harvest/year (in lbs.)	Per capita cash equivalent	Subsistence cash value for family of 3	Total income for family of 3 (cash + subsistence)
Homer	19,182				
Kenai	17,877				
Port Graham	17,265	227.2 [3.93]	$842.89	$2,678.68	$54,328.65
Seldovia	14,052				
Seward	16,615				
Soldotna	15,800				
Kodiak Island					
Akhiok	14,793	519.50 [3.93]	$2,041.63	$6,124.90	$50,459.52
Karluk	8,052	863.20 [3.93]	$3,392.37	$10,177.12	$34,288.02
Kodiak	22,951				
Larsen Bay	19,222	403.50 [3.93]	$1,585.75	$4,757.26	$61,896.57
Old Harbor	8,008	491.10 [3.93]	$1,930.02	$5,700.06	$29,807.65
Ouzinkie	16,530	369.10 [3.93]	$1,450.56	$4,351.68	$53,576.36
Port Lions	14,960	279.80 [3.93]	$1,099.61	$3,298.84	$47,867.67
Lake and Peninsula Borough					

Community	Adjusted income for family of 3	Per capita subsistence harvest/year (in lbs.)	Per capita cash equivalent	Subsistence cash value for family of 3	Total income for family of 3 (cash + subsistence)
Chignik	13,188	187.90 [3.93]	$738.44	$2,215.34	$41,684.38
Chignik Lagoon	19,604	220.20 [3.93]	$865.38	$2,596.15	$61,314.05
Chignik Lake	7,765	279.00 [3.93]	$1,096.47	$3,289.41	$26,363.88
Valdez-Cordova Census Area					
Chenega Bay	9,211	308.80 [4.53]	$1,398.64	$4,196.59	$31,826.82
Cordova	23,408	[3.78]			
Tatitlek	8,674	351.70 [3.93]	$1,382.18	$4,146.54	$30,136.44
Valdez	26,968				
Whittier	17,032				

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Community	Total income for family of 3	% total income from subsistence	1989 subsistence harvest (lbs.)	Cash value per capita subsistence, 1989	Cash value subsistence for family of 3, 1989	Percentage of income from subsistence, 1989	Change in % subsistence
Kenai Peninsula							
English Bay	$40,876.54	8%	140.6 [3.93]	$552.55	$1,657.67	4%	-4%
Homer							
Kenai							
Port Graham	$54,328.65	5%	121.6 [3.93]	$477.88	$1,433.66	2%	-3%
Seldovia							
Seward							
Soldotna							
Kodiak Island							
Akhiok	$50,459.52	12%	297.7 [3.93]	$1,169.96	$3,509.88	7%	-5%
Karluk	$34,288.02	29%	250.5 [3.93]	$984.46	$2,953.39	8%	-21%
Kodiak							
Larsen Bay	$61,896.57	7%	209.9 [3.93]	$824.90	$2,474.72	4%	-3%
Old Harbor	$29,807.65	19%	271.7 [3.93]	$1,067.78	$3,203.34	10%	-9%
Ouzinkie	$53,576.36	8%	88.8 [3.93]	$348.98	$1,046.95	2%	-6%
Port Lions	$47,867.67	6%	146.4 [3.93]	$575.35	$1,726.05	3%	-3%
Lake and Peninsula Borough							

Community	Total income for family of 3	% total income from subsistence	1989 subsistence harvest (lbs.)	Cash value per capita subsistence, 1989	Cash value subsistence for family of 3, 1989	Percentage of income from subsistence, 1989	Change in % subsistence
Chignik	$41,684.38	5%	208.6 [3.93]	$819.79	$2,459.39	6%	+1%
Chignik Lagoon	$61,314.05	4%	211.4 [3.93]	$830.80	$2,492.40	4%	n/a
Chignik Lake	$26,363.88	12%	447.6 [3.93]	$1,759.06	$5,277.20	20%	+8%
Valdez-Cordova Census Area							
Chenega Bay	$31,826.82	13%	146.1 [4.53]	$661.83	$1,985.49	6%	-7%
Cordova			[3.78]				
Tatitlek	$30,136.44	13%	214.8 [3.93]	$884.16	$2,532.49	8%	-5%
Valdez							
Whittier							

Sociocultural Implications

Subsistence pursuits are tied to all aspects of life in the villages affected by the oil spill and are key to the Alaska Native sociocultural system. For at least 11,000 years, Alaska Native people have depended on the lands and water of the EVOS area for their survival. Their traditional way of life is intimately tied to the harvesting, gathering, and use of subsistence foods.

The Alaska Native culture cannot easily be separated from the subsistence way of life and each person's relationship to the land, sea, and resources. The rules governing the harvesting and use of subsistence resources are derived from a combination of culture, tradition, and religious beliefs. Subsistence involves many social activities such as cooperative labor-sharing, the exchange of resources and information, transmission of knowledge and skills, and formation of values. The means of establishing prestige and maintaining peace traditionally involve the consumption, transfer, and exchange of fish, game, and their byproducts. These activities are necessary for the preservation of traditional family and community relationships that are essential to the physical and psychological well-being of Alaska Native communities. Continuous access to uncontaminated resources in a natural setting is also fundamental to the physical, spiritual, and psychological well-being of Alaska Native communities.

In Native villages, the hunt, the sharing of products of the hunt, and the beliefs surrounding the hunt, tie families and communities together, connect people to their social and ecological surroundings, link them to their past, and provide meaning for the present. Generous hunters are considered good men. Good hunters are often leaders. The cultural value placed on kinship and family relationships is apparent in the sharing, cooperation, and subsistence activities that occur in traditional Native society.

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 18 EVOS communities. Destruction and contamination of subsistence resources contributed to the sense of cultural dislocation experienced by some Alaska Natives in the area.

> Livelihoods destroyed, emotional stability of people destroyed, tremendous stress—these things will be etched on my mind for the rest of my lifetime, and I think that I will be grieving for many, many years to come over what I saw in the summer of 1989. (The Day the Water Died, 1990)

Real and perceived habitat contamination resulted in a 77-percent decline in subsistence resource harvesting (Fall 1990). 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, subsistence fishery was banned as a precaution against possible health-threatening effects of the oil spill on fish in the Sound. In Native villages, shortages of traditional foods resulted and persist.

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 harvesting 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. Contamination of traditional foods, and fear of contamination, led potential users to stop harvesting these resources. One Alaska Native had this to say:

> We depend on ourselves. . . And we depend on the seals, sea lions, butter clams, ducks, and sea life. Now they are disappearing. The sea life is disappearing. Even if they come around, we are staying away from them. (Alaska Oil Spill Commission, 1990)

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. Restoration proposals will address the contamination that continues to affect

Prince William Sound species and people who harvest them.

Commercial Fishing

Commercial fishing within the oil spill area is divided among three census regions (Figure III-A): Southcentral, which includes Prince William Sound and the outer Kenai Peninsula area; Kodiak, which surrounds Kodiak and Afognak Islands; and Bristol Bay, which includes the area between Kodiak and the Alaskan Peninsula.

During 1989, emergency commercial fishery closures were ordered throughout the spill area. Closures affected salmon, herring, crab, shrimp, rockfish, and sablefish. The 1989 closures resulted in sockeye overescapement in the Kenai River and in the Red Lake system (Kodiak Island). In 1990, a portion of Prince William Sound was closed to shrimp fishing. Spill-related sockeye overescapement is anticipated to result in low adult returns in 1994 and 1995. This may result in closure or harvest restrictions during these and, perhaps, subsequent years. Injuries and recovery status of rockfish, pink salmon, shellfish and herring are uncertain.

The fishing industry in the oil spill area is primarily a small-boat near shore fishery in contrast to the offshore highly capitalized fishery. The near shore fishery common in Prince William Sound, Cook Inlet, and Kodiak/Afognak Island area concentrate on seasonal salmon, herring, halibut, black cod and to a lesser extent on Dungeness, king, and tanner (snow) crab. The offshore fishery located in the western Gulf of Alaska is found well offshore, concentrating on groundfish, king, and tanner crabs. The nearshore fishery is dominated by Alaskan residents operating boats mostly in the 30 to 45 foot length. The offshore fishery is dominated by non-Alaskan residents operating much larger vessels whose values range up to $40 million for the large factory trawlers.

In 1986, there were 28,663 permits purchased for the Alaskan commercial fisheries. Of these, 84% (24,059) were purchased by Alaskan residents; the remainder (4,604) were purchased by non-residents.

Alaska is considered the most important fishing state in the United States. In 1989 Alaska accounted for almost half the nation's catch in pounds, and 38% in value. The major species groups contributing to Alaska's commercial fisheries are salmon, shellfish (primarily crabs and shrimps), groundfish (mostly pollock, flatfishes, Pacific cod, black cod and rockfish), halibut and herring. No other state comes close to Alaska in either total harvest weight or value,

according to statistics compiled by the U.S. Department of Commerce. Consequently, Alaska is a major exporter of fishery products.

The ex-vessel value of Alaska's commercial fishing industry ranks first among all U.S. states. The ex-vessel value of fishery landings in Alaska is more than twice the landed values of Washington, Oregon and California combined. In 1990, approximately 5.9 billion pounds of seafood worth $1.5 billion in ex-vessel value were landed into Alaskan ports. Salmon accounted for approximately 37% of the total value (Alaska Blue Book, 1991). In 1988, the value of the harvest in Prince William Sound (PWS) alone for salmon fisheries totalled $76 million; herring, $12.2 million; and shellfish, $2.4 million (AF&G, 1989).

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 non-profit (PNP) hatcheries, leaving a common property portion of the catch below the 10-year average (ADF&G, 1991).

The value of the combined 1989 commercial salmon harvest in Prince William Sound was estimated at $41.3 million, excluding hatchery sales. The drift gill net catch was valued at $23.8 million, setting the average earnings for the estimated 480 permit holders that fished in 1989 at $49,470. Seiners harvested $18.9 million worth of fish setting the average earnings for the estimated 235 permit fleet at $80,610. Because the Eshamy district was closed for the season, set net fishermen had no opportunity to fish in the Prince William Sound area in 1989 (ADF&G, 1991).

The Kodiak area commercial fisheries are dominated by salmon harvests, primarily pink, sockeye and chum. There is also a joint venture trawl fishery for walleye pollock in Shelikof Strait, and a longline fishery for halibut, sablefish, and cod. Herring are also harvested in the Kodiak/Afognak area, primarily in the spring for sac roe, as well as fall and winter fisheries for shellfish, primarily crab.

The fishery in Cook Inlet is geared primarily for sockeye salmon in the vicinity of the Kenai River. Further south along the Kenai Peninsula, the Homer area commercial fishing fleets target all species of salmon, shellfish, and halibut (USDOI, 1986).

Aside from the ex-vessel values of Alaska's fisheries and the economic activity (in terms of

employment and personal income) generated from them, fishing generates revenues directly to the State of Alaska from taxes and licenses. State revenues generated in FY-86 from fisheries equalled $47.3 million, of which $43.4 million went to the general fund and $3.9 million went to the fish and game fund. Fishery revenues included fish taxes, marine fuel taxes, fishing permits, fishing licenses and other similar items.

Legal gear for the commercial harvest of salmon include purse seines, both drift and set gill nets, and trolling gear. Set and drift gill nets and purse seines are the most common gear type in the Kodiak area. Set and drift gill nets are also the most common gear for the Cook Inlet fishery. Drift gill net fishermen are the most numerous in Prince William Sound and are permitted to fish in the Bering River, Copper River, Coghill, Unakwik, and Eshamy districts (Figure III-D). During the 1989 season, 408 drift gill net permit holders participated in the Prince William Sound salmon fisheries. Set gill net gear is legal only in the Eshamy district. There are 30 total permits for this gear type. Purse seine gear is legal in the Eastern, Northern, Unakwik, Coghill, Northwestern, Southwestern, Montague and Southeastern Districts. Purse seiners, which catch most of the fish in the sound, fish all Prince William Sound districts, except Eshamy, usually beginning in early or mid-July, depending upon the strength of early pink salmon runs. Purse seine fishing continues usually into the first or second week of August. An estimated 243 purse seine permits were active during the 1989 season (ADF&G, 1991).

The seafood industry is the largest non-governmental employer in Alaska, providing approximately 16.4% of the state's jobs. It has been estimated that the Alaskan seafood industry provides 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 (Royce, 1991).

The seafood industry (harvesting and processing) in Southcentral Alaska employs approximately 4,000. Residents in Southcentral earn more from seafood harvesting than any other Alaska region. In the Kodiak region, the seafood industry is the dominant economic activity, employing over 2,500 residents. The Kodiak region is the only region completely within the oil spill area, and accounts for nearly 1/4 of the state's seafood processing jobs. Only the far eastern areas of the Bristol Bay region are within the oil spill area. This region is more dependent on the seafood industry than any other Alaska region. More than 70 percent of the region's private industry employment is in the seafood industry (McDowell Group, 1989).

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Salmon Hatcheries and Management

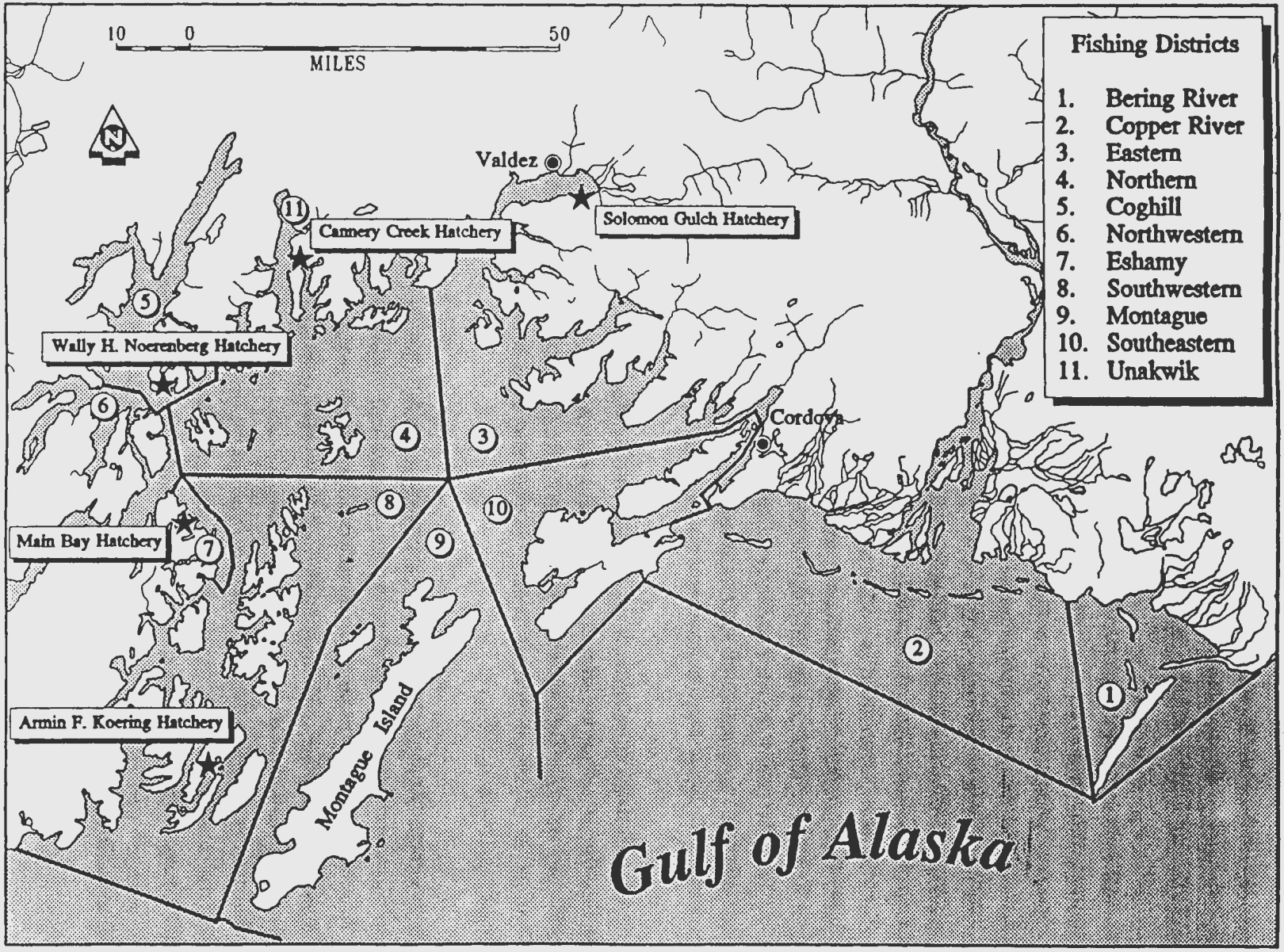

Figure III-D. Commercial Salmon Management Districts and hatcheries in the vicinity of Prince William Sound.

Article VIII, Section 5 of the Alaska Constitution authorizes the 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."

Salmon hatcheries in the Prince William Sound area include the Solomon Gulch Hatchery at Valdez operated by the nonprofit corporation, Valdez Fisheries Development Association (VFDA); The Main Bay Hatchery operated by ADF&G Fisheries Rehabilitation, Enhancement and Development (FRED); and the Armin F. Koering (AFK), Esther, (now the Wally H. Noerenberg Hatchery), and Cannery Creek hatcheries operated by the Prince William Sound Aquaculture Corporation (PWSAC). Cannery Creek is a FRED facility under a 20-year management lease to PWSAC (Figure III-D). Today, seven regional associations from Southeast Alaska to Kodiak produce salmon for common property fisheries (PWSAC, 1990).

The AFK and Cannery Creek Hatcheries produce primarily pink salmon; Noerenberg Hatchery produces all five species of Pacific salmon, the majority of which are pink, chum and coho. Main Bay Hatchery, in the western part of the Sound, currently produces pink salmon but is in the process of converting to sockeye salmon. The VFDA's Solomon Gulch hatchery in Valdez Arm produces pink, chum and coho salmon (PWSAC, 1990).

From the inception of the hatchery system, the intent has been to protect the fisheries from cyclical weaknesses. During the 1970's, salmon runs declined throughout the state. In PWS, seining did not open at all in 1972 and 1974 because the returning wild runs were below fisheries management escapement levels for reproduction and commercial harvest needs (PWSAC, 1990).

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 millon fish were harvested in common property fisheries, and 909,219 fish were harvested in the special harvest area sales harvests of the two major PNP hatcheries in the area. 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 (Sharr et al, 1988).

Because egg-to-fry survival is 80 percent or higher in hatcheries as opposed to 20 percent or less in natural spawning beds, hatcheries allow at least a 4-fold increase in production from a given number of spawners (PWSAC, 1990).

In an average year, the Prince William Sound hatcheries provide up to 40 percent of the salmon harvest in the Sound. In 1988, because of low natural runs of pink salmon, it is estimated that they contributed almost 90 percent of the Sound's total pink salmon harvest (AF&G, 1989).

Benefits from the introduction of the hatchery system have been achieved at some cost, not only financially, but in terms of fishery conditions, both perceived and real. Hatchery salmon production, intended to both increase catches and reduce harvest variability, has resulted in changes in the distribution of catches by species, the gear types used, seasonal opportunity to fish in historic and traditional areas, and fishing patterns.

Hatcheries have added new complexities to management of salmon returns. Generally, the major salmon returns to hatcheries overlap with the timing of adjacent wild stock systems. Hatchery fish are randomly mixed with wild stock fish, following the same migration routes to their respective points of origin. Unlike the wild stock pink systems distributed uniformly, hatchery stocks in Prince William Sound return in mass to a limited number of release sites. In these areas termed terminal areas, hatchery fish are concentrated which provides a management opportunity to specifically target the commercial harvest on the surplus production.

A shift in the composition of salmon in the harvest by the common property fishery can be attributed to the hatchery system. Since the inception of the hatchery program in 1978, the wild stock contribution has declined. In the 1988-89 harvest seasons, only 10-15% of the Prince William Sound catch was from wild stocks. Because recent wild stock returns have been quite small relative to hatchery returns, in order to achieve minimum escapement goals for wild stocks, it has been necessary to close the mixed stock areas of the general districts, and harvest a majority of the surplus hatchery returns in the hatchery terminal harvest areas (PWSAC, 1990).

Four Alaskan agencies are involved in managing Alaska's salmon fisheries: The Alaska Board of Fisheries sets policy and promulgates the regulations; the Alaska Department of Fish and Game (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 amount of fishing effort; and the Alaska Department of Public Safety enforces the regulations (NPFMC, 1990).

In-season fisheries management is the responsibility of the Alaska Department of Fish and Game. 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 Board of Fisheries establishes the regulations that govern fisheries. Actions considered by the Board include changes in areas for the salmon fisheries, and the allocation of harvests among the various groups of fishermen. While ADF&G determines when and where fishery openings can occur, the Board of Fisheries regulations determine who can fish in the designated areas.

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 (NPFMC, 1990).

Along with FRED, the U.S. Forest Service and PNPs have been largely responsible for implementing management measures or in-stream projects to rehabilitate, if necessary, and increase salmon populations in the Prince William Sound area. Past rehabilitation efforts have been aimed at restoring wild stocks to former levels of abundance through stream improvements, fish ladders, and other activities that improve natural spawning conditions. Stream rehabilitation projects are carried out by the U.S. Forest Service in cooperation with the ADF&G. The Forest Service has this responsibility since many of the spawning streams are located in the Chugach National Forest which surrounds Prince William Sound and the mouth of the Copper River. Between 1963 and 1982 there were 78 fish habitat improvement projects, 66 of which were completed by the Forest Service in Prince William Sound and Copper River delta areas.

Commercial Herring Harvest

move down

The Pacific herring is also an important species to the Alaskan fishing industry because its 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 it is consumed by larger commercial species of fish such as salmon and halibut (Royce, 1991).

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 man-made enclosures (this is known as the pound-kelp fishery). The fourth and most important commercial harvest is the "sac-roe" fishery, in which herring are netted to collect the mature female's egg filled membrane or sac. Each year the state limits the sac-roe harvest to 20% of the estimated herring stocks (Royce, 1991).

There are five different herring fisheries in the Prince William Sound management area, that all target on what is treated as a single major stock of herring in the Sound. Management of the Prince William Sound herring fishery involves a maximum exploitation rate of 20% for the Prince William Sound herring biomass for all fisheries combined. The food and bait fishery is the only one that occurs in the fall and winter, generally in the Knowles Head area. This fishery is not limited, but generally has fewer than 10 boats participating annually. The four spring fisheries usually occur in the month of April, coinciding with the spawn timing of the Prince William Sound herring stock. The spring fisheries include: 1) a purse seine sac row fishery, that accounts for a large portion of the harvest and limited to approximately 100 permit holders; 2) a gill net sac row fishery with 25 limited entry permit holders, 3) a roe on kelp produced in pounds fishery with approximately 125 limited entry permit holders, and 4) a wild harvest fishery of natural roe on kelp, that is open to entry and has annual participation between 100 to 200 (ADF&G, 1991).

A growing market has developed for bottomfish, particularly black cod and rockfish in the oil spill area. Little research as been completed to determine stock levels, and management initiatives are still developing. Throughout Alaska, the bottomfish fishery has grown, and recent plans for new bottomfish processing plants scheduled to come on line over the next few years are expected to add to harvests and associated employment for this portion of the commercial seafood industry (Alaska Blue Book, 1991).

Commercial 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, tourism's obvious growth in the 1980s gave it legitimacy as a major industry.

Although the nature and extent of injury varied, approximately 43 percent of the tourism businesses surveyed in 1990 felt they had been significantly affected by the oil spill. 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 (McDowell 1990). 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 (RPWG 1993).

A visitor survey conducted by the Alaska Division of Tourism under the Alaska Visitors Statistics Program II (AVSP) revealed important statistics on the tourism industry. The survey results indicated that more than 750,000 people visited Alaska in 1989 from around the world 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% of the $304 million (ADT 1989a). Sixty-nine percent of the total summer visitors were vacation/pleasure visitors. Southcentral Alaska accommodated more visitors per year than any other region but, among the vacation/pleasure visitors, Southeast was the most visited region, with nearly three out of every four vacation/pleasure visitors visiting the region. Southcentral was second with two-thirds of the vacation/pleasure tourism market (ADT 1989b). Southwest was visited by only 6% of the total vacation/pleasure visitors (ADT 1989a) and thus captured 5% of the $304 million (ADT 1989b).

Survey results indicated that Anchorage, Seward, Kenai/Soldotna, Homer, Valdez/Prince William Sound, and Whittier were among the most visited communities in the Southcentral region and that King Salmon, Kodiak, Bethel were among the most visited communities in the Southwest region. The most visited attractions on the Kenai Peninsula were Kenai River, Kenai National Wildlife Refuge, Resurrection Bay, Kachemak Bay, and Kenai Fjords National monument. 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. In addition, cultural attractions and museums were popular among Southcentral visitors (ADT 1989b).

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 and Denali. Hiking was also popular, especially among the Southwest and Denali visitors. Fishing was most popular in the Southwest, with twice the participation of the next leading fishing region, Southcentral (ADT 1989b).

The visitors of Southcentral 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 and was rated the best for flightseeing activity in the state (ADT 1989b).

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 non-developed recreational opportunities including hunting, fishing, hiking, camping, skiing, sightseeing, backpacking, climbing, dogsledding, snowmobiling, snowshoeing, kayaking, canoeing, power boating, sailing, flightseeing, photographing, and filming to the residents and visitors of the region (Castleman and Pitcher 1992). These recreational opportunities have helped create a growing tourism industry in the region.

The public land in the EVOS area include national parks and national forests, including Chugach National Forest, Kenai Fjords National Park, Katmai National Park and Preserve, Lake Clark National Park and Preserve, and Aniakchak National Monument and Preserve; national wildlife refuges including Alaska Maritime National Wildlife Refuge, Kenai National Wildlife Refuge, Kodiak National Wildlife Refuge, Alaska Peninsula National Wildlife Refuge, and Becharof National Wildlife Refuge; and state parks including Chugach State Park and Kachemak Bay State Wilderness Park (Figure III-B). Several other areas under State management, such as State Historic Sites, Marine Parks, Recreation Areas, and Recreation Parks also provide a variety of recreation. Besides the public lands and facilities, commercial recreational facilities exist in the oil spill area.

Hiking and camping, being relatively inexpensive and easily available, are by far the preferred mode of outdoor recreation for the majority of Alaska's residents and visitors. Although, there are very few trails, the vast taiga and tundra terrain (along with the perpetual daylight during hiking season) offers considerable flexibility to hikers (Castleman and Pitcher 1992). The abundant wildlife add the possibility of animal watching while hiking. Photography of the scenery, as well as the fauna and flora, go hand in hand with hiking and camping.

The oil spill has affected recreational activities in the area. The nature and extent of injury varied by user group and by area of use. About one quarter of respondents to a recreation survey in 1992 reported no change in their recreation experience, but others reported avoiding the spill area, reduced wildlife sightings, residual oil and more people. They also reported changes in their perception of recreation opportunities in terms of increased vulnerability to future oil spills, erosion of wilderness, a sense of permanent change, and concern about long-term ecological effects. However, some respondents reported a sense of optimism. There are indications that declines in recreation activities reported in 1989 appear to have reversed in 1990, but there is no evidence that they have returned to prespill levels. Large portions of land within Katmai National Park and the Becharof National Wildlife Refuge were oiled and have been designated wilderness areas by the Congress.

For the purposes of this section, the oil-spill area is divided into two regions: the Southcentral region which includes Anchorage, Kenai Peninsula, and Prince William Sound; and the Southwest region which includes Kodiak Island, Katmai, and other southwest locations. A brief description of recreational opportunities provided by each region is provided in the following sections.

Southcentral Alaska

Chugach National Forest, the second largest national forest, encompasses much of the Southcentral region. The 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 one major ski resort and six other resort facilities. The Portage visitor center and the Russian River located in this area are among the three most heavily visited areas in the state. Approximately 90% 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. Alaska's second-largest state park, Chugach State Park, located within this region,

encompasses nearly half a million acres. Hiking is the main recreational activity in this park with about a dozen well-maintained, well-used, moderate-to-difficult trails. Along with hiking, photography and wildlife-watching are popular recreational activities.

Southcentral Alaska includes some of the premier kayaking areas in the world. 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 includes both kayaking and wilderness camping.

The Kenai Peninsula is the most popular all around destination for both Alaskans and visitors (Kenai 1993). It is the most often viewed landscape in Alaska with the Seward/Anchorage highway being the most heavily used travel route in the state (USDA 1984). 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 in the Kenai Peninsula. The Kenai Fjords National Park, under the management of National Park Service, is an area with ice fields and a deep-water fjord coastline providing opportunities to see whales, sea otters, and various types of birds. At locations in the western and southern parts of the Peninsula, the Alaska Department of Natural Resources maintains public access and recreation sites (including the Kachemak Bay State Park) totaling several thousand acres (Kenai 1993).

Few refuges contain as diverse a landscape, as abundant fish and wildlife populations, or as varied recreational opportunities as the Kenai Refuge. Although not large compared to other refuges in Alaska, the Kenai Refuge supports more recreational use than any other refuge in the world. The wide array of facilities that support and encourage public use and protect refuge resources include, visitor centers, and 47 recreational sites including campgrounds, access areas, wayside, and trailheads. These facilities vary from small undeveloped sites to large campgrounds with tables, fire grates, parking-spurs, boat ramps, water wells, and sanitary facilities. Recreational opportunities in the Kenai Refuge include salmon fishing, camping in developed campgrounds along roads and trails to isolated and primitive areas, hunting, wildlife observation, sightseeing, canoeing, boating, horseback riding, crosscountry skiing, snowmobiling, and berry picking. Most visitors participate in several activities while on the refuge.

Besides the public lands, some cities also offer recreational opportunities on the Kenai Peninsula

and their economy, to some extent, is 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 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 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 (Kenai 1993).

Prince William Sound (PWS), located within the Southcentral region at the northern-most point of the Gulf of Alaska, is a unique, pristine, wilderness abundant with land and marine wildlife. The Sound is filled with deep fjords, snow-covered mountain ranges, tidewater glaciers, and hundreds of islands. Prince William Sound is primarily travelled by boat with some areas accessed by float-equipped aircraft. Prince William Sound covers over 2,700 miles of coastline, 4.4 million acres of National Forest and three of North America's major icefields. Prince William Sound offers tremendous opportunities for hiking, sightseeing, wildlife viewing, glacier viewing, and fishing (PWS 1993).

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 (PWS 1993).

Outdoor recreation plays an important role in the lifestyles of many Alaskan residents. A public survey conducted on the lifestyles of southcentral Alaskans yielded information on the recreational activities that these residents engage in (Table I) (USDA 1984). The results of the survey indicated that driving, walking, and fishing were the most popular activities among the Southcentral Alaskans. Respondents also indicated that the important attributes of their favorite activities include getting away from usual demands, being close to nature, doing something exciting, experiencing new and different things, and being with family and friends. Attributes of favorite recreational places considered important by the respondents included fishing

opportunities, scenery, and remoteness.

Recreation Participation of Southcentral Alaska Residents

Recreational Activities	Percent of Respondents who Engaged in Activity
Driving for pleasure	59
Walking/running for pleasure	53
Freshwater fishing	42
Attending outdoor sport events	37
Tent camping	31
Motor boating	30
Bicycling	29
Cross-country skiing	26
Target shooting	25
RV camping	24
Hiking with pack	22
Baseball/softball	19
Flying for pleasure	19
Sledding/tobogganing	17
Kayaking/canoeing	17
ORV winter	17
ORV summer	14
Outdoor tennis	17
Swimming/scuba diving	16
Alpine skiing	14

Southwest Alaska

The Southwest region includes the Kodiak Island group, the Alaska Peninsula, the Aleutian Islands, and Katmai. 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.

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 biggest brown bear population. Kodiak Refuge, established in 1941 to protect the habitat of brown bear and other wildlife, occupies about two-thirds 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 and bald eagle populations, the refuge is ideal for wildlife viewing. Other recreational activities include photography, rafting, canoeing, camping, backpacking, hiking, hunting, and fishing. A visitors 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 live, is accessible by air and is visited for viewing commercial fishing operations. The communities of Larsen Bay and Ports Lion on the Kodiak Island are visited for hiking, fishing, and hunting opportunities and their economy to a large extent is dependent on tourism (U.S. FWS 1987).

Sport Fishing and Hunting

Sport fishing and sport hunting constitute an important and distinct segment of the recreational activities in the EVOS region.

Sport Fishing

Sport fishing is one of the most popular recreational activity for both residents and visitors of Alaska. Marine and freshwater systems provide a variety of sport fishing opportunities in the oil-spill region. 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. Several species of Pacific salmon, rockfish, and halibut inhabit salt water. Species of Dolly Varden, rainbow and cutthroat trout are found in freshwater streams and lakes. Although sport fishing is popular throughout the state, seventy percent of Alaska's sport fishing occur in the Southcentral region and majority of which occur in the Kenai Peninsula because access by car from Anchorage to

Kenai Peninsula is relatively easy (Castleman and Pitcher 1992). The Kenai River is well known for king salmon fishing. 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 etc. (ADF&G 1992a). In addition, there are management plans for king salmon on the Kenai River.

Historically (between 1984 and 1988), the number of anglers, fishing days, and fish harvest in the oil-affected area had been increasing at a rate of 10 - 16% per year.Since 1977, there has been a 4.5% average annual increase in the number of residents who sport fish, while the number of non-residents sport fishing has increased 16% 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 due to closures, fear of contamination, the unavailability of boats, and congestion at some sites outside the spill area (Carson and Hanemann 1992). The estimated number of anglers in the oil-affected region decreased 13% from 120,160 in 1988 to 104,739 in 1989, the number of days fished decreased 6% from 312,521 to 294,598, and the number of fish harvested decreased 10% from 352,630 to 318,981 (ADF&G 1992b). The area outside the oil spill, however, continued to experience the increase. In 1992, an emergency order restricting cutthroat trout fishing was issued for western Prince William Sound due to low adult returns. The closure is expected to continue at least through 1993. Also the Kenai River sockeye salmon overescapement following the oil spill may severely affect sport fishing as early as 1994. An estimated 124,185 lost recreational fishing days were calculated for 1989 due to

Sport Hunting

Alaska has 12 species of big game, including several not found (muskox, Dall sheep), or very rare (wolf, wolverine, brown bear, caribou), in the other 49 states. Approximately 144,000 - 166,000 moose; 835,000 caribou; 60,000 - 80,000 Dall sheep; 32,000 -43,000 brown bears; over 100,000 black bears; 5,900-7,900 wolves; 2,100 muskoxen; 13,000 - 15,000 mountain goats; 350,000 - 400,000 black-tailed deer; 1,400 - 1,600 elk and 850 bison inhabit the state. Also abundant are 19 species of furbearers, three species of ptarmigan, four species of grouse, two species of hares and many species of waterfowl, migratory birds, raptors and marine mammals (Castleman and Pitcher 1992). Hunting is conducted according to the Alaska State Hunting and Trapping Regulations formulated by Alaska Department of Fish and Game, Board of Game Members (ADF&G 1992c, 1992d). These regulations specify bag limits and season

area-wise for hunting. The many wildlife refuges, parks, and national forests located within the oil-affected region provide tremendous opportunities for hunting.

Following the oil spill, sport hunting of harlequin ducks was reduced by restrictions imposed in 1991 and 1992 in response to damage assessment studies. It is likely that these restrictions will continue until the species shows signs of recovery.

Chapter IV. Environmental Consequences

This chapter forms the scientific and analytic basis for the comparison of impacts among the proposed alternative implementation strategies (the alternatives) for the *EVOS* Restoration Plan. The environmental impacts or consequences that could occur from the implementation of each of the proposed alternatives are discussed in this chapter. The conclusions presented in this analysis are intended to guide decisionmakers in selecting the preferred alternative for the Restoration Plan. This chapter will also guide decisionmakers in developing a Record of Decision in compliance with the National Environmental Policy Act (NEPA) after comments are received from the public on the Draft Environmental Impact Statement (DEIS) and changes are incorporated as appropriate into the Final Environmental Impact Statement (FEIS).

The environmental consequences of the alternatives are the results of the application of different combinations of restoration options. Different mixes of options produce varying impacts on the human and natural environment. The title and number given each of the options, the resources and services they target, and the alternatives in which the options would be included are presented in Table 4-1. A complete description of the activities included in the options, and their expected effectiveness in restoring resources and services damaged by the *EVOS* are presented in the Draft Restoration Plan.

The no action alternative (Alternative 1) has been described in Chapter II of this DEIS. The no action alternative is the baseline conditions that exist under the current agency management of the resources in the *EVOS* area. The no action alternative provides a benchmark that enables decisionmakers to compare the magnitude of environmental effects of the options included in the other proposed alternatives. The four proposed alternatives (Alternatives 2–5) include actions, activities, and guidance over and above what is included under normal agency management. Normal agency management is conducted by many agencies with jurisdiction over the resources and services affected by restoration options included in the proposed alternatives of the Draft Restoration Plan. The no action alternative would include numerous resource management plans and guidance documents directing agency activities within the *EVOS* area. A complete description of all agency mandates and guidance affecting the *EVOS* area is beyond the scope of this Draft EIS. Under the no action alternative, there would be no change from the way normal agency management is currently practiced. Therefore, the no action alternative does not address the issues identified in Chapter I of the DEIS, and it is not analyzed for each option as the other four alternatives are in the following discussion.

This chapter is organized by the five issues presented in Chapter I. Under each issue, the impacts of implementing each alternative are discussed for individual resources and services. Following the discussion of alternatives is an analysis of specific impacts resulting from individual options is presented. An economic impact assessment is presented separately under Issue 4 (land uses, local economies, and communities) because the economic impact assessment was conducted differently than the impact assessment of resources and services damaged by the

EVOS. The remainder of the chapter is devoted to discussions of threatened and endangered species, cumulative impacts associated with Restoration Plan implementation, irreversible and irretrievable commitments of resources, unavoidable adverse environmental consequences of Restoration Plan implementation, mitigation measures that may be appropriate for consideration when implementing Restoration Plan alternatives, and the analytical tools/methodology used in the impact analysis for this DEIS.

Option Descriptions

Table 4-1. List of alternatives and associated options.

Option	Alternative 3 Targets	Alternative 4 Targets	Alternative 5 Targets
Option 1: Implement cooperative programs between fishermen and agencies to reduce incidental take of harbor seals.	harbor seals	harbor seals	harbor seals
Option 2: Implement cooperative programs between subsistence users and agencies to assess the effects of subsistence harvest on sea otters and harbor seals.	harbor seals, sea otters	harbor seals, sea otters	harbor seals, sea otters
Option 3: Study techniques for changing black cod fishery gear to avoid conflicts between fishermen and killer whales.		killer whales	killer whales
Option 4: Intensify fisheries management to protect injured stocks.	sockeye salmon	cutthroat trout, Dolly Varden, pink salmon, rockfish, pacific herring, sockeye salmon	cutthroat trout, Dolly Varden, pink salmon, rockfish, pacific herring, sockeye salmon
Option 5: Improve freshwater wild salmon spawning and rearing habitats.			pink salmon, sockeye salmon
Option 6: Improve survival rates of salmon eggs to fry by using egg boxes, net pens, or hatchery rearing.	sockeye salmon	sockeye salmon	pink salmon, sockeye salmon

Option	Alternative 3 Targets	Alternative 4 Targets	Alternative 5 Targets
Option 7: Relocate hatchery runs of pink salmon to reduce the interception rate of wild stocks of pink salmon.		pink salmon	pink salmon
Option 8: Update the Alaska Anadromous Streams Catalog to ensure that the necessary protection and regulation is provided for all listed salmon streams in the spill area.			pink salmon, cutthroat trout
Option 9: Remove predators at injured colonies or remove predators from islands that supported murres, black oystercatchers, or pigeon guillemots before the spill.	common murre, pigeon guillemot	common murre, pigeon guillemot, black oystercatcher	common murre, pigeon guillemot, black oystercatcher
Option 10: Study use of artificial stimuli (decoys, vocalizations) to encourage recovery at affected murre colonies and accelerate recolonization of historic colonies.	common murre	common murre	common murre
Option 11: Study changes in fishing gear or timing as a way of minimizing incidental capture of marbled murrelets.	marbled murrelet	marbled murrelet	marbled murrelet
Option 12: Accelerate recovery of upper intertidal zone.	intertidal organisms	intertidal organisms	intertidal organisms, black oystercatcher
Option 13: Study the effects of disturbance in marine birds and mammals.	sea otter	sea otter, common murre, harbor seal	sea otter, common murre, harbor seal
Option 14: Study extent of oiling of mussel beds and techniques for removing oil from mussel beds.	harlequin duck, sea otter	harlequin duck, sea otter	harlequin duck, sea otter

Option	Alternative 3 Targets	Alternative 4 Targets	Alternative 5 Targets
Option 15: Propose modifications of sport and trapping harvest guidelines of injured river otter and harlequin duck populations to speed the rate of recovery.			river otter, harlequin duck
Option 16: Develop a site stewardship program to monitor archaeological sites.	archaeological sites	archaeological sites	archaeological sites
Option 17: Preserve archaeological sites and artifacts within the spill area.	archaeological sites	archaeological sites	archaeological sites
Option 18: Acquire replacements for artifacts removed from the oil spill area.	archaeological artifacts	archaeological artifacts	archaeological artifacts
Option 19: Develop new public recreation activities.	protect existing recreation opportunities	protect or increase existing recreation opportunities	protect or increase existing recreation opportunities, encourage new use
Option 20: Test subsistence foods for continued contamination.	subsistence foods	subsistence foods	subsistence foods
Option 21: Provide new access to traditional subsistence foods in areas outside the spill area to replace lost use.	subsistence foods	subsistence foods	subsistence foods
Option 22: Develop subsistence mariculture sites, shellfish hatcheries, and a technical research center.			subsistence foods

Option	Alternative 3 Targets	Alternative 4 Targets	Alternative 5 Targets
Option 23: Replace lost sport, commercial, and subsistence fishing opportunities by creating new fisheries for salmon or trout.	commercial and sport fishing, commercial tourism	commercial and sport fishing, commercial tourism	commercial and sport fishing, commercial tourism, subsistence fishing
Option 24: Develop and conduct public information programs through visitors' centers.			recreation and commercial tourism
Option 25: Establish a marine environmental institute and research foundation.			education

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

The impacts of restoration activities on each injured resource are analyzed by alternatives and individual options in the following section. Impacts on ecological services are discussed under Issue 3 (ecological change). Impacts on archaeological resources and injured human-based services are discussed under Issue 4 (land use, local economies, and communities).

Through implementation of Alternative 2, habitat protection and acquisition (HP&A) would not directly increase the rate of recovery of targeted injured resources and services beyond the natural rate, but would do the most toward assuring that the natural rate of recovery was achieved for all injured resources combined.

Alternative 3 would enhance the degree or rate of recovery over and above the natural processes occurring under Alternative 2 by including restoration activities for selected injured resources and services that are not included in Alternative 2.

Under Alternative 4, the degree or rate of recovery occurring under Alternatives 2 and 3 would be supplemented with general restoration activities intended to increase the rate of recovery for selected resources and services.

Alternative 5 would include restoration activities in addition to those included in Alternatives 2–4. These activities may increase the rate of recovery of selected species, in some instances above prespill levels.

The following discussion summarizes the effects of implementing restoration options included in each alternative for each of the resources and services targeted by restoration activities.

Biological Resources

Marine Mammals

Harbor Seals

Alternative 2 - Habitat Protection

Under Alternative 2, the majority of the restoration funds would be used for the implementation of HP&A. Special designations under HP&A could protect habitat areas used by harbor seals throughout the oil spill region. The impact of the implementation of Alternative 2 would be to secure undisturbed haulout sites and coastal habitat for harbor seals to use for pupping, molting, and foraging. Because HP&A would protect habitat over a wide region for a long duration, there is some potential for increasing the harbor seal population under this alternative. However, because habitat protection would not have a direct influence, any harbor seal population growth would be gradual over a long interval of time.

Alternative 3 - Limited Restoration

Options 1, 2, and 13 specifically target harbor seal populations under this alternative. Options 4 and 6 would indirectly affect harbor seals by increasing the short- and long-term fish supply available as a food source. Seventy-five percent of the restoration funds would be used for HP&A. Special designations under HP&A could protect habitat areas used by harbor seals throughout the oil spill region. Option 13 would also protect habitat, concentrating on areas used as haulouts for pupping, molting, and foraging. The main intent of Options 1 and 2 is to develop ways to keep subsistence users from overharvesting of harbor seals. This could maintain a healthy population for future use. The long-term impact of the implementation of Alternative 3 on harbor seals would be to provide larger areas of protected habitat, localized increases in food supply, and decreased mortality from bycatch. Short-term decreases in subsistence use would be an additional indirect effect of the alternative. Although the impacts described would positively impact harbor seals, the potential for increasing the harbor seal population under this alternative would be moderate and occur only gradually because of the indirect nature of most of the options.

Alternatives 4 and 5 - Moderate Restoration and Comprehensive Restoration

Options 1, 2, and 13 directly target and impact harbor seal populations under Alternatives 4 and 5. Alternative 4 differs from Alternative 5 only with regard to options indirectly impacting harbor seals. Options 4, 6, 7, 21, and 23 are included in Alternative 4 and have an indirect impact on harbor seals. These options potentially provide additional food sources through restoration options that could increase fish stocks in the *EVOS* area. Alternative 5 includes the same options having indirect impacts as Alternative 4 and includes an additional option, Option 5, that could indirectly impact harbor seals by increasing the number of salmon available as a food source. Alternative 4 would receive approximately 50 percent of allocated funding for HP&A while Alternative 5 would receive approximately 35 percent. HP&A funding could protect haulout and coastal habitats used by harbor seals throughout the oil spill area. Option 13 would also protect habitat, concentrating on areas used as haulouts for pupping, molting, and foraging. The main intent of Option 2 is to develop ways to promote a sustained harvest among subsistence users, which would maintain a healthy population for future use. Option 1 would establish a program to educate fishermen on methods to reduce bycatch of harbor seals. The long-term impact of the implementation of Alternatives 4 and 5 on harbor seals would be to provide larger areas of protected habitat, to indirectly promote localized increases in food supply, and decreased mortality from bycatch. Short-term decreases in subsistence use would be an additional indirect effect of the alternative.

The following discussion describes all options in Alternatives 3, 4, and 5 that have direct or indirect effects on harbor seal populations.

HP&A (Special designations)

One activity under HP&A would establish specially designated regions throughout the spill area to protect habitat. Assuming that important harbor seal utilize habitats are protected (although

sanctuaries would likely be designated only for other species), there would be an indirect; positive effect on harbor seals because they would have larger ranges of their preferred habitat available for undisturbed use. Protection of habitat would decrease the number of harbor seals killed incidental to commercial fishing or disturbed during haulout.

Option #4 (Intensify fisheries management to protect injured stocks)
Option #5 (Improve freshwater wild salmon habitats)
Option #6 (Improve survival of salmon eggs and fry)
Option #7 (Change or relocate existing hatchery salmon runs)
Option #23 (Create new salmon runs)

All of these options are designed to increase the abundance of salmon (and other fish) in the oil spill region. There would be a resulting indirect, positive effect on harbor seals because their main diet consists of the same fish affected by these options. By increasing fish numbers, harbor seals would have more to eat, be healthier due to steadier diet, and may slowly increase in abundance.

Option #13 (Reduce disturbance at bird colonies, haulout sites, etc)

The purpose of this option is to designate buffer zones encircling important sites for the species in order to decrease disturbance. It is assumed that buffer zones would be established around known harbor seal haulout sites in the oil spill area, and that buffer zones would be maintained through the pupping and molting seasons from May until October. This option would decrease disturbance at harbor seal haulouts during times when seals are prone to panic, often stampeding and causing injuries/deaths and weakening mother-pup bonds. Weakening mother-pup bonds increases pup abandonment and leads to higher pup mortality. This option would have the indirect, positive result of decreasing harbor seal mortality caused by haulout disturbance.

Option #1 (Reduce the bycatch of harbor seals)

The purpose of this option is to improve the understanding of fishing interactions and harbor seals and ultimate reduce any problems. The option could include cooperative programs with commercial fishermen for reducing bycatch of harbor seals through reduction of entanglement and deterrent measures. This option could have the direct, long-term effect of increasing harbor seal population by reducing mortality caused by commercial fishing.

Option #2 (Cooperative program with subsistence users)

This option involves working with subsistence users to develop a information exchange program. This would give users up-to-date information to manage their harvest levels. If it is determined that reduced harvest by subsistence users would enhance resource recovery, voluntary reductions would directly help the harbor seal population. This option would have a short-term, positive effect on the harbor seal population because harvesting would be reduced to allow more rapid recovery of the injured population.

Option #21 (Provide access to traditional subsistence foods)

This option would aid subsistence users in gaining access to traditional subsistence resources in areas unaffected by the oil spill. This option would continue until contamination in resources is eliminated and injured subsistence resources have recovered. Because harbor seals are a subsistence resource, this option would have an indirect, positive effect on local harbor seal populations. By subsistence users taking advantage of access to unaffected resources, less harvesting of local harbor seal populations would occur. This option is only a temporary measure until resources recover, so the effects on harbor seals would be short-term.

Killer Whales

Alternative 2 - Habitat Protection

Only HP&A would affect killer whales in Alternative 2. HP&A could afford protection to rubbing beaches if these beaches were included within designated areas intended to protect other marine mammals or birds. This would have an indirect impact on the health of killer whales, and could have positive impacts on increases in whale populations.

Alternative 3 - Limited Restoration

Under Alternative 3, no options specifically target killer whales. HP&A and Options 4 and 13 could impact killer whale populations including the AB pod. HP&A and Options 4 and 45 could have a positive long-term impact by promoting better health, and promoting the sustained availability of food supplies.

Alternatives 4 and 5 – Moderate Restoration and Comprehensive Restoration

Under Alternatives 4 and 5, Option 3 is targeted for killer whales. This option could have a positive indirect impact. Alternatives 4 and 5 also include HP&A and Option 4, which may indirectly impact killer whale populations by inadvertently protecting rubbing beaches and maintaining food sources.

Options Related to Killer Whales

HP&A (Special designations)

HP&A could provide additional protection for killer whales by including rubbing beaches as part of marine sanctuaries where they would be regulated to minimize disturbance.

Creating designated areas would have an indirect, long-term effect on the killer whales for the same reasons as identified in Option 13. Killer whales use rubbing beaches to remove dead skin and parasites, a necessary procedure for the killer whale to maintain health, which could reduce mortality and increase populations.

Option #4 (Intensify fisheries management)

This option would implement fisheries management programs to control exploitation of injured species of fish through research and development of recommendations for incorporation into fisheries regulations. Restricting existing fisheries or redirecting them to alternate sites could have an indirect effect on killer whale populations by providing a food source for the resident pods of killer whales in the Gulf of Alaska. An additional food source could assure the continued presence and growth of the killer whale population in the Gulf of Alaska.

Option #43 (Reduce disturbance at bird colonies, haulout sites, etc.)
The purpose of this option is to designate buffer zones encircling important sites for marine mammals in order to decrease human disturbance of the animals. If killer whale rubbing beaches exist within buffer zones established for other species, this option could affect killer whale populations. Buffer zones created to limit boat traffic and disturbance around beaches known to be used by killer whales for rubbing could have an indirect effect on the health and presence of killer whales by providing them with a safe habitat for rubbing. Rubbing is essential for killer whales, both for comfort and to remove dead skin and parasites.

Option #3 (Change black cod fishery gear)

This option would affect killer whales by studying ways to minimize conflicts between the whales and fishermen. Historically, the gear type used in the Gulf of Alaska for black cod fisheries is the longline (baited hook and line). The killer whale is attracted to the black cod on the line and certain pods have learned to strip the cod from the lines. This has resulted in harassment and occasional shooting of the killer whales. This option could have a direct, long-term positive effect on killer whale population by reducing the mortality that may result from these conflicts with fishermen.

Sea Otters

Alternative 2 - Habitat Protection

Under Alternative 2, almost all of the restoration funds would be used for the implementation of HP&A. HP&A could protect habitat areas used by sea otters throughout the oil spill region. The indirect impact of the implementation of Alternative 2 could be to secure undisturbed haulout sites and coastal habitat for sea otters to use. Because HP&A could protect habitat over a wide region for a long duration, there is potential for increasing sea otter populations under this alternative. However, because habitat protection would not directly affect sea otter populations, growth may be gradual, sustained over a long interval of time.

Alternatives 3, 4, and 5 - Limited, Moderate, and Comprehensive Restoration

Alternatives 3, 4, and 5 would include the same options, all having the same impacts on sea otters. Differences would occur, however, in the allocation of HP&A under each alternative. Options 2, 13, and 14 directly target sea otters under each of these three alternatives. HP&A

would affect sea otter populations under this alternative. Option 14 may increase the long-term availability of healthy intertidal foraging areas for the sea otter if methods for cleaning oil from mussel beds can be identified. Seventy-five percent of the restoration funds under Alternative 3 would be used for HP&A. Under Alternatives 4 and 5, 50 percent and 75 percent (respectively) of restoration funds would be used for HP&A. These activities could protect habitat areas used by sea otters throughout the oil spill region. Option 13 would also protect habitat, concentrating on areas used as haulouts. The long-term impact of the implementation of these alternatives on sea otter populations could be positive and include the creation of larger areas of protected habitat and increased quality of food supplies, which could indirectly increase populations. Short-term decreases in subsistence use could have an additional indirect effect under these alternatives if it is determined that the subsistence harvest has an effect on sea otter populations. Although the impacts described would positively impact sea otters, the potential for increasing sea otter populations under these alternatives may occur gradually because of the indirect nature of the options.

Options Related to Sea Otters

HP&A (Habitat protection and acquisition)

HP&A would acquire land for the purpose of protecting habitat areas. Assuming that habitats important to the sea otter are protected (e.g., coastal zones, haulouts) and not used for recreation purposes that would disturb otters, there would be an indirect, positive effect on sea otters because they would have larger ranges of their preferred habitat available for undisturbed use. Assuming that the habitat areas would continue to be protected for a considerable time, this option would have long-term effects on the sea otter population.

HP&A would also establish specially designated regions throughout the spill area to protect habitat. Protection of habitat would decrease the number of sea otters killed incidental to commercial fishing and by haulout disturbance. Assuming that the habitat areas would continue to be protected for a considerable time, this option would have long-term effects on the sea otter population.

Option #2 (Cooperative program with subsistence users)

This option involves working with subsistence users to develop a information exchange program. This would give users up-to-date information to manage their harvest levels. If it is determined that reduced harvest by subsistence users would enhance resource recovery, voluntary reductions would directly help the sea otter population. This option would have a short-term, positive effect on the sea otter population because harvesting would be reduced to allow more rapid recovery of the injured population.

Option #13 (Reduce disturbance at bird colonies, haulout sites, etc)

The purpose of this option would be to designate buffer zones around important sites marine bird and mammal concentration sites in order to decrease disturbance. This option would have a

limited effect on sea otters because their irregular haulout site use is less affected by disturbance. However, sea otters appear to need haulouts to clean and maintain the insulating qualities of their fur (Van Gelder, 1982). By protecting haulout areas, this option could have a slight, indirect, positive effect on increasing the health of the sea otter population.

Option #14 (Eliminate oil from mussel beds)

The purpose of this options would be to eliminate oil from mussel beds and decrease the oil contamination in the intertidal zone. Mussels and other intertidal invertebrates are the primary food source for sea otters. This option would have an indirect effect on the sea otter because of alterations in their primary food source. Food availability is limiting to sea otter populations because they need to eat large quantities in order to maintain the high metabolism necessary to stay warm in cold waters (Chapman, 1981). The short-term effect of disturbance and cleaning of the intertidal areas would be negative because of the decrease in food sources. The long-term, positive effect would be clean, uncontaminated sources of food for the future.

Terrestrial Mammals

River Otters

Alternatives 2, 3, and 4 - Habitat Protection, Limited and Moderate Restoration

Alternatives 2, 3, and 4 do not contain options that target river otters. However, under each of these alternatives, river otter populations could indirectly benefit from the protection afforded by HP&A. This protection could maintain existing populations and possibly lead to long-term increases in river otter populations if HP&A included parcels that increased the carrying capacity of river otter habitat.

Alternative 5 -Comprehensive Restoration

Alternative 5 is the only option that targets river otters. However, Option 15 could have a positive direct impact on river otter populations by reducing mortality that may occur from sport and trapping harvests.

Options Related to River Otters

HP&A (Habitat protection and acquisition)

HP&A could affect river otters by acquiring and protecting habitat necessary for otter survival. The option includes purchasing private land as a method of protecting river otter habitat. Suitable land would be purchased and managed by state or Federal agencies familiar with habitat requirements of river otter.

River otters of coastal Alaska live in abandoned burrows or lodges of other animals and in old growth forests along the shoreline and adjacent to suitable feeding areas. Acquiring and

protecting suitable habitat could indirectly affect river otter by providing protected areas for breeding and resting when traveling along their ranges. Managing acquired habitat to provide favorable breeding grounds could promote long-term river otter population increases.

HP&A would also affect river otter by providing additional protection from human disturbances. This option would involve designating some coastal shorelines as marine sanctuaries where they would be regulated to minimize human disturbance of wildlife populations.

Designating areas could have long-term, indirect effects on the river otters by protection them from trapping, protecting otter food supplies, and providing safe, undisturbed areas for breeding. Otter populations could respond to this protection by increasing over the long-term.

Option #15 (Sport and trapping harvest guidelines)

This option would affect river otter populations by restricting trapping to subsistence use only, reducing bag limits for commercial trappers, or reduction and/or closure of both subsistence and commercial trapping.

Reducing or eliminating the number of river otter trapped would directly affect the river otter population by eliminating a source of mortality, and would allow a greater opportunity for river otter populations to increase. To the extent that the river otter population is declining due to trapping, this could have a long-term, positive impact on river otter populations.

Birds

Bald Eagle

Alternatives 2, 3, 4, and 5 - Habitat Protection; Limited, Moderate, and Comprehensive Restoration

There are no options under Alternatives 2, 3, 4, and 5 targeting bald eagles. However, each of these four alternatives includes HP&A that could indirectly impact bald eagles. The primary protective measure for bald eagles designated under each of the Draft Restoration Plan Alternatives 2 through 5 is HP&A. Alternative 2 allocates the largest percentage of funding to HP&A (91 percent), and Alternative 5 allocates the least (35 percent). Alternatives 3 and 4 allocate 75 percent and 50 percent, respectively. Consequently, the geographic extent of land acquisition for bald eagles would be greatest under Alternative 2 and smallest under Alternative 5.

Under Alternatives 3, 4, and 5, Option 9 may result in the implementation of measures to reduce predation by eagles on marine bird colonies. If measures are taken to reduce predation by eagles, this option could have a direct adverse impact on bald eagle populations because of the possible removal of young eagles under a program of eagle relocation to limit predation.

Options Related to Bald Eagles

HP&A (Habitat protection and acquisition)

This option could affect bald eagles by acquiring and protecting habitat required for breeding and nesting.

This option would have an indirect, long-term, positive effect on bald eagles by reducing disturbances to nesting and wintering eagles. On National Forests in Alaska, protection measures for bald eagles and their nesting habitats are prescribed in the Memorandum of Understanding between the USDA Forest Service and the U.S. Fish and Wildlife Service. The Memorandum provides for the exclusion of all land use activities within a buffer zone of 100 meter radius around all active and inactive bald eagle nests.

Option #9 (Removal of predator species)

This option could affect bald eagles by reducing their occurrence around marine bird colonies. Young eagles may be removed and provided to the eagle reintroduction program in the lower 48 states.

This could have a direct, short-term, negative impact on bald eagle populations. The effect would be short-term because the number of young birds that can be handled through the reintroduction program may be a limiting factor and compliance with the Bald Eagle Protection Act of 1940 must be considered.

Black Oystercatchers

Alternative 2 - Habitat Protection

Under Alternative 2, HP&A would have an indirect impact on the black oystercatcher population by providing protected habitat and preventing disturbance in the coastal areas used for nesting. Over 90 percent of the restoration funds for this alternative are allocated to the implementation of HP&A. The geographic extent of the impact from implementing this alternative would be large, including the entire oil spill area. Assuming the habitat would remain under protected status, the duration of the impacts associated with this habitat protection would be long-term, potentially leading to increases in the species population. This alternative could create long-term positive benefits to the black oystercatcher by insuring the necessary habitat to maintain healthy populations in the oil spill area.

Alternative 3 - Limited Restoration

Under Alternative 3, no would target black oystercatchers. Options 19, 14, 12, and 9, as well as HP&A, would indirectly impact the black oystercatcher. Option 19 could potentially have an indirect negative impact on oystercatcher populations if new recreation facilities were located in coastal habitat utilized for breeding and nesting. Introduction of human disturbance could adversely affect this species during nesting. Options 14 and 12 could indirectly impact this species by increasing food supplies and restoring habitat. Implementation of Option 19 could

result in a reduction in terrestrial and avian predators of black oystercatcher chicks and eggs, having a positive impact on this species' population. HP&A would be implemented throughout the oil spill area, with 75 percent of the restoration funds being used to implement HP&A.

The primary emphasis of Alternative 3 is on the acquisition and protection of habitat as described in HP&A. Under Alternative 3, over 75 percent of restoration funds would be allocated to HP&A. Emphasis on this approach to restoration would have a long-term, positive impact on the black oystercatcher population if the habitat acquired provided protection of nesting and breeding habitat.

Alternative 4 - Moderate Restoration

Option 9, which would be directed at reducing predation, would be the only option targeting black oystercatchers under Alternative 4. As with Alternative 3, Alternative 4 devotes most of the available restoration funds (50 percent) to HP&A. As noted previously, this would have a positive, long-term impact on the black oystercatcher population by providing protected nesting, and breeding habitats throughout the oil spill area. Other options that would have an indirect impact on black oystercatchers, but that do not specifically target black oystercatchers, are the same in Alternative 4 as in Alternative 3 (i.e., Options 9, 12, 14, and 19).

Alternative 5 - Comprehensive Restoration

Under Alternative 5, Options 9 and 12 specifically target black oystercatchers. This differs from Alternative 4 in that Option 12 under Alternative 4 does not specifically target black oystercatchers. Similarly to Alternatives 3 and 4, Alternative 5 includes Options 14 and 19 that have a positive indirect impact on oystercatchers by potentially increasing nesting habitat and food sources. As a consequence of a larger number of options affecting this species, a larger restoration funding allocation (48 percent) has been proposed for implementing restoration options in addition to habitat acquisition and protection than in Alternatives 2, 3, or 4. A major focus of Alternative 5 is still habitat protection (allocated 35 percent of total funding), but there is a greater mix of options affecting the black oystercatcher under this alternative.

Options Related to Black Oystercatchers

HP&A (Habitat protection and acquisition)

Private land acquisition, or acquisition of partial interests in private lands, for the purpose of protecting habitats linked to resources injured by the oil spill, would be undertaken to prevent additional injury to those resources. Although black oystercatchers nest near the high tide zone, reduction of disturbance from upland activities could adversely affect species populations. Therefore, implementation of this option could have a positive, indirect, long-term effect on the black oystercatchers

HP&A could have an additional positive, indirect, long-term effect on increasing black oystercatcher populations because under this option marine and intertidal areas in public

ownership can be placed into special State or Federal land designations that provide increased levels of regulatory protection. By providing habitat protection and further reducing disturbances to the birds during their nesting periods, populations may increase.

Option #19 (Creation of new recreation sites and facilities)

Implementation of this option involves construction of new public recreation facilities which could have a negative, indirect, long-term effect on the black oystercatcher populations if creation of these facilities infringed on the breeding, nesting, or feeding habitat of this species. If creation of these facilities were not to infringe on their habitat requirements, but rather would draw tourists away from the breeding and nesting areas, this option would result in a potential positive, indirect, long-term impact to the black oystercatcher.

Option #14 (Eliminate oil from mussel beds)

Persistent oil in the mussel beds represents a potential threat to the black oystercatcher as this species utilizes the intertidal mussel beds for food. Implementation of this option could involve determination of the geographic extent of persistent oil as it pertains to the mussel beds and anadromous streams in Prince William Sound, and implementation of the most effective and least intrusive method of cleaning the beds and areas of contamination adjacent to anadromous streams.

This option could have a positive, indirect, long-term impact on the black oystercatcher because it could involve stripping or tilling of contaminated mussel beds and anadromous streams to increase flushing of residual oil, resulting in a reduction of the amount of oil available for bioaccumulation by mussels and other invertebrates. Therefore, less oil would be available for ingestion by predator species such as the black oystercatcher. There would also be a negative, indirect, short-term effect on the black oystercatcher due to the cleaning of the oiled mussel beds and anadromous streams. The proposed cleaning methods would result in a limited and temporary direct loss of mussels and associated invertebrates and algae from this habitat, ultimately resulting in a temporary reduction in prey for the black oystercatcher.

Option #12 (Accelerate recovery of upper intertidal zone)

The overall objective of this option is to facilitate recovery of the previously dominant brown algae *Fucus gardneri* (popweed). Implementation of this option would have a positive, indirect, and long-term effect on the black oystercatcher because this species utilizes the intertidal habitat to feed on limpets, mussels, clams, and chitons that would increase with the recovery of this zone. By implementing this option, it is anticipated that additional seaweeds and invertebrates would recolonize the intertidal zone, thus providing the black oystercatcher with an additional food source.

Option #7 (Removal of predator species)

Implementation of this option could result in a positive, indirect, long-term effect on black

oystercatcher reproduction from the removal of introduced fox from islands along the Alaska Peninsula and Aleutians. A secondary goal would be to reduce avian predators. Foxes are voracious predators of chicks and eggs, and their removal would allow black oystercatcher reproduction on these islands to increase.

The reduction of avian predators would have a positive, indirect, short-term effect on the black oystercatcher productivity because glaucous-winged gulls, northern ravens, and bald eagles can be effective predators on these nesting colonies.

Harlequin Ducks

Alternative 2 - Habitat Protection

HP&A would be implemented under Alternative 2, with more than 90 percent of available funds. Implementation of Alternative 2 would have an indirect impact on the harlequin duck reproductive potential if HP&A protected habitat for necessary breeding, nesting, and molting. The geographic extent of the impact from implementing this alternative would be large, including the entire oil spill area. Assuming the habitat would remain under protected status, the duration of the impacts associated with this habitat protection would be long-term, potentially leading to increases in the species population. This alternative could create long-term positive benefits to the harlequin duck by insuring the necessary habitat to maintain healthy populations in the oil spill area.

Alternative 3 - Limited Restoration

With respect to the harlequin duck, only Option 14 would specifically target the species under Alternative 3. Option 19, as well as HP&A, may also have indirect impacts under Alternative 3. Option 19 would potentially have an indirect, negative impact on the duck population because of human disturbance that could interrupt breeding, nesting, and molting if recreation facilities were sited within the harlequin's habitat. In contrast, if construction of these facilities would concentrate tourists away from the breeding and nesting areas, the indirect impact of this option on the reproduction potential of the harlequin duck would be positive. Option 14 could indirectly impact the harlequin duck by increasing food supplies which could improve the health of the population and increase the carrying capacity of the ecosystem. HP&A would be implemented throughout the oil spill area, with 75 percent of the restoration funds being used for this purpose.

The primary emphasis of Alternative 3 is on the acquisition and protection of habitat as described in HP&A. Emphasis on this approach to restoration could have a long-term, positive impact on the harlequin duck population by providing protected nesting, breeding, and molting habitat.

Alternative 4 - Moderate Restoration

Alternative 4 would implement the same options, impacting the harlequin duck, as Alternative 3. Therefore, the impacts associated with Alternative 4 would be the same as those associated

with Alternative 3. As with Alternative 3, Alternative 4 devotes a large portion of the available restoration funds (50 percent) to HP&A. As noted previously, this could have a positive, long-term impact on the harlequin duck population by providing protected nesting, and breeding habitats throughout the oil spill area.

Alternative 5 - Comprehensive Restoration

Alternative 5 includes the most options affecting the harlequin duck. Options 14 and 15 specifically target harlequins. Option 19, as well as HP&A, would also be implemented under this alternative. As a consequence of the larger number of options affecting this species, a larger amount of restoration funding (48 percent) is being proposed for implementing restoration options than was allocated in Alternatives 2, 3, or 4. HP&A is still a major focus of this alternative (35 percent of total funding), as with the previous alternatives, but there is a greater mix of options affecting the harlequin duck to be implemented under Alternative 5.

In addition to the effects described previously, Alternative 5 would serve to increase the harlequin duck population if it is determined that temporarily limiting sport harvesting would benefit this species. Opportunities to increase the harlequin duck population may be high in localized areas, but the overall magnitude of the impact would likely be small.

Options Related to Harlequin Ducks

HP&A (Habitat protection and acquisition)

Private land acquisition, or acquisition of partial interests in private lands, for the purpose of protecting habitats linked to the resources injured by the oil spill, would be undertaken to prevent additional injury to those resources. Implementation of this option may include the acquisition of upland habitat and undisturbed riparian lands around anadromous streams. These habitats are conducive to the breeding and nesting of the harlequin duck.

Protecting harlequin ducks breeding and nesting habitat would have a positive, indirect, long-term effect because the protection of breeding and nesting habitat could lead to population increases.

Option #15 (Develop sport harvest/trapping guidelines)

Implementation of this option could involve imposing temporary restrictions or closure of sport harvest and trapping of this species in the oil-spill area. Post oil spill information indicates that the harlequin duck has suffered a decline in population and exhibited near total reproductive failure in some portions of the oil-spill area. Under this option, harvest pressure would be reduced or eliminated when it is shown to suppress the natural recovery rate of the harlequin duck. At present, an early season closure on the harvesting period is in effect.

It is not known how many ducks are harvested by sport hunters in the oil-spill area as harvest figures are reported for all of Southcentral Alaska. It is thought that the harvest is small.

However, a harvest in September would take almost exclusively resident birds because migrants have not yet arrived from their breeding grounds further north.

Although the sport trapping and harvesting restrictions would be temporary, a reduction in harvest of this injured species would directly effect population levels by eliminating a source of mortality for resident birds, and providing additional opportunity for spill zone populations to reproduce. The effect would be long-term with regard to a potential recovery of the harlequin duck population in the oil-spill area if reproductive success is enhanced.

Option #19 (Creation of new recreation sites and facilities)

Implementation of this option would include construction of new public recreation facilities such as mooring buoys, boat ramps, picnic areas, campsites, and trails; and making public land available for commercial recreation facilities such as fuel stops, docks, and lodges. At this time, the specific proposed location of these new facilities is unknown, but it is assumed that facilities would be constructed in upland as well as tidal habitat.

The effects of implementing this option would be negative, indirect, and long-term on the harlequin duck population only if creation of these recreation sites and facilities would infringe on the pairing, breeding, and nesting habitat requirements of this species. If creation of these facilities were not to infringe on their habitat requirements, but rather would draw tourists away from the breeding and nesting areas, this option would result in a potential positive, indirect, long-term impact to the harlequin duck.

Option #14 (Eliminate oil from mussel beds)

Persistent oil in the mussel beds represents a potential threat to the harlequin duck, as the duck is dependent on these beds for food. This option would involve determining the geographic extent of persistent oil as it pertains to the mussel beds in Prince William Sound, and implementing the most effective and least intrusive method of cleaning the beds and areas of contamination adjacent to anadromous streams.

This option could have a positive, indirect, long-term effect on the harlequin duck because it would involve stripping or tilling of contaminated mussel beds and anadromous streams to increase flushing of residual oil, resulting in a reduction of the amount of oil available for bioaccumulation by mussels and other invertebrates. Therefore, less oil could be available for ingestion by predator species such as the harlequin duck. This could indirectly improve the health of this species by providing a healthy food source. There could also be a negative, indirect, short-term effect on the harlequin duck due to the cleaning of the oiled mussel beds and anadromous streams. The proposed cleaning methods would result in a limited and temporary direct loss of mussels and associated invertebrates and algae from this habitat, ultimately resulting in a temporary reduction in prey for the duck.

Common Murres

Alternative 2 - Habitat Protection

Under this alternative, over 90 percent of the restoration funds would be used to implement HP&A. Both activities under HP&A, habitat acquisition and special land designations could indirectly benefit common murres by protecting the nesting habitat if the HP&A activities include murre habitat.

Under this alternative there would be no direct effects on the common murre population. All indirect effects would be through the additional protection afforded the breeding colonies by regulations on public lands.

Alternative 3 - Limited Restoration

Under this alternative, common murres would be targeted by Options 9 and 10. For Option 9, studies to promote synchrony would be conducted, and for Option 10, there would be consideration of avian predator reduction. The emphasis of the options under this alternative is to stabilize the breeding synchrony and increase egg production at murre colonies. Because the geographic extent of the options in Alternative 3 covers the entire common murre breeding territory in the spill area, the magnitude of the combined positive indirect impacts of the options could be high. Similar to Alternative 2, HP&A would be included in Alternative, although less funding would be allocated (75 percent) under Alternative 3 than under Alternative 2.

Alternative 4 - Moderate Restoration

Option affecting common murres under this alternative are the same as listed under Alternative 3. Less money is available for HP&A, potentially resulting in increasing opportunities for human use of the area. The combined impacts on the common murre from these options could still be high.

Alternative 5 - Comprehensive Restoration

Under this alternative, common murres are targeted by three options (Options 9, 10, and 13). Implementation of Option 13 targets murres only under this alternative. Option 13 could result in regulating boat traffic around murre colonies. Because Alternative 5 includes more options than any of the other alternatives, as well as 35 percent allocation of funds for HP&A, the intensity or magnitude of the effects may be greater than under the other alternatives.

Options Related to Common Murres

HP&A (Habitat protection and acquisition)

Implementing this option could affect common murres by protecting breeding and fishing habitat throughout the oil spill area. However, only a few important murre habitats are available for

acquisition. Therefore, this option would have a only a minimal effect on increasing murre populations by further reducing disturbances to the birds during their nesting period.

Implementing this option could affect common murres by protecting breeding and fishing habitat throughout the oil spill area.

This option would have an indirect, long-term effect on increasing murre populations by further reducing disturbances to the birds during their nesting period.

Option #4 (Reduce disturbance at bird colonies, haulout sites, etc)

This option could restrict the speed or prohibit navigation of vessels within 1/2 or 1 mile of protected bird colonies. These restrictions could be implemented in all areas of the oil spill area. This option would affect the breeding and nesting success of common murres by reducing loud noises that can cause the adults to flush from the breeding ledges, kicking eggs off the cliffs and leaving eggs and young exposed to predators. The lower density and asynchronous nesting at the colonies within the oil-spill area have made the eggs and young more vulnerable to predation. Modifying boat traffic around these colonies may reduce additional disturbances.

This option could have a direct, long-term effect on common murre productivity by reducing the number of eggs lost and increasing the survival of chicks. While there is uncertainty regarding the exact level of disturbance that nearby boats have on nesting colonies, the decrease in potential disturbances could prevent additional loss of eggs and chicks during the recovery period. The effect of this option would be greatest during the initial recovery years while the proportion of young breeding birds is highest and additional measures are being undertaken to improve breeding synchrony. The effect could be long-term because the buffer zones would stay in place for the entire recovery period for the impacted colonies and may be left in place afterward as a protective measure when the colonies have been fully restored.

Option #16 (Increase productivity and success at murre colonies)

This option would affect common murres by developing and implementing a study to enhance social stimuli to promote breeding synchrony. This study would use decoys and recorded calls to give the illusion of typical breeding densities which may encourage a return to normal breeding patterns. The main effect of this study would be a direct, short-term increase in reproduction success since synchrony promotes earlier egg laying and increases the number of nesting birds to ward off predators. The effect would be short-term, in regards to total recovery time, because breeding synchrony is a density effect. In addition, Heinemann (1993) supports the idea that it is probably a threshold phenomenon, which means that until densities climb above the threshold, reproductive rates would stay very low. Once the required density has been reached, however, efforts to promote synchrony would no longer be needed. Negative effects of this technique may include decoys displacing breeding pairs or causing gaps between pairs thus increasing susceptibility to predation, and are assumed to be minimal and compensated for by the increase in synchrony.

Option #17 (Removal of predator species)

The primary goal of this option would be to reduce seabird egg and chick mortality by removing or reducing predators. Outside the spill area, the removal of introduced foxes from the islands would result in an indirect, long-term increase in murre production. Foxes are voracious predators of chicks and eggs and their removal would allow the productivity of these islands to increase.

The reduction of avian predators at the injured colonies would have an indirect, short-term increase in murre productivity. Glaucous-winged gulls, northern ravens, and bald eagles are effective predators on murre colonies with gulls sometimes accounting for 40% of the egg loss. Reducing avian predators at murre colonies is planned only for short-term benefits, because reduction techniques would likely not totally remove the predator populations.

Marbled Murrelets

Alternative 2 - Habitat Protection

Under this alternative, marbled murrelets could be affected by HP&A. Given the high level of funding, habitat acquisition is likely to extend throughout the range of the marbled murrelet. The magnitude of the impact for this alternative on marbled murrelets would be high because habitat acquisition is the most effective option for preventing rapid population declines and ensuring population recovery.

Alternatives 3, 4, and 5 - Limited, Moderate, and Comprehensive Restoration

Under each of the three alternatives (Alternative 3, 4, and 5), marbled murrelets would be specifically targeted by only one option (Option 11). The major differences among Alternatives 3, 4, and 5 are the amount of restoration funds allocated for HP&A, Alternative 3 including the most (75 percent) and Alternative 5 including the least (35 percent).

Options Related to Marbled Murrelets

HP&A (Habitat protection and acquisition)

HP&A would affect marbled murrelets by acquiring and protecting upland habitats necessary for successful breeding and nesting. An assumption concerning the implementation of HP&A is that some land containing these productive habitats is currently privately owned and consequently available for purchase or protection. This also assumes that the land area containing these habitats would meet the criteria necessary to make them a target for purchase or protection.

This activity would have an indirect, long-term effect on marbled murrelet populations. In the lower 48 States, the marbled murrelet has a declining nesting habitat base throughout most of its range where it nests in trees. Continued logging operations can be expected to cause a decline in population numbers. Land acquisition would help this species assuming that the land

bought was in danger of being logged and that it is suitable as nesting habitat.

Implementing the special designation activity under HP&A could also affect murrelets by protecting breeding and fishing habitat throughout the oil spill area.

This activity would have an indirect, long-term effect on increasing murrelet populations by protecting feeding and nesting locations. A large designation area that would limit development activities and pollution sources may have a positive effect on the prey base.

Option #11 (Minimize the incidental take of birds)

Under this option, the extent of marine bird mortality by commercial fishing activities associated with fisheries (gillnet, drift, and set net) would be examined. If the mortality is found to represent a significant source of mortality for populations in the spill area, an effort would be made to develop new technologies or strategies for reducing encounters. These could involve suspending nets below the surface, closure of certain areas, elimination of night fishing, or directing fishing away from injured marine bird habitats.

To implement this option a number of steps would have to be taken: (1) research and document the extent of marine bird mortality in the spill area, (2) research new technologies or strategies for reducing encounters, and (3) incorporate relevant methodologies and strategies in fishery management plans. Assuming that all steps have been completed, this option would have an indirect, long-term effect on reducing accidental mortality and increase the marbled murrelet population.

Fish

Cutthroat Trout

Alternative 2 - Habitat Protection

Under this alternative, over 90 percent of the restoration funds would be used to implement HP&A. HP&A would both protect and acquire habitat, and establish special land designations, indirectly benefiting cutthroat trout by protecting the habitat required for spawning and rearing of fish. The duration of the impacts would be long-term assuming that the protected habitat is managed to promote healthy ecosystems in perpetuity. Because the extent and duration of the impacts are large and wide-spread, and a large financial commitment is being made, the magnitude of the impacts of this alternative could be high, creating long-term, positive benefits to cutthroat trout by insuring the necessary habitat to maintain healthy fish populations.

Alternative 3 - Limited Restoration

There are no options under this alternative that specifically target cutthroat trout populations. Option 12, as well as HP&A, could indirectly increase cutthroat trout populations. Option 12 could increase the quantity and quality of food for adult cutthroat trout in the marine

environment. HP&A could protect spawning areas throughout the spill area from further exploitation and degradation allowing for natural recovery. HP&A has the greatest emphasis placed on it under this alternative, with 75 percent of the restoration funds being allocated for HP&A. An indirect impact of Alternative 3 could lead to an increase in spawning success of cutthroat trout which could ultimately increase populations.

Alternative 4 - Moderate Restoration

The options under Alternative 4 that could affect cutthroat trout include 4 and 12, as well as HP&A. Only Option 4 targets cutthroat trout populations under this alternative. Option 4 could directly impact cutthroat trout populations by reducing commercial, sport, and subsistence fishing pressures, thus increasing spawning success. The direct impact of Alternative 4 on cutthroat trout would be an increase of spawning success and, ultimately, an increase in cutthroat trout population. Option 12 and HP&A would be the same in Alternative 4 as in Alternative 3, except that HP&A would be allocated less funding under Alternative 4.

Alternative 5 - Comprehensive Restoration

Alternative 5 includes the most options targeting cutthroat trout. Like HP&A, Option 8 could provide further protection for spawning areas, allowing for increased spawning success. Option 5, which does not target cutthroat trout, is included in Alternative 5 and could indirectly impact this species if increased spawning habitat were made available through stream improvements intended to affect sockeye salmon. The impact of Alternative 5 on cutthroat trout could lead to an increase of spawning success and, therefore, a gradual increase in cutthroat trout population.

Options Related to Cutthroat Trout

HP&A (Habitat protection and acquisition)

HP&A could affect cutthroat trout populations throughout the spill area by acquiring damaged habitat and protecting it from further disturbance to allow for natural recovery. This would have a positive, indirect effect on the cutthroat trout by protecting spawning stocks so that reproductive success may increase. This would ultimately increase populations. The long-term effects would be that cutthroat trout habitat would be protected from further disturbance.

These activities could also affect cutthroat trout by giving special designations to uplands, coastal, and marine habitat that are utilized by trout for spawning and rearing. This could have an indirect, positive effect on cutthroat trout by protecting spawning habitats so that reproductive success could increase, thus increasing populations. The effect would be long-term because the habitat would be protected from future exploitation.

Option #4 (Intensify fisheries management)

This option would affect cutthroat trout by intensifying fisheries management of this species. This option would protect injured stocks from further exploitation and allow for natural recovery

through research and development of recommendations for incorporation into fisheries regulations by the Board of Fish. It is assumed that the intensified management of cutthroat trout would be designed to increase trout populations, but not to exceed the carrying capacity of the stocks. This option would have a positive, direct effect on trout populations by reducing commercial and sport fishing pressures on damaged stocks. This could increase the number of successful spawning adults, which would increase overall spawning success. The long-term effect would be an increase of cutthroat trout populations.

Option #5 (Improve freshwater wild salmon)

This option could affect cutthroat trout by improving access to salmon spawning areas by building fish passages or removing barriers. Creating fish passage for salmon could also provide opportunities for other anadromous species to utilize the streams for spawning. Cutthroat trout utilize some of the same streams as salmon. Therefore, this option could have an indirect, positive effect on cutthroat trout populations by creating fish passages and removing instream barriers. This would provide new and additional spawning habitat for cutthroat trout, which could increase spawning success and thereby increase populations. This could have a long-term effect on cutthroat trout because the new habitat could expand the current spawning area of trout for future reproduction. This effect would be long-term because the instream improvements could be maintained for many years.

Option #12 (Recovery of upper intertidal zone)

The option would have a very slight positive, indirect effect on cutthroat trout by improving habitat and the quantity of prey species available for adult trout. Adult cutthroat trout use the nearshore areas to feed after leaving the streams. Improving the intertidal zone would increase the quantity of prey species utilized by cutthroat trout. This could have a long-term effect on trout populations by increasing the survival rate of fish that may return to spawn.

Option #8 (Protect undocumented anadromous streams)

This option could affect cutthroat trout by listing streams utilized by salmon in the ADF&G Anadromous Stream Catalogue. Under the State Forest Practices Act, streams listed in the catalogue are provided with certain level of protection to avoid further disturbance. This could have an indirect, positive effect on cutthroat trout by protecting existing spawning areas from further disturbance, thus increasing spawning success and therefore increasing populations. The option would have a long-term effect because the streams would be protected from future degradation, allowing cutthroat trout populations to increase.

Dolly Varden

Alternative 2 - Habitat Protection

Under this alternative, over 90 percent of the restoration funds would be used to implement HP&A. HP&A would both protect and acquire habitat,and establish special land designations,

indirectly benefiting Dolly Varden by protecting the habitat required for spawning and rearing of fish. The duration of the impacts would be long-term, assuming that the protected habitat is managed to promote healthy ecosystems in perpetuity. Because the extent and duration of the impacts are large and wide-spread, and a large financial commitment is being made, the magnitude of the impacts of this alternative could be high, creating long-term, positive benefits to Dolly Varden by insuring the necessary habitat to maintain healthy fish populations.

Alternative 3 - Limited Restoration

There are several options under this alternative that would affect Dolly Varden populations, although none specifically target the species. Option 12, as ~~well~~ as HP&A, could ensure adequate food supplies for adult Dolly Varden in the marine environment. HP&A could protect spawning areas throughout the spill area, thereby allowing for natural recovery. HP&A has the greatest emphasis placed on it under this alternative, with 75 percent of the restoration funds being allocated for HP&A, and only 12 percent of the funds for other restoration options. Alternative 3 would also include Option 6, which could indirectly provide an additional food source for Dolly Varden by increasing the number of salmon eggs and fry in streams inhabited by this species. The impact of Alternative 3 could lead to an increase in spawning success of Dolly Varden which would ultimately increase populations.

Alternatives 4 and 5 - Moderate and Comprehensive Restoration

Alternatives 4 and 5 both include Option 4, which targets Dolly Varden. Dolly Varden would also be indirectly affected by Option 12, as well as by HP&A, with 50 percent allocation for HP&A in Alternative 4 and 75 percent in Alternative 5. Option 4 could directly impact Dolly Varden populations if measures were implemented that reduced sport fishing pressures, thereby increasing spawning success. Alternatives 4 and 5 would also include Option 6, which is included in Alternative 3 as well. The impact of Alternatives 4 and 5 on Dolly Varden could include an increase of spawning success and, therefore, a gradual increase in populations.

Options Related to Dolly Varden

HP&A (Habitat protection and acquisition)

HP&A could affect Dolly Varden populations throughout the spill area by acquiring damaged habitat and protecting it from further disturbance to allow for natural recovery. This would have a positive, indirect effect on the Dolly Varden by protecting spawning stocks so that reproductive success may increase. This would ultimately increase populations. The long-term effects would be that Dolly Varden habitat would be protected from further disturbance.

HP&A could also affect Dolly Varden by giving special designations to uplands, coastal, and marine habitat that are utilized by Dolly Varden for spawning and rearing. This could have an indirect, positive effect on Dolly Varden by protecting spawning habitats so that reproductive success could increase, thus increasing populations. The effect would be long-term because the habitat would be protected from future exploitation.

Option #4 (Intensify fisheries management)

This option would affect Dolly Varden by intensifying fisheries management of this species. This option would protect injured stocks from overexploitation and allow for natural recovery through research and development of recommendations for incorporation into fisheries regulations by the Board of Fish. It is assumed that the intensified management of Dolly Varden would be designed to increase Dolly Varden populations, but not to exceed the carrying capacity of the stocks. This option would have a positive, direct effect on Dolly Varden populations by reducing sport fishing pressures on damaged stocks. This could increase the number of successful spawning adults which would increase overall spawning success. The long-term effect would be an increase of Dolly Varden populations.

Option #12 (Recovery of upper intertidal zone)

The option would have a very slight positive, indirect effect on Dolly Varden by improving habitat and the quantity of prey species for adult Dolly Varden. Adult Dolly Varden use the nearshore areas to feed after leaving the streams. Improving the intertidal zone would increase the quantity of prey species available to Dolly Varden and increase the survival rate of fish that may return to spawn. Increasing the number of spawning fish could ultimately increase populations.

Option #6 (Improve survival of salmon eggs and fry)

This option could affect Dolly Varden by increasing survival of salmon eggs and larvae. Dolly Varden prey heavily on salmon eggs and larvae in the stream. An increase in the number of salmon eggs and larvae could have an indirect, positive effect on Dolly Varden by increasing the food supply for Dolly Varden. If salmon populations increase, this could have a long-term effect on the available food source for Dolly Varden, which would increase growth rates of Dolly Varden and thereby increase the number of adults that may return to spawn.

Pacific Herring

Alternative 2 - Habitat Protection

Under this alternative, over 90 percent of the restoration funds would be allocated to implement HP&A. HP&A would both protect and acquire habitat and establish special land designations. These activities would have no direct effects on open water Pacific herring.

Alternative 3 - Limited Restoration

Under Alternative 3, no options have been proposed that target Pacific herring. However, 75 percent of the restoration funds would be allocated to HP&A. As in Alternative 2, this would not directly affect open water Pacific herring.

Alternatives 4 and 5 - Moderate and Comprehensive Restoration

In addition to HP&A, Alternatives 4 and 5 include Option 4, which includes intensifying fisheries management of Pacific herring. Option 4 could lead to the implementation of management measures that reduce commercial, sport, and subsistence fishing. This could result in positive indirect impacts on herring stocks because of an increased number of spawning adults.

Options Related to Pacific Herring

Option #4 (Intensify fisheries management)

This option could affect Pacific Herring by intensifying fisheries management of this species. This option could protect injured stocks from overexploitation and allow natural recovery through research and development of recommendations for incorporation into fisheries regulations by the Board of Fish. The extent of damage to the herring population is unknown at this time. It is assumed that a damage assessment of the 1989 and 1990 year class of herring populations would be made, and that the results would indicate that recruitment of those year classes to the herring population was reduced and the population of herring has been reduced. This option would have a positive, direct effect on Pacific herring populations by reducing commercial and sport fishing pressures on damaged stocks. The effect would be long-term because the number of successful spawning adults would increase and thereby increase spawning success, which could ultimately lead to an increase in population.

Pink Salmon

Alternative 2 - Habitat Protection

Under this alternative, over 90 percent of the restoration funds would be used to implement HP&A. HP&A would both protect and acquire habitat and establish special land designations, indirectly benefiting pink salmon by protecting the habitat required for spawning and rearing of fish. The duration of the impacts would be long-term, assuming that the protected habitat is held by the public and managed to promote healthy ecosystems in perpetuity. Because the extent and duration of the impacts are large and wide-spread, and a large financial commitment is being made, the magnitude of the impacts of this alternative could be high, creating long-term, positive benefits to pink salmon by insuring the necessary habitat to maintain healthy fish populations.

Alternative 3 - Limited Restoration

No options specifically target pink salmon under Alternative 3. However, Option 23 could indirectly affect pink salmon populations by reducing local fishing pressures on wild stocks. HP&A would protect spawning areas from further exploitation and degradation, which may allow for increased spawning and a gradual increase in pink salmon populations. Under this alternative the majority of the funds would be used for habitat acquisition, which could result in a long-term, positive impact to pink salmon populations if the habitat acquired protects needed salmon spawning and rearing streams.

Alternative 4 - Moderate Restoration

Alternative 4 includes two options that specifically target pink salmon, Options 4 and 7. Option 23 and HP&A could indirectly increase pink salmon populations. Option 23 could reduce commercial fishing pressure, thus protecting wild stocks, and HP&A would protect spawning areas from further exploitation and degradation, allowing for increased spawning. Option could directly impact pink salmon populations by reducing commercial, sport, and subsistence fishing pressures, thus increasing spawning success. Option 7 could affect pink salmon populations buy reducing the number of wild stocks intercepted during harvest of hatchery runs. The impact of Alternative 4 on pink salmon could lead to increased spawning success in the spill area, resulting in gradual population increases. Because Options 4 and 7 are specifically targeted to pink salmon populations, and all other options indirectly increase populations, the likelihood of increasing populations under this alternative is high.

Alternative 5 - Comprehensive Restoration

Alternative 5 specifically targets pink salmon under options 4, 5, 6, 7, and 8. Options 4 and 7 are the same as described under Alternative 4. Options 5 and 6 are intended to increase the availability of spawning and rearing habitat and success. Option 8 is intended to indirectly maintain or increase pink salmon populations by protecting streams not previously included in the anadromous stream catalog. Option 23 could affect pink salmon populations as identified in Alternative 3. HP&A would protect spawning areas from further exploitation and degradation as in Alternative 4, but a smaller allocation of funds (35 percent of the total) would be included in Alternative 5 than in Alternative 4 (50 percent). Because five options in Alternative 5 target pink salmon populations, the likelihood of increasing populations under this alternative is high.

Options Related to Pink Salmon

HP&A (Habitat protection and acquisition)

HP&A could affect pink salmon by protecting habitat throughout the spill area by acquiring damaged habitat and protecting it from further disturbance to allow for natural recovery. This would have a positive, indirect effect on the pink salmon by protecting spawning stocks so that reproductive success may increase. This would ultimately increase populations. The long-term effects would be that pink salmon habitat would be protected from further disturbance.

HP&A could also affect pink salmon by giving special designations to uplands, coastal, and marine habitat that are utilized by salmon for spawning and rearing. This could have an indirect, positive effect on pink salmon by protecting spawning habitats so that reproductive success could increase, thus increasing populations. The effect would be long-term because the habitat would be protected from future exploitation.

Option #4 (Intensify fisheries management)

This option involves research and the development of recommendations for restricting or

redirecting of existing fisheries. Changes to fisheries management would be implemented through regulations promulgated by the Alaska Board of Fish. This option could affect pink salmon by protecting injured stocks from excessive fishing pressures and allowing for natural recovery. It is assumed that the intensified management of pink salmon would be designed to increase salmon populations, but not to exceed the carrying capacity of the stocks to avoid further damage to the wild stocks. This option would have a positive, direct effect on salmon populations by reducing commercial and sport fishing pressures on damaged stocks. This could increase the number of successful spawning adults which would increase overall spawning success. The long-term effect would be an increase of pink salmon populations.

Option #5 (Improve freshwater wild salmon habitats)

This option could affect pink salmon by using two restoration techniques to increase populations: (1) construct salmon spawning channels and instream improvements and (2) improve access to salmon spawning areas by building fish passes or removing barriers.

Construction of salmon spawning channels and instream improvements of streams for pink salmon would have a direct, positive effect on salmon populations by increasing the spawning habitat quality to insure that stream flow, substrate, and dissolved oxygen concentrations are sufficient for egg and larvae survival, therefore increasing spawning success. This effect could be long term because the instream improvements might be maintained for many years. The extent of these improvements would be limited by the fact that approximately 80% of pink salmon spawning occurs in intertidal areas and would not benefit from this option.

Option #23 (Create new salmon runs)

This option would provide new commercial, sport, and subsistence fishing opportunities to replace those opportunities lost from the spill. In addition, this option might relieve fishing pressure on stocks damaged by the spill, assuming that timing and location of new fish runs would be managed in accordance with genetic and disease control guidelines to avoid further damage to natural stocks. Therefore, this option would have an indirect, positive effect on pink salmon by reducing fishing pressure and allowing damaged stocks to naturally recover and therefore increase populations. Increased competition for food and habitat from the introduced salmon would be minimal if the new salmon runs are terminated after wild populations have recovered.

Option #8 (Protect undocumented anadromous streams)

This option could affect pink salmon by listing streams utilized by salmon in the ADF&G Anadromous Stream Catalogue. Under the State Forest Practices Act, streams listed in the catalogue are provided with certain level of protection to avoid further disturbance. This could have an indirect, positive effect on pink salmon by protecting existing spawning areas from further disturbance, thus increasing spawning success and therefore increasing populations. The option would have a long-term effect because the streams would be protected from future degradation, allowing pink salmon populations to increase.

Option #6 (Improve survival of salmon eggs and fry)

This option could affect pink salmon by rearing wild pink salmon eggs and fry in boxes, net pens, or hatcheries. Assuming that strict guidelines to prevent disease and overescapement are employed, this option could have a direct, positive effect on pink salmon by increasing the survival of eggs and larvae and improving spawning success. This would facilitate an increase in population. The effects would be long-term because it would restore wild pink salmon populations.

Option #7 (Relocate salmons runs)

This option would affect pink salmon by relocating or changing the timing of existing hatchery salmon runs in PWS. The concept is to minimize the interaction of hatchery reared fish and wild stocks during commercial harvests. This could have an indirect, positive effect on wild pink salmon in PWS because it would relieve fishing pressures on wild stocks. This could increase the number of spawning adults, thereby increasing spawning success. The effect would be long-term because the population of wild stocks could ultimately increase.

Rockfish

Alternative 2 - Habitat Protection

Under this alternative, over 90 percent of the restoration funds would be allocated to implement HP&A. Because rockfish are open water fish, acquisition of inland and coastal habitat would not directly affect this species. However, HP&A would indirectly benefit rockfish by protecting through special designations (such as marine sanctuaries) the habitat required for the spawning and rearing of fish, which could lead to increases in the numbers of fish. The magnitude of the impacts of this alternative on rockfish could be relatively low, with small benefits to rockfish stocks in the oil spill area.

Alternative 3 - Limited Restoration

Alternative 3 contains no options targeting rockfish populations. As in Alternative 2, HP&A could effect rockfish through the special designation and protection of potential rockfish habitat. This would allow uninterrupted reproduction in localized areas if appropriate habitat were included in the specially designated areas. This could ultimately increase rockfish populations on a relatively small basis.

Alternatives 4 and 5 - Moderate and Comprehensive Restoration

In addition to HP&A, Alternatives 4 and 5 include Option 4, which intensifies fisheries management of rockfish. This could directly impact rockfish populations in the spill area if management activities initiated under this option reduced rockfish exploitation, thus increasing the number of reproducing adults. This could provide greater opportunity for increasing rockfish populations in the affected areas.

Options Related to Rockfish

Option #4 (Intensify fisheries management)

This option would affect rockfish by intensifying fisheries management of this species. This option would protect injured stocks from further exploitation and allow for natural recovery through research and development of recommendations for incorporation into fisheries regulations by the Board of Fish. This option would have a positive direct effect on rockfish populations by reducing commercial and sport fishing pressures on damaged stocks. This could increase the number of adults for reproduction which would increase success. The long-term effect would be an increase of rockfish populations.

HP&A (Special Designations)

HP&A could affect rockfish by giving special designations to coastal and marine habitat that are utilized by rockfish for spawning and rearing. This could have an indirect, positive effect on rockfish by protecting spawning habitats so that reproductive success could increase, thus increasing populations. The effect would be long-term because the habitat would be protected from future exploitation.

An assumption concerning this activity is that the designation of marine sanctuaries containing rockfish would be included.

Sockeye Salmon

Alternative 2 - Habitat Protection

Under this alternative, over 90 percent of the restoration funds would be used to implement HP&A. HP&A would both protect and acquire habitat, and establish special land designations indirectly benefiting sockeye salmon, possibly protecting habitat required for spawning and rearing of fish, leading to an increase in sockeye populations. The duration of the impacts would be long-term, assuming that the protected habitat is managed to promote healthy ecosystems in perpetuity. Because the extent and duration of the impacts is large and wide-spread, and a large financial commitment is being made, the magnitude of the impacts of this alternative could be high, creating long-term positive benefits to sockeye salmon by insuring the necessary habitat to maintain healthy fish populations.

Alternatives 3 and 4 - Limited and Moderate Restoration

Under these alternatives, Options 4 and 6 specifically target sockeye salmon. Option 23 could indirectly increase sockeye salmon populations under Alternatives 3 and 4 if, for example, Kenai River sockeye fishing is closed or restricted for multiple years and alternative runs are created to partially compensate for the loss. HP&A (75 percent and 50 percent, respectively) could protect spawning areas from further exploitation and degradation if the land acquired or

protected included sockeye spawning habitat. Option 4 could directly impact sockeye salmon populations by managing populations to increase populations that were reduced because of overescapement. Option 6 could directly impact salmon populations by increasing the survival rate of eggs and larvae.

Because Options 4 and 6 are specifically targeted to increase sockeye salmon populations, and the remaining options indirectly increase populations, the magnitude of the impacts of these alternatives could be high.

Alternative 5 - Comprehensive Restoration

This alternative includes all the options and associated effects documented in Alternatives 3 and 4, with the addition of Option 5 that specifically targets sockeye salmon. HP&A, allocated 35 percent of available restoration funds under this alternative, would provide habitat protection throughout the spill area. The impact of Alternative 5 on sockeye salmon could be to increase spawning success, potentially increasing populations in the spill area.

Options Related to Sockeye Salmon

HP&A (Habitat protection and acquisition)

HP&A could affect sockeye salmon throughout the spill area by acquiring damaged habitat and protecting it from further disturbance to allow for natural recovery. This would have a positive, indirect effect on the sockeye salmon by protecting spawning stocks so that reproductive success may increase. This would ultimately increase populations. The long-term effects would be that sockeye salmon habitat would be protected from further disturbance.

HP&A could also effect sockeye salmon by giving special designations to uplands, coastal, and marine habitat that are utilized by salmon for spawning and rearing. This could have an indirect, positive effect on sockeye salmon by protecting spawning habitats so that reproductive success could increase, thus increasing populations. The effect would be long-term because the habitat would be protected from future exploitation.

Option #4 (Intensify fisheries management)

This option would affect sockeye salmon by intensifying fisheries management of this species. This option would protect injured stocks from further exploitation and natural recovery through research and development of recommendations for incorporation into fisheries regulations by the Board of Fish. It is assumed that the intensified management of sockeye salmon would be designed to increase salmon populations, but not to exceed the carrying capacity of the stocks. This option would have a positive, direct effect on salmon populations by reducing commercial and sport fishing pressures on damaged stocks. This could increase the number of successful spawning adults which would increase overall spawning success. The long-term effect would be an increase in sockeye salmon populations.

Option #5 (Improve freshwater wild salmon)

This option would affect sockeye salmon by using three techniques to increase populations: (1) construct salmon spawning channels and instream improvements, (2) fertilize lakes to improve sockeye salmon rearing success, and (3) improve access to salmon spawning areas by building fish passes or removing barriers.

Construction of salmon spawning channels and instream improvements of streams for sockeye salmon would have a direct, positive effect by increasing the spawning habitat quality to insure that stream flow, substrate, and dissolved oxygen concentrations are sufficient for egg and larvae survival. This habitat improvement would increase spawning success, and subsequently increase the population. This effect would be long-term because the instream improvements could be maintained for many years.

Fertilization of degraded rearing lakes would increase the primary food source of sockeye salmon by supplementing nutrients in the lake to increase primary productivity and zooplankton, the primary food source for young salmon. Fertilizing the lakes would have an indirect, positive effect on sockeye salmon by allowing an increased escapement, increasing the number of spawning adults, increasing survival of juvenile salmon, and therefore increasing the sockeye population. The effect would be short-term, lasting only as long as the lake fertilization is continued. The effect could be long-term if fertilization was continued and forage fish remained abundant as a food source for growing adult populations.

Improving access to salmon spawning areas by building fish passes or removing barriers would have a direct, positive effect on sockeye salmon populations by providing new or additional habitat for sockeye salmon spawning. This could improve spawning success and increase the population of sockeye salmon. This would be a long-term effect because this new habitat would be available for the life of the salmon fishery.

Option #23 (Create new salmon runs)

This option would provide new commercial, sport, and subsistence fishing opportunities to replace those opportunities lost from the spill. In addition, this option might relieve fishing pressure on stocks damaged by the spill, assuming that timing and location of new fish runs would be managed in accordance with genetic and disease control guidelines to avoid further damage to natural stocks. Therefore, this option would have an indirect, positive effect on sockeye salmon by reducing fishing pressure and allowing damaged stocks to naturally recover and therefore increase populations. Increased competition for food and habitat from the introduced salmon would be minimal if the new salmon runs are terminated following recovery of wild populations.

Option #6 (Improve survival of salmon eggs and fry)

This option could affect sockeye salmon by rearing wild sockeye salmon eggs and fry in boxes, net pens, or hatcheries. Assuming that strict guidelines to prevent disease and overescapement

were implemented, this option could have a direct, positive effect on sockeye salmon by increasing the survival of eggs and larvae and improving spawning success, thereby facilitating an increase in population. The effects would be long-term because it would restore wild sockeye salmon populations.

Coastal Communities

Intertidal Organisms

Alternative 2 - Habitat Protection

HP&A would impact the intertidal zone only where marine ecosystems are designated as sanctuaries. The magnitude of impacts to intertidal organisms associated with HP&A would depend in part on the number of marine sanctuaries designated. Alternative 2 would allocate the largest amount of funds to HP&A of all the alternatives.

Alternatives 3 and 4 - Limited and Moderate Restoration

Option 12 under Alternatives 3 and 4 specifically targets intertidal organisms. Option 12 would include a study to determine ways to reestablish intertidal organisms in areas where they have been damaged. Option 14 could also affect intertidal organisms under Alternatives 3 and 4. Option 14 would study methods to remove oil from mussel beds. Option 21 may indirectly affect intertidal organisms as a result of increases in harvesting by subsistence users. Option 19 could indirectly affect intertidal organisms thorough the creation of recreation facilities that may adversely affect intertidal habitats that were previously undisturbed. Depending on the results of studies conducted under Options 12 and 14, these alternatives could have a high magnitude of impact on intertidal organisms.

Alternative 5 - Comprehensive Restoration

Under Alternative 5, the same options and impacts included in Alternatives 3 and 4 would be included. HP&A would also be included, but at a lower level of funding (35 percent). Additionally, Alternative 5 would include Option 22 to replace subsistence harvest of bivalve shellfish. This option could indirectly affect intertidal organisms by increasing their populations where bivalve mariculture feasible. Alternative 5 could have a high magnitude of impact on intertidal organisms depending on the results of studies under Option 12, and the feasibility of implementing Option 22.

Options Related to Intertidal Organisms

Option #19 (Create new recreation sites and facilities)

It is assumed that new recreation areas associated with the implementation of this option were not previously areas of high human activity. Consequently, construction of new recreational facilities could have an adverse, indirect, long-term effect on intertidal organisms because these

facilities could contribute to increased use of a damaged areas that previously were little used or unused. Increased human use might include pollution, resource exploitation, trampling of sensitive vegetation, and disturbance of wildlife. This could slow the growth or reduce the number of organisms living in the damaged intertidal area.

Option #14 (Eliminate oil from mussel beds)

This option would produce a positive, direct, short-term effect on the mussel beds present on the intertidal environment by removing residual oil that is present in and adjacent to the mussel beds and reducing or eliminating the potential for further contamination of the mussels in the long-run. Consequently, less oil would be available for bioaccumulation by mussels and other invertebrates, and a positive, indirect effect would result to the health and safety of the predatory species (i.e., harlequin duck, black oystercatcher, sea otter, river otter) and humans (i.e., subsistence gatherers) that consume mussels. A direct, short-term, adverse effect would occur, in that, a minimal amount of mussels would be lost during the cleaning process; however, this effect would be a one-time event. This option would also include monitoring to assess the efficacy of stripping oil from mussel beds (i.e., the fate of oil in mussels and substrate, and the effects of oil on growth and reproduction of mussels). The effect from monitoring would be a positive, direct, long-term effect, because this knowledge would ensure more beneficial clean-up procedures in the event of future spills.

Option #12 (Accelerate recovery of upper intertidal zone)

This option would have a positive, direct, long-term effect on the intertidal zone because it would provide a mechanism to accelerate the recovery and increase the population of *Fucus* by providing improved growing and attachment substrates (i.e., installing burlap for substrate), irrigation, and supplementing the population of adult, reproductive-sized plants. Because many organisms in the intertidal zone depend on *Fucus* for food and cover, this would have a positive, indirect, long-term effect on these intertidal organisms.

Option #21 (Provide access to traditional subsistence foods)

It is assumed that subsistence harvests currently occur in the intertidal areas. Consequently, this would result in a positive, direct, short-term effect on spill-damaged areas of the shallow intertidal environment because it would restrict further subsistence activities in spill-damaged areas, thus preventing activities that might slow the recovery of populations of intertidal organisms.

Option #22 (Replace subsistence harvest opportunities for bivalve shellfish)

It is assumed that the development of subsistence mariculture sites would reduce further disturbance of the oil-damaged intertidal organisms by subsistence users. Consequently, a positive, direct, long-term effect on the intertidal environment would result from this option because it would prevent collection activities that might slow the population growth and recovery of clams and mussels, thus allowing the clam and mussel population to increase. It is also

possible that hatchery-grown shellfish could be used to re-seed native oil-damaged beaches that are no longer oiled. Consequently, the option to develop a bivalve shellfish hatchery and research center would produce a positive, direct, long-term effect on the clams and mussels of the intertidal habitat by providing a mechanism for augmenting and accelerating the recovery and increasing the population of the native species.

Subtidal Organisms

Alternative 2 - Habitat Protection

HP&A may affect the subtidal zones through special designations, such as marine sanctuaries. Although Alternative 2 allocates more funds to HP&A than the other alternatives, the impacts would probably be of low magnitude because of the localized area affected in comparison to the total amount of subtidal zone within the *EVOS* area.

Alternatives 3, 4, and 5 - Limited and Moderate Restoration

Alternatives 3, 4, and 5 would include Option 14 that could indirectly impact subtidal organisms in an adverse manner because more oil may temporarily be suspended in the subtidal ecosystem if a mussel bed cleaning process were implemented. Option 14 would also have an indirect, positive impact on subtidal organisms by cleaning up the mussel beds and removing oil that would bioaccumulate in organisms over the long term. The indirect impact from Option 14 could have a low magnitude because even though the option may be implemented throughout the spill zone, it would affect only localized areas. Alternatives 3, 4, and 5 would also include Option 21, which may increase harvesting of subtidal organisms by subsistence users. This option may have a small localized impact on subtidal organisms within the *EVOS* area.

Options Related to Subtidal Organisms

Option #14 (Eliminate oil from mussel beds)

This option would produce an adverse indirect, short-term effect on organisms of the subtidal habitat because residual oil would be removed from the mussel beds and adjacent areas in the intertidal habitat and oil may temporarily become more available, in the water column, to the subtidal organisms. However, a positive, indirect, long-term effect would also occur because this oil would then be subject to more extensive weathering and eventually, less oil would be available for bioaccumulation by organisms of the subtidal environment.

Option #21 (Provide access to traditional subsistence foods)

It is assumed that subsistence harvests currently occur in the shallow subtidal areas. Consequently, this would result in a positive, direct, short-term effect on spill-damaged areas of the shallow subtidal environment because it would restrict further subsistence activities in spill-damaged areas, thus preventing activities that might slow the recovery of populations of subtidal organisms.

Issue 2: How would activities directed at injured resources and services affect non-target resources and services?

The impacts of restoration activities on nontarget resources are analyzed by alternatives and individual options in the following section. Impacts on ecological services are discussed under Issue 3 (ecological change). Impacts on nontarget human-based services are discussed under Issue 4 (land use, local economies, and communities).

Habitat acquisition and protection is the principal means for conserving non-target species within the Restoration Plan for Alternatives 2 through 5. Alternatives 2 through 5 could have a positive, indirect, long-term effect on non-target species conservation.

Many nontarget species reside within, or migrate through, the *EVOS* area. To varying degrees, they depend on the biological resources of the area for food, shelter, and reproduction. For example, Prince William Sound is a major feeding area for humpback whales in the North Pacific between spring and autumn. However, because no evidence of injury has been observed from the *EVOS*, no options have been proposed that impact humpback whales. There may be some indirect impacts to humpback food supplies or disturbances from recreational activities related to certain of the proposed restoration options, but the linkage between these impacts and the options is unclear and very speculative. Similarly, Peale's peregrine falcons rely on the *EVOS* resources for food and shelter. It is possible that habitat acquisition related to restoration plan would benefit falcons by preventing loss of habitat required for breeding and nesting. The projected impacts of restoration options for other nontarget species are discussed below.

Black Bear, Brown Bear, and Sitka Black-tailed Deer

No options were identified under Alternatives 2 through 5 that direct;y target black bear, brown bear, and Sitka black-tailed deer. These terrestrial species occasionally forage in the intertidal zones that may have been affected by the *EVOS*, but no direct link to injury has been shown to currently exist. HP&A that could involve acquisition of upland habitats used by these species could have a positive impact on bear and deer by ensuring the long-term maintenance of habitat necessary for their survival. Some restoration options included in Alternatives 3 through 5, such as those that would create new salmon runs, could indirectly benefit bears by providing them with a sustained long-term source of food. The intent of these options, however, is not to provide bear with an additional food source, rather, the intent is to increase populations of salmon. Consequently, though bears and deer may benefit from options targeting other resources and services, the impacts on these species would not be expected to have a high magnitude.

Steller's Sea Lions

Several lions are a marine mammal who like the terrestrial mammals (i.e., bear and deer), have not been specifically targeted by any of the options included in the proposed Restoration Plan alternatives. Several options included in Restoration Plan alternatives could indirectly impact sea lions by increasing the short and long-term food supplies. The long-term benefits sea lions

from implementing alternatives would be larger areas of protected habitat and localized increases in food supply. Although these impacts would positively impact sea lions, the potential for increasing sea lion populations as a result of these indirect effects would be of a low magnitude because of the indirect nature of the effects.

Black-legged Kittiwake, Glaucous-winged Gull, Pigeon Guillemot, and Storm Petrel

HP&A targeting other terrestrial and marine species of birds and mammals would also affect the black-legged kittiwake, glaucous-winged gull, pigeon guillemot, and storm petrel by providing protected habitat for breeding and nesting. Up to 90 percent of the restoration funds allocated for these alternatives are allocated for HP&A. The geographic extent of the impact from implementing these alternatives would be large, including the entire *EVOS* area. Assuming the habitat would remain under protected status, the duration of the impacts associated with this habitat protection would be long-term and could provide long-term benefits to the black-legged kittiwake, glaucous-winged gull, pigeon guillemot, and storm petrel by insuring the necessary habitat to maintain healthy populations in the oil spill area. Options implemented under Alternatives 3 through 5 could lead to increases in those bird species' food supplies. Other options, such as those that are intended to minimize disturbance or depredation of other targeted species that share their habitat may indirectly benefit black-legged kittiwakes, glaucous-winged gulls, pigeon guillemots, and storm petrels. Positive impacts associated with these options could occur for a long duration but would not be expected to have a high magnitude.

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

The acquisition of private lands for habitat protection and the placing of public lands into special State and Federal land designations would promote only beneficial ecological change within the *EVOS* area. By enhancing the ecological integrity of the Greater *EVOS* Area Ecosystem, these activities would substantially promote the conservation of biodiversity. Therefore, implementation of habitat protection and acquisition (HP&A) under Alternatives 2 through 5 is the principal means for implementing ecosystem management and conserving biodiversity under the Restoration Plan. General restoration activities implemented under Alternatives 3, 4, and 5 would further enhance recovery of selected species toward natural ecological conditions.

As discussed in Chapter III, the physical and biological environment is better described as the Greater *EVOS* Area Ecosystem and includes the marine ecosystem, coastal ecosystem, and terrestrial ecosystem. All of the options could have some effect, although not always measurable or significant, on these ecosystems. Nonetheless, the cumulative effect of recovering resources constitutes a substantial benefit to the ecosystem. The relative benefits to biodiversity conservation within the Greater *EVOS* Ecosystem are presented below for each Alternative, and are subsequently discussed in more detail for individual restoration options.

Alternative 2 - Habitat Protection

Under this alternative, over 90 percent of the restoration funds would be used to implement habitat protection and acquisition. HP&A is the principal means for implementing ecosystem management within the restoration plan and would have a strong positive, direct, long-term effect on biodiversity conservation. Special land designations under HP&A would also implement ecosystem management measures, albeit on the smaller scale of existing public lands, and would have a moderate positive, direct, long-term effect on biodiversity conservation. The large amount of funding allocated HP&A under this alternative (the entire budget minus 10 percent for administration and public information, and monitoring and research) indicates that Alternative 2 would be implemented over a wide geographic extent and would include parcels totaling a large number of acres. Assuming that the acquisition of lands includes management in perpetuity for ecosystem integrity, the duration of this effect would be long-term. Because of these factors, the magnitude of the impact on biodiversity conservation of this alternative would be high.

Alternative 3 - Limited Restoration

Nearly all of the options in the restoration plan would affect biodiversity conservation to some extent. Options 1, 3, 4, 6, 7, 9, 10, 11, 13, 15, and 22 would have very slight to slight positive, indirect effects on biodiversity by contributing to population enhancement of individual species. Options 5 and 12 would have a greater positive effect on biodiversity by improving local habitat conditions for whole communities of organisms. Habitat alteration from the construction of recreational sites (Option 19) and the possible oversupply of salmon (Option 23)

could have slight negative effects on biodiversity. Research and information dissemination into the ecosystem status of the *EVOS* area under Options 8, 24, and 25 would have a slight positive, indirect effect on biodiversity.

Under Alternative 3, the impacts of these general restoration options would be overwhelmed by the strong positive effects of the habitat protection and acquisition. The large amount of funding allocated to the HP&A (75 percent of the entire budget) indicates that, as in Alternative 2, this alternative would implement habitat protection and acquisition over a wide geographic extent and include parcels totaling a large number of acres. Assuming that the acquisition of lands includes management in perpetuity for ecosystem integrity, the duration of this effect would be long-term. Because of these factors, the magnitude of the impact from this alternative on biodiversity conservation would be high.

Alternative 4 - Moderate Restoration

Nearly all of the options in the restoration plan would affect biodiversity conservation to some extent. Options 1, 3, 4, 6, 7, 9, 10, 11, 13, 15, and 22 would have very slight to slight positive, indirect effects on biodiversity by contributing to population enhancement of individual species. Options 5 and 12 would have a slightly greater positive effect on biodiversity by improving local habitat conditions for whole communities of organisms. Habitat alteration from the construction of recreational sites (Option 19) and the possible oversupply of salmon (Option 23) could have slight negative effects on biodiversity. Research and information dissemination on the ecosystem status of the *EVOS* area under Options 8, 24, and 25 would have a slight positive, indirect effect on biodiversity.

Under Alternative 4, the impacts of these options would be added to the strong positive effects of the habitat protection and acquisition. The substantial amount of funding still allocated to the HP&A (50 percent of the budget) indicates that this alternative would implement habitat protection and acquisition over a moderate geographic extent and include parcels totalling a lesser number of acres. Assuming that the acquisition of lands includes management in perpetuity for ecosystem integrity, the duration of this effect would be long-term. The combination of slight benefits from general restoration options and major benefits of habitat protection and acquisition would produce a moderate to high magnitude of the impact on biodiversity conservation for this alternative.

Alternative 5 - Comprehensive Restoration

Nearly all of the options in the restoration plan would affect biodiversity conservation to some extent. Options 1, 3, 4, 6, 7, 9, 10, 11, 13, 15, and 22 would have very slight to slight positive, indirect effects on biodiversity by contributing to population enhancement of individual species. Options 5 and 12 would have a slightly greater positive effect on biodiversity by improving local habitat conditions for whole communities of organisms. Habitat alteration from the construction of recreational sites (Option 19) and the possible oversupply of salmon (Option 23) could have slight negative effects on biodiversity. Research and information dissemination on the ecosystem status of the *EVOS* area under Options 8, 24, and 25 would have a slight

positive, indirect effect on biodiversity.

Under Alternative 5, the impacts of these general restoration options would be added to the strong positive effects of the habitat protection and acquisition. The more limited amount of funding allocated to HP&A (35 percent of the budget) indicates that this alternative would implement habitat protection and acquisition over a limited geographic extent and include parcels totalling a moderate number of acres. Assuming that the acquisition of lands includes management in perpetuity for ecosystem integrity, the duration of this effect would be long-term. The combination of slight benefits from general restoration options and a lesser amount of major benefits of habitat protection and acquisition would produce a moderate magnitude impact on biodiversity conservation for this alternative. The greater emphasis on increased human uses under Alternative 5 could reduce the positive impact on biodiversity conservation.

Options Related to the Greater *EVOS* Ecosystem

Because the goal of the Restoration Plan is to benefit resources and services within the Greater *EVOS* Ecosystem, each of the options makes some contribution to the conservation of biodiversity. In order to discriminate relative degrees of benefit to biodiversity, a set of ten biodiversity evaluation criteria was applied to each restoration option. These criteria are adapted from the recent Council on Environmental Quality (1993) document on incorporating the consideration of biodiversity in to the NEPA process.

1. Does the option manage resources from a "big picture" or ecosystem perspective?

2. Does it protect communities and ecosystems?

3. Does it minimize fragmentation and promote the natural pattern and connectivity of habitats?

4. Does it promote native species and avoid introducing non-native species?

5. Does it protect rare and ecologically important species?

6. Does it protect unique or sensitive environments?

7. Does it maintain or mimic natural ecosystem processes?

8. Does it maintain or mimic naturally occurring structural diversity?

9. Does it protect genetic diversity?

10. Does it monitor for biodiversity impacts, acknowledge uncertainty, and retain flexibility in management?

Where possible, each option was evaluated in terms of its potential effect on the area of sensitive

habitats, status of sensitive habitats, number of sensitive species, population status (including genetic composition) of sensitive species, and status of the landscape.

Special attention was also paid to the various degrees of linkage among the different species within the greater ecosystem. Although, some impacts may be small on individual resources, the combined impact on the ecosystem may be substantial. At the same time, the impacts of some options may be large for certain species within the ecosystems, but not significant for the ecosystem. Because of the complexity of interactions within an ecosystem, natural recovery should be encouraged wherever possible. At the same time, this approach must include diligent protection of the system from continuing and new impacts. In any case, long-term monitoring of the recovery process and effectiveness of restoration activities is essential.

HP&A (Habitat protection and acquisition)

HP&A involves private land acquisition, or acquisition of partial interests in private lands, for the purpose of protecting habitats linked to the resources injured by the oil spill or to prevent additional injury to those resources. Implementation may include the acquisition of critical upland habitat for injured species, such as undisturbed riparian lands around anadromous streams or nesting areas in mature forests. This option directly addresses biodiversity conservation in coastal and terrestrial ecosystems, and by extension marine ecosystems (which are linked through ecological processes and are especially vulnerable to degrading activities occurring in upland environments).

Special designation activities under HP&A also directly address biodiversity conservation. Marine, coastal, and terrestrial areas in public ownership can be placed into special State or Federal land designations that provide increased levels of regulatory protection. An important feature of special designations is that they can provide a regulatory basis for managing an area on an ecosystem level, with the primary objective of restoring spill injuries. Like habitat acquisition, special designations would promote biodiversity by maintaining ecosystem integrity. It could also enhance the recovery of injured resources, because their recovery may be substantially delayed or prevented by future development on private lands.

Both land acquisition and special designation activities address each of the biodiversity evaluation criteria described above. In fact, the habitat acquisition criteria (HAC) developed under the Restoration Plan for identifying parcels often parallel these biodiversity evaluation criteria. The following discussion describes how HP&A (and its habitat acquisition criteria) address each of these biodiversity evaluation criteria.

1. HP&A takes a "big picture" or ecosystem view of *EVOS* restoration as evidenced by HAC #2 (The parcel should function as an intact ecological unit or essential habitats on the parcel must be linked to other elements/habitats in the greater ecosystem).

2. HP&A directly protects communities and ecosystems by preserving land units rather than managing individual species. HAC #4 (The parcel should benefit more than one species or service) is consistent with community rather than single species management.

3. HP&A could minimize fragmentation by uniting private parcels with lands already in protected status. This would promote the natural pattern and connectivity of habitats. The inclusion of HAC #6 in the parcel selection process (select vulnerable or potentially threatened areas) is evidence that without protection degradation of many parcels through logging, or other incompatible human uses, is imminent.

4. HP&A could promote native species and avoid introducing non-native species by transferring private lands into management programs that follow guidelines excluding exotic introductions.

5. Under HP&A, HAC #5 (the parcel ~~should~~ contain critical habitat for depleted, rare, threatened, or endangered species) explicitly includes protection of rare and ecologically important species. However, it is unlikely that individual parcels contain important for listed threatened or endangered species, or that the distribution of these species could be used to select parcels.

6. Under HP&A, HAC #1 explicitly states that selected parcels should contain essential habitats or sites, i.e., unique or sensitive environments. For example, old growth stands could be protected from logging through the acquisition of forested parcels.

7. HP&A could maintain natural ecosystem processes as evidenced by HAC #3 (adjacent land uses will not significantly degrade the ecological function).

8. Under HP&A, acquisition of prospective timber lands could help maintain naturally occurring structural diversity that would be lost through logging operations. Typically, logging simplifies natural forest pattern by reducing age classes and removing snags and downed wood.

9. HP&A could protect genetic diversity by maintaining the natural complement of subpopulations and individual variation within the ecosystem. In contrast, single species approaches to resource management can reduce genetic diversity of wild populations.

10. HP&A acknowledges the uncertainty inherent in ecosystem restoration. By maintaining a reservoir of natural areas, this HP&A could provide a benchmark for biodiversity monitoring and provide flexibility for future management decisions.

In summary, HP&A would have a strong positive, direct, long-term impact on the marine, coastal, and terrestrial ecosystems.

Option #1 (Reduce the bycatch of harbor seals)

The purpose of this option is to improve the understanding of fishing interactions and harbor seals and ultimately reduce any problems. The option could include cooperative programs with commercial fishermen for reducing bycatch of harbor seals through reduction of entanglement and deterrent measures. This option could contribute to population increases (improved species

population status) of harbor seals. To the extent that these populations returned to natural levels, this option would have a very slight, indirect, long-term, positive effect on the marine and coastal ecosystems.

Option #3 (Facilitate Changes in Black Cod Fishery Gear)

This option is designed to prevent the harassment and shooting of the killer whales that strip cod from longline gear. This option could contribute to improved population status of individual killer whale pods. To the extent that these populations returned to natural levels, this option would have a very slight, indirect, long-term, positive effect on the marine ecosystem. These positive effects would be limited by their small magnitude (changes in populations numbers of a single species).

Option #4 (Intensify fisheries management)

This option involves research and the development of recommendations for restricting or redirecting of existing fisheries. Changes to fisheries management would be implemented through regulations promulgated by the Alaska Board of Fish. This option could contribute to population increases (improved species population status) of individual fish species. To the extent that these populations returned to natural levels, this option would have a moderate, indirect, long-term, positive effect on the marine, coastal, and terrestrial (as defined to include anadromous migration into freshwater streams) ecosystems. These positive effects would be limited by their magnitude (changes in populations numbers of selected species) and extent (expected changes in abundance only in targeted areas), but would be enhanced by the important ecological roles played by these abundant fish species.

Options #5 (Improvements to freshwater wild salmon habitats)

This option would involve a number of techniques designed to restore and enhance wild salmon populations in the oil-spill area including construction of salmon spawning channels and instream improvements, fertilization of lakes to improve rearing success, and improvement of access to spawning areas the construction of fish passes or the removal of barriers. This option could contribute to population increases (improved species population status) of pink and sockeye salmon. To the extent that these populations returned to natural levels, this option would have a very slight, indirect, long-term, positive effect on the marine, coastal, and terrestrial (as defined to include anadromous migration into freshwater streams) ecosystems. These positive effects would be limited by their small magnitude (changes in population numbers to only a two species) and moderate extent (expected changes in abundance only in targeted areas). To the extent that habitats would be modified from natural conditions to benefit salmon, other native species could be adversely affected. In particular, nutrient enrichment might adversely affect natural invertebrate communities adapted to low nutrient conditions. Achieving passage beyond manmade blockages would benefit all species and constitute a moderate, positive, direct, long-term impact on the freshwater terrestrial ecosystem.

Option #6 (Improve survival of salmon eggs and fry)

This option is designed to increase survival of salmon eggs and larvae through the rearing of wild salmon eggs in boxes, netpens, or hatcheries, and their release into native streams. This option could contribute to population increases (improved species population status) of pink and sockeye salmon, and perhaps on predators feeding on salmon eggs and fry such as Dolly Varden. To the extent that these populations returned to natural levels, this option would have a very slight, indirect, long-term, positive effect on the marine, coastal, and terrestrial (as defined to include anadromous migration into freshwater streams) ecosystems. These positive effects would be limited by their small magnitude (changes in populations numbers to only a few species) and moderate extent (expected changes in abundance only in targeted areas).

Option #7 (Change or relocate existing hatchery runs)

This option would involve changing the timing of hatchery run releases or releasing hatchery fish at remote locations to minimize the interaction of hatchery fish and wild salmon stocks during commercial harvest. This option would benefit natural populations of native species by reducing the adverse impacts of genetic mixing with hatchery fish. In contrast, relocation of hatchery runs may upset the natural conditions in new habitats adversely affecting resident species. Assuming that new runs would be undertaken only in streams previously supporting salmon populations (e.g., those blocked by dams or other obstructions), this option would result in a very slight, positive, indirect, short-term impact on the marine, coastal, and terrestrial (freshwater) ecosystems.

Option #8 (Protect undocumented anadromous streams)

This option involves listing undocumented anadromous streams in the State's catalogue to afford them legal protection under the State Forest Practices Act and protect injured anadromous species and their habitats. This option could improve the understanding of natural ecosystem conditions in the *EVOS* area and could lead to better management decisions affecting the marine, coastal, and terrestrial ecosystems. This option would have a slight, positive, indirect, long-term impact on these ecosystems.

Option #9 (Removal of introduced predator species)

The primary goal of this option would be to remove introduced fox from islands along the Alaska Peninsula and Aleutians. A secondary goal could be to reduce avian predators. This option could contribute to population increases (improved species population status) in a number of species that face predation from introduced foxes. To the extent that fox removal is accomplished and natural community composition is returned, the coastal and terrestrial ecosystems could improve. Where natural predators are controlled, natural ecosystems processes may be temporarily disrupted. Assuming that foxes are successfully removed from large areas, this option would result in a slight, positive, direct, long-term impact on the coastal and terrestrial ecosystem. Although removal of introduced species can have a strongly beneficial

impact on natural ecosystems, the limited extent of areas affected by foxes prevents the removal option from having a greater effect.

Options #10 (Increase murre productivity and nesting ledges)

Enhancing social stimuli, such as using decoys and recorded calls to give the illusion of typical breeding densities may encourage a return to normal breeding patterns. Largely experimental techniques that provide breeding ledges with sills, add partitions and/or roofs on nesting ledges, enlarge nesting ledges, and clear debris from otherwise suitable nesting sites would be undertaken following determination of feasibility. If specific techniques were shown to be feasible, this option could contribute to population increases in murres (improve species population status). To the extent that these populations returned to natural levels, this option would have a very slight, indirect, long-term, positive effect on the marine and coastal ecosystems. It is possible that intense management of these breeding areas may have negative affects on the coastal ecosystem through habitat alteration or disturbance, but it is assumed that these considerations would be taken into account during the determination of feasibility. The positive effects would be limited by their small magnitude (changes in populations numbers to only one species) and small extent (expected changes in abundance only in a few areas).

Option #11 (Minimize the incidental take of marine birds)

Under this option, the extent of marbled murrelet mortality resulting from gillnets and driftnets would be examined. If the mortality is found to represent a significant source of mortality for populations in the spill area, an effort would be made to develop new technologies or strategies for reducing encounters. This option could contribute to population increases (improved species population status) of this species. To the extent that these populations returned to natural levels, this option would have a very slight, indirect, long-term, positive effect on the marine and coastal ecosystems. These positive effects would be limited by their small magnitude (changes in population numbers to only a few species) and small extent (expected changes in abundance only in a few areas).

Option #12 (Accelerate recovery of the upper intertidal zone)

This option would involve methods to remediate habitat heavily oiled and subjected to intensive clean-up measures. Implementation of this option would include installation of trickle irrigation systems designed to enhance moisture retention, use of biodegradable materials as additional substrate for germling attachment and cover, and transplanting adult plants attached to small rocks and cobble. The overall objective of this option is to facilitate recovery of the previously dominant brown algae *Fucus gardneri* (popweed). The loss of *Fucus* algae had a severe impact on the intertidal community that depends on this species for substrate attachment and physical shelter. Return of this algae could greatly benefit the intertidal community (increase area and improve status of sensitive habitats), and to a lesser degree those species that feed on intertidal organisms. Because of the degraded condition of the *Fucus*-based community, it is assumed that intrusive methods of restoration would not have significant adverse effects on the ecosystem. Therefore, this option would have a moderate, positive, direct, long-term impact on the coastal

ecosystem. Only the limited extent to which this option can be implemented prevents it from having a larger positive impact.

Option #13 (Reduce disturbance at bird colonies, haulout sites, and concentration areas)

This option would involve the possible establishment of buffer zones around these sensitive areas, or other measures to reduce disturbance by permitting agencies. This option could contribute to population increase of individual bird and mammal species. To the extent that these populations returned to natural levels, this option would have a slight, indirect, long-term, positive effect on the marine and coastal ecosystems. These positive effects would be limited by their small magnitude (changes in populations numbers to only a few species) and moderate extent (expected changes in abundance only in targeted areas). Creation of small buffer areas would also benefit other seabirds that nest on target islands.

Option #14 (Eliminate oil from mussel beds)

This option would determine the geographic extent of remaining oil in mussel beds and implement the most effective and least intrusive method of cleaning. Persistent oil in the mussel beds continues to have adverse effects on the marine, coastal, and terrestrial (freshwater) ecosystems. The elimination of toxic effects to a variety of organisms and the return of spawning substrates and microhabitats to their natural condition (increase area of sensitive habitats) could greatly benefit the local aquatic communities. Lesser benefits could be reaped by species dependent on these beds and streams for food and habitat. In contrast, mechanical manipulation of mussel bed or stream bottom structure could have adverse effects on the aquatic communities, especially in the short term. Assuming that intrusive methods of oil removal would be required, the slight, direct, net positive effects of this option on the marine and coastal ecosystems would be likely only be realized in the long term.

Option #15 (Develop sport and trapping harvest guidelines)

This option would involve imposing temporary restrictions or closure of sport harvest and trapping of river otters and harlequin ducks in the oil-spill area. This option could contribute to population increases (improved population status) of these species. To the extent that these populations returned to natural levels, this option would have a very slight, indirect, long-term, positive effect on the coastal and terrestrial ecosystems. These positive effects would be limited by their small magnitude (changes in populations numbers to only two species) and moderate extent (expected changes in abundance only in targeted areas).

Option #20 (Test subsistence foods for hydrocarbon contamination)

Testing subsistence foods for hydrocarbon contamination is assumed to be unrelated to toxic effects on native species. Therefore, this option would have no impact on the marine, coastal, or terrestrial ecosystems.

Option #22 (Replace subsistence harvest opportunities for bivalve shellfish)

This option would provide the facilities and infrastructure to restore, replace, and/or enhance affected shellfish populations and in particular, the subsistence use of shellfish. Additionally, there is the potential to use hatchery shellfish to re-seed native species on beaches damaged by oiling or clean up, once those beaches are no longer oiled. This option would not contribute to natural populations of native species, but might reduce harvest pressure on these populations. In addition, populations of species prey on bivalves may benefit. Therefore, this option would have a very slight, positive, indirect, short-term impact on the marine ecosystems.

Option #23 (Create new salmon runs)

This option would involve terminal hatchery runs and saltwater releases. This option would not contribute to natural populations of native species, but might reduce harvest pressure on these populations. Assuming that the new runs would be terminated following the recovery of wild stocks, predatory birds and mammals that feed on forage fish consumed by salmon would not be adversely affected by overabundant salmon depleting the food source. Therefore, this option would have a very slight, positive, indirect, short-term impact on the coastal and terrestrial ecosystems.

Option #24 (Visitor center)

This option involves construction and operation of a large visitor-center or expansion of an existing visitor center somewhere in the oil-affected area. Information from the visitor center would also be available to other visitor centers, government agencies, and organizations in the spill area. This option would remove natural habitat and alter ecological conditions at a single site over an area too small to produce a significant adverse effect on the coastal or terrestrial ecosystems. At the same time, this option could improve the public understanding of natural ecosystem conditions in the *EVOS* area and could lead to more compatible human uses of the area. This option would have a slight, positive, indirect, long-term impact on the marine, coastal, and terrestrial ecosystems.

Option #25 (Establish a marine environmental institute)

This option involves construction of a new marine environmental institute in an easily accessible area within the oil- spill region, for the purpose of studying the marine environment and providing public education. This option could remove natural habitat and alter ecological conditions at a single site over an area too small to produce a significant adverse effect on the coastal or terrestrial ecosystems. At the same time, this option could improve the public understanding and scientific knowledge of natural ecosystem conditions in the *EVOS* area and could lead to better management decisions and more compatible human uses of the area. This option would have a slight, positive, indirect, long-term impact on the marine, coastal, and terrestrial ecosystems.

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

The impacts of restoration activities on land uses, local economies, and communities are presented in the following section. Specifically, each injured human-based resource and service are analyzed by alternatives and individual options. Impacts on subsistence services are discussed under Issue 5 (subsistence).

Land Uses

Land uses surrounding local communities could be changed in response to habitat protection and acquisition activities. In some areas, timber management (including logging) and mining, would be replaced with expanded fishing and tourism opportunities. Under HP&A, future land uses would compliment the resource management goals and objectives of the Restoration Plan.

Under Alternative 2, the acquisition of private land for habitat protection and the special designation of public lands would preclude future development and reduce resource exploitation uses and in a large number of areas.

Under Alternatives 3 and 4, acquisition of private land for habitat protection and the special designation of public lands would preclude future development and reduce resource exploitation uses in a moderate to large number of areas.

Under Alternative 5, acquisition of private land for habitat protection and the special designation of public lands would preclude future development and reduce resource exploitation uses in a small to moderate number of areas.

Local Economies

Under Alternative 2, HP&A would receive 90% of restoration funds and therefore habitat acquisition might entail precluding substantial parts of the *EVOS* area from resource exploitation, principally logging. This could have a negative, short-term impact on local economies dependent on timber harvesting. In contrast, local economies dependent on tourism and marine resource exploitation (fishing) would benefit from protection of the ecosystem and the recovery of fisheries services. In the long term, sustainable development of *EVOS* area natural resources could be enhanced by protection of critical habitat areas.

Under Alternatives 3, 4, and 5 habitat acquisition would have a negative, short-term impact on local economies dependent on timber harvesting. In contrast, local economies dependent on tourism and marine resource exploitation (fishing) would benefit. General restoration activities under these alternatives might involve short-term disruption of some fishing activities, but the long-term recovery of the ecosystem and fisheries services would have a positive impact on all local economies.

Communities

The communities of the *EVOS* area are diverse in their economic base, infrastructure, and social organization. Nevertheless, all the communities experience and share in the region's areas of natural beauty and resources to some extent. Through the habitat acquisition and the special designation of public lands activities included in the Alternatives, the Restoration Plan would contribute to the preservation and protection of the greater ecosystem upon which *EVOS* community economies and social systems are dependent. Fishing and tourism are important industries in the *EVOS* area. The Alternatives would contribute to the comprehensive long-term management of these resources, and therefore facilitate the sustainable use of *EVOS* resources for all *EVOS* communities. Although short-term job displacement would occur in the timber industry, fishing and tourism would be enhanced.

The quality of life and lifestyle offered by the *EVOS* physical environment is important to community residents. Although habitat acquisition and the special designation of public lands may require *EVOS* communities to make short-term economic adjustments, long-term benefits outweigh short-term adjustments. The acquisition of land and changes in land use would permit comprehensive management of *EVOS* area resources for the long-term benefit of all *EVOS* communities.

Alternative 2 principally addresses the acquisition of private land for habitat protection and the special designation of public lands. The Alternative could have a short-term affect on certain local communities by shifting employment opportunities from forest industries to fishing and tourism industries. At the same time, habitat acquisition and protection efforts could provide long-term benefits to *EVOS* communities by enhancing the quality of life and lifestyle practiced.

Alternative 3, 4, and 5 also addresses the acquisition of private land for habitat protection and the special designation of public lands. This might affect community land use plans and reduce employment opportunities in the timber industry. At the same time, community benefits might accrue related to the enhancement of the fishing and tourism industries, and the protection of quality of life and lifestyle values. General restoration activities under these alternatives would might involve minor short-term adjustment in some social and cultural activities (see discussion of subsistence impacts under Issue 5), but the long-term recovery of the ecosystem and fisheries services would have a positive impact on all communities.

The remainder of this discussion summarizes the specific impacts of each alternative and individual options on the injured resources of wilderness areas and archaeological resources, and on the injured services of recreation (including sport fishing and hunting), commercial tourism, commercial fishing, and passive use relative.

Resources

Designated Wilderness Areas

Alternative 2, 3, 4, and 5 do not address specifically designated wilderness areas, but currently unplanned Congressional efforts to designate existing wilderness study areas (or non-study areas) would be consistent with the special designation activities under HP&A.

Archaeological Resources

Alternative 2 - Habitat Protection

This alternative does not address archaeological resources. The existing condition of archeological artifacts and resources would continue.

Alternative 3 - Limited Restoration

Under this Alternative Options 16 and 17 would affect archaeological resources. Option 16 would enhance the preservation of these resources by educating the public on the importance and uniqueness of the *EVOS* archaeological resources. The site stewardship program would encourage local communities to actively participate in and take responsibility for the preservation of archaeological resources. Option 17 addresses the need to repair damaged archaeological sites and would have the direct, positive, long-term effect of reducing additional degradation or decline of resources and services associated with archeological sites and artifacts.

Alternatives 4 and 5 - Moderate and Comprehensive Restoration

Options 16, 17, and 18 affect archaeology under these alternatives. The effects of Options 16 and 17 are described in Alternative 3. Option 18 would have the direct, positive long-term effect of replacing lost artifacts and increasing the number of resources and services associated with archaeological sites and artifacts. Both alternatives should provide long-term protection and preservation of the archaeological resources within the *EVOS* area.

Option #1 (Archaeological site stewardship program)

This option establishes an archaeological site stewardship program. Beach cleanup activities following the oil spill resulted in increased public knowledge of the exact locations of archaeological sites throughout the *EVOS* area. Archaeological sites and artifacts affected by looting and vandalism directly attributable to the oil spill has been occurring at disturbing levels. The site stewardship program would involve the recruitment, training, and coordination of a corps of local interested citizens to watch over threatened archaeological sites located within their home districts.

Although archaeological sites and artifacts cannot be restored, the site stewardship program is designed to stop additional damage to archaeological resources from looting and vandalism.

Members of the citizen corps may receive small cash payments for their volunteer duties. These payments may benefit the local economy by introducing additional cash into the economy..

Option 1 could have the effect of increasing local knowledge of and appreciation for archaeological sites and artifacts and ultimately stimulate interest and action in protecting archaeological resources for the long term.

Option #10 (Preserve archaeological sites and artifacts)

This option addresses the need to repair archaeological sites that sustained injury from oiling, oil spill cleanup, or vandalism, as well as the need to recover salvageable information from areas of illegal excavation. It has been estimated that at least 113 archaeological sites located on State and Federal lands within the *EVOS* area sustained injury. This option would focus on the 24 archaeological sites for which clear evidence of injury would benefit from restorative actions taken to prevent additional injury and provide professional documentation on archaeological sites. This option would have a direct, positive long-term effect on reducing additional degradation or decline of the resources and services associated with archaeological sites and artifacts.

Option #18 (Negotiate with museums and agencies to acquire replacements for artifacts looted from the spill area)

This option seeks to replace and/or recover those artifacts that have been lost as a result of oil spill cleanup activities or vandalism. It also seeks to place returned/recovered artifacts into public ownership for appropriate public display and scientific uses. Individuals and institutions with oil spill artifacts will be approached with offers of artifact purchase from the *Exxon Valdez* Oil Spill Trustees (member agencies). Acquired artifacts would be transferred to appropriate public institutions within the oil spill area for public display and appropriate scientific uses. This effort would provide replacement artifacts for those lost and would have a direct, positive long-term effect on the value of resources and services associated with archaeological sites and artifacts. Replacement would have the effect of providing Alaskans access to their rich cultural heritage.

Services

Recreation

Alternative 2 - Habitat Protection

Under this alternative, over 90 percent of the funds would be used to implement HP&A. Habitat protection would provide enhanced recreational opportunities throughout the oil spill region and would specifically acquire habitats for developing recreational sites. Assuming that the habitat protection through special designation and land acquisition is afforded in perpetuity, the extent and the duration of the impacts could be high, creating long-term, positive benefits to recreation.

Indirect, negative impacts to recreation could also occur from restrictions on certain recreational activities that otherwise occurred on these lands. The impact would be short-term, assuming that the restrictions would be removed after the population of the targeted injured species have recovered. Therefore, the magnitude of the short-term impact would be low.

Alternative 3 - Limited Restoration

Under this alternative, Options 13, 11, 17, 19, 10, and 9, as well as HP&A, would affect recreation. Options 13, 11, 10, and 9 could indirectly benefit recreation throughout the oil spill area by increasing the population of marine birds and associated bird watching opportunities. Option 17 would benefit recreation by preserving archeological sites and artifacts that would attract visitors. Option 19 would have direct, positive impacts on recreation by constructing new recreational facilities throughout the oil spill area. As in Alternative 2, a large proportion (75 percent) of the restoration funds would be used for HP&A and could have long-term, positive impacts to recreation.

Alternative 4 - Moderate Restoration

Under this alternative, Option 18 would be added to the suite of options in Alternative 3. Option 18 would produce indirect, long-term, positive impacts on recreation by acquiring artifacts removed from the spill area. Approximately 50 percent of restoration funds would be allotted to HP&A and would have long-term, positive benefits to recreation as discussed previously.

Alternative 5 - Comprehensive Restoration

Under Alternative 5, Options 8, 24, and 25 would be added to the suite of options in Alternative 4. Option 8 would produce indirect, long-term, positive impacts on recreation. Options 24 and 25 would have direct, positive impacts on recreation by attracting visitors. The greater mix of options affecting recreation in Alternative 5 would have both short-term and long-term benefits to recreation within the *EVOS* area.

Options Related to Recreation

HP&A (Habitat protection and acquisition)

HP&A involves acquisition of or partial interests in private inholdings within Federal and State protected lands such as parks and refuges, to protect and better manage the habitat types linked to resources and services injured by the oil spill. Public ownership and enhanced protection of these lands would facilitate natural recovery by restricting activities stressful to already damaged populations, guard against future habitat degradation, and enhance the services provided. It is assumed that habitats for recreational sites would be acquired in visible areas readily accessible by roads.

HP&A also involves placing nearshore, coastal, and upland habitats in public ownership into

special State or Federal land designations to provide increased levels of legal protection to injured resources and services supported by these lands. Designations include Alaska State Parks, Alaska Department of Fish and Game Special Areas, National Marine Sanctuaries, Federal Wilderness Areas, and State Public Use Areas.

Direct, long-term, positive effects would occur from habitat acquisitions for developing recreational sites. Direct, long-term effects would also occur from designations such as Alaska State Park and State Public Use Areas, which would provide additional recreational opportunities on these lands. These sites would attract more people, concentrate public use, and enhance recreational opportunities provided in the area. Other habitat protection activities would have indirect, long-term, positive effects on recreation. Indirect, long-term, positive effects would occur from other habitat acquisitions which would protect the ecosystem and wilderness quality of the area. Healthier ecosystems resulting from enhanced protection would attract visitors, potentially providing increased non-developed recreational opportunities. Short-term, negative effects on recreation could occur where habitat protection restricted or limited certain types of recreational activities on the protected lands.

Option #8 (Protect undocumented anadromous streams)

This option involves listing undocumented anadromous streams in the State's catalogue to afford legal protection under the State Forest Practices Act to injured anadromous species and their habitats. Short-term, negative effects would occur due to restrictions of ongoing instream activities. However, long-term effects would be realized as healthier ecosystems, resulting from enhanced resource protection, would provide increased recreational opportunities.

Option #9 (Increase productivity and survival of marine birds through predator control)
Option #10 (Increase productivity and success of murre colonies)
Option #11 (Minimize the incidental take of birds)

These options involve enhancing the population of marine bird species, especially on common murres, black oystercatchers, and pigeon guillemots, and marbled murrelets. Techniques including terrestrial and avian predator control, enhancing murre productivity at nest sites, and reducing encounters between these birds and gillnets deployed in high seas and coastal fisheries. Implementation of these options would have indirect, long-term, positive effects on recreation. These effects would occur because enhanced population of marine bird species would provide additional bird watching opportunities.

Option #13 (Reduce disturbance at bird colonies, haulout sites, etc)

As with the previous options, Option 13 would have positive effects on recreation in the long-term by increasing wildlife viewing opportunities associated with the increase in population of these injured species. This option involves establishment of buffer zones as special designation areas around important murre colonies and harbor seal haulout sites to reduce human disturbance. Restrictions within the buffer zones can range from limiting the speed of boat traffic within a couple hundred feet of a specific site for a short time each year, to prohibiting

boat or air traffic within a half mile or mile of the location. Less stringent regulations would require tour or charter boat companies to change their use patterns for part of the year, but would not prohibit access. The most restrictive buffer zones could prevent access to a favorite viewing or fishing locations.

Implementation of this option would have indirect, long-term, positive and short-term, negative effects on recreation. Short-term, negative effects on recreation would be localized and would occur due to restrictions imposed on boat traffic that would limit opportunities for viewing murre colonies. It is assumed that the buffer zone restrictions would be removed once the population of injured species recover.

Option #18 (Acquire archeological artifacts)

This option seeks to replace and/or recover archeological artifacts that have been lost subsequent to the oil spill and return them to public ownership for appropriate public display in museums. The implementation of this option would have indirect, long-term, positive effects on recreation because it would enhance opportunities for the public to see these artifacts.

Option #19 (Create new recreation sites and facilities)

This option involves construction of new recreation sites and facilities on public land. In particular, the option involves construction of additional backcountry public facilities such as mooring buoys, boat ramps, picnic areas, caches, cabins, camping sites, and trails in National forests, monuments, parks, and wildlife refuges and state parks in the oil spill region. In addition, the option would make public land available for commercial recreation facilities such as fuel stops, docks, campgrounds, and lodges. This option would provide funds for planning and marketing these sites in the oil-spill area. It is assumed that recreational sites and facilities would be developed in easily accessible areas.

Implementation of this option would have direct, short-term, negative and long-term, positive effects on recreation. Short-term, negative effects would occur during construction activities that would limit or restrict temporary use of the site. Long-term, positive effects to recreation would occur because better sites and facilities would attract people and provide enhanced recreational opportunities. New sites and facilities would also enable the land managers to focus their information and education programs. Providing education on environmental awareness would enhance public knowledge for a common goal of sustained, sensitive, high-quality interaction with the environment. Recreational facilities would confine public use, limit human intervention, preserve the wilderness quality, resulting in enhanced sight-seeing and other non-developed recreational opportunities. Indirect, long-term, negative effects to non-developed recreation would occur due to congestion and loss of perceived pristine environment associated with increased human use. These negative effects would be minimized if the facilities are constructed in areas of previous human activity.

Option #24 (Visitors centers)

This option involves construction and operation of a large visitor center or expansion of an existing visitor center somewhere in the oil-affected area. Information from the visitor center would also be available to other visitor centers, government agencies, and organizations in the spill area. Implementation of this option would have direct and indirect, long-term, positive effects on recreation. Direct effects would occur because new visitor centers would attract visitors and confine public use. Indirect effects would occur because visitor centers would educate the public of oil spill-related injuries and subsequently help them better utilize and enjoy the area.

Option #25 (Marine environmental institute and research foundation)

This option involves construction of a new marine environmental institute in an easily accessible area, designated for the study of the marine environment and provision of public education within the oil spill region. Public exhibits and marine aquaria would be an integral part of the institute. Public exhibits would include living examples of Alaskan marine habitats, plants, animals, and seabirds. Implementation of this option would have direct and indirect, long-term, positive effects on recreation. Direct effects would occur because the facility would attract visitors. Public exhibits, especially the aquaria, would allow the public to closely observe marine creatures and habitats that they might never see. Indirect, long-term, positive effects to recreation would occur from environmental education programs developed and implemented by the institute to minimize additional human effects on injured resources and services.

Sport Fishing

Alternative 2 - Habitat Protection

Under this alternative, over 90 percent of the restoration funds would be used to implement HP&A. Habitat protection associated with rearing and spawning of fish species could potentially increase the population of these species in the long-term and, therefore, indirectly benefit sport fishing. Assuming that habitat protection through special designation and acquisition is afforded in perpetuity or until a self-sustaining population is reached, the extent and duration of the impacts would be large, creating long-term, positive benefits to sport fishing by protecting the habitat necessary to maintain a healthy population of fish.

Slight, indirect, negative impacts could also occur on sport fishing as a result of additional sport fishing restrictions (that did not exist prior to the acquisition or designation). Assuming the restrictions would be removed after the population of the injured species reached levels acceptable for harvest (as determined by the management agencies), the duration of the impact would be short-term.

Alternative 3 - Limited Restoration

Options affecting sport fishing under this alternative include Options 4, 13, 9, 19, 23, and 6,

as well as HP&A. Options 4, 5, 23, and 6, as well as HP&A, would benefit sport fishing either directly or indirectly by ultimately increasing the population fish. HP&A would receive 75 percent of the restoration funds.
As in Alternative 2, the emphasis on HP&A could have long-term, positive impacts to sport fishing by increasing species population available for fishing. Option 4 could have an adverse, indirect impact on sport fishing if restrictions are placed on areas where fishing can occur, and Option 19 could have a direct, positive impact on sport fishing when new facilities are constructed to improve access to sport fishing locations.

Alternative 4 - Moderate Restoration

In addition to the options under Alternative 3, Option 7 is included in this Alternative. This option has the potential to provide additional short-term benefits to sport fishing. As with Alternatives 2 and 3, Alternative 4 devotes most of the available restoration funds (approximately 50 percent) to the protection and acquisition of habitat. This can have long-term, positive benefits to sport fishing by enhancing the population of fish and associated sport fishing opportunities.

Alternative 5 - Comprehensive Restoration

Alternative 5 includes implementation of all the options (4, 13, 5, 19, 23, 8, 6, and 7, as well as HP&A) affecting sport fishing. Option 8 is not included in other alternatives, and could produce additional indirect, long-term, positive impacts on sport fishing by enhancing the population of anadromous fish species. A larger amount of the restoration funding (48 percent) is being proposed for general restoration options under Alternative 5, although HP&A is still the major focus (35 percent of total funding). The greater mix of options affecting sport fishing in Alternative 5 would have both short-term and long-term benefits to sport fishing.

Options Related to Sport Fishing

HP&A (Habitat protection and acquisition)

HP&A involves acquisition of or partial interests in private inholdings within Federal and State protected lands such as parks and refuges throughout the oil spill area, to protect and better manage the habitat types linked to resources and/or services injured by the oil spill. It also involves designation of upland, coastal, and marine habitats in public ownership into special State or Federal land designations such as Alaska Department of Fish and Game Special Areas, Federal Wilderness Areas, and Marine Sanctuaries throughout the oil spill area. Both activities could affect sport fishing by protecting the habitat associated with fish rearing and spawning. It is assumed that certain designations would be subject to sport fishing restrictions that did not exist prior to the designation and that these restrictions would be removed once the populations recover.

Implementation of this option would produce indirect, long-term, positive effects on sport fishing, because habitat protection would enhance fish population and associated sport fishing

opportunities. Short-term, negative effects could occur due to additional restrictions limiting sport fishing opportunities on the designated areas. The positive effects would be long term assuming that the habitat protection is afforded in perpetuity or until a self-sustaining population is reached.

Option #4 (Intensify fisheries management)

This option involves intensifying fisheries management to speed the natural recovery of injured stocks of pink salmon, sockeye salmon, herring, rockfish, Dolly Varden, and cutthroat trout by restricting existing fisheries or redirecting them to alternative sites. It is assumed that temporary restrictions on sport fishing would be imposed by the Board of Fish (following research and recommendations) until the injured stock increased to levels determined by management agencies to be acceptable for harvest. Long-term, positive effects could occur if increased fisheries management enhanced fish population in the long-term, thereby creating additional opportunities for sport fishing. Short-term, negative effects to sport fishing could occur from restrictions on sport fishing until the injured species recover.

Option #5 (Improve freshwater wild salmon habitats)

The objective of this option is to restore and enhance wild salmon populations by improving or supplementing its spawning and rearing habitats. Implementation of this option would have indirect, long-term, positive effects on sport fishing due to increases in wild salmon populations and associated sport fishing opportunities. Assuming wild salmon populations remain at high levels after the initial improvements, the effects would be long term .

Option #6 (Improve survival of salmon eggs and fry)

This option involves improving survival of salmon eggs and fry to restore injured salmon runs to pre-spill levels or to enhance either injured or equivalent runs above pre-spill levels. Wild salmon eggs would be reared in boxes, netpens, or hatcheries and subsequently released into streams. This option could have indirect, long-term, positive effects on sport fishing because increased salmon populations from artificial rearing of salmon eggs and fry would provide additional sport fishing opportunities. The effects could be long term if the subsequent reproduction of fish provided by the artificial rearing result in long-term increases in the harvest of naturally produced stocks.

Option #7 (Change or relocate existing hatchery salmon runs)

This option involves shifting the location and the timing of salmon runs released from hatcheries to decrease interception of injured, wild-stock pink salmon returning to spawning streams; thereby helping injured populations to recover more rapidly. The option would have indirect, long-term, positive effects on sport fishing similar to Option 6 by providing additional salmon fishing opportunities.

Option #8 (Protect undocumented anadromous streams)

This option involves listing undocumented anadromous streams in the State's Anadromous Stream Catalog to afford the stream protection under the State Forest Practices Act, which could increase protection of injured anadromous species and their habitat. Implementation of this option would have indirect, long-term positive effects through enhanced populations of anadromous species and associated sport fishing opportunities.

Option #13 (Reduce disturbance at bird colonies, haulout sites, etc)

This option involves research and recommendations for designation of buffer zones around important marine birds and mammal habitats. The restrictions within the buffer zone could include limiting boat speeds or prohibiting boat traffic within a certain distance of the habitat for part of the year. It is assumed that the buffer zones may encompass favorite fishing locations and the restrictions would be in place during the fishing season. Implementation of this option could have direct, negative effects on sport fishing. If the species of concern recover rapidly and the buffer zones are removed, the adverse effects to sport fishing would be short term.

Option #19 (Create new recreation sites and facilities)

This option involves construction of boat ramps, mooring buoys, docks, and campsites on public land within the oil spill area. Implementation of this option would have direct, long-term, positive effects on sport fishing. New facilities would provide additional sport fishing opportunities by providing easy access to fishing locations and enhanced services.

Option #23 (Create new salmon runs)

This option entails starting new salmon runs on rivers that currently do not support such runs, to replace fishing opportunities lost due to closures resulting from the oil spill. Implementation of this option would have direct, positive effects on sport fishing by creating additional opportunities for sport fishing. Assuming the runs are terminated once the other target species recover, the effects would be short term.

Sport Hunting

Alternative 2 - Habitat Protection

Under this alternative, over 90 percent of the restoration funds would be used to implement HP&A. Habitat protection associated with game species population needs could potentially increase the population of these species in the long-term and, therefore, indirectly benefit sport hunting. Assuming that habitat protection through special designation and acquisition is afforded in perpetuity or until a self-sustaining population is reached, the extent and duration of the impacts would be large, creating long-term, positive benefits to sport hunting by protecting the habitat necessary to maintain a healthy population of game animals.

Slight, indirect, negative impacts could also occur on sport hunting as a result of additional sport hunting restrictions (that did not exist prior to the acquisition or designation). Assuming the restrictions would be removed after the population of the injured species reached levels

acceptable for harvest (as determined by the management agencies), the duration of the impact would be short-term.

Alternatives 3 and 4 - Limited and Moderate Restoration

As in Alternative 2, the emphasis of theses alternatives is on the habitat acquisition and protection (75 and 50 percent of the restoration funds), likely resulting in a long-term, positive impact to sport hunting by increasing game species populations available for hunting. Option 19 is also included and would have indirect, long-term, positive impacts on sport hunting by making cabins and other facilities available for use by the hunters. This option could also have an indirect, long-term, negative impact on sport hunting because of conflicts with increased recreationists in the same area.

Alternative 5 - Comprehensive Restoration

Alternative 5 includes implementation of Options 15 and 19, as well as HP&A. These activities would have both direct and indirect, long-term, positive impacts on sport hunting, as well as potential negative impacts on recreation as described previously. In contrast, Option 15 could have a direct, short-term negative impact by restricting sport hunting opportunities. To the extent that these restrictions contribute to recovery of the game populations, this option would have a long-term positive impact on sport hunting. Alternative 5 allocates the largest amount of the restoration fund (48 percent) to general restoration options affecting sport hunting.

Options Related to Sport Hunting

HP&A (Habitat protection and acquisition)

This option involves acquisition of or partial interest in private lands associated with injured species and services for protecting these resources. It also involves designation of upland, coastal, and marine habitats in public ownership into special State or Federal land designations such as Alaska Department of Fish and Game Special Areas, Federal Wilderness Areas, and Alaska State Parks throughout the oil spill area. These activities would affect sport hunting by protecting the habitat associated with game species. It is assumed that important habitats under private ownership are available for purchase or protection and that these and special designation areas would be subject to more stringent regulations for sport hunting of injured game species until their populations recover.

Implementation of HP&A would have long-term, positive effects from increases in hunting opportunities as a result of increases in population of game species. Short-term, negative effects on hunting would occur due to additional restrictions that could temporarily close or restrict sport hunting on these lands.

Option #15 (Develop sport and trapping harvest guidelines for injured species)

This option would affect sport hunting by temporarily restricting or closing sport harvests and

trapping of the injured species of harlequin duck and river otter in the oil spill region. The closure of or reduction in sport harvest and commercial trapping would be based on population data and harvest rates, and it is assumed that the restrictions would be in place for a maximum of two years.

Direct, short-term, negative effects would result from restrictions on sport hunting of the injured species. The magnitude of this effect would vary with the type of restriction. If the restrictions include complete closures of sport harvest, then the magnitude would be high. If the restrictions include reduction in bag limits or limited closure of the season, then the magnitude would be lower. Because the restrictions would apply only to harlequin ducks and river otters, the overall effect on sport hunting of all game species would be low. Enhanced population of these species would provide additional opportunities for sport hunting.

Option #19 (Create new recreation sites and facilities)

This option involves construction of recreational facilities such as cabins, campsites, caches and other facilities on public land throughout the oil spill area. It is assumed that the cabins and other facilities would be constructed in areas where they can be used by hunters during the hunting season. Long-term, positive effects would occur because cabins and other facilities would provide hunters a place to stay while on a hunting trip. Long-term, negative effects to sport hunting could might result from conflicts with additional recreationists attracted to the sites. The effects could be minimized if facilities are constructed specifically for the hunters and are not used by the recreationists during the hunting season.

Commercial Tourism

Alternative 2 - Habitat Protection

Under this alternative, over 90 percent of the funds would be used to implement HP&A. Habitat acquisition and special designations would indirectly benefit commercial tourism because healthier ecosystems attract more tourists who, in turn, create demand for tourism-related goods and services. Assuming that the habitat protection continued in perpetuity, the magnitude of the impacts of this alternative could be high, creating long-term, positive benefits to commercial tourism.

Indirect, negative impacts on commercial tourism could also occur at specific sites if limits were imposed on human use of the area (e.g., restricted boat traffic). In general, however, visitation and tourism to protected areas should increase, and site specific restrictions would not create lesser demand on tourism-related goods and services.

Alternative 3 - Limited Restoration

Options affecting recreation under this alternative include Options 13, 11, 17, 19, 10, and 9, as well as HP&A. Options 13, 11, 10, and 9 could indirectly benefit tourism by ultimately increasing the population of marine birds and associated bird watching opportunities which, in

turn, would create demand for additional charter and tour-boat services and cruises. Option 17 could benefit tourism by creating demands for tour guides, visitor information booths, and other tourism-related services associated with visiting archeological attractions. Option 19 could have direct, positive impacts on commercial tourism by constructing new commercial recreational facilities that would attract more tourists throughout the oil spill area. As in Alternative 2, emphasis continues to be on HP&A (75 percent of funds) likely resulting in a long-term, positive impact to commercial tourism by creating healthier ecosystems and ultimately attracting more tourists.

Alternative 4 - Moderate Restoration

In addition to all the options identified in Alternative 3, Option 18 is included in this alternative. Option 18 would produce indirect, long-term, positive impacts on tourism related to viewing archeological resources. The combined impact of this alternative would be direct and indirect, long-term, positive and short-term, negative as described previously. As with Alternatives 2 and 3, Alternative 4 devotes most of the available restoration funds (approximately 50 percent) to the protection and acquisition of habitat. This would have long-term, positive benefits to commercial tourism.

Alternative 5 - Comprehensive Restoration

Alternative 5 includes the options in Alternative 4 with the addition of Options 8, 24, and 25. Option 8 could produce indirect, long-term, positive impacts on commercial tourism by protecting valued salmon runs. Options 24 and 25 would have direct, positive impacts on commercial tourism by attracting tourists and creating demands for tourism-related goods and services. The larger number of general restoration options under Alternative 5 provides a greater mix of options affecting commercial tourism and would replace some indirect effects of HP&A with direct positive effects related to archaeology-based tourism.

Options Related to Commercial Tourism

HP&A (Habitat protection and acquisition)

HP&A involves acquisition of or partial interest in private lands associated with injured species and services for their protection. It also involves placing nearshore, coastal, and upland habitats in public ownership into special State or Federal land designations to provide increased levels of protection to injured resources and services supported by these lands. Several designations including Alaska State Parks, Alaska Department of Fish and Game Special Areas, National Marine Sanctuaries, Federal Wilderness Areas, and State Public Use Areas are considered.

Implementation of these activities would have long-term, positive effects because healthier ecosystems resulting from enhanced protection would attract more tourists who in turn would create demand for tourism-related goods and services. Short-term, negative effects on tourism might result from restrictions limiting human use of specific areas (e.g., restricted boat traffic) and fewer people would be visiting these areas.

Option #8 (Protect undocumented anadromous streams)

This option involves listing anadromous streams in the state catalog to increase protection of injured anadromous species and their habitat under the State Forest Practices Act. Implementation of this option would have indirect, long-term positive effects on commercial tourism. After the ecosystem is restored and fisheries enhanced, the area would attract more tourists for sport fishing and other recreational activities.

Option #9 (Increase productivity and survival of marine birds through predator control)

This option involves reducing predator populations on marine birds, especially on common murre, pigeon guillemot, and black oystercatcher colonies, to enhance productivity and survival of these bird species. Implementation of this option would have similar effects on tourism as Option 11 by increasing bird watching opportunities.

Option #10 (Increase productivity and success of murre colonies)

This option involves increasing common murre productivity and the success of murre colonies. Common murres colonies are one of the most visited tourist attractions in the oil-spill area. Common murres suffered the greatest direct mortality from the oil spill of any bird species. It is assumed that some restrictions, similar to Option 13, would be imposed in and around the murre nesting sites to reduce human intervention in these areas. Implementation of this option would have indirect, short-term, negative and long-term, positive effects on tourism similar to Option 13.

Option #11 (Minimize the incidental take of birds)

This option involves facilitating recovery of marine bird species (common murre and marbled murrelets) by employing measures to reduce encounters between these birds and gillnets deployed in high seas and coastal fisheries. Implementation of this option would have indirect, long-term, positive effects on the tourism industry because enhanced marine bird populations would create additional opportunities for bird watching and consequently higher demand for various tourism-related services such as tour boats, tour guides, and cruises.

Option #13 (Reduce disturbance at bird colonies, haulout sites, etc)

This option involves designation of buffer zones around important marine birds and mammals habitats. The restrictions within buffer zones could include prohibiting boat or air traffic within a certain distance from the habitat. This could require tour or charter-boat companies to change their routes, and in critical conditions could prevent access to a favorite viewing or fishing location. Short-term, negative effects could occur from temporary restrictions imposed on charter and tour-boat companies, and air traffic; however, these effects would be localized. Long-term positive effects to tourism could occur when the populations of injured species recover creating additional wildlife viewing opportunities and consequently creating demand for additional charter and tour-boat services and cruises.

Option #18 (Acquire archeological artifacts)

This option seeks to replace and/or recover archeological artifacts that have been lost subsequent to the oil spill and to return them to public ownership for appropriate public display in museums. Implementation of this option would have indirect, long-term, positive effects on tourism similar to Option 17.

Option #19 (Create new recreation sites and facilities)

This option involves construction of new recreational sites and facilities on public land. This option involves construction of additional backcountry public facilities such as mooring buoys, boat ramps, picnic area, outhouses, caches, cabins, campsites, and trails. Assuming that these new facilities are operated and managed by the Federal or State government, implementation of this option would have direct, long-term, positive and negative effects on commercial tourism. Positive effects would occur because additional facilities would attract additional tourists and these tourists in turn would create demand on tourism-related goods and services. On the other hand, commercial tourism could be negatively affected because new facilities managed by government would might divert tourists from privately owned recreational facilities.

In addition, this option involves the planning and marketing of public land for new commercial recreation facilities such as fuel stops, docks, campgrounds, and lodges. Implementation of this activity would have direct, long-term, positive effects on commercial tourism because additional facilities would attract more tourists, create greater demand on goods and services, and enhance the tourism-related economy.

Option #24 (Visitor centers)

This option involves construction and operation of a large visitor center to provide information about the oil spill and the status of recovery. This option would have direct, long-term, positive effects on commercial tourism. Direct effects would result from tourists visiting the center and creating demands for goods and tourism-related services, such as tour buses and boats.

Option #25 (Marine environmental institute and research foundation)

This option involves establishing a new Marine Environmental Institute within the oil-spill area. Live exhibits and marine aquaria would be an integral part of this institution. This option would have direct, long-term, positive effects on tourism similar to Option 24, attracting tourists and creating demand for tourism-related goods and services.

Commercial Fishing

Alternative 2 - Habitat Protection

Under this alternative, over 90 percent of the restoration funds would be used to implement HP&A. HP&A would both protect and acquire habitat and establish special land designations,

indirectly benefiting commercial fishing by protecting the habitat required for the spawning and rearing of fish and potentially increasing the numbers of fish harvested commercially. Assuming that the protection afforded habitat acquired for the public domain is held by the public and managed to promote healthy ecosystems in perpetuity, the impacts would create long-term, positive benefits to commercial fishing by insuring the necessary habitat to maintain healthy fish stocks in the oil spill area.

Alternative 3 - Limited Restoration

Options affecting commercial fishing in this alternative include Options 4, 13, 11, 19, 1, and 6, as well as HP&A. Options 4 and 6, as well as HP&A, would benefit commercial fishing either directly or indirectly by ultimately increasing the number of fish available for commercial harvest. HP&A would utilize 75 percent of the restoration funds. Options 1 and 11 could have direct, adverse impacts on commercial fishing resulting from the economic consequences of potential regulatory changes to existing methods of fishing. Options 13 and 19 could have adverse, indirect impacts on commercial fishing from restrictions placed on areas where fishing can occur, or conflicts with recreational boaters.

As in Alternative 2, the emphasis on HP&A can have long-term, positive impacts to commercial fishing by increasing fish populations available for harvest. This in turn increases the potential to increase income for commercial harvesters and processors.

Alternative 4 - Moderate Restoration

The options included in Alternative 4 that affect commercial fishing are Options 4, 13, 5, 19, 23, 3, 1, 6, and 7, as well as HP&A. Options 13, 5, 23, 6, and 7, as well as HP&A, have either direct or indirect, positive impacts on the commercial fishery by increasing the number or availability of fish for harvesting. Option 13 would lead to increases in the stocks of herring and pink salmon, rockfish, and sockeye salmon. Option 5 would lead to increases in the number of sockeye for harvest. Options 23 and 6 would ultimately lead to increases in the number of salmon available for harvest. Options 13, 11, 19, 3, and 1 would have either direct or indirect, adverse economic impacts on commercial fisheries in various locations throughout the oil spill area. However, as with Alternatives 2 and 3, Alternative 4 devotes most of the available restoration funds (approximately 50 percent) to the protection and acquisition of habitat. As noted previously, this can have positive, long-term impacts to commercial fishing through long-term maintenance of spawning and rearing habitat necessary to maintain fish stocks throughout the oil spill area.

Alternative 5 - Comprehensive Restoration

In addition to the options under Alternative 4, this alternative includes Option 8. Options 8 would have indirect, positive impacts on increases in salmon population through protection of anadromous streams. The larger amount of the restoration fund (48 percent) being proposed for general restoration options provides greater direct benefits to fish populations and consequently commercial fishing opportunities.

Options Related to Commercial Fishing

HP&A (Habitat protection and acquisition)

HP&A could affect commercial fishing by protecting habitat throughout the oil spill area. The absence of degrading activities in upland habitats is necessary to ensure the productivity of estuaries, streams, and lakes that produce the stocks of fish harvested commercially. It is assumed that land containing these productive habitats is currently privately owned and consequently available for purchase or protection after meeting the criteria necessary to make them a target for purchase or protection.

The effect on commercial fishing would be indirect, and fishing would benefit only if (1) the stocks of commercially harvested fish increase, or (2) the consistency of the harvest is ensured through the protection of productive fish spawning and rearing habitats. Additional stocks of fish for harvest would translate into additional income to commercial fishermen and commercial fish processing facilities. These benefits would be long-term assuming the habitat protection is afforded in perpetuity.

HP&A would also affect commercial fishing by establishing special designations throughout the oil spill area to protect upland, coastal, and marine habitats that contain productive fish producing or harvesting areas. Based on the assumption that marine sanctuaries containing a commercially harvestable fishery would be included, commercial fishing would be directly affected by limiting the area available for commercially harvesting fish. This would have an adverse economic effect on the fishermen that rely on these area for all or portions of their catch.

Option #1 (Reducing the bycatch of harbor seals)

This option involves research and recommendations for changing harvesting methods and harvest areas to prevent accidental take of harbor seals. The option could have direct, adverse effects on commercial fishermen resulting from the costs of modifying fishing methods and fishing gear to prevent the accidental take of harbor seals. Reductions in the number of fish harvested because of area restrictions and potential reduced effectiveness of the modified harvest gear may also reduce the income of fishermen participating in the affected fishery.

The effects of implementing this option would be long-term assuming that once the gear restrictions have been implemented they would likely be difficult to repeal.

Option #3 (Change black cod fishing gear)

This option would affect commercial fishing by subsidizing a voluntary change in the way black cod fisheries are harvested. Instead of using long lines (hook & line), some other gear type such as "pots" like those used in the British Columbia black cod fishery would be used. The objective of the option is to find a method of fishing for black cod that does not attract or provide the opportunity for killer whales to strip the catch, in turn reducing the conflict between

killer whales and commercial fishermen.

For analysis purposes, it is assumed that long lines would be replaced by the "pot" type gear, which requires a boat of a certain size (larger than many currently used) to place and retrieve the pots.

Direct effects to commercial fishing would occur as a result of the costs incurred learning how to use the new gear types effectively. Costs may also be incurred by fishermen who choose to switch to the pot type gear but do not have boats large enough to use this gear type. Fishermen currently using small boats that cannot afford to acquire larger boats would not be able to participate in the fishery, and would either have to switch to a new fishery (assuming entry was permitted). The economic consequences to the individual who could no longer participate in the fishery could be severe.

Changing the gear types for the commercial black cod fishery would have short-term effects because it is assumed that changing the harvesting method would occur over a relatively short period of time, with a one-time cost for switching the gear and a short learning curve for determining the effective use of the new equipment.

Option #4 (Intensify fisheries management)

This option could affect commercial fishing by restricting existing fisheries or redirecting them to alternative sites. The option involves development of recommendations for new fishing regulations that would be implemented by the Alaska Board of Fish. In addition, this option may include research concerning commercial fisheries that would identify fish harvest levels, age and sex composition, natural mortality, seasonal movements, stock abundance, and recruitment. Commercial species that could be affected by this option include pink salmon and herring, sockeye salmon, and rockfish.

Direct effects on commercial fishing from management actions aimed at protecting injured stocks would include the added cost of redirected harvesting that requires longer travel times to and from port, and the loss, from regulatory constraints placed on harvest, of fisheries previously available for harvest. These effects would be direct, but would last for a short period of time, until the injured stock increased to levels acceptable for harvest (determined by the management agencies).

Indirect effects related to implementation of this option involve the increase in the long-term availability of salmon for harvest. Increased numbers of salmon resulting from the management activities could provide additional harvest opportunities, and a consequent increase in the income from the harvest. Additionally, the long-term viability of commercial fisheries would be enhanced by the research activities that provide better information for future management decisions that maintain stock availability and reduce harvest variability.

Option #5 (Improve freshwater wild salmon habitats)

This option would affect commercial fishing by increasing the number of wild salmon stocks available for harvest. The numbers of fish made available would be the result of improvements in the availability of food in spawning and rearing habitats and accessibility to spawning areas, which would increase fish survival and improve growth rates.

The indirect effect of implementing this option would be to enhance the opportunities for harvest through an increase in the number of fish available for harvest. Consequently, the value of the harvest would increase (assuming prices did not commensurately decline), increasing the income of the fishermen participating in the harvest.

The effects of implementing this option would be long term if wild salmon populations remained at high levels after the initial improvements were implemented.

Option #6 (Improving survival of salmon eggs and fry)

This option would affect commercial fishing by rearing wild salmon eggs in boxes, netpens, or hatcheries, and releasing them to native streams. This could increase the numbers of wild salmon available for harvest along the migration routes of adult salmon.

An indirect effect on commercial fishing from the improved survival of salmon eggs and fry would be more fish available for harvest, and additional harvest opportunities. An increase in the salmon catch would increase income for commercial harvesters and fish processors.

This option could have long-term effects if the additional fish provided by artificial rearing increase the potential for long-term increases in the harvest of naturally produced stocks.

Option #7 (Change or relocate existing hatchery runs)

This option involves changing the timing of hatchery run releases, or releasing hatchery fish at remote locations in an effort to minimize the interaction of hatchery fish and wild salmon stocks during commercial harvests. Ultimately, the objective of the option is to increase wild salmon stocks.

The short-term direct effect to commercial fishing from implementing this option could involve harvest area closures, changes in the time of year for harvesting, and possible increases in the distances traveled to reach open harvesting areas. These changes in harvest strategy could have economic consequences such as increases in the cost of harvest. Because the implementation of the option would require careful planning to ensure that interception of the wild stocks is avoided, consideration of the costs of the harvest should be an important part in the planning process. If fishermen are not willing to travel to the locations where the hatchery runs have been relocated, the objective of this option would be compromised.

The long-term, indirect effects from implementing this option would occur as a result of an

increase in the wild salmon stocks. Once the stocks have recovered to a level where they can be sustained under harvesting, an economic benefit to commercial fishing would be realized from the additional fish available for harvest, and the associated value of those additional fish.

Option #8 (Protect undocumented anadromous streams)

This option would affect commercial fishing by protecting streams that contribute to the number of anadromous fish available for harvesting. This option would identify streams for inclusion in the Anadromous Stream Catalogue, which would afford them protection under the State Forest Practices Act. Any stream listed in the catalogue would be protected by a buffer zone to prevent stream encroachment (development close to the stream).

It is assumed that the streams currently not in the catalogue could add to the available fishery if they were included (i.e., there is some damage currently occurring to the stream that has reduced its productivity), and that harvesting is currently allowed in the area during the migration of the adult fish. Based on the assumptions, commercial fishing could directly benefit from the increase in the number of fish available for harvest, and the consequent additional income that could result from that harvest.

The positive effects associated with the implementation of this option would be expected to be long-term because of the continued protection afforded the stream once it is listed in the catalogue.

Option #11 (Minimize the incidental take of birds)

This option would be directed at the commercial fishing activities associated with gillnet, drift, and set net fisheries. The option could involve suspending nets below the surface, closure of certain areas, elimination of night fishing, or directing fishing away from injured marine bird habitats.

This option could directly affect the commercial fishing industry as a result of costs incurred to modify gillnets for use while suspended below the surface. If fisheries were closed, this could also cause direct, adverse economic effects by reducing the volume of fish caught, increasing the cost to travel to new harvest locations, and increasing competition for the available fishery. This would reduce fishing opportunity and the associated volume of the harvest for boats previously utilizing the closed areas.

The effects of implementing this option could be long-term, lasting for as many years as it may take for the injured species populations to rebound to preferred management levels.

Option #13 (Reduce disturbance at bird colonies, haulout sites, etc)

This option could affect commercial fishing operations by restricting the speed or prohibiting navigation of fishing vessels near protected bird colonies and marine mammal haulout sites. If recommended, these restrictions would be implemented would occur from May to September

to encompass the affected species' molting and pupping seasons.

An assumption concerning the effects of implementing this option is that there are commercially harvestable fish populations that would be encompassed by the protected zone near the colonies and haulout sites. The indirect effect to commercial fisheries from protecting these sites would be a reduction in available harvest locations, which may affect the volume of the harvest. If vehicle speed reductions restrict the type of fishing gear that could be used, this may also indirectly affect the ability to commercially harvest fish.

This option may result in long-term effects lasting until the injured species populations being protected recover.

Option #19 (Create new recreation sites and facilities)

This option could affect commercial fishing throughout the oil spill area by increasing the number of boat ramps, mooring buoys, and other facilities that increase the number of recreational boaters.

The effects of implementing this option would be indirect as a result of increased recreational boater traffic and potential conflicts with commercial fishing boats and gear. These conflicts could occur if recreational boaters accidently snagged commercial fishing gear causing the gear to fail, or inhibited the operation of the fishing vessel by operating too close to the vessel. In general, the greater the number of boats operating in the same area, the greater the potential for conflicts and collisions. Damage to gear or the fishing vessel would have an adverse economic effect on the commercial operator involving repair costs.

Option #23 (Create new salmon runs)

This option could affect commercial fishing by creating new salmon runs. The option would involve the placement of a hatchery or remote release site at a river where a terminal harvest could occur.

The indirect effects on the commercial fishery of new salmon runs (and the consequent increase in salmon populations) would be to increase opportunities for harvesting salmon. An increase in the number of salmon harvested would have direct positive economic effects on commercial fishermen involved in the harvest. There may also be direct adverse economic effects on commercial fishermen if the distance traveled to the harvest site is greater than previously required to harvest the same number of fish.

If the runs are terminated once the other target species have recovered, the effects of this option would be short term.

Transportation

EVOS Restoration Plan options 4, and 12 may indirectly affect transportation in the EVOS area: Option 4 may restrict the routes of ferries and aircraft traveling near marine bird colonies or marine mammal haulout sites. Option 12 could affect transportation by construction of recreational facilities, that could increase traffic on the existing transportation systems in the vicinity of the new facilities. The type of transportation system affected would depend on where the facilities are located (e.g., along ferry routes, major highways, etc.).

Alternative 1 - No Action Alternative

The No Action Alternative does not involve implementation of any option. Under this alternative, transportation services would operate as they do currently. None of the effects related to the various options described in the above section would occur.

Alternative 2 - Habitat Protection

Under this alternative, only options 37 and 40 would be implemented. It is unlikely that this alternative would have an impact on transportation.

Alternatives 3, 4, and 5 - Limited Restoration/Moderate Restoration/Comprehensive Restoration

Options affecting recreation in these alternatives are the same, and include options 4, and 12. Options 4 could adversely impact ferry and aircraft related transportation services because of the potential to require changes in the routes of these services. Option 12 may adversely affect any or all of the existing transportation services (roads, boats, air traffic) by increasing traffic on the existing systems. By far the greatest emphasis of all of these alternatives is habitat acquisition and protection (options 37 and 40), which are unlikely to impact transportation.

Options Related to Transportation

Option #4 (Reduce disturbance at bird colonies, haulout sites, etc.)

This option may affect transportation because of the restrictions on entry into buffer zones used to prevent disturbance of bird colonies and haulout sites. The assumption being made is that these buffer zones could encompass ferry routes and aircraft routes. Restricting the routes of ferries and aircraft would be an indirect adverse impact to transportation because rerouting these routes would increase transport time and cost (additional fuel). The effects could be long-term lasting until the buffer zone restrictions are removed.

Option #12 (Creation of new recreation sites and facilities)

Option 12 would be implemented throughout the EVOS area, and it is assumed that recreational sites and facilities would be constructed in easily accessible areas along existing roadways, ferry routes or aircraft routes. Consequently, it is assumed that this option would not involve

construction of major roadways for accessing these sites. Implementation of this option could have indirect, long-term adverse effects on transportation by increasing traffic on the existing transportation systems in the vicinity of the new recreational facilities.

Passive Use

The natural beauty, quality of life, and lifestyle offered by the *EVOS* area is important to *EVOS* residents, Alaska residents, and residents of areas beyond Alaska. Appreciation of the unique attributes offered by the *EVOS* area is a passive use of *EVOS* resources which extends far beyond local boundaries. Preservation and protection of the *EVOS* environment and resources permits a continuation of the passive use values. Potentially, the passive use of *EVOS* resources could result in economic benefits to the *EVOS* area associated with stimulated tourism.

Alternative 2 allocates over 90% of restoration funds to HP&A. The protection of natural habitat areas in public ownership (especially when they received special designation) is the principal means for enhancing and ensuring the passive appreciation of the environment by the general public. Therefore, the protection of the *EVOS* ecosystem afforded under this alternative would greatly enhance the passive use of *EVOS* natural resources.

Alternatives 3, 4, and 5 also allocate large proportions of restoration funds to HP&A (35 to 75%). In addition, they include general restoration options that directly enhance the recovery of individual injured natural resources with the *EVOS* area. To a lesser extent, these alternatives enhance the passive use of the greater *EVOS* ecosystem by ensuring and designating protected natural areas. The positive impact of HP&A is augmented by the greater passive enjoyment the public receives from knowing that individual species are recovering to their natural levels.

Economic Impacts

As noted in the Analytical Tools section of Chapter II, the Forest Service's IMPLAN economic computer model was used to perform an economic impact assessment identifying the economic impacts of implementing each of the proposed *EVOS* Restoration Plan alternatives. Because Alternative 1 is the No Action Alternative, it is reflected in the "baseline" condition against which the impacts of Alternatives 2-5 are compared.

IMPLAN estimates change in income and employment as the product of the demand change (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 level by using borough population and employment data, and ratios of employment to output. The boroughs and census areas included in this assessment are the Municipality of Anchorage, Kenai Peninsula Borough, Kodiak Island Borough, and the Valdez-Cordova Census Area. This area covers the *EVOS* area and the closest major economic center (Anchorage), which was included to insure that the flow of goods in and out of the oil spill area is adequately accounted for in the IMPLAN economic model. At present, the benchmark national data is for 1990.

The key assumptions in the IMPLAN economic assessment are that each industry has an output and that 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 timeless and technology does not change.

IMPLAN's output classification system is based on systems defined by the Bureau of Economic Analysis (BEA-Department of Commerce) and the Standard Industrial Classification (SIC) used by the Office of Management and Budget. The analysis is conducted using 528 industries and the results are aggregated into 10 sectors. The 10 sectors are as follows:

1. Agriculture, Forestry and Fishing - These businesses engage in agricultural production, forestry, commercial fishing, hunting and trapping and related services. Agricultural production firms produce crops and livestock. Forestry firms operate timber tracts, tree farms, forest nurseries or perform forestry services. Fishing, hunting and trapping covers commercial fishing, fish hatcheries, fish and game preserves and commercial hunting and trapping.

2. Mining - These businesses extract minerals occurring naturally. Mining includes quarries, wells, milling and other preparations commonly done at mine site.

3. Construction - These businesses build new work, additions, alterations and repairs.

4. Manufacturing - These businesses mechanically or chemically transform materials or substances into new products. The materials and substances are produced by other

sectors (e.g., agricultural, forests and fisheries) or other manufacturers.

5. Transportation, communication and utilities - These businesses provide to the public or to other businesses passenger and freight transportation, communication services, electricity, gas, steam, water or sanitary services. The U.S. Postal Service is included here.

6. Trade - These businesses retail merchandise to households or wholesale it to retailers; other wholesalers; to other businesses; or act as agents or brokers in buying or selling goods.

7. Finance, Insurance and Real Estate - These businesses engage in the fields of finance, insurance and real estate.

8. Services - These businesses provide a variety of services for individuals, businesses, governments, and other organizations. Examples include hotels, amusements, health, legal, engineering and other professional services.

9. Government - This sector includes the legislative, judicial, administrative and regulatory activities of Federal, State, local and international governments. Government-owned businesses are classified according to the activity in which they are engaged.

10. Misc. Special Services - These cannot be classified in any other industry.

For each Restoration Plan alternative, the amount of funds allocated for each expenditure is divided among restoration activities and the economic sector participating in those activities, as follows:

Administration and public information - Federal, State and local government

Monitoring and research - Federal, State and local government and universities

General restoration - State and local government, private fisheries and construction

Habitat protection - Forestry, real estate, households

Respending of Habitat Protection - Securities, social services, construction, households

The last category "Respending of Habitat Protection" does not appear in the Summary. It is part of the modeling exercise. 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).

When 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 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 for baseline conditions in the six columns shown in Table IV-B. These baseline conditions represent the No Action Alternative. 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. Value added 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 man-year equivalents to produce industry output.

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 $630 million of the civil settlement funds in five alternatives spending scenarios were analyzed. The spending represents annual amounts continuing for ten years. The results are given for the six economic indicators described previously, and by sector. Table IV-B depicts the regional economy as it currently exists with no consideration of restoration fund spending. Analysis of the spending scenarios identify absolute change from the baseline.

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.

Table IV-B. Baseline economic conditions used for the economic impact assessment of *EVOS* Restoration Plan alternatives implementation.

Base	Analysis of Alternatives 1990$ Millions					
Economic Sector	Final Demand $	Industry Output $	Employee Comp. $	Property Income $	Value Added $	Employment #
Agriculture, Forest and fisheries	340.7	462.1	28.1	151.3	189.6	8,091
Mining	6,061.0	6,199.0	502.4	2,835.3	4,745.4	6,335
Construction	1,246.1	1,420.3	495.1	363.9	861.9	11,751
Manufacturing	948.6	1,072.4	226.5	82.0	319.5	7,655
Transportation, communication and Utilities	1,933.3	2,265.9	543.7	768.5	1,405.1	13,795
Trade	1,125.7	1,252.6	752.6	138.2	1,035.4	33,790
Finance, insurance, and real estate	988.3	1,137.4	245.4	337.3	734.1	11,329
Services	2,018.0	2,514.4	944.9	546.2	1,507.8	48,779
Government	2,105.6	2,151.5	1,934.2	76.5	2,010.7	46,428
Misc. Special sectors	44.5	12.3	0.0	33.4	33.4	0
Total	16,811.8	18,487.9	5,673.1	5,332.7	12,843.0	187,953

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.

Using Alternative 2 (Habitat Acquisition) as an example, the total change in the regional economy is depicted as follows: Final demand, the regional purchases of goods and services is reduced by 0.08%, with the largest drop (0.19%) in the agriculture/forest/fisheries sector, and the largest gains in the construction sector (0.05%); industry output, the regional supply of goods and services, falls by 0.13% with the largest loses (0.20%) in agriculture/forest/fisheries, and the largest gains (0.04%) in construction. Employee compensation increases by (0.009%) with the largest increases occurring in the services sector (0.08%) and the largest decrease in the agriculture/forest/fisheries sector (0.14%). Property income decreases by 0.10%, with no sector reporting more than a 0.02% increase, but the agriculture/forest/fisheries sector declining by 0.09%. Value added, the costs added within the region to produce industry output, drops by 0.04% with the construction and services sectors each experiencing growth exceeding 0.03%, while agriculture/forest/fisheries declines more than 0.11%. And lastly, employment, which is the number of person-year equivalents to produce industry output, increases by slightly more than 0.35% with the largest gains in the services sector (0.51%), and the largest loss of jobs in the agriculture/forest/fisheries sector (0.23%). By far, the largest economic impact from the implementation of Alternative 2 would be the adverse impact experienced by the agriculture/forest/fisheries 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% 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 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.

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 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.

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

Subsistence harvesting contributes to the overall income of *EVOS* residents. Acquisition of private land for habitat protection or placing public lands into special State and Federal land designations might restrict subsistence uses on certain lands. In contrast, general restoration activities would benefit subsistence hunting and fishing through increases in populations of selected species, enhancement of opportunities for subsistence use, and cultivation of replacement species. Under Alternatives 3, 4, and 5, acquisition of private land for habitat protection or placing public lands into special designations might restrict subsistence uses.

Subsistence resource harvesting is important to residents within the *EVOS* area. The residents of most *EVOS* communities supplement their cash incomes by the harvesting of subsistence food sources. In addition, the seasonal nature of most cash employment opportunities and the expense and limited availability of commercially produced goods increases the importance of subsistence resources. The Restoration Plan Alternatives seek to preserve and protect the resources of the *EVOS* area. Consequently, the Alternatives could have a positive impact on *EVOS* communities by enhancing the subsistence harvesting opportunities.

There would be no effects on human health and safety resulting from implementation of any of the proposed Restoration Plan alternatives.

Subsistence

Alternative 2 - Habitat Protection and Acquisition

HP&A could affect subsistence use of resources if protection measure such as the designation of marine sanctuaries prohibited short-term subsistence harvesting. There may also be some effect on subsistence harvests depending on whether the land that is acquired is transferred into state versus Federal ownership. Subsistence rights differ under State and Federal law as discussed in Chapter B of the DEIS. The difference in State versus Federal ownership may be reflected in terms of the competition for resources among subsistence harvesters. Lands under State ownership may be available to more subsistence users than land under Federal ownership because of the State definition of subsistence users is broader than what is stated under Federal law.

Alternatives 3 and 4 - Limited and Moderate Restoration

Alternatives 3 and 4 include 3 options that specifically target subsistence use of resources in the *EVOS* area. Options 20, 21, and 23 would evaluate the safety of subsistence foods, provide access to uninjured resources, and replace harvest opportunities (respectively). Additionally, under Alternatives 3 and 4, HP&A could change the nature of access to some *EVOS* areas.

Option #23 (Replace Subsistence Opportunities by Creating New Salmon Runs)

This option entails starting new salmon runs to replace fishing opportunities lost due to closure resulting from the oil spill. This option may restore services by providing replacement harvests, but may not restore injuries to fish species populations.

Terminus runs originating from and returning to hatcheries or remote release sites could be started under Option 23.

In an effort to minimize additional injury to subsistence and other user groups. Fishing pressures could be redirected to target these new runs until injured stocks recover. In addition, this option could enhance fishing opportunities above pre-spill levels. The impact to subsistence users may be of a high magnitude over the short-term, providing needed replacement of lost harvest opportunities.

Option #20 (Test Subsistence Foods for Hydrocarbon Contamination)

This option addresses the need to restore the confidence of subsistence users in the safety of subsistence resources. Subsistence harvesters may be reluctant to harvest and consume food resources perceived as contaminated. This option could involve the monitoring of hydrocarbon levels in selected subsistence species, communicating findings to subsistence harvesters, and integrating the findings of other studies of oil-spill related injuries into previously developed health advice.

Although the overall restoration monitoring may serve to scientifically define the "edibility" of subsistence foods, involvement of the impacted community representatives in the sampling, testing, and analysis processes may help to overcome the hydrocarbon contamination health risks perceived by subsistence harvesters. This option would have a high likelihood of stimulating the return of subsistence harvest to pre-spill levels and may reduce subsistence harvesters' anxiety about the safety of these resources.

Option #21 (Provide Subsistence Users Access to Traditional Foods)

This option could provide transportation funds to transport subsistence harvesters from areas that have experienced declines to areas where resources were not injured. In addition, funds would be provided to allow people in other subsistence communities to gather, preserve, and send subsistence foods to subsistence communities damaged by the *EVOS*.

The continuation of subsistence harvest activities could help ensure that traditional hunting skills and culturally important harvesting and sharing practices would not be diminished. The option may improve subsistence recovery by providing traditional subsistence foods to villages where they are not readily available. The provision of transportation funding would continue until populations have recovered from oil spill-related injuries, and foods are no longer perceived to be contaminated. The magnitude of these impacts could be high because of the importance of subsistence harvests on subsistence communities.

Alternative 5 - Comprehensive Restoration

Alternative 5 would include the same option continued in Alternatives 3 and 4, and would also include an additional option specifically targeting subsistence uses of the environment: Alternative 5 includes Option 22, which is not included in Alternatives 3 and 4. Option 22 could provide additional opportunities for harvesting bivalve shellfish. Similar to Alternatives 2 through 5 includes HP&A, although the allocation of funding for HP&A would be lower.

Option #22 (Subsistence Harvest Opportunities for Bivalve Shellfish)

This option would provide the facilities and the infrastructure to restore, replace, and/or enhance affected bivalve shellfish populations, such as mussels and clams, affected by the oil spill and cleanup efforts. Facilities and infrastructure to restore, replace, and/or enhance affected shellfish populations could be provided. Particular emphasis could be placed on the replacement and/or enhancement of shellfish used for subsistence.

Option 22 would fund the development of shellfish mariculture in subsistence communities. Cultivated species may include oysters, mussels, scallops, and a variety of clams. The cultivated shellfish would be used to supplement subsistence harvests as a replacement for traditional foods damaged by the *EVOS*.

Complementing this option would be the creation of a shellfish hatchery using concepts already developed for the Seward shellfish hatchery and the Alaska Fish and Game Mariculture Technical Center. Engineering and biological expertise will be retained to conduct a feasibility analysis of the project. If construction funds are approved at a later date, direct restoration, replacement, and/or enhancement of bivalve shellfish will be accomplished via an onshore production hatchery operated by the private sector using technology developed at a State-operated research center. The hatchery will provide seed stock for mariculture operations or the re-seeding of beaches.

Shellfish farming in subsistence communities could provide a food source to replace traditional food sources that were injured by the oil spill, or are perceived by subsistence user as being unsafe to eat. Farmed shellfish could be a replacement for contaminated shellfish or for other types of traditional foods that are in lower abundance. As with any option that could replace or enhance the amount of subsistence harvests in subsistence communities, this option could have a high magnitude of impact, with positive benefits throughout the duration of the mariculture operations.

Threatened and Endangered Species

The U.S. Fish and Wildlife Service and the National Marine Fisheries Service have jurisdiction over Federally listed threatened and endangered species. At present, these agencies are considering the potential impacts of implementation of the Restoration Plan on listed threatened and endangered species, and candidate species for listing.

Cumulative Impacts

According to CEQ regulations (40 CFR 1508.6), cumulative impacts result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes these other actions. Significant impacts can result from actions that are individually minor but that in combination can have significant impacts over a period of time. Cumulative impacts could include the effects of other planned management actions, facilities and transportation construction, and other restoration actions being undertaken.

At the programmatic level, cumulative impacts are mainly the result of management actions, regulations, and policy decisions by other agencies (i.e., effects of programs on other programs) than effects from site-specific projects. For site-specific projects, proximity to other actions is an important determinant in assessing the cumulative impact. This component is generally missing at the programmatic level where general types of actions are considered.

To identify the potential impacts of other agencies' actions on the Restoration Plan's proposed alternatives, information on planned projects was requested from Federal, State, and local agencies, as well as Native entities located in or managing lands within the oil spill area. Among the agencies contacted were those that could have cumulative impacts at the programmatic level, such as the Federal Highway Administration, the U.S. Soil Conservation Service, the U.S. Bureau of Mines, the U.S. Army Corps of Engineers, the Environmental Protection Agency, the Federal Aviation Administration, the Alaska Marine Highway System, the Alaska Department of Transportation, the Alaska Department of Commerce, and the Alaska Energy Authority.

Several programmatic management actions are planned for the oil spill area. Many of these actions have been the subject of NEPA documentation. Environmental Impact Statements have been completed for the Chugach National Forest Plan and the Kenai National Wildlife Refuge. In addition, NEPA documentation is occurring at the site-specific level and will continue as specific projects are proposed for implementation in response to the Restoration Plan. An example of this is the EIS currently in progress for the expansion of the Main Bay Hatchery in Prince William Sound.

While the Final Restoration Plan is being developed, several projects similar to those proposed for the Plan have already been implemented under Annual Work Plans or have been proposed by the State and acted on by the Trustee Council. Alaskan House Bill No. 269 has already appropriated funds from the *Exxon Valdez* Oil Spill Restoration Fund for acquiring inholdings to the Kachemak Bay State Park for the protection and restoration of resources damaged by the spill, to enhance sport fishing services lost or diminished by the oil spill, and to restore, replace, or enhance subsistence resources. The Chenega Bay IRA Council is planning dock and port improvements and the development of a Chenega Bay Marine Service Center and is requesting matching funds from the Trustee Council. In addition, separate restoration actions are being planned using funding from the Alyeska settlement.

Several other transportation-related activities are currently planned or under way for the spill area. Any cumulative impacts of these planned activities would generally result from increased human access to formerly remote areas; this increased access could lead to gains in commercial tourism, recreation, commerce, sport fishing, and sport hunting. Increased access could also require new or increased infrastructure. Additional impacts, such as stormwater runoff, sedimentation, and increased human activity could be associated with construction of new facilities.

Under ADOT and FAA, construction has begun on a small airport at Chenega Bay, which was formerly accessible only by float plane. Activities included in the 1993-1999 Federal Highway Expansion Program, such as construction of a Cordova access road, may also affect implementation of the options contained in the Final Restoration Plan. Construction of a road from Whittier to Portage, replacing the train and ferry lines, is another reasonably foreseeable future development that could affect implementation of Restoration Plan options. Plans are also being developed to construct a 6-mile road from Cordova to Shepherd Point, which would allow access to a deep-water port that could accommodate freight and cruise ship traffic. Finally, the Department of Transportation is researching the possibility of constructing a new ferry dock in Tatitlek and a road to the new dock. Building a new road and ferry dock is also planned for Chenega Bay.

With the exception of construction projects to promote recreational opportunities, the majority of activities in the Restoration Plan would be implemented by regulation or through land acquisition. Cumulatively, land acquisition could have an effect on the amount of timber available for harvest, but until specific properties are targeted for purchase, the cumulative effects are unknown.

Irreversible and Irretrievable Commitment of Resources

Irreversible use of a resource results in the loss of the option of use in the future. Irreversible commitment applies primarily to the effects of use of nonrenewable resources, such as minerals or cultural resources, or to those factors, such as soil productivity that are renewable only over long periods of time.

Identifying a resource as irretrievable refers to the loss of production, harvest, or use of natural resources. For example, some or all of the timber production from an area is lost irretrievably while an area is serving as a recreational facility. The production lost is irretrievable, but the action is not irreversible. If the use changes, it is possible to resume timber production.

The alternatives proposed for implementation in the *EVOS* Restoration Plan do not involve any irreversible or irretrievable commitments of resources. Some options would ultimately involve construction of recreational facilities or in-stream physical habitat improvements (e.g., fish ladders). No site specific plans for construction activities were included for review in this DEIS. Upon proposal of detailed construction plans, an environmental analysis will be performed that will determine whether resources would be irreversibly or irretrievably affected.

Mitigation

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Mitigation, as defined by the Council on Environmental Quality (CEQ) in 40 CFR 1508.20, includes impact avoidance through choosing not to implement an action, or parts of that action; minimizing impacts through limiting the degree or magnitude of the action and its implementation; correcting impacts by repairing, rehabilitating, or restoring the affected environment; reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and compensating for the impact by replacing or providing substitute resources or environments.

At a programmatic level, mitigation would be comparable to implementation of planning activities as documented in Forest Service Management Plans, State or Federal highway administration management plans, and State or Federal resource management plans (e.g., Alaska State Hunting Regulations). Standards specified in Federal and State regulations are intended to provide a level of protection for all managed resources that is adequate to mitigate significant adverse environmental impacts from implementation of the proposed *EVOS* Restoration Plan. For example, the National Forest Management Act regulations and Forest Service Directives System would be used as a guideline for standard procedures and appropriate mitigation pertaining to the use and future development of wilderness areas for recreational purposes, including construction of backcountry sanitation facilities. The Alaska State Hunting Regulations specify bag limits and hunting seasons by species and game management unit to protect these resources from overharvesting. Regulations are not mitigation in the NEPA context, although these regulations can have the some effect as mitigation proposed where no regulatory agency has jurisdiction.

Although all practical means to minimize any adverse environmental effects resulting from implementation of the proposed *EVOS* Restoration Plan would be employed, no specific mitigation measures have been proposed as additional environmental analysis are expected at the project level.

The following Federal and State laws and regulations would provide protection to affected resources and services, and although those statutes are not mitigation in the NEPA context, they would help to ensure the prevention of adverse effects from implementation of the proposed *EVOS* Restoration Plan:

- Endangered Species Act of 1973 (16 U.S.C. 1531)
- Marine Mammal Protection Act of 1972 (16 U.S.C. 1361 *et seq.*)
- Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712)
- Bald Eagle Protection Act of 1940 (16 U.S.C. 668)
- Alaska Coastal Management Act of 1977 (A.S. 46.40)
- Coastal Resource District Management Plans (6 AAC 80 & 85)
- ADF&G Anadromous Stream and Fishway Acts (A.S. 16.05.870)
- Clean Water Act of 1977 (33 U.S.C. 1251 & 1344)
- National Historic Preservation Act of 1966 (16 U.S.C. 470 *et seq.*)
- Section 22 (g) of Alaska Native Claims Settlement Act of 1972

- State and local zoning regulations.

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Site specific mitigation measures will be included in future environmental documents prepared for specific projects proposed pursuant to the *EVOS* Restoration Plan.

Analytical Tools/Methodology

This section describes the general principles and specific aspects of the impact assessment methodology used for this analysis of the impacts projected to result from implementation of the *Exxon Valdez* Oil Spill Restoration Plan. The impact assessment methodology described below was used to analyze each of the proposed alternatives.

This methodology takes into account both the dynamic nature of the Restoration Plan and the generic definition of the options to be included in the Restoration Plan alternatives. For each of the resources and services being evaluated, certain assumptions regarding the actual implementation of options were necessary. As appropriate, these assumptions are identified in the analysis of impacts in Chapter IV for each resource and service included in the analyses.

To perform the impact analysis of the proposed action (implementing the Restoration Plan) presented in Chapter IV, analysts employed a methodology that accounted for the various impacts that affect the biological, physical, and socioeconomic environment. Impacts were classified in five ways: direct, indirect, short-term, long-term, and cumulative. These types of impacts are interdependent. There can be long-term direct impacts, short-term cumulative impacts, and so on. For each resource or service being evaluated, the analysts identified the type of impact to help the reviewers and decisionmakers make sound, reasoned decisions for the short term as well as for the long term.

Direct impacts are those that are the immediate result of, or the initial reaction to, the action being evaluated. Indirect impacts are those that are the reaction to the direct impacts, or the second-tier impacts. In other words, indirect impacts are the consequence of direct impacts, and are not in themselves a direct result of the action. Indirect impacts are often difficult to identify because they may or may not occur, making their definition speculative. Quantifying indirect impacts is usually not possible or warranted. Additionally, there is often little distinction between indirect impacts, particularly in the long term, and cumulative impacts.

Cumulative impacts are a summation of the impacts related to the action being evaluated and concurrent actions being taken that are similar to, or are in close proximity to, the action being considered. Cumulative impacts often are not identifiable until well after the action has been taken. At the same time, however, they can be the source of controversy and litigation. The analysts responsible for writing this EIS have made every effort to account for cumulative impacts in the environmental impact analyses.

Short-term impacts are those that occur for a relatively short time and then abate. If the time frame is an important variable that should be considered by the decisionmaker, this is stated in the text. Long-term impacts are those whose duration or manifestation occurs for a relatively long time or that become manifest at some future time. As with short-term impacts, the long-term time frame is specified if it may influence the decisions to be made. To ensure that the full impact of the action being considered is identified, the full complement of impact types is considered in the environmental impact analysis.

As a basis for the determination of impacts, the analysts considered certain predetermined factors to arrive at impact determinations. When performing the analysis of impacts on various resources and services, the action being analyzed was viewed in terms of these factors. This approach allowed the analysts to preform a systematic analysis and to document the process used to reach their determinations and conclusions.

For determining the affects of proposed actions on the natural environment, the following four factors were used:

- Magnitude
- Geographic extent
- Duration and frequency
- Likelihood.

The ***magnitude*** of an impact reflects its relative size, amount, or intensity. The ***geographic extent*** of an impact considers how widespread the impact might be. The ***duration and frequency*** of an impact considers whether it is a one-time event, an intermittent occurrence, or a chronic occurrence. The ***likelihood*** of an impact assesses whether a possible impact is likely to occur.

Because the magnitude of an impact captures its intensity, taking into consideration the other three factors, this criterion has been closely analyzed and given particular attention in the assessment of environmental impacts. If the magnitude of an impact is expected to be large, this is generally stated in the impact analyses.

The specific aspects of the process followed by EIS team analysts, while following the general procedure described above, depended upon the resource or service being evaluated. In general, however, the process of developing and presenting minimum levels of evidence and analysis of impacts for all resources and services is essentially the same. The reasons for using a generally uniform, systematic approach are (1) to satisfy the NEPA requirement for a "hard look" at the actions being proposed, and (2) to provide decisionmakers with sufficient information to make informed decisions, while ascribing to the "rule of reason" implicit in the NEPA process.

Whereas an Environmental Assessment (40 CFR 1508.9) aims to provide sufficient evidence and analysis for determining the significance of impacts, an EIS assumes that significant impacts would occur from the implementation of the proposed action, in this case the *EVOS* Restoration Plan. Consequently, impacts described in this Draft EIS are presented with the intent of providing decisionmakers with an analysis of all impacts, regardless of their significance.

The first step in the analysis was the review of impact-related data and literature. This information was synthesized to provide a "snapshot" of the baseline conditions described in Chapter III of the EIS. Because this is a programmatic EIS, involving no new research, the use

Direct effects calculated by IMPLAN are changes associated with the immediate effects of changes in demand. Indirect effects reflect changes in input needs such as additional purchases to produce additional output in industries associated with the directly affected industries. Induced effects are the changes in spending patterns caused by the changes in income generated by the direct and indirect effects.

For example, the purchase of development rights would cause a decrease in output by the forest products industry (direct effect). In turn, the industries that supply the forest products industry would see their sales fall (indirect effects). Finally, the decrease in demand would cause income and employment to fall, reducing spending in the economy in general (induced effects). The corollary is also true. In this example, the purchase of development rights increases the income of the owners of the rights. They spend this income, which increases demand for the products they buy (direct effects). In turn, the industries that supply the directly affected industries experience an increase in demand for their products (indirect effects). Finally, this increase in demand increases employment and income, which stimulates the economy in general (induced effects).

At its simplest level, the estimated change in income and employment is the product of the demand change (in this case, an alternative) and a multiplier. Multipliers are specific to a region and industry. Multipliers have the ability to consider three interrelated factors. First, not all alternative-related income would be spent; some would be saved. Second, some alternative-related spending would occur outside the economic study region. Third, only some alternative-related income spent within the region may create more jobs. The IMPLAN approach considers these factors when it computes multipliers for the economic impact assessment presented in this chapter.

of existing data was essential. No new research efforts or analytical tools were necessary or warranted for the EIS given the nature of the decisions to be made regarding Restoration Plan alternatives.

After obtaining the necessary understanding of the resources (species) and services (human uses) included in Restoration Plan alternatives, the most important aspect of the evaluation process was to define, to the degree possible, each of the options being proposed for implementation in the various alternatives. In order to do this, all information available describing the options has been reviewed. This includes all option write-ups that currently exist, such as option short-forms, project proposals, "Opportunities for Habitat Protection/Acquisition," and Restoration Framework documents. The specificity of the option descriptions were the limiting factor in the identification of impacts.

Each analyst compared the issues identified in Chapter I with the restoration options affecting the resource or service being evaluated. A determination of the degree to which each of the issues is addressed by each alternative was compiled and presented following the impact analyses of all options and alternatives. This effort was intended to ensure that each issues was addressed to the fullest extent possible.

For resources and services such as air, water, sediment, or designated wilderness areas for which no restoration options were identified, no determination of impact has been made. Statements regarding the future submission of proposals affecting these resources include references to the preparation of additional environmental analyses (i.e., Environmental Assessments or Environmental Impact Statements). In addition to those resources for which no restoration options were proposed, resources or services affected by proposed and possible future options that specifically target an area, species population, or user group may also require further environmental analysis. The intent of identifying this need is to ensure that future options that the Trustee Council may want to consider for funding are not precluded from consideration under the Restoration Plan because they were not considered in the EIS.

The economic impact analysis was conducted apart from the impact analysis for physical, biological, and cultural resources. For the economic impact assessment of Restoration Plan implementation, the USDA Forest Service's IMPLAN economic impact assessment model was used. Results of IMPLAN analyses are presented for each alternative in the Restoration Plan.

IMPLAN is a computer model developed by the United States Department of Agriculture to perform regional economic impact analysis. The model is versatile and allows analysis of economies as small as one county and its associated industries. For this analysis, the Alaska data set, based on 1990 Census data, was used.

Using IMPLAN to perform an economic impact analysis proceeds as follows. First, the regional economy experiences a change, up or down, in demand. Next, the changes in spending and respending associated with the demand change are traced through the economy. Finally, the consequences of the demand change are stated in terms of direct, indirect, and induced changes in regional income, population, and employment.