EIS
C

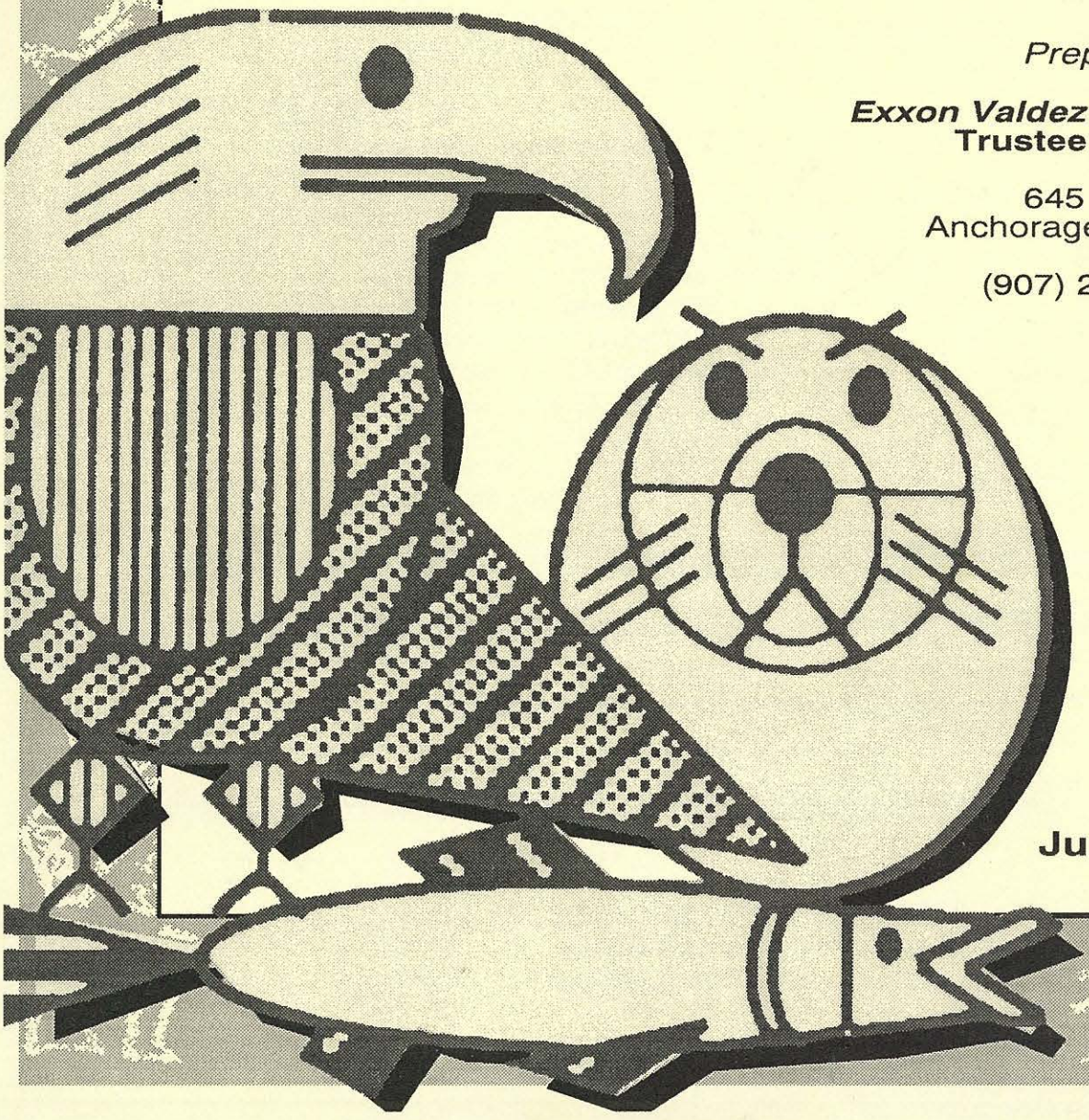
Supplement

to

DRAFT

EXXON VALDEZ OIL SPILL RESTORATION PLAN

Summary of Alternatives for Public Comment



Prepared by:

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

645 G Street
Anchorage, Alaska
99501
(907) 278-8012

June 1993

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Supplement to the

DRAFT *EXXON VALDEZ* OIL SPILL RESTORATION PLAN

Summary of Alternatives for Public Comment

In response to your request, this Supplement is being provided to help you understand and comment on the newspaper brochure that you previously received, the Draft *Exxon Valdez* Oil Spill Restoration Plan: Summary of Alternatives for Public Comment. The Summary of Alternatives asked you to express your opinion on how the Trustee Council should restore injured resources and lost or reduced services. It also specifically requested comment on policy questions and restoration alternatives. At public meetings and presentations in April and May, many people asked for more information before making comments. This Supplement to the Summary of Alternatives provides commonly requested information. Remember, public comments on the Summary of Alternatives are due by August 6th.

The Supplement consists of the following six sections.

SECTION A - Allocation of the Civil Settlement Fund (June 1993): This section describes expenditures from the $900 million civil settlement, including projects funded under the 1992 and 1993 Annual Work Plans.

SECTION B - Injury and Recovery: This section describes injuries to resources and lost or reduced services. Information on the recovery status of these resources and services is also presented. This section is based on the latest available data from injury assessment studies.

SECTION C - Habitat Protection and Acquisition: Section C describes the process used to date for protecting and acquiring habitat on private lands. Examples are provided of how land parcels are ranked. The section also explains likely changes in the habitat evaluation process and options for protecting habitat on land already in public ownership.

SECTION D - General Restoration Options: Section D provides examples of options for restoring injuries. Some options involve direct manipulation of resources, such as improving salmon spawning and rearing habitat. Others focus on managing human uses of resources, such as implementing cooperative programs to assess effects of subsistence harvests on marine mammals.

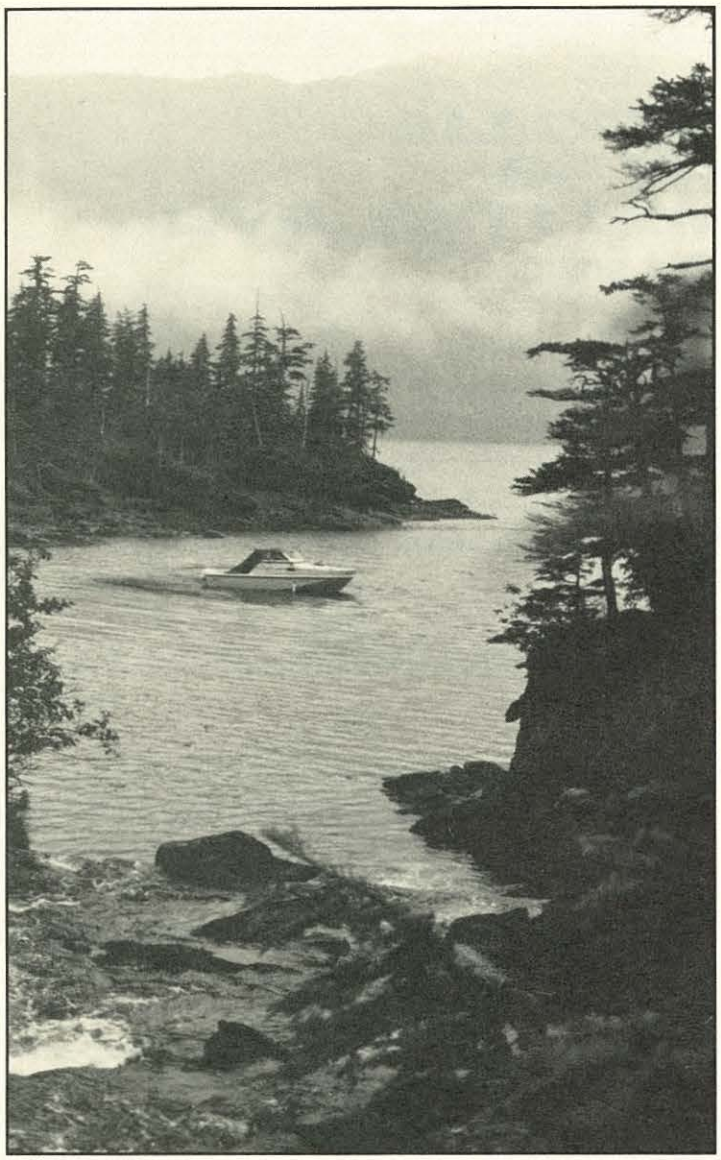
SECTION E - Restoration Monitoring and Research Program: The restoration program will likely include monitoring of recovery and restoration activities. Ecosystem monitoring and research on new restoration techniques may also be included. This section describes all of these components.

SECTION F - Boundaries of the Oil Spill Area: This section contains a map of the area affected by the oil spill. This map is a revised version of the one included in the Summary of Alternatives, and now includes Perryville and Ivanof Bay. These changes were made in response to public comments which pointed out that these areas met the established criteria for inclusion in the spill area.

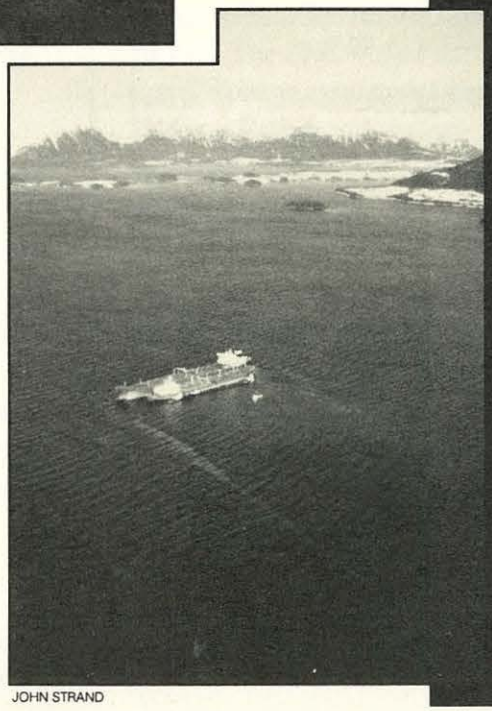
Section A

ALLOCATION OF CIVIL SETTLEMENT FUND

(June 1993)



U.S. FOREST SERVICE



JOHN STRAND

Section A

ALLOCATION OF THE CIVIL SETTLEMENT FUND

(June 1993)

In a civil settlement, Exxon Corporation agreed to pay the United States and the State of Alaska $900 million over a 10-year period to restore resources injured by the *Exxon Valdez* oil spill and reduced or lost services.

Table A-1 shows the schedule of payments over this period.

As of June 1993, $240 million of the $900 million civil settlement has been paid by Exxon Corporation. Exxon makes its restoration payments to a Joint Trust Fund held by the U.S. District Court for use by the Trustee Council. About $200 million has been reimbursed directly to accounts of the governments, credited to Exxon, or committed for restoration and damage assessment projects and administration. Some of the approved expenditures have not yet been withdrawn from the balance in the Joint Trust Fund. This section contains five more tables that describe how the Trustee Council has used these funds.

Table A-2 shows how the $240 million was allocated: 45% was reimbursed to the state and federal governments for expenses; nearly 23% was committed to Work Plans for 1992 and 1993; and 17% was credited to Exxon for cleanup expenses. About 16% is uncommitted. On May 13, 1993, the Trustee Council approved purchase of Seal Bay, Afognak Island, for $38.7 million pending results of negotiations and appraisal. This potential acquisition is not fully reflected in these figures.

Table A-3 shows how reimbursements to the state and federal governments have been allocated. Of the $58 million reimbursed to the state government, 30% was for litigation, 33% was for damage assessment, and 37% was for cleanup and response. The federal government received about $49 million. Data on the distribution of reimbursements to the federal government are not available. An additional $39.9 million was credited to Exxon for the cost of cleanup required by the U.S. Coast Guard after January 1, 1991.

Table A-4 shows how the 1992 Work Plan allocated funds among restoration projects, damage assessment, and administration **Table A-5** does the same for the 1993 Work Plan. The figures reported for the 1993 Work Plan are for the period 3/1/93 - 9/30/93. The 1993 Work Plan is for a 7-month period of transition to the federal fiscal year, which begins 10/1/93. The 1992 Work Plan emphasized completion of damage assessment studies; the 1993 Work Plan emphasizes restoration. Restoration includes monitoring, habitat protection, and general restoration projects.

Table A-6 combines allocations for both work plans. Of the $54 million approved by the Trustee Council for both work plans, 68% has been for restoration, 15% for damage assessment, and 17% for administration. Over half the allocation to restoration projects was for habitat protection.

TABLE A-1

Schedule of Payments

DATE	AMOUNT
December 1991	**$90 million**
December 1992	**$150 million**
September 1993	**$100 million**
September 1994	**$70 million**
September 1995	**$70 million**
September 1996	**$70 million**
September 1997	**$70 million**
September 1998	**$70 million**
September 1999	**$70 million**
September 2000	**$70 million**
September 2001	**$70 million**
TOTAL	**$900 million**

Table A-2

Allocation of Civil Settlement Received as of June 1993

PURPOSE	ALLOCATION	PERCENT	COMMENTS
Reimbursements to state and federal governments	**$107,500,000**	**44.8%**	See Table A-3 for details.
1992 Work Plan	**$19,211,000**	**8.0%**	See Table A-4 for details.
1993 Work Plan	**$35,054,000**	**14.6%**	See Table A-5 for details.
Credit to Exxon for cleanup costs after 01/01/91.	**$39,900,000**	**16.6%**	
Uncommitted	**$38,335,000**	**16.0%**	
TOTAL	**$240,000,000**	**100.0%**	

Funds not yet withdrawn from the Joint Trust Fund are earning interest.

Table A-3

REIMBURSEMENTS TO STATE AND FEDERAL GOVERNMENTS

PURPOSE	AMOUNT	PERCENT
STATE		
Litigation	$17,400,000	30%
Damage Assessment	$19,300,000	33%
Cleanup and Response	$21,600,000	37%
SUBTOTAL	**$58,300,000**	**100%**
FEDERAL	$49,200,000	
TOTAL	**$107,500,00**	

Table A-4

1992 WORK PLAN

The Trustee Council approved $19,211,000 for the 1992 Work Plan, which was undertaken during the period 3/1/92 through 2/28/93. Of that amount, 39% was used to close out or continue Natural Resource Damage Assessment, 26% was for administration, and 35% was for restoration. Because the focus of this planning process is restoration, this table describes only restoration projects approved in the 1992 Work Plan. It does not describe damage assessment or administration projects.

Restoration Projects

PROJECT NUMBER	PROJECT TITLE	PROJECT DESCRIPTION	AMOUNT APPROVED	PERCENT
R11 RM	**Murre Restoration Recovery Monitoring**	Document rate of recovery of murres breeding in the Barren Islands and Puale Bay.	**$316,700**	
R15 HP	**Marbled Murrelet Restoration Study**	Determine marbled murrelet nesting habitat in the spill area and identify their use of those habitats.	**$419,300**	
R47 HP	**Stream Habitat Assessment**	Identify and prioritize private lands where an imminent and significant habitat alteration threat exists.	**$399,600**	
R53 RM	**Kenai River Sockeye Salmon Restoration**	Restore injured Kenai River sockeye salmon stocks through im-proved stock assessment, capabilities, regulation of spawning levels, and modification of human use.	**$674,200**	
R59 RM	**Genetic Stock Identification**	Use genetic stock identification to protect injured Kenai River salmon in mixed-stock areas.	**$320,900**	
R60AB RM	**Prince William Sound Pink Salmon**	Recover coded-wire tags in the catches and spawning populations of pink salmon in Prince William Sound.	**$1,479,700**	
R60C	**Pink Salmon Egg/Fry**	Monitor recovery of wild pink salmon stocks in Prince William Sound	**$492,800**	
R71 HP	**Harlequin Duck Restoration and Monitoring**	Locate, identify and describe harlequin duck nesting habitat in PWS; determine width of forested buffer strips, and feasibility of stream habitat enhancement techniques	**$424,500**	
R73 RM	**Harbor Seals**	Monitor movements, hauling out, and diving behavior of harbor seals in Prince William Sound.	**$25,000**	

Table A-4 *continued*

PROJECT NUMBER	PROJECT TITLE	PROJECT DESCRIPTION	AMOUNT APPROVED	PERCENT
R90	**Dolly Varden Char Monitoring**	Remove weir material and camp equipment from field locations and produce final report	**$91,500**	
R92	**GIS Mapping and Analysis: Restoration**	Develop information as needed to evaluate or implement restoration projects.	**$125,500**	
R102	**Herring Bay Experimental and Monitoring Study**	Determine what factors limit or facilitate recolonization of the intertidal by algae, especially Fucus, and invertebrates; and to provide controlled, long-term natural recovery monitoring of intertidal communities.	**$485,600**	
R103	**Oiled Mussels**	Determine the geographical extent of oiled mussel beds in the spill area, the intensity of oil remaining in mussels, and the underlying organic mat in order to assess possible linkage with continuing injury to harlequin ducks, oystercatchers, juvenile sea otters, and river otters.	**$874,000**	
R104A	**Site Stewardship**	Recruit, educate, and involve local people to protect archaeological resources in their areas.	**$159,200**	
R105	**Study and Evaluation of Instream Habitat and Stock Restoration Techniques for Anadromous Fish**	Determine preliminary restoration techniques for specific sites; select the most appropriate fish restoration projects.	**$348,100**	
R106	**Dolly Varden Restoration**	Prepare final report for the data collected in this project through 1991.	**$34,900**	
R113	**Red Lake Sockeye Salmon Restoration**	Increase survival of wild salmon in Red Lake (Kodiak Island) by incubating eggs and rearing fry in Pillar Creek Hatchery and transplanting them to the lake.	**$55,900**	
		RESTORATION PROJECTS - Subtotal	**$6,727,400**	**35%**
		DAMAGE ASSESSMENT	**$7,407,500**	**39%**
		ADMINISTRATION	**$5,076,100**	**26%**
		TOTAL	**$19,211,000**	**100%**

Table A-5

1993 WORK PLAN

The Trustee Council approved $35,054,000 for the 1993 Work Plan, which will be undertaken during the 7-month period 3/1/93 through 9/30/93. Of that amount, less than 2% will used for Natural Resource Damage Assessment, 12% will be for administration, and over 86% will be used for restoration. Because the focus of this planning process is restoration, this table describes only restoration projects approved in the 1993 Work Plan. It does not describe damage assessment or administration projects.

Restoration Projects

PROJECT NUMBER	PROJECT TITLE	PROJECT DESCRIPTION	AMOUNT APPROVED	PERCENT
93003	**Salmon Egg to Pre-emergent Fry Survival**	Continue to monitor egg mortalities in the oiled and unoiled wild pink salmon streams.	**$686,000**	
93006	**Site-Specific Archaeological Restoration**	Assess injury at 24 sites and restore 19 of them.	**$260,100**	
93012	**Genetic Stock Identification of Kenai River Sockeye Salmon**	Develop a comprehensive database of sockeye salmon stocks in Cook Inlet.	**$300,600**	
93015	**Kenai River Sockeye Salmon Restoration**	Increased monitoring and management of the sockeye salmon stocks in the Kenai River and Upper Cook Inlet north of Anchor Point.	**$512,600**	
93016	**Chenega Bay Chinook and Silver Salmon (NEPA Compliance)**	NEPA compliance for the replacement of subsistence resources by permitted releases of chinook and coho salmon at designated sites near Chenega village from stocks of hatchery near Esther Island.[1]	**$10,700**	
93017	**Subsistence Food Safety Survey and Testing**	Work with communities to identify and map areas and resources of continuing concern to subsistence users; sample subsistence foods from these areas.	**$307,100**	
93022	**Monitor Murre Colony Recovery**	Monitor the recovery of murres in the Barren Islands.	**$177,200**	
93024	**Restoration of Coghill Lake Sockeye Salmon Stock**	Sockeye Salmon Stock Restore natural productivity of Coghill Lake for sockeye salmon through use of lake fertilization techniques.	**$191,900**	

[1] Although NEPA (National Environmental Policy Act of 1969, as amended) compliance was undertaken in 1993, the project itself will be deferred until 1994.

Table A-5 *continued*

PROJECT NUMBER	PROJECT TITLE	PROJECT DESCRIPTION	AMOUNT APPROVED	PERCENT
93033	**Harlequin Duck Restoration Monitoring Study in PWS, Kenai and Afognak Oil Spill Areas**	Study harlequin duck reproductive failure in western PWS; on outer Kenai coast and Afognak Island determine if there is reproductive failure and characterize their nesting habitat.	**$300,000**	
93034	**Pigeon Guillemot Colony Survey**	Identify and map pigeon guillemot colonies.	**$165,800**	
93035	**Black Oystercatchers/ Oiled Mussel Beds**	Determine whether black oystercatchers breeding on shorelines with persistent oil contamination in Prince William Sound are affected by their use of these habitats.	**$107,900**	
93036	**Oiled Mussel Beds**	Document continued bioavailability of petroleum hydrocarbons to consumers of contaminated mussels and determine the rate of recovery of oiled mussel beds.	**$404,800**	
93038	**Shoreline Assessment**	Assess the shoreline hydrocarbon concentrations and, where appropriate, carry out necessary treatment using local work crews.	**$539,200** [2]	
93039	**Herring Bay Experimental and Monitoring**	Determine what factors limit or facilitate recolonization of the intertidal by algae, especially Fucus, and invertebrates; and to provide controlled, long-term natural recovery monitoring of intertidal communities.	**$507,500**	
93041	**Comprehensive Monitoring**	Design the monitoring component of the Restoration Plan.	**$237,900**	
93042	**Killer Whale Recovery**	Obtain photographs of individual killer whales occurring in AB pod and document natural recovery.	**$127,100**	
93043	**Sea Otter Demographics and Habitat**	Restore sea otter populations by determining what is limiting their recovery and identifying important sea otter habitat in Prince William Sound for possible protection.	**$291,900**	
93045	**Marine Bird / Sea Otter Surveys**	Obtain annual estimates of the summer and winter populations of marine birds and sea otters in Prince William Sound to determine whether populations that had declined are recovering.	**$262,400**	

2 This amount includes $15,000 for U.S. Coast Guard transportation.

Table A-5 *continued*

PROJECT NUMBER	PROJECT TITLE	PROJECT DESCRIPTION	AMOUNT APPROVED	PERCENT
93046	**Habitat Use, Behavior, and Monitoring of Harbor Seals in PWS**	Monitor the abundance and trends of harbor seals in oiled and unoiled areas of Prince William Sound and characterize habitat use, hauling out and diving behavior.	**$230,500**	
93047	**Subtidal Monitoring**	Monitor recovery of sediments, hydrocarbon-degrading microorganisms, eelgrass beds, and shallow fish species in the subtidal environment.	**$1,000,800**	
93051	**Habitat Protection Information for Anadromous Streams and Marbled Murrelets**	Assess marbled murrelet nesting habitat; survey anadromous fish streams on candidate lands for habitat protection.	**$1,222,300**	
93053	**Hydrocarbon Database**	Estimate the amount of Exxon Valdez oil that is present in environmental samples analyzed for hydrocarbons that are collected during restoration.	**$105,500**	
93057	**Damage Assessment Geographic Information System**	Complete statistical analysis and geographic information system mapping support for existing damage assessment studies and provide a database for restoration.	**$67,500**	
93059	**Habitat Identification Workshop**	Identify parcels of nonpublic lands with habitat necessary for recovery of injured resources and services under imminent threat.	**$42,300**	
93060	**Accelerated Data Acquisition**	Collect and organize existing resource data needed to evaluate habitat protection and acquisition proposals.	**$43,900**	
93062	**Restoration Geographic Information System**	Provide statistical and spatial analysis and geographic information system mapping support for approved restoration projects.	**$123,300**	
93063	**Anadromous Stream Surveys**	Develop proposals and designs for appropriate and cost-effective instream habitat and stock restoration projects.	**$59,400**	
93064	**Imminent Threat Habitat Protection**	Protect habitat under imminent threat.	**$20,000,000**	

Table A-5 *continued*

PROJECT NUMBER	PROJECT TITLE	PROJECT DESCRIPTION	AMOUNT APPROVED	PERCENT
93065	**Prince William Sound Recreation Project**	Develop proposals for restoration of recreation in Prince William Sound and evaluate recreation management by identifying and evaluating potential state and/or federal special recreation designation.	**$71,000**	
93066	**Alutiiq Museum and Culture Center**	Construct a Native museum and culture center to educate the public and provide a center for research and preservation.	**$1,500,000**	
93067	**Pink Salmon Coded-Wire Tag Recovery Program**	Recover coded-wire tags from pink salmon in Prince William Sound to distinguish between wild stocks and hatchery stocks.	**$220,000**	
93068	**Non-Pink Salmon Coded-Wire Tag Recovery Program**	Recover coded-wire tags from fish other than pink salmon.	**$126,400**	
		RESTORATION PROJECTS - Subtotal	**$30,203,600**	**86%**
		DAMAGE ASSESSMENT	**$714,600**	**2%**
		ADMINISTRATION	**$4,135,800**	**12%**
		TOTAL	**$35,054,000**	**100%**

Table A-6

Combined Allocations for 1992 and 1993 Work Plans

PURPOSE	1992 ALLOCATION	1993 ALLOCATION (3/1/93-9/30/93)	TOTAL	PERCENT
RESTORATION PROJECTS	**$6,727,400**	**$30,203,600**	**$36,931,000**	**68%**
DAMAGE ASSESSMENT	**$7,407,500**	**$714,600**	**$8,122,100**	**15%**
ADMINISTRATION	**$5,076,100**	**$4,135,800**	**$9,211,900**	**17%**
TOTAL	**$19,211,000**	**$35,054,000**	**$54,265,000**	**100%**

Section B

INJURY AND RECOVERY

W. PERRY CONWAY

ED KLINKHART

VANESSA VICK

Section B

INJURY AND RECOVERY

Background

The *T/V Exxon Valdez* struck Bligh Reef in March, just before the most biologically active season of the year. The resulting oil spill occurred during the seaward migration of salmon fry, major migrations of birds, and the primary breeding season of most species of birds, mammals, fish, and marine invertebrates in the spill's path. Approximately 1500 miles of southcentral Alaska's coastline were oiled (about 350 miles were heavily oiled), frequently with devastating impact to the upper intertidal zone. Direct oiling killed many organisms, and beach cleaning, particularly high pressure, hot water washing had a devastating effect on intertidal communities. The spill also affected human uses (services), including subsistence, recreation, commercial fishing, and other uses. Some resources and services remain vulnerable to persistent oil in intertidal areas.

This section describes in detail the injuries sustained by individual resources and services, and what scientists and resource managers know about the present status of recovery. **Table B-1** lists injured resources and lost or reduced services. Where possible expectations for the progress of natural recovery are also made. Information on injury and recovery is summarized in **Tables B-4, B-5** and **B-6** at the end of the section.

Table B-1

Injured Resources and Reduced or Lost Services

Resources

POPULATION DECLINE	INJURED, BUT NO POPULATION DECLINE	OTHER
Black oystercatcher	Bald eagle	Archaeological resources
Common murre	Cutthroat trout	Designated wilderness areas
Harbor seal	Dolly Varden	
Harlequin duck	● Killer whale	
Intertidal organisms	Pacific herring	
Marbled murrelet	● Pink salmon	
Pigeon guillemot	River otter	
Sea otter		
Sockeye salmon		
Subtidal organisms		

● *For these species, the Trustee Council's scientists have considerable disagreement over the conclusions to be drawn from the results of the damage assessment studies.*

Services

(Human uses)

Commercial fishing
Commercial tourism
Passive use
Recreation including sport fishing, sport hunting, and other recreation use
Subsistence

INJURY TO NATURAL RESOURCES

A natural resource has experienced injury if it has sustained a loss due to exposure to oil spilled by the *T/V Exxon Valdez,* or a loss which otherwise can be attributed to the oil spill and clean-up.

Loss includes:

1) ***direct mortality: animals killed by contact with oil or by the cleanup;***

2) ***sublethal and chronic effects: injuries to a life stage such as eggs or larvae, but that may not result in mortality; and***

3) ***degradation of habitat: alteration or contamination of flora, fauna, and the physical components of the habitat.***

In some cases, injuries result in measurable population declines that may persist for at least one generation. In other cases, they do not.

Population-Level Injuries

The most serious injuries are those that have resulted in measurable declines in population. In these cases, injury may persist for more than one generation; that is, the injury will not usually be repaired over the life span of the generation affected. For example, the common murre was the most severely impacted bird species; several large colonies in the Gulf of Alaska may have lost 35% to 70% of their breeding adults, a loss that may not be restored for many generations.

The oil spill and cleanup altered and contaminated the flora, fauna, and physical components of the habitats of many species. This is most pronounced in intertidal and shallow subtidal areas where populations of many species of plants and invertebrates declined as a result of oiling or cleanup. The persistence of oil in some intertidal habitats may continue to affect the many natural resources that use these habitats as well as the services they provide.

If serious enough, direct mortality, sublethal effect, or degradation of habitat may result in measurable population declines.

Injured But No Measurable Population Decline

There are several reasons why an oil spill injury may not result in a measurable population decline that persists for more than one generation. Natural variability associated with the estimate of abundance for a species may mask any effect of the injury; that is, available scientific measurement techniques may be insensitive to detection of some injuries. Also, some affected species may compensate for injury by increasing productivity. Other species did not suffer mortality. Rather, their injuries were sublethal.

INJURY TO OTHER NATURAL RESOURCES

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

The spill also resulted in oiling of waters adjacent to designated wilderness areas, with oil deposited above the high tide line in many cases. The intense cleanup that followed resulted in an unprecedented disturbance of the area's undeveloped and normally uninhabited landscape. The massive intrusion of people and equipment associated with cleanup has ended, but direct injury to wilderness and intrinsic values lingers.

REDUCED OR LOST SERVICES

Human use (service) has experienced reduction or loss if the *Exxon Valdez* oil spill or cleanup:

1) has significantly reduced the physical or biological functions performed by natural resources; or

2) has significantly reduced aesthetic and intrinsic values, or other indirect uses provided by natural resources.

This definition covers a wide range of services dependent upon the injured natural resources. Some examples are commercial fishing, subsistence (hunting, fishing, and gathering), passive use, commercial tourism and recreation. Some recreation examples include sea kayaking, backcountry camping, sport fishing, and hunting.

CONCEPTS CRITICAL TO UNDERSTANDING RECOVERY

Many resources and services will recover to prespill levels without intervention. For many resources and services, there is no known restoration approach that will effectively accelerate recovery. Other resources and services that were declining before the spill will continue to decline if present trends continue.

To maximize the benefits of restoration expenditures, the Trustee Council may consider the effects of natural recovery before investing restoration dollars. The Trustee Council has adopted the following definition of recovery to address this need.

In a scientific sense, full ecological recovery will have been achieved when the prespill population of flora and fauna are again present, healthy and productive, and there is a full complement of age classes at former abundances. A fully recovered ecosystem is one which provides the same functions and services as were provided by the prespill, uninjured system.

To predict the amount of time needed for a species to recover is extremely difficult. Scientists often use models based on factors such as population numbers and growth rates. However, for many of the biological resources injured by the *Exxon Valdez* oil spill, the background information was not available to develop these predictive models. For those resources, peer reviewers and agency scientists based their estimates of recovery on the best available information from the damage assessment and restoration studies, the scientific literature and other sources.

Estimates of recovery provided in this section should be used with caution, but they are the best that can be provided under the circumstances. For some estimates, there is also substantial disagreement within the scientific community. The estimates are likely to change as recovery continues, more information is provided through monitoring, and scientists learn more about the species. Recovery estimates for services are not provided. Recovery is linked, in part, to the resources that support the service, but is also linked to changes in human perception of injury and can vary widely among user groups.

MARINE MAMMALS

Harbor Seals

INJURY:

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

Many seals were exposed to oil in 1989. At 25 haulout areas in Prince William Sound that have been regularly surveyed since 1984, 86% of the seals seen in the postspill spring (April) survey were extensively oiled and a further 10% were lightly oiled. This included many pups. By late May, 74% 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.

RECOVERY:

Because harbor seal populations have declined precipitously since 1984, and the underlying causes of this decline are unknown, it is difficult to predict recovery from the oil spill. However, stable counts in 1990 to 1992 at haulouts within Prince William Sound may indicate an end to the ongoing decline within the Sound. There is evidence suggesting that the subsistence harvest has declined since the spill, which may contribute to the stabilization of the population. If the population has stabilized, growth may soon begin to replace the estimated 345 seals killed during the spill. However, additional information on the rate of exchange between seal populations in Prince William Sound and the Gulf of Alaska, particularly with the large Copper River Delta population, as well as a better understanding of the causes of the prespill decline, would be required to improve predictions of the time needed for recovery.

Humpback Whales

INJURY:

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 reproduction been affected.
Photodocumentation studies confirmed that normal use of lower Knight Island Passage resumed in late 1989.

RECOVERY:

Other than a temporary displacement, there is no evidence of injury. No estimate of recovery was made.

Killer Whales

INJURY:

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% per year, so it would be unusual for more than three to four 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% mortality rate. In 1990, an additional six individuals were found missing from AB pod, resulting in an annual mortality rate of 20.7% (prespill mortality for the resident AB pod typically ranged from 3.1% to 9.1% 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 strong 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 whale biology, the circumstances of the spill and the toxicity of crude oil, these deaths may not be due to contact with oil spilled by the *T/V Exxon Valdez*.

RECOVERY:

Despite the loss of a large number of reproductive females, AB pod is growing again. One birth was recorded in 1991; and two births were recorded in 1992. It is expected that AB pod may not recover to its prespill level of 32 to 36 individuals for more than a decade.

Sea Lions

INJURY:

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 last 30 years in the north Pacific Ocean—as great as 93%. This decline combined with seasonal movements, which are significant but not well understood, hindered determining if the sea lion population in the Gulf of Alaska was 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.

RECOVERY:

Because it was not possible to establish that sea lions were injured by the oil spill, no estimate of recovery time was made.

Sea Otters

INJURY:

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 a total of 150,000 animals in Alaska.

During 1989, 1013 sea otter carcasses were collected, including animals that died during capture and rehabilitation. Veterinarians determined that up to 95 percent of the deaths were attributable to oil. This information coupled with estimates of the probability of finding carcasses, data from boat surveys, and computer models, indicated that injuries were extensive, killing an estimated 3,500 and 5,500 sea otters in the first few months following the spill.

Studies conducted throughout the spill area 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, rather than mainly juvenile and old

otters, as were found before the spill. A study of survival of recently weaned sea otters also showed a 22% 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 weanling 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.

RECOVERY:

While little or no evidence of recovery has been detected, sea otters are expected to eventually recover to their prespill population. The rate of recovery will be dependent on the growth rate of the injured population. Under ideal habitat conditions (abundant high quality food and little competition) sea otters can expand their population at more than 10% per year. For sea otter populations already established in an area, the growth rate is probably closer to 2% to 3% per year.

Future habitat conditions and corresponding population growth rates are difficult to predict in the spill area. If the habitat remains degraded, the sea otter population may not recover for several decades. If their habitat recovers rapidly and stress remains negligible, recovery may take less than two decades. In order to achieve this recovery rate, the population would have to sustain a growth rate greater than 5% per year.

TERRESTRIAL MAMMALS

Brown Bear

INJURY:

In the Kodiak Archipelago and on 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 found dead in 1989. The mortality rate for cubs is close to 50% for the first two years, and it is uncertain if this death was associated with oil exposure.

RECOVERY:

Since there is no evidence that brown bears were injured by the spill, no estimate of recovery time was made.

Black Bear

INJURY:

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.

RECOVERY:

Since there is no evidence that black bears were injured by the spill, no estimate of recovery time was made.

River Otters

INJURY:

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 unoiled 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 (Esther 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 also could be caused by disease, handling stress, and parasites.

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 was 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 prespill 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.

RECOVERY:

Most of the evidence of injury to the river otters was gathered in 1989 and 1990, although some of the parameters that are designed to indicate continuing sublethal injury still showed differences in 1991, including length-weight differences. Without a reliable way to detect small changes in populations (an estimated 50 animals were killed), it is difficult to predict when the population will recover. With a population density of approximately one otter for every two to three kilometers of shoreline in suitable habitats, the percentage of the population that requires replacement appears to be relatively small. Without much further study, however, scientists cannot estimate a time to recovery.

▼▼▼

Sitka Black-tailed Deer

INJURY:

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 to contain, in some cases, slightly elevated concentrations of oil. 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.

RECOVERY:

Since there is no evidence that Sitka black-tailed deer were injured by the spill, no estimate of recovery time is required.

▼▼▼

Mink

INJURY:

Mink forage in the intertidal zone and, therefore, could have been exposed to oil by contact or by ingestion of contaminated food. However, due to the lack of prespill information on population abundance and distribution and the difficulties of assessing population trends postspill, an assessment of injury to mink employing field studies was judged impractical. Instead, a laboratory study of mink was carried out to determine if oil-contaminated food affected reproduction. However, no reproductive effects were documented, even when high concentrations of weathered

crude oil were added to their diet.

RECOVERY:
Since there is no evidence that mink or other small mammals were injured by the spill, no estimate of recovery time is required.

BIRDS

Bald Eagles

INJURY:
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 postspill study were found in forests 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 these data. Estimates for the three postspill 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.

RECOVERY:
Since the number of eagles lost appears to be less than the change that can be detected by the aerial survey techniques, it may not be possible to follow recovery to prespill numbers. It also appears that the lost chick production in 1989 will not have a measurable impact on the population. Bald eagles are recovering, and may have already recovered from the effects of the spill.

Black Oystercatchers

INJURY:
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. Prespill (1972-1973, 1984) and postspill population surveys suggest that within Prince William Sound, an estimated 120 to 150 black oystercatchers representing 12% to 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 prespill 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

cleanup activities of oiled study areas, for example, Green Island, contributed to these differences.

RECOVERY:

While black oystercatchers are recovering, an estimate of their recovery time is difficult to make. There is significant uncertainty associated with any estimate of recovery made because the population growth rate for black oystercatchers is unknown. However, if the growth rate is equal to Eurasian oystercatchers (6.25%) and there are no lingering sublethal injuries, the calculated estimate of recovery is several decades. Finally, the potential contribution of immigration from unoiled areas on recovery is not easily estimated.

▼▼▼

Murres

INJURY:

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 to 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% and 70% of the breeding adults at the above colonies were killed by the spill. It is not known where prebreeding 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.

RECOVERY:

The degree of recovery necessarily varies among the affected colonies. There are preliminary indications of recovery at the Barren Islands in 1991 and 1992, but it is not yet known when the timing of reproduction will return to normal. Agency scientists estimate that it could take many decades and perhaps a century before the injured murre populations return to their prespill levels. These estimates assume that disturbance does not increase near the colonies over this time interval.

▼▼▼

Harlequin Ducks

INJURY:

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 1,000 harlequin ducks were killed by the spill. The resident prespill population of harlequin ducks in western Prince William Sound was estimated to be approximately 2,000. 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 Prince William 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.

RECOVERY:

There appears to be diminished reproduction in harlequin ducks in oiled areas of western Prince William Sound. There are no indications that recovery has occurred. Scientists disagree on the time it will take harlequin ducks to recover to their prespill levels, but estimates suggest that recovery may not occur for several decades. Recovery could depend upon final degradation of oil in intertidal habitats where harlequin ducks feed, if it can be assumed that continued injury is due to ingestion of oil-contaminated food.

▼▼▼

Marbled Murrelets

INJURY:

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% to 10% of the current population in the affected area. The available postspill data indicated that the marbled murrelet population has 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.

RECOVERY:

Since the spill, surveys conducted in Prince William Sound have resulted in population estimates of 107,000 in 1989, 81,000 in 1990, and 106,000 in 1991. With such variation in postspill population estimates, it is not yet possible to determine a trend in marbled murrelet abundance in Prince William Sound. The data collected in the 1970s and 1980s indicate that the population was declining before the spill. Although there is uncertainty associated with the causes of this decline, scientists expect it to continue. There are several factors that could account for this decline including a diminished food supply, increased predation, reduced nesting habitat, or fishery interactions, but there are no conclusive data that indicate if any or all of these factors affected the population.

Because of the population decline, the marbled murrelet population is not expected to return to prespill population levels. Estimates of when the population may stabilize vary widely among experts but may be more than a decade. Estimates of further decline range from 20% to 50%, but again there is much uncertainty.

▼▼▼

Pigeon Guillemots

INJURY:

Because these birds forage near shore 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% to 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 postspill surveys indicated a 40% decline in abundance compared to the latest prespill 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.

RECOVERY:

Pigeon guillemots may not return to prespill population levels, as their population was probably declining prior to the spill. The reasons for the long-term decline are unknown which makes predictions of future population trends extremely difficult. The population is expected to stabilize sometime over the next several decades, but estimating the population size when it stabilizes is even more uncertain.

Other Birds

INJURY:

There were numerous other birds affected by the spill. The most direct evidence of injury comes from the carcasses of birds found on the beaches after the spill in 1989. Some of the other species found dead included falcons, ducks, sandpipers, phalaropes, gulls, terns, auklets, puffins, various passerines, loons, grebes, shearwaters, petrels, cormorants, kittiwakes, and geese. Other important information comes from boat surveys carried out after the spill using similar techniques to those used in 1972-1973 and 1984-1985 surveys. Other birds that declined more in oiled than in nonoiled areas since the early 1972-1973 surveys include the Northwest crow and cormorant. A similar comparison based on the 1984-1985 surveys showed that cormorant, Arctic tern and tufted puffin declined more in oiled areas.

Injuries to murres, eagles, marbled murrelets, pigeon guillemots, black oystercatchers, and harlequin ducks are discussed individually above; however, these are only six of the approximately 90 species of birds represented in the collections of dead birds recovered after the spill. A list of the species recovered during the spill can be found in **Table B-4**. In general, the number of dead birds recovered probably represents only 10% to 15% of the total numbers of individuals killed. For most species, there are no reliable prespill data that will allow accurate assessment of the significance of estimated losses.

RECOVERY:

There is a great deal of uncertainty about the recovery of populations of individual species because many were not studied.

FISH

Cutthroat Trout and Dolly Varden

INJURY:

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.

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 significant. There also are no prespill 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. Dolly Varden growth rates were also reduced between 1989 and 1990.

RECOVERY:

Dolly Varden and cutthroat trout in oiled areas may have sustained a sublethal injury (slower growth in oiled areas). Scientists cannot estimate a recovery

time without much further study.

Pacific Herring

INJURY:

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. 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 to heavily 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 underrepresented in the 1992 spawning migration. Compared to Sitka Sound, which correlates closely with Prince William Sound in herring recruitment, the 1992 returns of the 1989 year class were lower in Prince William Sound than expected. Data comparing herring biomass and age composition of Prince William Sound and Sitka Sound from 1969 to 1992 demonstrates a statistically significant correlation between the size and age structure of herring migrations in these two areas. However, since the 1989 year class was not fully recruited to the adult population until 1993, analysis of 1993 data could be more instructive. 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.

RECOVERY:

The complex population dynamics of Pacific herring make it is very difficult to predict the extent of injury or estimate natural recovery rates. However, analysis of 1993 data may give a more complete picture of injuries suffered by the 1989 year class.

Pink Salmon

INJURY:

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% to 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.

RECOVERY:

The most apparent injury to pink salmon is to egg survival. This difference in mortality rates between oiled and unoiled streams persisted in 1991. For at least the first three years after the spill, the rate appears to be worsening, both in oiled and unoiled areas. While there is disagreement among experts on whether population level injuries exist, those who do believe that the spill reduced the adult population estimate that recovery will take more than a decade.

▼▼▼

Rockfish

INJURY:

The oil spill may have caused sublethal injuries to rockfish, but it is unknown whether or not population declines also occurred. There is little prespill data on rockfish in the spill area. Many dead rockfish were reported to have been sighted after the spill, although only 20 adult yelloweye rockfish were recovered by biologists. Of these, only five were in good enough condition to chemically analyze. All five 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 prevalances 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 fish collected from 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 and herring) in 1989, commercial fishers increased their take of rockfish. Rockfish harvests in Prince William Sound increased from approximately 93,000 pounds in 1989 to over 489,000 pounds in 1990. 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.

RECOVERY:

Because there is still considerable uncertainty that rockfish experienced significant direct mortality or sublethal effects, a natural recovery rate was not estimated.

▼▼▼

Sockeye Salmon

INJURY:

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. Public comments have indicated that sockeye overescapements may have occurred in the Chignik Lake 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: 1989, 30 million; 1990, six million; 1991, 2.5 million; and 1992, less than one million.

Outmigrations of smolt from the system have been on the decline since 1990, and the forecasted returns in 1994 and 1995 are below escapement goals.

RECOVERY:

There are no indications of recovery in either the Kenai River or Red Lake systems. Estimates of population recovery vary among experts but could exceed a decade to attain a 10-year population average similar to the prespill population levels. The Kenai River recovery could be prolonged if plankton populations do not recover to prespill population concentrations and salmon develop a cyclic pattern with large returns in some years followed by very small returns in others. Recovery could occur more quickly if plankton populations return to normal by 1993, and there is a normal adult escapement.

SHELLFISH

Crab, Shrimp, Sea Urchin and Oyster

INJURY:

While clams, mussels, crab, shrimp, sea urchins and oysters are all commonly referred to as shellfish, injuries to clams and mussels are addressed in the section on Intertidal Communities.

Dungeness crab and brown king crab studies ended early in 1989 due to the scarcity of these species in the spill area. Fishing pressure and natural predation may have reduced population levels prior to the spill.

There also is little conclusive evidence to suggest that spot shrimp were injured by the oil spill. There were no studies on sea urchins, and oyster studies (on farmed oysters) ended after a legal interpretation indicated that the Natural Resource Damage Assessment Rules (Comprehensive Environmental Response, Compensation and Liability Act of 1980, 42 U.S.C 9601) did not apply. However, since oil is known to have impacted subtidal sediments and communities, it is possible that undocumented exposure and injury occurred for several shellfish species not studied.

RECOVERY:

Because it was not possible to establish that these species were injured by oil, no estimate of recovery was made.

INTERTIDAL COMMUNITIES

Intertidal Communities

INJURY:

The intertidal zone is the area of beach between the low and high tide extremes. The oil spill caused population declines and sublethal injuries to the community of plants and animals living in the intertidal zone. Portions of 1500 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 prespill 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 was 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 littleneck 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.

RECOVERY:

The lower and middle intertidal zones have recovered to a large extent, but injuries persist most strongly in the upper intertidal zone, especially on rocky sheltered shores. Natural recovery of the upper intertidal zone will occur in stages as the different species in the community respond to improved environmental conditions.

Recovery in the upper intertidal appears to depend on the return of adult *Fucus* in large numbers to this zone. In the absence of a well-developed canopy of adult plants, eggs and developing propagules of *Fucus* lack sufficient moisture to survive. The reduced canopy of rockweed in the upper intertidal zone also appears to have made it easier for oystercatchers to prey on limpets. Accordingly, the recovery of limpets and other invertebrates also is linked to the recovery of rockweed. Existing adult plants will act as centers for the outward propagation of new plants, and it is estimated that recovery of *Fucus* may

take a decade. Full recovery of the intertidal community may take more than a decade, since it may take several years for invertebrate species to return after *Fucus* has recolonized an area.

SUBTIDAL COMMUNITIES

Subtidal Communities

INJURY:

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: eel grass 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 six to 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.

RECOVERY:

Analysis of invertebrates associated with eelgrass beds collected in 1991 indicated that differences noted in 1990 between oiled and unoiled areas had started to converge. Another year of study in 1993 may indicate if this trend has continued. Because recovery has been observed in shallow (<20m) subtidal habitats, full recovery is expected in most cases within several years.

OTHER RESOURCES

Archaeological Resources

INJURY:

The oil spill area has been occupied by Native peoples for at least 11,000 years. The spill area also contains artifacts from the post-European contact era. It is estimated that the oil spill area contains between 2,600 and 3,137 historic properties, including 1,287 known sites that have been recorded in the Alaska Heritage Resources Survey.

Currently, 24 sites are known to have been adversely affected by oiling, cleanup activities, or looting and vandalism linked to the oil spill. One hundred thirteen sites are estimated to have been similarly affected. Injuries attributed to looting and vandalism (linked to the oil spill) are still occurring.

Injuries to archaeological sites include theft of surface artifacts and masking of subtle clues that archaeologists depend upon to identify and classify sites. Key diagnostic artifacts have been illegally taken, ancient burials have been violated and pot-

holes dug by looters have destroyed critical evidence contained in the layered sediments. Additionally, vegetation has been disturbed which has exposed sites to accelerated erosion. The effect of oil on the soil chemistry and organic remains has reduced or eliminated the utility of radiocarbon dating. Other injuries to archaeological sites have not yet been reported and the actual extent of damage will not be known for decades.

Some injuries, particularly looting and vandalism, are continuing and are on the rise in the spill area because of ongoing human intrusion into previously pristine areas.

RECOVERY:

Archaeological sites cannot recover in the same sense as biological species or organisms. They represent a category of finite, nonrenewable resources. Injury to this resource results not only in the loss of important scientific data, but in an irretrievable loss of Alaska's cultural heritage. Restoration cannot regenerate what has been destroyed, but it can successfully prevent further degradation of both sites and the scientific information. Documentation of injured sites is necessary to preserve the artifacts and scientific data which remains in the vandalized sites.

Designated Wilderness Areas

INJURY:

Areas formally designated as wilderness within the spill area are: Katmai National Park, Becharof National Wildlife Refuge, and Kachemak Bay State Wilderness Park. Four federal areas are currently being formally considered for wilderness designation: Kenai Fjords National Park, Lake Clark National Park, Aniakchak National Monument and Preserve, and the Nellie Juan/College Fjord area of the Chugach National Forest. Federal wilderness areas are managed according to the 1964 Wilderness Act and the Alaska National Lands Conservation Act (ANILCA) of 1980. State wilderness areas are managed according to enabling legislation and subsequent management plans. Generally, the areas are managed to maintain their natural landscape, a sense of solitude, and their wild character. Evidence of human presence is generally limited to temporary uses. Various state and federal lands not legislatively designated as wilderness or wilderness study areas are managed according to each agencies' enabling legislation and subsequent regulations. These areas allow a broader range of uses and increased human development and thus have increased human presence.

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

RECOVERY:

Oil remains in isolated pockets in these wilderness areas. Although the oil is disappearing, it will be decades before the wilderness returns to its pristine condition. As a result, direct injury to wilderness and intrinsic values continue. The massive intrusion of people and equipment associated with oil spill cleanup has now ended.

SERVICES (HUMAN USES)

Commercial Fishing

INJURY:

During 1989, emergency commercial fishery closures were ordered in Prince William Sound, Cook Inlet, and the waters around Kodiak Island and the Alaska Peninsula. Harvests were closed or restrict-

ed for pink and sockeye salmon, herring, crab, shrimp, smelt, rockfish and sablefish. In 1990, portions of Prince William Sound were closed to shrimp and salmon fishing for the same reason. *(See **Table B-2**)* All of the 1989 and 1990 closures were done to prevent harvest of oiled fish and were not triggered by population reductions in these species. There are currently no spill-related commercial fishery closures in effect.

Significant impacts on fisheries may result from too many fish returning to the Kenai River and Red Lake (Kodiak Island) systems in 1989. During the 1989 commercial sockeye fishery closures, large numbers of fish escaped harvest to spawn. This resulted in an unusually large number of salmon fry moving into the lakes to feed. Sockeye fry spend up to two years feeding in fresh water before migrating to the ocean. It is hypothesized that the salmon fry overgrazed the zooplankton available to them in the upper layers of the lakes. This reduced rates of growth and survival for the fry. Previous Kenai River overescapements in 1987 and 1988 compounded the problem. Fry survival in the Kenai system was very poor for two years in a row, and Red Lake fry may have stayed in the lake an extra year to feed. This will probably result in severely reduced adult returns to these systems starting in 1994. It is also likely that 1995 returns to the Kenai River will be very low. Closure of Kenai River sockeye fisheries would have major impacts on many user groups.

The extent of injury to rockfish is not fully understood, although a few mortalities were caused by exposure to petroleum hydrocarbons and residual hydrocarbons have been found in tissues and bile. An additional, indirect injury may have been inflicted by significantly increased commercial fishing pressures. Following the multiple, spill-induced fishery closures, many commercial fishermen redirected harvest efforts towards rockfish. Little is known about current population levels and how well they will be able to withstand the increased pressure. However, rockfish are known to have low rates of reproduction and growth and have been seriously damaged by overfishing in other places. Thus, the possibility exists that the increased rockfish harvest may overfish the population.

Public comment indicated concern that the oil spill had caused or could cause the following fishery impacts:

1) ***poor Prince William Sound pink salmon returns in 1992;***

2) ***potential reductions of sockeye returns in Chignik Lake due to 1989 sockeye overescapements;***

3) ***poor Prince William Sound herring returns and disease problems in 1993; and***

4) ***decreased Prince William Sound spot shrimp populations.***

At this time, biologists do not know whether these events were caused by the oil spill.

RECOVERY:

Sockeye recovery status is unknown but will depend on recovery and availability of zooplankton populations in the lakes used by rearing fry. This will probably occur sooner in Red Lake than the Kenai system, although less is known about recovery in Red Lake. It is not yet known how many year classes of sockeye fry will be directly impacted by food shortages. However, the number of outmigrating Kenai River smolt was extremely low in 1991 and 1992, indicating that at least two consecutive year classes were impacted by overescapement. Kenai River smolt will return as adults in 1994 and 1995. The number of adults returning from these reduced outmigrations will almost certainly be lower than normal and may not be able to produce enough eggs to rebuild the runs within a single generation. If this turns out to be the case, adult returns to the Kenai in 1999 and 2000 may also be low.

Insufficient data exist to determine whether rockfish continue to be impacted by hydrocarbon contamination or if they are being harmed by overfishing. The lack of data could result in additional damage to the species. Likewise, the recovery status of herring and pink salmon is unknown.

Table B-2

Commercial Fishery Closures

PRINCE WILLIAM SOUND

PACIFIC HERRING	Gillnet and purse seine sac roe fisheries and pound and wild roe-on-kelp fisheries all closed April 3, 1989.
SHRIMP	Pot shrimp fishery closed while in progress on April 3,1989. Trawl shrimp fishery closed on April 9, 1989. A small pot shrimp harvest area near Knight, Eleanor and Smith Islands was closed in 1990.
SABLEFISH (BLACK COD)	Closed April 1, 1989. Reopened in inside waters only, in conjunction with the halibut opening on June 12, 1989.
DUNGENESS CRAB	Closed April 30, 1989.
KING CRAB	Closed on October 1, 1989.
GROUNDFISH	Closed April 30, 1989. Reopened with the June 12, halibut opening.
MISCELLANEOUS SHELLFISH	On April 24, 1989 it was announced that no miscellaneous shellfish permits would be issued.
PINK AND SOCKEYE SALMON	Closures of commercial drift and set net fisheries in Eshamy District, Northern District (surrounding Naked and Perry Islands), parts of Culross Island Subdistrict, Southwestern District, and parts of Montague Island District. In 1990, two set net areas near Eshamy Bay were closed for four days and then reopened. In addition, portions of the northern and eastern shorelines of Latouche Island,and waters around Eleanor and Ingot Islands were closed to fishing.

UPPER COOK INLET

SOCKEYE SALMON	With the exception of a very minor opening of a small portion of the Central District, the commercial drift gillnet season was closed because of oil. In addition, setnet fishing in the Upper Subdistrict south of the Kasilof River was closed for the 12 hour regular fishing period on July 7, 1989, due to the presence of oil on beaches.

LOWER COOK INLET

SHRIMP	Closed April 30, 1989. Reopened July 7, 1989.
MISCELLANEOUS SHELLFISH	On April 24, 1989, it was announced that no miscellaneous shellfish permits would be issued to harvest these species in the Outer and Eastern Districts until the danger of oil contamination had passed.
GROUNDFISH	The Outer and Eastern Districts were closed at noon, April 30, 1989. The fishery reopened to all species except sablefish, June 12 in conjunction with the 24-hour halibut opening.
SMELT	Smelt was closed along with groundfish in the Outer and Eastern Districts on April 30, 1989. When groundfish reopened, smelt fishing remained closed.
PACIFIC HERRING	The sac roe fishery in the Outer and Eastern Districts closed on April 15, 1989, prior to the anticipated opening date of April 20, 1989.

Table B-2 *continued*

LOWER COOK INLET *(continued)*	
PINK SALMON	The seine fishery in the Kamishak District opened on June 1, 1989 and was closed by emergency order on June 8, 1989. Portions of Kamishak District north of Contact Point were opened after July 20 based on run strength. The Tutka Bay Subdistrict north of the powerlines was closed to seining on July 10, and opened later the same day after further assessment showed the commercial fishery would not be impacted.

KODIAK	
PACIFIC HERRING	Approximately 34 of 56 management units were closed for the duration of the sac roe fishing season.
SOCKEYE AND PINK SALMON	The commercial season was scheduled to begin June 9,1989. The fisheries were postponed until June 19, when only the setnet fishery in the Alitak District opened; there were approximately 114 days fished in this setnet fishery by 87 fishermen. The only other commercial opening to occur during the 1989 salmon season was a two day seine opening in Karluk Lagoon, on the west side of Kodiak Island, in mid-September. The entire Kodiak Management Area closed to commercial salmon fishing at the conclusion of the Lagoon fishery.

CHIGNIK	
SOCKEYE SALMON	The Chignik fishery opened on June 12, 1989. However, portions of the Eastern District were closed due to the presence or close proximity of oil in the Kilokak Rocks area, and in Imuya and Wide Bays. The ADF&G announced a 24-hour fishing period on June 26 for a portion of the Chignik Bay District. The area was limited to a small portion of this district due to the presence of oil in surrounding areas, and was later closed the same day due to the presence of mousse and sheen. Additional closures occurred on July 27 and August 5,1989.

Commercial Tourism

INJURY:

Much of the injury to Commercial Tourism is similar to Recreation. For example, passengers on guided sailboats and those on recreation sailboats may experience similar changes. For this reason, much of the information listed under the Recreation and Recreation - Sport Fishing and Hunting applies to Commercial Tourism. After the spill, a consulting firm, McDowell and Associates, surveyed Alaskan tourism businesses to find out the effect of the spill. Approximately 43% of the tourism businesses surveyed by McDowell and Associates felt their businesses had been significantly or completely affected by the oil spill in Summer 1989. The net loss in visitor spending in Southcen-tral and Southwest Alaska in 1989 was $19 million. *[See also Recreation and Recreation - Sport Fishing and Hunting.]*

RECOVERY:

By 1990 only 12% of the tourism businesses surveyed felt their businesses had been significantly or completely affected by the oil spill. *[See also Recreation and Recreation -Sport Fishing and Hunting.]*

▼▼▼

Passive Use

INJURY:

Passive uses of resources include the appreciation of the aesthetic and intrinsic values of undisturbed areas, the value derived from simply knowing that a resource exists, and other nonuse values. The areas of Alaska impacted by the oil spill supported a large diverse ecosystem that was valued by large numbers of the American public who did not visit the area. The spill killed substantial numbers of different bird species and marine mammals as well as oiling much of the coastline in the impacted areas. The spill also had substantial effects on the fish, bird, and wildlife populations. While some of these effects may be of relatively short duration, others such as recovery of various bird populations are likely to take decades. A contingent valuation study of the American public done in 1991 found that approximately 95% were still aware of the *Exxon Valdez* oil spill, and that over 50% spontaneously named the spill as one of the worst environmental accidents to occur in the world during their lifetime. The median household was willing to pay $31 to prevent a spill similar to the *Exxon Valdez* in the future. Multiplied by the number of U.S. households, this results in an estimate of spill damages of $2.8 billion.

RECOVERY:

The animals initially killed are irreplaceable. Fish and wildlife populations are recovering at different rates. Much of the oil in shoreline areas has been removed or has weathered to varying degrees.

▼▼▼

Recreation

INJURY:

In 1992 a key informant study was conducted to obtain current information about abroad range of recreation uses. The study canvassed 92 users in the following ten user groups: air taxi operators, camping/kayaking, conservation/education, lodge-owner, Native corporations, public recreation managers, sailing/motorboating, sport fishing/hunting, tour operators, and tourism associations. The study was not based on a random sample of recreation users. Instead, it surveyed individuals knowledgeable about recreation in the spill area. The response rate was 45%.

Informants were asked how their recreation experience had changed. About a quarter of the respondents reported no change in their experience. However, others reported the following changes:

1) ***avoidance of heavily oiled areas and displacement to less affected areas, primarily northern Prince William Sound and parts of Kenai Fjords;***

2) ***reduced wildlife sightings and fewer fish;***

3) ***residual oil in the form of tar balls and sheens that affect the enjoyment of coastal areas and raise concerns about tainted fish; and***

4) ***more interest in the spill area and more people using it. Recreational use of Prince***

William Sound and the Outer Kenai Coast appeared to be most severely affected; less severe effects were reported in Kodiak and Kachemak Bay.

Informants were also asked whether there are changes not reflected in their experiences that concern the way they think about the area or perceive their recreation opportunities. Most of the respondents (80%) said their perceptions had changed. This group included at least half of each user group except air-taxi operators.

Those indicating a change in perception of recreation opportunities cited one or more of the following changes:

1) ***increased sense of vulnerability with regard to future oil spills, the fragility of the ecosystem, and threats to archaeological resources;***

2) ***erosion of wilderness caused by the spill itself as well as the intrusion of cleanup and restoration activities;***

3) ***a sense of permanent change;***

4) ***a sense of unknown or unseen ecological effects that may alter the environment in the future. Some of the respondents reported a sense of optimism about the future.***

RECOVERY:

Although the status of recovery of recreation was not asked in the key informant interview, respondents volunteered information. They 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.

Recreation - Sport Fishing and Hunting

INJURY:

While there were no sport fishery closures until 1992, ADF&G data documented a significant decline in sport fishing from 1989 to 1990 and quantified the losses at $31 million. Declines in the number of anglers, fishing trips and fishing days were noted for saltwater fisheries in Prince William Sound, Cook Inlet and the Kenai Peninsula areas. In addition, damages to public perception of the spill zone as a pristine environment may have been largely responsible for reductions in sport-fishing activities.
The only spill-related sport fish closure has resulted from a 1992 emergency order restricting cutthroat trout fishing in western Prince William Sound due to low adult returns. This closure will remain in effect until runs return to a sustainable level. Damage assessment from 1991 studies suggested that growth and survival rates of cutthroat were lower in oiled areas. This could be due to injuries to the food chain, which result in insufficient food for fish feeding in nearshore marine waters.

Significant impacts on fisheries may result from too many fish returning to the Kenai River and Red Lake (Kodiak Island) systems in 1989. Discussions of injury to sockeye salmon and rockfish are found under the description of injury to commercial fishing. Sport hunting of harlequin duck was affected by restrictions imposed in 1991 in response to damage assessment studies.

RECOVERY:

Sockeye recovery depends on recovery and availability of zooplankton populations in the lakes used by rearing fry. This will probably occur sooner in Red Lake than the Kenai system. It is not yet known how many year classes of sockeye fry will be directly impacted by food shortages. However, the number of outmigrating Kenai River smolt was extremely low in 1991 and 1992, indicating that at least two consecutive year classes were impacted by overescapement. These smolt will return as adults in 1994 and 1995. The number of adults returning from these reduced outmigrations will almost certainly be lower than normal and may not be able to produce enough eggs to rebuild the runs within a single generation. If this turns out to be the case, adult returns in 1999 and 2000 may also be low.

Cutthroat trout fishing may remain closed or restricted in the western Sound in 1993, and will not reopen until populations recover. Recovery may be contingent upon recovery of the ecosystem which supports the food chain in nearshore marine waters where these fish feed.

Insufficient data exist to determine whether rockfish continue to be impacted by hydrocarbon contamination or if they are being harmed by overfishing. The lack of data could result in additional damage to the species.

Harvest restrictions for harlequin duck are expected to continue through 1993.

Subsistence

INJURY:

The Division of Subsistence, Alaska Department of Fish and Game, determined before the *Exxon Valdez* oil spill, that 15 Native Alaskan communities (with about 2200 people) of Prince William Sound, Lower Cook Inlet, Kodiak and the Alaska Peninsula relied heavily on subsistence resources. These resources included salmon, halibut, cod, rockfish and Dolly Varden; marine invertebrates such as clams, chitons, shrimp, crabs, and octopus; marine mammals (harbor seals and sea lions); land mammals such as deer (Prince William Sound and Kodiak Island), black bear and goats (Prince William Sound and Lower Kenai Peninsula); birds including ptarmigan, waterfowl, and gulls eggs; and wild plants. Many of these species were studied after the spill, and the results of these studies are summarized in this section. The mean number of resources used per household ranged from 10 to 25, and generally every household participated in subsistence harvests. The per capita subsistence harvest ranged from nearly 200 pounds to over 600 pounds per year.

Table B-3 illustrates changes in harvest levels in the first year (April 1989 to March 1990) following the spill. Subsistence harvests of fish and wildlife in nine of these villages (Chenega Bay, Tatitlek, Nanwalek [English Bay], Port Graham, Karluk, Old Harbor, Ouzinkie, Port Lions, and Chignik Lagoon) declined from 4% to 78%, compared to prespill averages. The reasons for this decline varied among communities and households, but most dealt with the reduced availability of injured species and perceived consequences of the oil spill, especially the concern for potential health effects as a result of consuming subsistence resources from the spill area.

Chemical analytical studies conducted in 1989-1991 measured levels of petroleum hydrocarbon and metabolites in the bile and edible tissues of subsistence foods. These studies found that most resources tested (fish, some species of shellfish, deer, ducks, marine mammals) contained no or very low levels of petroleum hydrocarbons, and that eating foods with those levels posed no health risk. Exposure to oil did not necessarily render organisms unsafe to eat since some exposed animals were found to have low or nonexistent levels of hydrocarbons and their metabolites in their edible tissues. Some samples of shellfish, however, had unacceptably high levels of petroleum hydrocarbons prompting advisories in 1989-1991 that shellfish should not be collected from obviously oil-contaminated areas.

RECOVERY:

Table B-3 summarizes changes in harvest levels in Native villages following the oil spill. The finding that subsistence harvests had increased in five villages during the 1990-1991 timeframe suggested increased confidence in using some subsistence resources. However, the continued very low levels of harvest at Chenega Bay and Tatitlek, Nanwalek (English Bay) and Ouzinkie, and the continued concern in some households in many villages that some subsistence foods remained unsafe to eat, suggested that the injury persisted through the second year following the spill.

While published reports are not yet available for the period of April 1991 to the present, it is believed that subsistence harvests have not returned to prespill averages in all affected Native communities, especial-

ly Chenega Bay and Tatitlek. Concern over potential long-term health effects of consuming resources from the spill area, a loss of confidence on the part of subsistence hunters and fishermen in their abilities to determine if traditional foods are safe to eat, and the reduction in available resources, are all factors likely to affect recovery of subsistence use.

Table B-3

Subsistence Harvests Before and After the *Exxon Valdez* Oil Spill

COMMUNITY	PRE-SPILL YEAR ONE (per capita harvest in pounds)	PRE-SPILL YEAR TWO (per capita harvest in pounds)	OIL SPILL YEAR (per capita harvest in pounds)	PERCENT CHANGE (b)	POST- SPILL YEAR ONE (4/90-3/91) (per capita harvest in pounds)
PRINCE WILLIAM SOUND					
Chenega	308.8	374.2	148.1	-60.4	143.1
Tatitlek	351.7	643.5	214.8	-66.6	155.2
LOWER COOK INLET					
Nanwalek (English Bay)	288.8	(c)	140.6	-51.3	181.1
Port Graham	227.2	(c)	121.6	-46.5	213.5
KODIAK ISLAND					
Akhiok	519.5	159.3	297.7	+86.9	(d)
Karluk	863.2	381.0	250.5	-34.3	395.2
Larsen Bay	403.5	200.9	209.9	+4.5	340.4
Old Harbor	491.1	419.3	271.1	-35.2	(d)
Ouzinkie	369.1	405.7	88.8	-78.1	204.9
Port Lions	279.8	328.3	146.4	-55.4	(d)
ALASKA PENINSULA					
Chignik Bay	187.9	(c)	208.6	+11.1	(d)
Chignik Lagoon	220.2	(c)	211.4	-3.7	(d)
Chignik Lake	279.0	(c)	447.6	+60.1	(d)
Ivanof Bay	455.6	(c)	489.8	+8.4	(d)
Perryville	391.2	(c)	394.2	+1.0	(d)

(a) Prespill study years are: TATITLEK 1987-88 and 1988-89; CHENEGA, 1984-85 and 1985-86; NANWALEK (ENGLISH BAY) and PORT GRAHAM, 1987; KODIAK ISLAND BOROUGH, 1982-83 and 1986; ALASKA PENINSULA, 1984. The "spill year" is 1989 for all communities, except Chenega and Tatitlek, for which it is April 1989-March 1990.

(b) Based on most recent previous year.

(c) Only one previous measurement.

(d) Not determined.

The tables in this part of the supplemental information package summarize the results of the injury assessment studies for all natural resources and archaeology completed after the *Exxon Valdez* oil spill. For most resources, the "Description of Injury" columns focus on injury that took place during 1989 —just after the spill. **Table B-4** shows whether there was initial mortality caused by the spill, whether the spill caused a measurable population decline that will persist for more than one generation, and whether there is evidence of injury but without a measurable population decline. For some resources, an estimate is available for the total number of animals initially killed by the spill. If available, that estimate is shown in parentheses under the initial mortality column. For many resources, the total number killed will never be known. For other resources, and archaeology, listed in **Table B-5,** information on injury is not quantitative.

The "Status of Recovery" columns show the best estimate of recovery using information from 1992. (Most information comes from the 1992 summer field season). The columns show resources' progress toward recovery to the population levels that scientists estimate would have occurred in the absence of the spill. The "Current Population Status" column shows a resource's progress from any "Decline in Population after the Spill." Similarly, the column labeled "Evidence of Continuing Sublethal Effects" shows whether an initial sublethal injury is continuing.

Table B-4

Resources: Summary of Results of Injury Assessment Studies Done After the *Exxon Valdez* Oil Spill

RESOURCE	DESCRIPTION OF INJURY			STATUS OF RECOVERY IN DECEMBER, 1992		GEOGRAPHIC EXTENT OF INJURY (a)				COMMENTS/DISCUSSION
	Oil Spill Mortality *(total mortality estimate) (b)*	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
MARINE MAMMALS										
Harbor Seals (c)	YES (345)	YES	YES	Possibly Stable, but Not Recovering (a)	Unknown	YES	YES (d)	Unknown	Unknown	Many seals were directly oiled. There was a greater decline in population indices in oiled areas compared to unoiled areas in PWS in 1989 and 1990. Population was declining prior to the spill and no recovery was evident in 1992. Oil residues found in seal bile were 5 to 6 times higher in oiled areas than unoiled areas in 1990.
Killer Whales	YES (13)	YES	Unknown	Recovering	Unknown	YES	Unknown	Unknown	Unknown	13 adult whales of the 36 in AB pod are missing and presumed dead. The AB pod has grown by 2 whales since 1990. Some experts think that the loss of 13 whales in 1989,1990 is unrelated to oil spill.
Humpback Whales	NO	NO	NO	(e)	(e)	(e)	(e)	(e)	(e)	Other than fewer animals being observed in Knight Island Passage in Summer 1989, which did not persist in 1990, the oil spill did not have a measurable impact on the north Pacific population of humpback whales.
Sea Lions (c)	Unknown	Unknown	NO	Continuing Decline	(e)	(e)	(e)	(e)	(e)	Several sea lions were observed with oiled pelts and oil residues were found in some tissues. It was not possible to determine population effects or cause of death of carcasses recovered. Sea lion populations were declining prior to the oil spill.
Sea Otters	YES (3,500 to 5,500)	YES	YES	Stable, but Not Recovering	YES, Possibly	YES	YES	YES (d)	YES (d)	Postspill surveys showed measurable difference in populations and survival between oiled and unoiled areas in 1989,1990 and 1991. Survey data have not established a significant recovery. Prime-age animals were still found on beaches in 1989, 1990 and 1991. Sea otters feed in the lower intertidal and subtidal areas and may still be exposed to hydrocarbons in the environment.

(a) There may have been an unequal distribution of injury within each region;
(b) Adjusted for carcasses not found, not reported, scavenged, or otherwise lost;
(c) Population may have been declining prior to the spill;
(d) Based on recovery of dead animals from this region of the spill zone;
(e) If no injury was detected or known, no assessment of recovery could be made;
(f) Total body count, not adjusted for carcasses not found.

Table B-4 *(continued)*

RESOURCE	DESCRIPTION OF INJURY			STATUS OF RECOVERY IN DECEMBER,1992		GEOGRAPHIC EXTENT OF INJURY (a)				COMMENTS/DISCUSSION
	Oil Spill Mortality *(total mortality estimate) (b)*	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic	PWS	Kenai	Kodiak	Alaska Penin.	
TERRESTRIAL MAMMALS										
Brown Bear	NO	NO	NO	(e)	(e)	(e)	(e)	(e)	(e)	Hydrocarbon exposure was documented on Alaska Peninsula in 1989 including high hydrocarbon levels in the bile of one dead cub. Brown bear feed in the intertidal zone and may still be exposed to hydrocarbons in the environment.
Black Bear	NO	NO	NO	(e)	(e)	(e)	(e)	(e)	(e)	No field studies were completed.
River Otters	YES (Number Unknown)	Unknown	YES, Possibly	Unknown	YES	YES	Unknown	Unknown	Unknown	Exposure to hydrocarbons and possible sublethal effects were determined, but no effects were established on population. Sublethal indicators of possible oil exposure remained in 1991. River otters feed in the intertidal and shallow subtidal areas and may be still be exposed to hydrocarbons in the environment.
Sitka Black-tailed Deer	NO	NO	NO	(e)	(e)	(e)	(e)	(e)	(e)	Elevated hydrocarbons were found in tissues in some deer in 1989.
Mink	NO	NO	NO	(e)	(e)	(e)	(e)	(e)	(e)	Studies limited to laboratory toxicity studies.

(a) There may have been an unequal distribution of injury within each region;
(b) Adjusted for carcasses not found, not reported, scavenged, or otherwise lost;
(c) Population may have been declining prior to the spill;
(d) Based on recovery of dead animals from this region of the spill zone;
(e) If no injury was detected or known, no assessment of recovery could be made;
(f) Total body count, not adjusted for carcasses not found.

Table B-4 *(continued)*

RESOURCE	DESCRIPTION OF INJURY			STATUS OF RECOVERY IN DECEMBER, 1992		GEOGRAPHIC EXTENT OF INJURY (a)				COMMENTS/DISCUSSION
	Oil Spill Mortality *(total mortality estimate) (b)*	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
BIRDS										
Bald Eagles	YES (200 or more)	YES, Possibly	YES	Possibly Recovered	Unknown	YES	YES	YES (d)	YES (d)	Productivity in PWS was disrupted in 1989, but returned to normal in 1990. Exposure to hydrocarbons and some sublethal effects were found in 1989, but no continuing effects were observed on populations.
Black-legged Kittiwakes	YES (Number Unknown)	NO	NO	NO Change	NO	YES	YES (d)	YES (d)	YES (d)	Total reproductive success in oiled and unoiled areas of PWS has declined since1989. Hydrocarbon contaminated stomach contents were detected in 1989 and 1990. This species is known for great natural variation and reproductive failure may be unrelated to the oil spill.
Black Oystercatchers	YES (120-150 Adults, Unknown for Chicks (f)	YES	YES	Recovering	YES	YES	YES (d)	YES (d)	YES (d)	Differences in egg size between oiled and unoiled areas were found in 1989. Exposure to hydrocarbons and some sublethal effects were determined. Populations declined more in oiled areas than unoiled areas in postspill surveys in 1989, 1990 and 1991. Black oystercatchers feed in the intertidal areas and may be still be exposed to hydrocarbons in the environment.
Common Murres	YES (170,000 to 300,000)	YES	YES	Degrees of Recovery Varies in Colony	YES	NO	YES	YES	YES	Measurable impacts on populations were recorded in 1989, 1990 and 1991. Breeding is still inhibited in some colonies in the Gulf of Alaska.
Glaucous-winged Gulls	YES (Number Unknown)	Not Detected	NO	NO Change	NO	YES (d)	YES (d)	YES (d)	YES (d)	While dead birds were recovered in 1989, there is no evidence of a population level impact when compared to historic (1972,1973) population levels.

(a) There may have been an unequal distribution of injury within each region;
(b) Adjusted for carcasses not found, not reported, scavenged, or otherwise lost;
(c) Population may have been declining prior to the spill;
(d) Based on recovery of dead animals from this region of the spill zone;
(e) If no injury was detected or known, no assessment of recovery could be made;
(f) Total body count, not adjusted for carcasses not found.

Table B-4 *(continued)*

RESOURCE	DESCRIPTION OF INJURY			STATUS OF RECOVERY IN DECEMBER, 1992		GEOGRAPHIC EXTENT OF INJURY (a)				COMMENTS/DISCUSSION
	Oil Spill Mortality *(total mortality estimate) (b)*	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
BIRDS										
Harlequin Ducks	YES (Approx. 1,000)	YES	YES, Possibly	Unknown	YES	YES	YES (d)	YES (d)	YES (d)	Postspill samples showed hydrocarbon contamination. Surveys in 1990-1992 indicated population declines and possibly reproductive failure. Harlequin ducks feed in the intertidal and shallow subtidal areas and may still be exposed to hydrocarbons in the environment.
Marbled Murrelets (c)	YES (8,000 to 12,000)	YES	NO	Stable or Continuing Decline	Unknown	YES	YES (d)	YES (d)	YES (d)	Measurable population effects were recorded in 1989, 1990 and 1991. Marbled murrelet populations were declining prior to the spill.
Peale's Peregrine Falcons	Unknown	Unknown	NO	(e)	(e)	(e)	(e)	(e)	(e)	When compared to 1985 surveys a reduction in population and lower than expected productivity was measured in 1989 in the PWS. Cause of these changes are unknown.
Pigeon Guillemots (c)	YES (1,500 to 3,000)	YES	NO	Stable or Continuing Decline	Unknown	YES	YES (d)	YES (d)	YES (d)	Pigeon guillemot populations were declining prior to the spill. Hydrocarbon contamination was found externally, on eggs.
Storm Petrels	YES (Number Unknown)	NO	NO	NO Change	Unknown	YES (d)	YES (d)	YES (d)	YES (d)	Few carcasses were recovered in 1989 although petrels ingested oil and transferred oil to their eggs. Reproduction was normal in 1989.
Other Seabirds	YES (Number Unknown)	Varies by Species	Unknown	Varies by Species	Unknown	YES (d)	YES (d)	YES (d)	YES (d)	Seabird recovery has not been studied. Species collected dead in 1989 include common, yellow-billed, Pacific, and red-throated loon; red-necked and horned grebe; northern fulmar; sooty and short-tailed shearwater; double-crested, pelagic, and red-faced cormorant; herring and mew gull; Arctic and Aleutian tern; Kittlitz's and ancient murrelet; Cassin's, least, parakeet, and rhinoceros auklet; and horned and tufted puffin.

(a) There may have been an unequal distribution of injury within each region;
(b) Adjusted for carcasses not found, not reported, scavenged, or otherwise lost;
(c) Population may have been declining prior to the spill;
(d) Based on recovery of dead animals from this region of the spill zone;
(e) If no injury was detected or known, no assessment of recovery could be made;
(f) Total body count, not adjusted for carcasses not found.

Table B-4 *(continued)*

RESOURCE	DESCRIPTION OF INJURY			STATUS OF RECOVERY IN DECEMBER, 1992		GEOGRAPHIC EXTENT OF INJURY (a)				COMMENTS/DISCUSSION
	Oil Spill Mortality *(total mortality estimate) (b)*	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic Effects	PWS	Kenai	Kodiak	Alaska Penin.	
BIRDS										
Other Sea Ducks	YES (875) (b)	NO	Unknown	Unknown	Unknown	YES	YES (d)	YES (d)	YES (d)	Species collected dead in 1989 include Stellar's. king and common eider; white-winged, surf and black scooter, oldsquaw; bufflehead; common and Barrow's goldeneye; and common and red-breasted merganser. Sea ducks tend to feed in the intertidal and shallow subtidal areas which were most heavily impacted by oil.
Other Shorebirds	YES (Number Unknown)	Unknown	Unknown	Unknown	Unknown	YES	YES (d)	YES (d)	YES (d)	Species collected dead in 1989 include golden plover; lesser yellowlegs; semipalmated, western, least and Baird's sandpiper; surfbird; short-billed dowitcher; common snipe; red and red-necked phalarope.
Other Birds	YES (Number Unknown)	Unknown	Unknown	Unknown	Unknown	YES (d)	YES (d)	YES (d)	YES (d)	Species collected dead in 1989 include emperor and Canada goose; brant; mallard; northern pintail; green-winged teal; greater and lesser scaup; ruddy duck; great blue heron; long-tailed jaeger; willow ptarmigan; great- horned owl; Stellar's jay; magpie; common raven; north western crow; robin; varied and hermit thrush; yellow warbler; pine grosbeak; savannah and golden- crowned sparrow; white-winged crossbill.
FISH										
Cutthroat Trout	NO	NO	YES	(e)	Unknown	Unknown	NO	NO	NO	Differences in survival between anadromous adult populations in the oiled and unoiled areas were not statistically different; however, differences in growth between adult populations in the oiled and unoiled areas were found in 1989, 1990, and 1991.
Dolly Varden	NO	NO	YES	(e)	Unknown	Unknown	Unknown	Unknown	Unknown	Differences in survival between anadromous adult populations in the oiled and unoiled areas were not statistically different. Growth rates between 1989 and 1990 were reduced.

(a) There may have been an unequal distribution of injury within each region;
(b) Adjusted for carcasses not found, not reported, scavenged, or otherwise lost;
(c) Population may have been declining prior to the spill;
(d) Based on recovery of dead animals from this region of the spill zone;
(e) If no injury was detected or known, no assessment of recovery could be made;
(f) Total body count, not adjusted for carcasses not found.

Table B-4 *(continued)*

RESOURCE	DESCRIPTION OF INJURY			STATUS OF RECOVERY IN DECEMBER,1992		GEOGRAPHIC EXTENT OF INJURY (a)				COMMENTS/DISCUSSION
	Oil Spill Mortality *(total mortality estimate) (b)*	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic	PWS	Kenai	Kodiak	Alaska Penin.	
FISH										
Pacific Herring	YES, To Eggs and Larvae	NO (g)	YES	Unknown	NO	YES	Unknown	Unknown	Unknown	Measurable difference in egg counts between oiled and unoiled areas were found in 1989 and 1990. Lethal and sublethal effects on eggs and larvae were evident in 1989 and to a lesser extent in 1990; in 1991 there were no differences between oiled and unoiled areas. It is possible that the 1989 year class was injured and could result in reduced recruitment to the fishery.
Pink Salmon (Wild) (c)	YES, To Eggs	Possibly	YES	See Comments	YES	YES	Unknown	Unknown	Unknown	There was initial egg mortality in 1989. Egg mortality continued to be high in 1991. Abnormal fry were observed in 1989. Reduced growth of juveniles was found in the marine environment, which can be correlated with reduced survival.
Rockfish	YES (f) (20)	Unknown	YES	Unknown	Unknown	YES	YES	Unknown	Unknown	Few dead fish were found in 1989 in condition to be analyzed. Exposure to hydrocarbons with some sub-lethal effects were determined in those fish, but no effects established on the population. Closures to salmon fisheries increased fishing pressures on rockfish which may be impacting population.
Sockeye Salmon	Unknown	YES	YES	See Comments	YES	Unknown	YES	YES	YES	Smolt survival continues to be poor in the Red Lake and Kenai River systems due to over escapements in Red Lake in 1989, and in the Kenai River in 1987, 1988, 1989. As a result, adult returns are expected to be low in 1994 and successive years. Trophic structures of Kenai and Skilak Lakes have been altered by over escapement.

(a) There may have been an unequal distribution of injury within each region;
(b) Adjusted for carcasses not found, not reported, scavenged, or otherwise lost;
(c) Population may have been declining prior to the spill;
(d) Based on recovery of dead animals from this region of the spill zone;
(e) If no injury was detected or known, no assessment of recovery could be made;
(f) Total body count, not adjusted for carcasses not found.

Table B-4 *(continued)*

RESOURCE	DESCRIPTION OF INJURY			STATUS OF RECOVERY IN DECEMBER, 1992		GEOGRAPHIC EXTENT OF INJURY (a)				COMMENTS/DISCUSSION
	Oil Spill Mortality *(total mortality estimate) (b)*	Decline in Population after the spill	Evidence of Sublethal or Chronic Effects	Current Population Status	Evidence of Continuing Sublethal or Chronic	PWS	Kenai	Kodiak	Alaska Penin.	
SHELLFISH										
Clam	YES (Number Unknown)	Unknown	Possibly; Final Analyses Pending	Unknown	Unknown	YES	YES	YES	YES	Native littleneck and butter clams were impacted by both oiling and cleanup, particularly high pressure, hot water washing. Littleneck clams transplanted to oiled areas in 1990 grew significantly less than those transplanted to unoiled sites. Reduced growth recorded at oiled sites in 1989 but not 1991.
Crab (Dungeness)	NO	NO	NO	(e)	(e)	(e)	(e)	(e)	(e)	Crabs collected from oil areas were not found to have accumulated petroleum hydrocarbons.
Oyster	NO	NO	NO	(e)	(e)	(e)	(e)	(e)	(e)	Although studies were initiated in 1989, they were not completed because they were determined to be of limited value.
Sea Urchin	NO	NO	NO	(e)	(e)	(e)	(e)	(e)	(e)	Studies limited to laboratory toxicity studies.
Shrimp	NO	NO	NO	(e)	(e)	(e)	(e)	(e)	(e)	No conclusive evidence presented for injury linked to oil spill.
INTERTIDAL/SUBTIDAL COMMUNITIES										
Intertidal Organisms/ Communities	YES	YES	YES	Variable by Species, See Comments	YES	YES	YES	YES	YES	Measurable impacts on populations of plants and animals were determined. The lower intertidal and, to some extent, the midintertidal is recovering. Some species *(Fucus)* in the upper intertidal zone have not recovered, and oil may persist in and mussel beds.
Subtidal Organisms/ Communities	YES	YES	YES	Variable by Species, See Comments	YES	YES	Unknown	Unknown	Unknown	Measurable impacts on population of plants and animals were determined in 1989. Eelgrass and some species of algae appear to be recovering. Amphipods in eel grass beds recovered to pre-spill densities in 1991. Leather stars and helmet crabs show little sign of recovery through 1991.

(a) There may have been an unequal distribution of injury within each region;
(b) Adjusted for carcasses not found, not reported, scavenged, or otherwise lost;
(c) Population may have been declining prior to the spill;
(d) Based on recovery of dead animals from this region of the spill zone;
(e) If no injury was detected or known, no assessment of recovery could be made;
(f) Total body count, not adjusted for carcasses not found.

Table B-5

Other Natural Resources and Archaeology: Summary of Results of Injury Assessment Studies Done After the *Exxon Valdez* Oil Spill

RESOURCE	DESCRIPTION OF INJURY	STATUS OF RECOVERY IN DECEMBER, 1992	GEOGRAPHIC EXTENT OF INJURY (a)				COMMENTS/DISCUSSION
			PWS	Kenai	Kodiak	Alaska Penin.	
OTHER NATURAL RESOURCES AND ARCHAELOLOGY							
Air	Air quality standards for aromatic hydrocarbons were exceeded in portions of PWS. Health and safety standards for permissible exposure levels were exceeded up to 400 times.	Recovered	YES	NO	NO	NO	Impacts diminished rapidly as oil weathered and lighter fractions evaporated.
Sediments	Oil coated beaches and became buried in beach sediments. Oil laden sediments were transported off beaches and deposited on subtidal marine sediments.	Patches of oil residue remain intertidally on rocks and beaches and buried beneath the surface at other beach locations. Oil remains in some subtidal marine sediments and has spread to depths greater than 20 meters.	YES	YES	YES	YES	Unweathered buried oil will persist for many years in protected low-energy sites.
Water	State of Alaska water quality standards may have been exceeded in portions of PWS. Federal and State oil discharge standards of no visible sheen were exceeded.	Recovered	YES	YES	YES	YES	Impacts diminished as oil weathered and lighter fractions evaporated.
Archaeological Sites/ Artifacts	Currently, 24 sites are known to have been adversely affected by oiling, cleanup activities, or looting and vandalism linked to the oil spill. 113 sites are estimated to have been similarly affected. Injuries attributed to looting and vandalism (linked to the oil spill) are still occurring.	Archaeological sites and artifacts cannot recover; they are finite nonrenewable resources.	YES	YES	YES	YES	
Designated Wilderness Areas	Many miles of Federal and State Wilderness and Wilderness Study Area coastlines were affected by oil. Some oil remains buried in the sediments of these areas.	Oil has degraded in many areas but remains in others. Until the remaining oil degrades, injury to Wilderness areas will continue.	YES	YES	YES	YES	

(a) There may have been an unequal distribution of injury within each region.

Services: Summary of Results of Injury Assessment Studies

Table B-6 summarizes information concerning lost or reduced services damaged by the spill. Much of the damage to services and the information about those damages is not quantitative. The table reflects the qualitative content of the information. The "Description of Injury" column recounts the situation for each service in the year following the spill. The "Status of Recovery in 1992" shows the 1992 situation for that service.

The information used for this table is taken from injury assessment studies, information from agency managers, and, for recreation, a Key Informant Interview study conducted the Restoration Planning Working Group in December 1992.

Table B-6

Services: Summary of Reduced or Lost Services (As a Result of Injury to the Natural Resources) Following the *Exxon Valdez* Oil Spill

SERVICE	DESCRIPTION OF INJURY	STATUS OF RECOVERY IN DECEMBER, 1992	GEOGRAPHIC EXTENT OF INJURY (a)				COMMENTS/DISCUSSION
			PWS	Kenai	Kodiak	Alaska Penin.	
Commercial Fishing	During 1989, emergency commercial fishery closures were ordered in PWS, Cook Inlet, Kodiak and the Alaska Peninsula. This affected salmon, herring, crab, shrimp, smelt, rockfish and sablefish. The 1989 closures resulted in sockeye over-escapement in the Kenai River and in the Red Lake system (Kodiak Island). In 1990 portions of PWS were closed to shrimp and salmon fishing.	Currently there are no area-wide oil spill-related commercial closures in effect. Management actions to try to compensate for the spill are still in effect. EVOS related sockeye over-escapement in the Kenai River and Red Lake system is anticipated to result in low adult returns in 1994 and 1995. These over-escapements may result in closure or harvest restrictions during these and perhaps in subsequent years.	YES	YES	YES	YES	Injuries and recovery status of rockfish,pink salmon, shellfish and herring are uncertain. Therefore, future impacts on these fisheries is unknown.
Commercial Tourism	Approximately 43% of the tourism businesses surveyed felt their businesses had been significantly affected by the oil spill in summer 1989. The net loss in visitor spending in the oil spill area in 1989 was $19 million.	By 1990, 12 % of the tourism businesses surveyed felt their businesses had been significantly affected by the oil spill.	YES	YES	YES	YES	
Passive Use	The areas of Alaska impacted by the oil spill supported a large diverse ecosystem that was valued by large numbers of the American public who did not visit the area. The spill killed substantial numbers of different bird species and marine mammals as well as oiling much of the coastline in the impacted areas. The spill also had substantial effects on the fish, bird, and wildlife populations. While some of these effects may be of relatively short duration, others such as recovery of various bird populations are likely to take decades.	The animals initially killed are irreplaceable. Fish and wildlife populations are recovering at different rates. Much of the oil in shoreline areas has been removed or has weathered to varying degrees.	YES	YES	YES	YES	A contingent valuation study of the American public done in 1991 found that approximately 95% were still aware of the *Exxon Valdez* oil spill, and that over 50% spontaneously named the spill as one of the worst environmental accidents to occur in the world during their lifetime. The median household was willing to pay $31 to prevent a spill similar to the *Exxon Valdez* oil spill in the future. Multiplied by the number of U.S. households, this results in an estimate of spill damages of $2.8 billion.

(a) There may have been an unequal distribution of injury within each region.

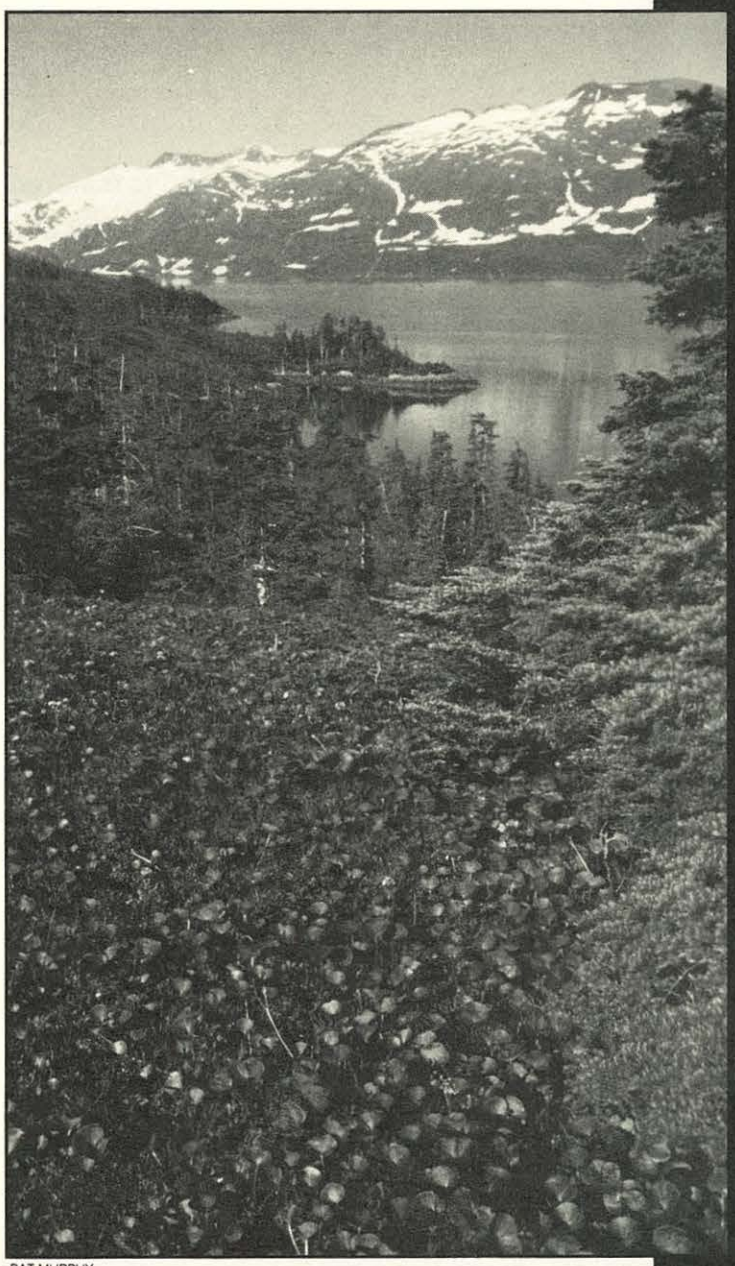
Table B-6 *(continued)*

SERVICE	DESCRIPTION OF INJURY	STATUS OF RECOVERY IN DECEMBER, 1992	GEOGRAPHIC EXTENT OF INJURY (a)				COMMENTS/DISCUSSION
			PWS	Kenai	Kodiak	Alaska Penin.	
Recreation (e.g., hunting, fishing, camping, kayaking, sailboating, motorboating, environmental education)	The nature and extent of any reduction or loss of services varied by user group and by area. About a quarter of key informants interviewed reported no change in their recreation experience, but others reported avoidance of the spill area, reduced wildlife sightings, residual oil, and more people. Overall, recreation use declined significantly in 1989. Between 1989 and 1990 a decline in sport fishing (number of anglers, fishing trips and fishing days) were recorded for PWS, Cook Inlet and the Kenai Peninsula. In 1992, an emergency order restricting cutthroat trout fishing was issued for western PWS due to low adult returns. Sport hunting of harlequin duck was affected by restrictions imposed in 1991 in response	Declines in recreation activities reported in 1989 appear to be recovering for some user groups, but the degree of recovery is unknown. EVOS related sockeye over-escapement in the Kenai River and Red Lake system is anticipated to result in low adult returns in 1994 and 1995. These over-escapements may result in sport fishing closures or harvest restrictions during these and perhaps subsequent years. The 1992 sport fishing closure for cutthroat trout is expected to continue at least through 1993. Harvest restrictions are expected to continue for harlequin duck through 1993.	YES	YES	YES	YES	Survey respondents also reported changes in their perception of recreation opportunity in terms of increased vulnerability to future oil spills, erosion of wilderness, a sense of permanent change, concern about long-term ecological effects, and in some, a sense of optimism.
Subsistence	Subsistence harvests of fish and wildlife in 9 of 15 villages surveyed declined from 4 - 78% in 1989 when compared to pre-spill levels. At least 4 of the 9 villages showed continued lower than average levels of use in the period 1990-1991; this decline is particularly noticeable in the Prince William Sound villages of Chenega and Tatitlek. In 1989-1991, chemical analysis indicated that most resources tested, including fish, marine mammals, deer, and ducks, were safe to eat. In 1989-1991, health advisories were issued indicating that shellfish from oiled beaches should not be eaten.	Many subsistence users believe that continued contamination to subsistence food sources is dangerous to their health. In addition, village residents believe that subsistence species continue to decline or have not recovered from the oil spill.	YES	YES	YES	YES	For detailed information on village subsistence use, see Table B-3.

(a) There may have been an unequal distribution of injury within each region.

Section C

HABITAT PROTECTION AND ACQUISITION



PAT MURPHY

Section C

HABITAT PROTECTION AND ACQUISITION

This category of restoration actions includes protection and acquisition of habitat on private lands, and protection of habitat on public land. Most of this section explains the Habitat Protection and Acquisition process for *private* land. The last part of this section discusses Habitat Protection on public land.

Development, such as harvesting timber or building subdivisions, can sometimes harm resources or services that rely on the land. The object of protecting and acquiring land is to prevent further impacts to resources and services, and allow recovery to occur at its natural rate. For example, the recovery of harlequin ducks may be helped by protecting nesting habitat from future changes that could degrade the habitat or disturb the nests.

The Trustee Council may purchase private land or partial interests in land such as conservation easements, mineral rights, or timber rights as methods of restoration. The settlement requires that any purchase must benefit resources or services affected by the spill. These lands would be managed to protect the resources and services. The Council's decision to purchase inholdings in Kachemak Bay State Park is an example of habitat protection and acquisition on private land.

The process for Habitat Protection and Acquisition is different for public and private lands. Public lands are already protected by existing agency management and have as yet received little attention from Trustee Council staff. To protect habitats on public land, the Trustee Council may in the future recommend changing agency management practices, or recommend placing public land and waters into special protective designations.

INTRODUCTION

The goal of habitat protection and acquisition on private land is to prevent further damage to resources and services by protecting key fish and wildlife habitat or human use areas, or by providing habitat for equivalent resources or services. To accomplish this goal, the Trustee Council may provide for the purchase of key habitats to prevent development on private land, or they may use other protection techniques such as conservation easements, acquisition of partial interests, cooperative management agreements, and other mechanisms. After land and interests in land have been purchased, they will be managed by the appropriate state or federal agency in a manner that is consistent with the restoration of the affected resources and services.

Work Completed: *Imminent Threat Process*

To date, the Habitat Protection and Acquisition process has focused on lands for which some threat, usually logging, will occur soon. A longer evaluation process might have meant that some lands with habitat important to the recovery of injured resources or services would be developed while the evaluation was being conducted. Trustee Council staff evaluated only those lands for which the State of Alaska received forest practice notifications or other development plans were known. This process is called the Imminent Threat Process. As a result of this process the Trustee Council allocated funds to purchase inholdings in Kachemak Bay State Park, have approved purchase of private land surrounding Seal Bay on Afognak Island contingent on negotiations and appraisal, and are negotiating for other threatened habitat.

Work to be Done: *The Comprehensive Process*

Trustee Council staff is now beginning the Comprehensive Process. It is different from the Imminent Threat Process in two ways: it may use some improved procedures, and it will include many more private lands in the spill area.

Trustee Council staff are currently reviewing procedures used for the Imminent Threat Process. If staff, experts, or public review as part of this supplement provides better methods to evaluate lands for habitat protection and acquisition, the imminent threat lands will be re-evaluated using the improved procedures.

The Trustee Council also sent a letter asking private landowners with 160 or more acres in the spill area whether they would be willing to have their land considered by the Habitat Protection and Acquisition process. The letter did not ask for a commitment to sell, only whether the landowner was willing to have their land evaluated, and was willing to explore the possibility of cooperative agreements, or selling full or partial title. At this writing, responses are still being received. The Comprehensive Process will add to the imminent threat evaluations all private lands where the landowner is willing to participate.

The Comprehensive Process will complete an initial ranking and evaluation of private lands in the fall which will be circulated for public review.

This section describes the Imminent Threat Process. It also discusses some improvements to procedures that staff has already recommended for the Comprehensive Process. Further changes may also be made on the basis of public comment, further staff analysis, and expert review.

Linkage: *Which Resources and Services to Target*

Habitat Protection and Acquisition benefits the injured resources and services that are linked to upland and nearshore habitats. These resources and services are listed in **Table C-1**. The table shows that all but two of the injured resources summarized in the Summary of Alternatives are linked to upland and nearshore habitats: killer whale, and rockfish.

Linkage for resources means that they are dependent on upland and nearshore habitats during critical life history stages, such as reproduction, feeding, or molting. Linkage for services includes the habitats that injured species depend on, but it may also include areas for human use such as viewsheds, or camping and sport-fishing sites. For example, stream habitats support reproduction of anadromous fish. They are also movement corridors between spawning and rearing habitat and the open sea. Commercial and sport fisheries depending on the resources produced by those streams. Harlequin ducks nest in forest areas near streams, and use streams as a movement corridor to their intertidal feeding habitat.

Answers to the policy questions presented in the Summary of Alternatives will influence the process of evaluating lands for potential acquisition and protection. One issue is whether restoration activities, including Habitat Protection and Acquisition, should address all injured resources or exclude those biological resources whose population did not measurably decline because of the spill. A second issue is whether restoration should cease once a resource as recovered; that is, once a resource is recovered, should new acquisition or other measures be initiated specifically to protect that resource. If not all resources are addressed, then future Habitat Protection and Acquisition will not target some of the resources listed in **Table C-1.** These and other issues are more fully addressed in the alternatives. For more information, see the Summary of Alternatives.

Table C-1

Resources and Services that Use Upland or Nearshore Habitats and Would Benefit From Protection

Resources			Services (Human uses)
POPULATION DECLINE	**INJURED, BUT NO POPULATION DECLINE**	**OTHER**	
Black oystercatcher	Bald eagle	Archaeological resources	Commercial fishing
Common murre	Cutthroat trout	Designated wilderness areas	Commercial tourism
Harbor seal	Dolly Varden		Passive use
Harlequin duck	● Killer whale		Recreation including sport fishing, sport hunting, and other recreation use
Intertidal organisms	Pacific herring		Subsistence
Marbled murrelet	● Pink salmon		
Pigeon guillemot	River otter		
Sea otter			
Sockeye salmon			
Subtidal organisms			

● *For these species, the Trustee Council's scientists have considerable disagreement over the conclusions to be drawn from the results of the damage assessment studies.*

Threat

Habitat Protection and Acquisition protects recovering resources and services from adverse impacts by human activity. Potential threats to the habitat of resources and services include both disturbance and habitat degradation. Habitat degradation may be caused by changes in land use such as development. An example of habitat degradation would be pollution of spawning or breeding habitat, cutting down of nesting habitat, or development harmful to a viewshed important to recreation or tourism. Human disturbance can disrupt reproductive activity or displace animals from important feeding areas. For example, marine mammals are sensitive to disturbance when hauled out on land.

Although upland areas were not oiled, they often contain key habitats of resources or services that were directly affected by the spill and clean-up activities. For example, in some cases timber harvest, mining, subdivisions or other development activities may jeopardize the nesting habitat of marbled murrelets or harlequin ducks. They may disturb animals that are dependent upon intertidal or nearshore habitats. Wilderness values and tourism may be adversely impacted by clearcutting, buildings, or other development activities. Habitat Protection and Acquisition measures are intended to lessen these and other threats to affected resources and thereby maintain recovery rate.

Although the goal of this process is to protect habitats linked to resources and services in **Table C-1**, other resources will also be affected, including water quality and other non-injured fish and wildlife.

THE IMMINENT THREAT PROCESS

This part of the section describes the Habitat Protection and Acquisition process as it was used for the Imminent Threat Process. Some changes in procedures may be made as a result of public, staff, and peer review.

Habitat Protection and Acquisition procedures characterize, locate, and evaluate habitat areas linked to the recovery or replacement of resources injured by the oil spill and the lost services that depend on those resources. The process is built around a sequence of steps beginning with characterizing habitats and leading to the protection of those key habitats. It evolved from discussions with local experts, literature reviews, public comment, and reviews of damage assessment and restoration studies, and collaboration with agency personnel. These steps can be grouped into three phases:

A) ***Evaluation and Selection;***

B) ***Acquisition and Protection; and***

C) ***Management.***

Table C-2 summarizes this process.

Table C-2

Key Steps in the Habitat Protection and Acquisition Process for Private Land

A EVALUATION AND SELECTION

1. Characterize essential habitat types for injured resources and services.
2. Identify key habitat types on specific parcels and determine the optimum boundary necessary to protect resource or service values.
3. Apply threshold criteria to private lands with linked habitats.
4. Evaluate and rank each candidate parcel.
5. Establish restoration objectives.

B ACQUISITION AND PROTECTION

6. Decide which land protection tools will accomplish the restoration objectives.
7. Secure management agreements or acquire fee title to, or partial interests in, the highest ranked parcels.

C MANAGEMENT

8. Implement a management plan for each acquired parcel that facilitates recovery of injured resources and services and provides for long term protection.

A EVALUATION AND SELECTION

The first part of the Habitat Protection and Acquisition process determines which habitats are linked to injured resources and services. And of these, which are the most important ones to protect. Of the five steps in this part of the process two are particularly important: applying threshold criteria, and evaluation and ranking criteria.

Step 1
Characterize habitat types

To protect key habitats for injured resources and services, it is necessary to define them. Examples of key habitats are reproduction and feeding habitats, spawning areas for anadromous fish, etc.

Step 2
Identify key habitats on specific parcels

The next step is to determine what key habitats exist on each parcel.

Step 3
Threshold Criteria

After a parcel has been nominated for protection, and biologists have determined which key habitats linked to injured resources and services exist on the parcel, staff evaluate the parcel against a set of Threshold Criteria. These criteria determine whether a nomination is acceptable for further consideration. A nomination will be rejected if it is not in compliance with ALL threshold criteria.
Table C-3 lists the Threshold Criteria used for the Imminent Threat Process. The criteria may be modified as a result of staff, peer, and public review.

Table C-3

Threshold Criteria for the Imminent Threat Process

- There is a willing seller of the parcel or property right;
- The parcel contains key habitats that are linked to, replace, provide the equivalent of, or substitute for injured resources or services.
- The seller acknowledges that the government can purchase the parcel or property right only at or below fair market value.
- Recovery of the injured resource or service would benefit from protection in addition to that provided by the owner and applicable laws and regulations; and
- The acquired property rights can reasonably be incorporated into public land management systems.

STEP 4

Evaluation and Ranking Criteria

Nominations that comply with all the threshold criteria become Candidate Lands. To determine which candidate lands are most important to protect, the lands are evaluated using Evaluation and Ranking Criteria. The first step in this assessment is to determine the parcel boundary that contain the habitats and support systems that need to be protected. Once the optimum boundary is determined, the parcel is evaluated and ranked using the criteria. These evaluation criteria are designed to determine the degree of linkage of injured resources and services to specific parcels, and the potential for benefit that implementation of habitat protection would have on each linked resource and service.

• • •

The next eight paragraphs discuss the evaluation and ranking criteria. They were developed using a mix of professional judgement and scientific data. They are interim criteria developed for the Imminent Threat Process and were used to develop a ranking of threatened habitats. They are currently being re-evaluated.

1) The parcel contains essential habitat(s) for injured resources or services.
Essential habitats include feeding, reproductive, molting, roosting, and migration concentrations; key areas known or presumed to be high public use areas. Factors for determining these habitat are:

a) population of animals or number of public users,

b) number of key habitats on parcel, and

c) quality of key habitats.

This criterion estimates the degree of linkage between the resource or service and the parcel. Each linked habitat, known to occur on the parcel, is rated as high, moderate or low. This rating is derived from the estimated benefit that the resource or service would get from protection of the parcel. Because it is the most important, it is the only one that is weighted.

2) The parcel can function as an intact ecological unit or essential habitats on the parcel are linked to other elements/habitats in the greater ecosystem. The parcel must contain enough connections to natural systems outside of its boundary so that it can sustain populations of

linked species. Both the size and shape of the parcel must meet the area requirements of linked resources or services.

3) Adjacent land uses will not significantly degrade the ecological function of the essential habitat(s) intended for protection. The parcel must maintain the integrity of the injured species populations and services even if adjacent lands are developed.

4) Protection of the habitats on parcel would benefit more than one injured resource or service (unless protection of a single resource or service would provide a high recovery benefit). This criterion recognizes parcels that contain more than one linked resource or service. Example of high benefits to a single species would be the protection of an especially productive anadromous stream, or of a forest area with a dense nesting population of marbled murrelets.

5) The parcel contains critical habitat for a depleted, rare, threatened, or endangered species. This criterion recognizes the benefit of preserving both species and habitat diversity. Rare, threatened, depleted, or endangered species often have very specialized habitat requirements or exist only in a few small areas. Protection of habitat areas of these species, that are important to recreation or commercial uses, helps to maintain normal population levels.

6) Essential habitats on parcel are vulnerable or potentially threatened by human activity. Habitat alteration or destruction is a major cause in the reduction in species numbers. Injured, rare or species populations with low resilience are particularly vulnerable to changes in land use that affect essential habitats.

7) Management of adjacent lands is, or could easily be made compatible with protection of essential habitats on parcel. Management policies, on adjacent lands, that would facilitate both recovery and long term protection goals are recognized by this criterion. This criterion also considers management costs for potential acquisitions.

8) The parcel is located within the oil spill area. Linked habitats on parcels within the oil spill area are more likely to contain affected populations than those outside of the area. However, one of the issues addressed in the alternatives asks whether restoration activities should take place in the spill area only, or anywhere there is a link to injured resources and services. If the latter answer is chosen, the Habitat Protection and Acquisition Process may consider parcels outside the spill area as long as they benefit resources or services injured by the spill. However, most parcels considered by the process will likely be within the spill area.

STEP 5
Restoration Objectives

After establishing the parcel rankings, staff determine the objectives for each parcel. These objectives will help guide which protection and acquisition tool(s) are chosen. For example, if the objective is to maintain anadromous fish habitat, protecting larger stream buffers from development may be adequate. If the objective is public use, fee simple title may be a better tool.

For example, the restoration objectives for the purchase of inholdings in Kachemak Bay State Park were:

- ***maintain water quality of the estuary and associated riparian habitats for anadromous fish;***
- ***maintain bald eagle, marbled murrelet, and harlequin nesting habitat;***
- ***maintain and enhance recreational opportunities and scenic values; and***
- ***maintain public access to Leisure Lake stream.***

B ACQUISITION AND PROTECTION

Step 6

Decide Which Protection Tool(s) are Appropriate

The Trustee Council has a suite of tools at its disposal for habitat acquisition and protection. These tools range from the simple, voluntary land owner agreement, to the purchase of full title to land. Protection tools between these include management agreements, leases, and temporary and permanent conservation easements. Each tool has strengths and limitations. For example, while a voluntary management agreement may be simple to obtain and cost nothing, it is not enforceable. On the other hand, acquisition of an easement may provide the desired permanent protection, yet it may be costly to purchase and difficult to manage. Acquisition of fee simple interests in lands provides the maximum protection, but it is the most expensive to purchase. Care must be taken to apply the most appropriate protection tool to each situation.

The Trustee Council, in concert with any agency that may become responsible for managing the affected lands, will decide which land protection tool is most appropriate for each situation. The final decision on which protection tools are employed will be the result of negotiations with landowners.

For discussion of the complete range of available land protection tools, please refer to "Options for Identifying and Protecting Strategic Fish and Wildlife Habitats and Recreation Sites: A General Handbook," Section 3.3, The Nature Conservancy, December 1991, prepared for The Exxon Valdez Oil Spill Restoration Planning Work Group.

Step 7

Secure protection using the appropriate tool.

Acquisition will proceed for the highest-ranked parcels. Acquisition or protection of lands or interests in lands is based on standard realty principles and practices. Although there are minor differences in the ways the Federal government and the State of Alaska conduct acquisitions, the essential elements of real estate acquisitions are included in both processes. All acquisitions will require evidence of title, appraisals of fair market value, hazardous materials surveys, legal review of title, and negotiations. In addition, some acquisitions will require land surveys.

Once a tract is identified for acquisition and protection by the Trustee Council, it will be assigned as an acquisition and protection case to an agency, multi-agency team, or other group. In addition, assistance in acquisitions may be obtained from other groups such as non-profit land conservation groups. The party with responsibility for an acquisition will receive direction from the Trustee Council and staff to assure that acquisitions are conducted according to Trustee Council directives and will fulfill restoration objectives. Once an acquisition has been fully negotiated regarding all terms and conditions, and price, the Trustee Council will have final authority to approve funds for the acquisition and protection. The agency or group that would receive title to the tract would need to accept title.

From the time an acquisition and protection case begins negotiation to its completion will typically take six months to two years, depending on its complexity. Factors that influence the complexity include title conditions, potential contamination, need for land surveys, protracted negotiations, and approvals by corporate boards.

Acquisition and protection could involve land exchanges, if suitable federal or state lands can be identified for exchange. Identifying public lands that are agreeable for exchange is difficult. Land exchanges involve both the acquisition and disposal of lands, they are more complex than purchases. They typically take a minimum of two years.

C MANAGEMENT

Step 8

After the Trustee Council has secured for an agency the right to manage the protected habitat, the land must be managed to fulfill the identified restoration objectives. The Trustee Council will likely require that the federal or state agency that receives title manage the land for restoration purposes. The management actions needed for fulfilling these purposes will be specific to each parcel of land conveyed.

Land managers for the acquired habitat may be requested to produce or revise management plans. Special management designations may be recommended. Possible special designations include: Alaska State Parks, Alaska Department of Fish and Game special areas, State Public Use Areas, National Recreation Areas, National Marine Sanctuaries, Federal Wilderness areas, or a variety of administrative designations. As restoration objectives are accomplished over time, some restrictions imposed on management of the lands may be removed.

Intensive management of lands may be required to meet restoration objectives. It could require specific research and monitoring, public education, possibly enhancement activities, etc. Consideration will be given to providing funding for management from settlement funds and from the land managers.

EXAMPLES OF THE RANKING AND EVALUATION: IMMINENT THREAT PROCESS

The process described in this section is easiest to understand using examples. This part of the section shows examples of how the Imminent Threat analysis was applied to two highest-ranking parcels in the analysis: China Poot in Kachemak Bay, and Seal Bay on Afognak Island.

Tables C-4 and C-5 show how habitat protection and acquisition in these two areas would benefit the resources and services affected by the oil spill. They show the results of the analysis completed for these two areas during the Imminent Threat Process. **Table C-6** shows how the parcels were ranked using the Evaluation and Ranking Criteria explained earlier.

On December 11, 1992, the Trustee Council allocated funds to purchase China Poot in Kachemak Bay. On May 13, 1993, the Trustee Council directed staff to begin negotiations on the other four parcels. They have currently come to tentative agreement to purchase property at Seal Bay and Tonki Cape, on Afognak Island for $38.7 million, pending further negotiation and appraisal.

Table C-4

Example 1: China Poot, Kachemak Bay

Landowner:	**Seldovia Native Association** *(other owners may own partial rights such as timber or minerals)*
Parcel acreage:	**7,500 acres**
Total acreage held by owner in the spill area:	**106,000 acres**
Estimated area to be affected by imminent development activity:	**5,300 acres**

EXAMPLE PARCEL: CHINA POOT, KACHEMAK BAY

INJURED RESOURCE/SERVICE	POTENTIAL FOR BENEFIT	COMMENT
Anadromous Fish	MODERATE	Five cataloged anadromous streams on parcel. Coho, chum, sockeye, and pink salmon and Dolly Varden spawning and rearing habitat; enhanced sockeye salmon runs in Leisure Lake and Hazel Lake.
Bald Eagle	HIGH	Intertidal foraging and feeding on anadromous fish. Thirty seven documented nest sites on parcel.
Black Oystercatcher	LOW	Likely that oystercatchers use gravel spit sand intertidal for feeding and nesting.
Common Murre	MODERATE	Murre colony (est. 5,075 birds) on Gull Rock may benefit from adjacent habitat protection.
Harbor Seal	MODERATE	Harbor seals feed in area and frequently haul-out on nearshore rocks and bars.
Harlequin Duck	MODERATE	Probable nesting in upper riparian areas; probable feeding in streams and estuaries.
Intertidal/Subtidal Biota	HIGH	China Poot Bay is documented as one of the most productive shallow benthic habitats in Kachemak Bay.
Marbled Murrelet	HIGH	High confidence that nesting occurs on parcel. Large numbers of murrelets forage on Kachemak Bay.
Pigeon Guillemot	LOW	Foraging occurs in adjacent marine waters.
River Otter	MODERATE	High use area for feeding and latrine sites; possible denning inland.
Sea Otter	LOW	Established population in area; feeding and possible pupping in adjacent marine waters.

Table C-4 *(continued)*

EXAMPLE PARCEL: CHINA POOT, KACHEMAK BAY

INJURED RESOURCE/SERVICE	POTENTIAL FOR BENEFIT	COMMENT
Recreation/Tourism	HIGH	Neptune, Peterson, and China Poot Bay sand Gull Rock receive high use. Highly visible from Homer and Kachemak Bay. Adjacent to Kachemak Bay State Park.
Wilderness	LOW	Area is moderately developed, primarily recreational home-sites. High human use area.
Cultural Resources	MODERATE	Twenty eight documented archaeological sites on parcel.
Subsistence	MODERATE	Within resource use area of Port Graham and English Bay.

ECOLOGICAL SIGNIFICANCE:
China Poot, Neptune, and Peterson bays are highly productive estuaries that provide habitat for birds, anadromous fish, mammals, and intertidal marine life. This area receives very high recreational use, has significant archaeological sites, and is highly visible from Homer and adjacent marine waters. The timbered lands are probably important to marbled murrelets. This area also provides access to a recreational dip-net fishery at the outlet of Leisure Lake.

ADJACENT LAND MANAGEMENT:
This parcel is adjacent to Kachemak Bay State Park; the park receives a significant amount of recreational use by residents of Anchorage and the Kenai Peninsula and is also an important tourist attraction. The parcel is also adjacent to other Seldovia Native Association lands.

IMMINENT THREAT/OPPORTUNITY:
This parcel is proposed for logging in 1993. Permit approvals are pending additional information, Corps of Engineers Public Notice, and Alaska Coastal Management Review Preview.

PROTECTION OBJECTIVE:
1) Maintain water quality of the estuary and associated riparian habitats for anadromous fish; 2) maintain bald eagle, marbled murrelet, and harlequin nesting habitat; 3) maintain and enhance recreational opportunities and scenic values; and 4) maintain public access to Leisure Lake stream.

USEFUL PROTECTION TOOL(S):
Timber acquisition; fee simple purchase; conservation easement; cooperative management; public access acquisition.

RECOMMENDED ACTION:
The Trustee Council has approved a resolution to acquire fee title for Kachemak Park in holdings. Habitat and service values are among the highest for imminent threat lands evaluated. Request Seldovia Native Association to provide interim protection; begin negotiations to acquire long term protection; December 31, 1993 deadline.

Table C-5

Example 2: Seal Bay on Afognak Island

Landowner:	**Akhiok-Kaguyak-Old Harbor d.b.a. Seal Bay Timber Company** *(other owners may own partial rights such as timber or minerals).*
Parcel acreage:	**17,391 acres**
Total acreage held by owner in the spill area:	**253,000 acres**
Estimated area to be affected by imminent development activity:	**8,443 acres**

EXAMPLE PARCEL: SEAL BAY ON AFOGNAK ISLAND

INJURED RESOURCE/SERVICE	POTENTIAL FOR BENEFIT	COMMENT
Anadromous Fish	MODERATE	Six documented anadromous streams; pink, sockeye, coho, Dolly Varden, steelhead.
Bald Eagle	HIGH	Eleven documented active nest sites; feeding and roosting along shoreline.
Black Oystercatcher	MODERATE	Feeding in intertidal; probable nesting along shoreline and nearshore islets.
Common Murre	NONE	
Harbor Seal	MODERATE	Area historically supported large numbers of seals. Feeding in nearshore waters and haul-outs on nearshore rocks.
Harlequin Duck	MODERATE	Up to 64 birds observed in Seal Bay. Nearshore habitat appears good for feeding and molting. Potential for nesting appears low.
Intertidal/subtidal biota	MODERATE	Productive sheltered rocky intertidal and shallow subtidal habitat. Steep slopes adjacent to intertidal may become source of erosion sedimentation. No documented oiling of shoreline.
Marbled Murrelet	HIGH	High confidence that nesting occurs on parcel; high use of adjacent marine waters for feeding; good nesting habitat characteristics in forest areas; adjacent area on Alaska Joint Venture land had highest nesting habitat characteristics in spill area; logging has fragmented some forest stands which has diminished nesting characteristics in some areas.
Pigeon Guillemot	MODERATE	Documented nesting of up to 36 birds on or immediately adjacent to parcel; feeding in nearshore waters.
River Otter	MODERATE	Probable feeding and latrine sires along shoreline. Possible denning. Habitat characteristics appear very favorable for river otters.
Sea Otter	MODERATE	Known concentration area off Tolstoi Point. Feeding in nearshore waters.

Table C-5 *(continued)*

EXAMPLE PARCEL: CHINA POOT, KACHEMAK BAY

INJURED RESOURCE/SERVICE	POTENTIAL FOR BENEFIT	COMMENT
Recreation/Tourism	MODERATE	Area has historically supported high value wilderness-based recreation for boats and lodge. Access was previously difficult but is now road accessible.
Wilderness	MODERATE	Wilderness characteristics have declined due to recent clearcuts and road; timber harvest and roads are visible from Seal Bay; wilderness characteristics in remaining portion of parcel will be maintained.
Cultural Resources	MODERATE	Six archaeological sites documented on parcel.
Subsistence	LOW	Marine invertebrates, deer, elk, marine mammals.

ECOLOGICAL SIGNIFICANCE: This parcel contains mature forest habitat adjacent to highly productive marine waters. An estimated 1,190 acres (7% of commercial forest habitat) have been logged. Streams within the parcel support a diversity of anadromous fish. Forests on this parcel are believed to provide high value marbled murrelet nesting habitat. Acquisition of entire parcel would stop fragmentation which is probably diminishing nesting use. Recreation values, particularly for fishing, hunting, and non-consumptive uses are high. Parcel supports high numbers of non-injured species including deer, elk, and brown bear.

ADJACENT LAND MANAGEMENT: Afognak Joint Venture to west; Ouzinkie Corporation to south (managed primarily for timber harvest and tree farming).

IMMINENT THREAT/OPPORTUNITY: Commercial forest stands on this parcel are being logged as part of ongoing timber management by Koncor Forest Products. Akhiok-Kaguyak has offered to sell this parcel to the Trustee Council as one of three options for habitat protection.

PROTECTION OBJECTIVE: 1) Maintain water quality and riparian habitat associated with five anadromous fish streams; 2) maintain marbled murrelet and bald eagle nesting habitat; 3) minimize disturbance to harbor seal, sea otter, river otter, harlequin duck, pigeon guillemot, and intertidal/subtidal biota; 4) maintain and enhance wilderness-based recreational opportunities; 5) maintain and promote continued use by non-injured wildlife including elk, deer, and brown bear; 6) rehabilitate logged areas to enhance wildlife use and service values.

USEFUL PROTECTION TOOL(S): Fee title acquisition; timber acquisition; conservation easement.

Ranking and Evaluating the Example Parcels

Two tables follow. **Table C-6** shows the summary rankings and the formula used to determine the two parcels' ranking scores. **Table C-7** shows the categories for Ranking and Evaluation Criteria #1. That is the criteria that estimates the benefit that the resource or service would get from protecting the parcel. Because it is the most important, it is the only one of the eight criteria that is weighted.

Table C-6

Parcel Ranking Analysis, Example Parcels
Imminent Threat Parcels

	RANKING AND EVALUATION CRITERIA [1]								
PARCEL NAME	1	2	3	4	5	6	7	8	SCORE [2]
China Poot; Kachemak Bay	4-H,7-M	Y	Y	Y	N	Y	Y	Y	45
Seal Bay; Afognak Island	2-H,11-M	Y	N	Y	N	Y	N	Y	30

Table Footnotes: For Criteria, refer to table in box at the bottom of this page.

1. Criteria 1:
   H = High Benefit
   M = Moderate Benefit
   L = Low Benefit

   Criteria 2 - 8:
   N = No (does not meet criteria)
   Y = Yes (does meet criteria)

2. Scoring Formula
   Parcel Score = (Sum of H + (0.5 x Sum of M)) x Sum of Y
   China Poot Score = (4 + (0.5 x 7)) x 6) = (4 + 3.5) x 6 = 45
   Note: Formula emphasizes degree of linkage to injured resource/service.

RANKING & EVALUATION CRITERIA

1. Parcel contains key habitat(s) for injured resources or services.
2. Parcel can function as intact ecological unit or essential habitats on the parcel are linked to other elements/habitats in the greater ecosystem.
3. Adjacent land uses will not significantly degrade the ecological function of the essential habitat(s)intended for protection.
4. Protection of the habitats on parcel would benefit more than one injured resource or service (unless protection of a single resource or service would provide a high benefit to recovery).
5. Parcel contains critical habitat for a depleted, rare, threatened, or endangered specie.
6. Essential habitats on parcel are vulnerable or potentially threatened by human activity.
7. Management of adjacent land is, or could easily be made compatible with protection of essential habitats on parcel.
8. Parcel is located within the oil spill area.

Table C-7 shows the categories for Ranking and Evaluation Criteria #1. They describe the benefit that each resources or services would get from protecting the parcel. In some cases they are not identical to the resources or services injured by the spill that would benefit from protection. That list is given in **Table C-1**. The differences are slight and facilitate the evaluation.

Table C-7

Criteria for Rating Benefit to Injured Resources and Services Imminent Threat Analysis

INJURED RESOURCE/SERVICE	HIGH	MODERATE	LOW
Anadromous Fish	High density of anadromous streams per parcel; multiple injured species, and/or system known to have exceptional productivity.	Average density of anadromous streams for area; two or more injured species present.	Few or no streams on parcel; one or less injured species.
Bald Eagle	High density of nests on parcel; and/or known critical feeding area.	Average density of nests on or immediately adjacent to parcel (at least one); important feeding area.	Few or no nests on parcel; may be used for perching and/or feeding.
Black Oystercatcher	Area known to support nesting concentration area for feeding.	Possible nesting; known feeding area.	Probable feeding.
Common Murre	Known nesting on or immediately adjacent to parcel.	Nesting in vicinity of parcel; known feeding concentration adjacent to parcel.	Possible feeding in area adjacent to parcel.
Harbor Seal	Known haul out on or immediately adjacent to parcel.	Probable haul outs in vicinity of parcel; probable feeding in near-shore waters adjacent to parcel.	Probable feeding in near-shore waters.
Harlequin Duck	Known nesting or molting on parcel; feeding concentration area.	Probable nesting on or adjacent to parcel; probable feeding instream, estuary, or intertidal adjacent to parcel.	Probable feeding and loafing in area adjacent to parcel
Intertidal/subtidal biota	Known high productivity/ species richness. Oiled or adjacent to oiled area where recruitment may be important.	High productivity/species richness; not oiled or near oiled area.	Average productivity/ species richness; no documented shoreline oiling.
Marbled Murrelet	Known nesting or high confidence that nesting occurs; concentrated feeding in near-shore waters.	Good nesting habitat characteristics; known feeding in near-shore waters adjacent to parcel.	Low likelihood of nesting; possible feeding in near-shore waters.
Pigeon Guillemot	Known nesting on or immediately adjacent to parcel; feeding concentrations in near-shore waters.	Low likelihood of nesting; possible feeding in near-shore waters.	Good nesting habitat characteristic; known feeding in near-shore waters adjacent to parcel.

Table C-7 *(continued)*

INJURED RESOURCE/SERVICE	HIGH	MODERATE	LOW
River Otter	Known high use of parcel for denning/latrine sites.	Known or probable latrine and/or denning sites; known feeding in adjacent intertidal/ streams/near-shore area.	Probable feeding in adjacent intertidal/streams.
Sea Otter	Known haul-out or pupping concentrations.	Concentration area for feeding and/or shelter; potential pupping.	Feeding in adjacent waters.
Recreation/Tourism	Receives high public use; highly visible to a large number of recreationists or tourists; area nominated for special recreational designation.	Accessible by road, boat, or plane; adjacent area used for recreational boating; adjacent area receives high public use.	Occasional recreational use; access may be difficult.
Wilderness	Area remote; little or no evidence of human development.	Area remote; evidence of human development.	Area accessible; high/moderate evidence of human development (roads, clearcuts, cabins).
Cultural Resources	Documented concentration or significant cultural resources/sites on parcel.	Evidence of cultural resources/sites on or adjacent to parcel.	Possible cultural resources/sites on parcel.
Subsistence	Known resource harvest area; multiple resource use.	Known harvest area for at least one resource.	Possible harvest area.

LIKELY CHANGES IN THE PROCEDURES FOR THE COMPREHENSIVE PROCESS

While this section has explained the Imminent Threat Process, the Trustee Council staff is evaluating not only the private lands for which development will occur soon, but all private lands in the spill area where the owner is a willing to participate in the process. They are also evaluating the process to see if it can be improved. Two changes in particular have already been suggested by staff and the public.

During the Imminent Threat Process, the parcels were sized to include the imminent development. For example: where timber harvest was expected, the parcel that was analyzed was an ecologic unit such as a small watershed that surrounds the land for which forest practice notifications had been received. Staff and the public suggested that in the Comprehensive Process, staff rate larger areas that protect more linked habitats. This change will reduce the problem that the parcel score is dependent on parcel size.

Many people suggested that the resources and services used in **Table C-7** lumped together categories with different habitat requirements. To solve this problem, the Anadromous Fish category in the table will be separately rated for pink salmon, sockeye salmon, cutthroat trout, and Dolly Varden trout. Also, Recreation and Tourism which were rated together will be subdivided into: Recreational Use (Non-consumptive), Recreational Use (Consumptive), Commercial Use (Non-consumptive), and Commercial Use (Consumptive).

The proposed changes to the rating categories are outlined in **Table C-8.**

Table C-8

Changes to Benefit Rating System for Injured Resources and Services:
Changes Proposed for Comprehensive Process

INJURED RESOURCE/SERVICE	HIGH	MODERATE	LOW
Pink Salmon	High density of pink salmon streams per parcel; system known to have exceptional productivity; pink salmon are unique to the area.	Average density of pink salmon streams on parcel; average productivity for the area.	Few or no pink salmon streams on parcel; low productivity for the area.
Sockeye Salmon	High density of sockeye salmon streams on parcel; system known to have exceptional productivity; sockeye salmon are unique to the area.	Average density of sockeye salmon streams on parcel; average productivity for the area.	Few or no sockeye salmon streams on parcel; low productivity for the area.
Cutthroat Trout	High density of cutthroat trout streams on parcel; system known to have exceptional productivity; cutthroat trout are unique to the area.	Average density of cutthroat trout streams on parcel; average productivity for the area.	Few or no cutthroat trout streams on parcel; low productivity for the area.
Dolly Varden	High density of Dolly Varden streams on parcel; system known to have exceptional productivity; Dolly Varden are unique to the area.	Average density of Dolly Varden streams on parcel; average productivity for the area.	Few or no Dolly Varden streams on parcel; low productivity for the area.
Recreational Use: ***Non-consumptive***	Receives high public use primarily of a non-consumptive nature (hiking, nature and wildlife viewing, boating, photography, camping, etc.; secondary use may include fishing or hunting); area highly visible to the recreational user; area nominated for special recreational designation.	Accessible by road, boat, or plane; maintained foot or off-road vehicle trails in vicinity; adjacent waters used for recreational boating; adjacent area receives high public use.	Occasional recreational use; access may be difficult.
Recreational Use: ***Consumptive***	Receives high public use primarily of a consumptive nature (fishing, hunting, berry-picking; secondary use may include camping, hiking, photography and nature viewing); area well known to support consistently high wild fish and game populations; area highly visible to the recreational user.	Accessible by road, boat, or plane; maintained foot or off-road vehicle trails in vicinity; adjacent waters used for recreational boating and fishing; adjacent area receives high recreational fishing and hunting use.	Occasional recreational fishing and hunting use; access may be difficult.

Table C-8 *(continued)*

INJURED RESOURCE/SERVICE	HIGH	MODERATE	LOW
Commercial Use: *Non-consumptive*	Receives high use by tour guide operators primarily of a non-consumptive nature (hiking, nature and wildlife viewing, boating, photography, camping, etc.; secondary use may include fishing or hunting); area highly visible to the recreational user; area nominated for special recreational designation.	Parcel likely to be used by local tour guide operators because it is accessible by road, boat, or plane, and has maintained foot or off-road vehicle trails in vicinity; adjacent waters or lands used by tour guide operators.	Occasional use by tour guide operators; access may be difficult.
Commercial Use: *Consumptive*	Receives high commercial outfitter or guide use primarily of a consumptive nature (fishing and hunting; secondary use may include camping, hiking, photography and nature viewing); area well known to support consistently high wild fish and game populations; area highly visible to the recreational user.	Accessible by road, boat, or plane; maintained foot or off-road vehicle trails in vicinity; adjacent waters used for guided fishing; adjacent area receives high guided or outfitted fishing and hunting use.	Occasional guided or outfitted fishing and hunting use; access may be difficult.

The Comprehensive Process may be different from the Imminent Threat Process in other ways as well. Staff, expert peer reviewers, and the public may suggest changes. Public review as part of this Supplement is an important way for staff to learn of problems or improvements.

Habitat Protection on Public Land

Habitat Protection on public lands can include making recommendations for changing agency management practices, modifying statutes and regulations, and putting public lands and waters into special designations. The goal is, in appropriate situations, to provide a level of protection for recovering resources and services, not provided by existing regulations and management activities. Appropriate protective actions on public land would be determined by first identifying injured resources and services on those lands whose recovery could be hampered by expected human activities. In cases where existing management practices did not provide appropriate protection, options for management would be analyzed for adequacy and feasibility. Management changes would only be funded to the extent that implementing the change was not already funded as part of normal agency management.

Many changes in management actions that increase protection to injured resources and services have costs to the economy and to one or more user groups. The decision that the benefit to recovery outweighs the cost to society must be made with public review by the Trustee Council, the implementing agency, or in some cases by the Alaska Legislature or the U.S. Congress.

One type of management action involves placing marine and intertidal areas, and publicly owned uplands into state or federal special designations which 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. Special designations may not be appropriate for restoration when they place burdensome restrictions on injured services or encourage intensive public use of recovering habitats.

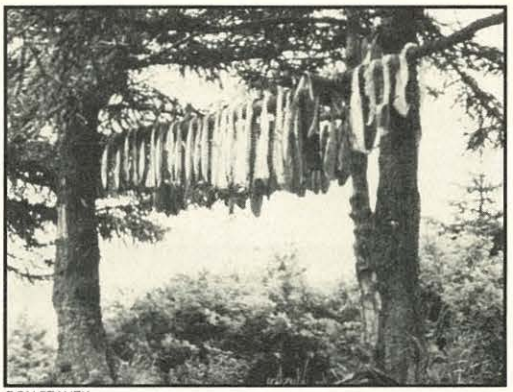
Different management designations will place varying amounts of emphasis on providing resource protection, opportunities for public uses, and scientific research. The appropriate designation can be determined by examining which injured resources and services are present, what type of additional regulatory protection is required to continue recovery, existing and planned human uses, and public review. Possible special designations include: Alaska State Parks, Alaska Department of Fish and Game special areas, State Public Use Areas, National Recreation Areas, National Marine Sanctuaries, Federal Wilderness areas, or a variety of administrative designations. New types of special designations can also be created, if necessary. An important factor in the success of any special designation is sufficient funding to support management and enforcement activities.

Management actions need not involve a special designation. In many cases, agencies can take appropriate protective action under existing statutes and procedures.

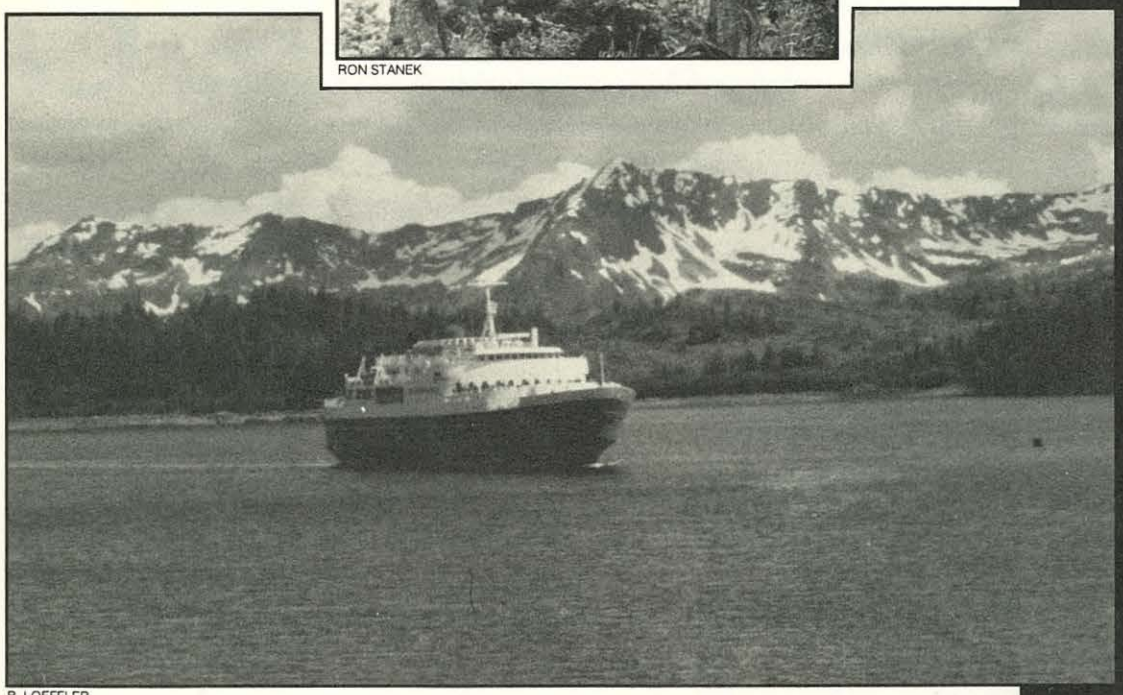
At this time, the Trustee Council has not proposed changes in public land and water management, although it may do so in the future. In the meantime, agencies may be initiating some changes on the basis of their existing statutory authority. For example, the USDA Forest Service is evaluating the current direction provided by the Chugach National Forest Land Management Plan for Prince William Sound in light of new environmental information from oil spill activities, Forest Service monitoring efforts, and other existing data; and in light of possible restoration projects. The current version of the plan was completed in 1984, before the spill, and the revision is expected to be completed in 1997.

Section D

GENERAL RESTORATION



RON STANEK



R. LOEFFLER

Section D

GENERAL RESTORATION

Introduction

Since 1990, agencies and the public have proposed hundreds of ideas for general restoration. Some of the suggested activities would restore injured resources and reduced or lost services through direct manipulation. Examples include building fish passes to benefit salmon runs, or replanting seaweed to restore the intertidal zone to prespill conditions. Other ideas focus on managing human use to aid restoration such as redirecting hunting and fishing harvest, or reducing human disturbance around sensitive bird colonies. This section provides information on the process used to develop and evaluate general restoration options, and descriptions of some general restoration options that received favorable evaluations. General Restoration does not include Habitat Protection and Acquisition or Monitoring and Research *(see Sections C and E respectively).*

Developing General Restoration Options

The restoration planning process has identified a wide range of restoration ideas and projects based on suggestions from the public and from state and federal agencies. These ideas and projects were grouped together by their objectives into categories called restoration options. **Figure D-1** provides an example of how several ideas that accomplish the same objective are combined into a single restoration option. Fish ladders and removing barriers in streams allow fish to reach new spawning habitat. Constructing spawning channels provides new spawning habitat directly. Fertilizing sockeye rearing lakes improves food availability in existing habitat. All four accomplish the same objective: improving or providing more spawning or rearing habitat for wild stocks of salmon.

Figure D-1

Example of a General Restoration Option

The Public Suggested:

- **Fish ladders**
- **Spawning channels**
- **Remove barriers**
- **Fertilize lakes**

We Developed This Option:

- **Improve salmon spawning and rearing habitat**

One option may include similar activities for different resources or services. In the example above, the option could improve spawning and rearing habitat of pink salmon as well as sockeye salmon. In most situations, implementing the option would be different for each species because specific project designs would have to be tailored for the targeted resource or service. In this example, implementing this option could also benefit services (commercial fishing and sport fishing) that were lost or reduced as a result of the oil spill.

Option Evaluation

Many options have undergone extensive evaluation and review as part of the planning process. Initially, options were evaluated to determine if they met the terms of the civil settlement, were technically feasible (or warranted research on the feasibility), and were not likely to cause substantial harm to injured resources. Options which passed this evaluation went through a second evaluation using criteria developed from the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (42 U.S.C. 9601). Restoration ideas which failed any one of these criteria, from either evaluation process, were rejected from further consideration. These criteria include:

CRITERIA	ADDITIONAL INFORMATION
Technical feasibility	Are the technology and management skills available to successfully implement the restoration option in the oil spill area?
Potential to improve the rate or degree of recovery	Will the implementation of the restoration option make a difference in the recovery of an injured resource or service? This criterion was used to evaluate the effectiveness of options for benefiting resources.
The relationship of expected costs to expected benefits	Do benefits equal or exceed costs? Ability to meet this criterion was not based on a cost/benefit analysis, but on a broad consideration of the direct and indirect costs and the primary and secondary benefits.
Consistency with applicable federal and state laws and policies	Is the restoration option consistent with the directives and policies with which the Trustee agencies must comply?
The potential for additional injury resulting from the option, including long-term and indirect impacts	Will implementation of the restoration option result in additional injury to target or non target resources or services?

This part describes some examples of different General Restoration Options that have undergone a rigorous technical evaluation.

The descriptions include:

1) an explanation of how the option would help the injured resources or reduced or lost services,

2) a brief description of how the option can relate to policy questions, and

3) information on annual costs and project durations.

The costs are rough estimates expressed in 1993 dollars and may change when detailed project proposals are developed.

Some injured resources may benefit from changes in management such as harvest restrictions or manipulation of habitat such as creation of spawning channels. Unfortunately, there is very little that can be done directly for other species. Some options are experimental and must be tested before they can be considered for broad-scale application. These are identified as **Special Studies**. Other options may be effective only in certain areas and cannot be generally applied to the injured resource. These options are identified as providing "localized benefits only." Some options are most effective outside the spill area. However, activities outside the spill area would be undertaken only if consistent with the Final Restoration Plan. Several examples of general restoration options are provided. These represent a cross-section of the options that have been evaluated to date.

• • •

EXAMPLE 1
Marine Mammals

Implement cooperative programs between subsistence users and agencies to assess the effects of subsistence harvest on sea otters and harbor seals.

This example demonstrates a marine mammal option that involves management of human uses.

Harbor seals and sea otters are legally harvested by subsistence users in the spill area. In this option, agency wildlife biologists and subsistence users would cooperatively identify and gather needed information, and, possibly, assess the need for voluntary harvest reductions. If it was mutually agreed that an injured species was being overharvested, subsistence users and biologists could determine voluntary reductions in subsistence harvest levels which could remain in place until populations had recovered from oil-spill injuries. Harvest reductions could enhance the rate of natural recovery of injured species by reducing harvest pressures. Subsistence harvest and other services dependent on these species would also benefit in the long-run from population recovery.

Funding would be used to pay for biologists to travel to subsistence areas and meet with subsistence hunters and, possibly, to reimburse subsistence hunters for assistance provided in gathering relevant biological information or samples. This would facilitate regular, face-to-face discussion of the latest information on the injury status of subsistence species and would supplement on-going public information efforts, such as newsletters and videos put out by the Subsistence Division of the Alaska Department of Fish and Game. This option would be closely coordinated with all such on-going agency programs.

How will this help recovery?

If current subsistence harvest levels are slowing species recovery, and voluntary harvest reduction can be mutually agreed upon, reduced harvest pressures could enhance the rate of recovery. Increased communication between agency biologists and subsistence users could help the users decide if their traditional harvest activities might be slowing the recovery of the injured populations. Face-to-face contact between agency researchers and subsistence users increases community understanding of scientific data and facilitates discussion of the politically and culturally sensitive topic of subsistence harvest levels. In addition, biological and harvest information provided to agency biologists by subsistence hunters could provide useful supplements to existing data.

How does this relate to the policy questions?

This option is found in alternatives 3, 4, and 5 for harbor seals and sea otters because it may provide substantial benefit or protection to aid in recovery, and because both of these species suffered population declines.

Cost and Duration:

The cost estimates for implementing this option may be approximately $30,000 per year depending upon the effort and geographic scope. Implementation of this option may extend throughout the life of the settlement. (Estimates given in 1993 dollars.)

• • •

EXAMPLE 2
Fish

Improve freshwater wild salmon spawning and rearing habitats

This example demonstrates an option that involves the manipulation of habitat to benefit injured fish resources and the sport and commercial fisheries that rely on them. This is also an example of an option that provides "localized benefits only" because it may be effective only in certain areas and cannot be applied to the injured resource on a broad scale.

There are a variety of techniques for improving or supplementing spawning and rearing habitats to restore and enhance the wild salmon populations.

Three different techniques are described under this option:

1) construct salmon spawning channels and instream improvements;

2) fertilize lakes to improve sockeye rearing success; and

3) improve access to salmon spawning areas by building fish passes or removing barriers.

Surveys of the oil-spill area will determine where these options would be applied. This option could be used to restore injured pink and sockeye salmon runs to pre-spill levels or to enhance either injured or equivalent runs above pre-spill levels.

Pink salmon, which swim to sea in their first year, depend primarily on spawning and rearing habitat available within stream channels and intertidal areas. Upstream spawners may benefit from construction of improved spawning channels and fish passages, removal of barriers impeding access to upstream spawning habitats, and addition of woody debris to provide cover and food.

Young sockeye salmon grow in lakes for 1-3 years before emigrating to sea. Appropriate restoration and enhancement techniques for sockeye salmon are determined by the amount of spawning and rearing habitat in the lake and river system. In lake systems with inadequate spawning habitat, spawning channel or fish passage improvement may be appropriate to increase the amount of available spawning

habitat. Fish passes are currently prohibited on the Kenai River system. In lake systems with damaged rearing habitat, chemical fertilizers may be added to lakes to temporarily supplement the nutrients needed to sustain the prey on which fry feed.

It is critical that use of any of these techniques be integrated into existing salmon management plans to prevent an overproduction of fry that could not be supported by available feeding, rearing and spawning habitats and to prevent management problems created by additional fish.

How will this help recovery?

Salmon runs in individual streams would increase due to greater availability of spawning areas following improvements to spawning channels or construction of fish passes. The egg-to-fry survival of salmon in spawning channels is 5 to 6 times greater than survival in unimproved streams. Lake fertilization will greatly improve sockeye over-winter survival and smolt-to-adult survival, by providing nutrients for prey species. Increased stock productivity and adult returns could result from these restoration techniques. This option would primarily benefit species with population level injuries by increasing the overall numbers of fish.

How does this relate to the policy questions?

The different techniques that are included in this option would apply to different alternatives based on their potential effectiveness. **Techniques 1 and 3** (spawning channels, fish passes and removing barriers), may be found under alternative 5 only, for pink and sockeye salmon since these techniques would only provide some benefit to recovering salmon. These techniques would have localized benefits only and would not provide substantial increases in overall productivity.

Technique 2, fertilizing sockeye salmon rearing lakes, is found in alternatives 3, 4 and 5 because it is highly effective for benefiting the sport and commercial fisheries dependent on specific sockeye salmon runs. Lake fertilization benefits the services, but not the injured populations. Lake fertilization is not needed, or is not feasible, in Red Lake and Kenai River systems. However, by increasing fish production in other lakes, this option could improve or create additional fishing opportunities.

Cost and Duration:

The cost estimates for implementing this option may range from $150,000 to $1,900,000 per year depending upon the effort and geographic scope. Implementation of this option may take from 3 to 10 years depending upon the species and the number of locations targeted. (Estimates given in 1993 dollars.)

• • •

EXAMPLE 3
Birds

Remove predators at injured colonies or remove predators from islands that previously supported murres, black oystercatchers or pigeon guillemots

Example 3 is an option that could be undertaken inside and outside the spill area to replace birds that were injured by the spill, if the Final Restoration Plan allows for restoration activities outside of the spill area.

Predation can have a significant affect on the productivity of seabirds. Fox, which are not indigenous to many of the islands of the Aleutian chain and Gulf of Alaska, were introduced on more than 400 islands to be raised and trapped for their furs. Introduced fox reduced and even eliminated populations of surface, burrow and in some cases cliff-nesting birds in a matter of years. Birds were also harmed by incidental introductions of rodents, many of which were released to the islands to provide food for the fox.

Eagles, gulls, ravens and crows are also known predators of murres and other seabirds.

The primary application of this option outside of the spill area would be to remove introduced fox from islands along the Alaska Peninsula, Pribilofs and the Aleutians. Several steps would need to be taken to accomplish this task including identifying and prioritizing target islands, and working with the Environmental Protection Agency and Department of Agriculture to secure registration for toxicants. Programs to eradicate red and arctic ("blue") fox on islands have been successful in the past and would increase Alaska's population of marine birds including species injured by the spill (common murres, black oystercatchers and pigeon guillemots) although it would not increase birds inhabiting colonies within the spill area.

Within the spill area, reducing avian predators such as ravens and gulls, and terrestrial predators such as fox and mink at injured colonies is feasible, but would be difficult to implement for long-term effects. Removing gulls from islands would require traps or poison baits but care would have to be taken to minimize killing non-target species. Eagle predation could also be reduced by providing young eagles to the eagle reintroduction program in the lower 48 states. Reducing predation for nesting pigeon guillemots would be more difficult due to the dispersed nest locations. Initial predation studies would need to be completed to determine the feasibility of benefiting guillemots through predator removal. At least one season of intensive research is needed to determine if this program can be justified.

How will this help recovery?

On some small islands, spectacular increases in breeding birds have been documented after the disappearance or removal of fox. Their removal allows a variety of native birds, including common murres, marbled murrelets, pigeon guillemots, black oystercatchers and various waterfowl, to re-inhabit these islands. Fox are voracious predators of chicks and eggs and climb among the nesting birds to feed. Their removal will allow the productivity of these islands to increase with increased survival of chicks and eggs.

Glaucous-winged gulls, northern ravens, and bald eagles are effective predators on murre colonies in the oil-spill area. Murre eggs and chicks are especially vulnerable when the colony density is reduced or when nesting is not synchronized. These are both problems at colonies injured by the oil spill. Gulls are believed to be a major source of egg mortality at some colonies, sometimes accounting for 40% of the egg loss. Reducing avian predator populations at murre colonies during recovery could increase the productivity.

How does this relate to the policy questions?

This particular option may be found under alternative 3, 4, and 5 for common murres and pigeon guillemots because both species suffered population decline and the option may provide substantial benefit to aid recovery. However, it is only in alternatives 4 and 5 for black oystercatchers since it would be applied only outside the spill area for this species.

Cost and Duration:

The cost estimates for implementing this option may range from $150,000 to $400,000 for each location. Implementation of this option may take from 4 to 10 years depending upon the intensity of the effort each year. (Estimates given in 1993 dollars.)

• • •

EXAMPLE 4
Multiple Wildlife Resources

Determine if eliminating oil from mussel beds removes a potential source of continuing contamination to food for injured wildlife resources and take appropriate action. (Special Study)

This example is a Special Study option because it is experimental and must be tested before it can be considered for broad-scale application, or evaluated for its effectiveness.

Persistent oil in mussel beds represents a potential threat to living resources such as sea otters and harlequin ducks that utilize them as food or habitat. Chemical analyses of mussel tissue and sediments from contaminated mussel beds revealed very high levels of petroleum contamination.

The objective of this option is to determine the geographic extent of persistent oil in and adjacent to oiled mussel beds and to explore potential linkages to other injured resources. The study will also determine the concentration of oil remaining in mussels, the underlaying organic mat and substrate. This study will determine the most effective and least intrusive method of cleaning oiled mussel beds. Once the results of these studies are available, the most effective cleaning techniques will be used in certain areas with persistent oiling. This study would also provide chemical data to assess the possible linkages of oiled mussel beds to harlequin ducks and juvenile sea otters.

This option also includes a monitoring component designed to assess the efficacy of the stripping technique to eliminate oil from mussel beds. Both the fate of oil in mussels and in the substrate and the effects of oil on growth and reproduction of mussels will be followed at oiled and unoiled study sites.

How will this option help recovery?

Stripping or tilling of contaminated mussel beds could increase flushing of residual oil. By exposing buried oil to the air, residual oil would be eliminated through weathering and microbial degradation. Consequently, less oil would be available for bioaccumulation by mussels and other invertebrates. Less oil also would be available as contaminated prey for predator species such as harlequin duck, black oystercatcher, sea otter and river otter.

How does this relate to the policy questions?

Because this option is experimental and because the relationship between oiled mussels and continuing injury to sea otters and harlequin ducks is still unknown, the effectiveness of the option cannot be determined. At this time, this option is included in alternatives 3, 4, and 5 for sea otters and harlequin ducks because both species suffered population declines and the option has potential to provide substantial benefit to these injured resources.

Cost and Duration:

The cost estimates for implementing this option may range from $340,000 to $640,000 per year depending upon the effort and geographic scope.
Implementation of this option may take from 4 to 7 years depending upon the geographic scope.
(Estimates given in 1993 dollars.)

• • •

EXAMPLE 5
Subsistence

Test subsistence foods for continued contamination as a means of restoring confidence in the safety of subsistence resources within the spill area.

This is an example of an option that follows the recovery of several resources that subsistence users rely on, and helps to restore lost subsistence opportunities.

The goal of this option is to restore the knowledge and confidence of subsistence users in the safety of the subsistence resources by monitoring hydrocarbon levels in selected subsistence species, communicating findings to subsistence harvesters, and integrating findings of other studies of spill-related injuries into previously developed health advice. Community participation in all aspects of this option is critical to ensure the credibility of results. Communities which rely substantially on subsistence in the spill area include: Akhiok, Ivanof Bay, Ouzinkie, Chenega Bay, Karluk, Perryville, Chignik Lagoon, Larsen Bay, Port Graham, Chignik Lake, Nanwalek, Port Lions, Chignik, Old Harbor, and Tatitlek.

This option is directly aimed at restoring the knowledge and confidence of subsistence users in the safety of traditional foods. The overall restoration monitoring program may achieve some of the same objectives.

Tissue and bile samples of subsistence species, including mussels, rockfish and harbor seals, will be collected from the harvest areas of impacted communities. Community representatives will assist in site selection, as well as collection of samples. The samples will be analyzed for hydrocarbon contamination. The results of the tests, along with findings from other damage assessment and restoration studies, will be reported to the communities in an informational newsletter and community visits.

This option could be implemented on a yearly basis. At the end of each year, the degree of recovery of the resources, as well as that of the subsistence economy, should be re-evaluated to determine whether the program should be continued. The confidence of the subsistence users in the safety of subsistence foods is likely to lag behind the recovery of the resources to some extent, if so, this option should be continued as long as it is necessary.

How will this help recovery?

Only limited recovery to pre-spill subsistence harvest levels has occurred. A primary reason for continued relatively low levels of subsistence harvests are the communities' concerns about the long-term health effects of using resources from the spill area. By involving the communities in the monitoring of the recovery of the resources, and by bringing information concerning the safety of the resources back to the communities, it is anticipated that subsistence harvests will begin to approach pre-spill levels, and anxiety about their use will be reduced.

How does this relate to the policy questions?

This option may be found under alternatives 3, 4, and 5 for subsistence because it is likely to produce substantial improvement in restoring lost opportunities for subsistence users by increasing confidence in the safety of traditional foods.

Cost and Duration:

The cost estimates for implementing this option may range from $300,000 to $350,000 per year depending upon the effort and geographic scope.
Implementation of this option may extend for 2 to 5 years, or until the subsistence resources have recovered. (Estimates given in 1993 dollars.)

• • •

EXAMPLE 6
Multiple Services

Replace lost sport, commercial and subsistence fishing opportunities by creating new fisheries for salmon or trout

This is an example of an option that benefits fishing opportunities that were lost or reduced as a result of the spill.

This option would start new salmon or trout runs to replace fishing opportunities lost due to fishing closures or injuries resulting from the oil spill. For example, if Kenai River sockeye fishing is closed or restricted for multiple years, alternative runs could partially compensate the loss. The option restores services by providing replacement harvests, but does not restore the injured populations of fish. Commercial, sport and subsistence fishermen could potentially benefit.

The option consists of creating terminal runs, that originate from and return to hatcheries or remote marine release sites. Fish would not be stocked in streams. Returning fish would be harvested and brood stock would be used to artificially propagate the next generation. Since the runs would be dependent on artificial fertilization, the new runs could be terminated once recovery of target fisheries occurs.

Alaska Department of Fish and Game standards and requirements for genetic and disease screening and brood stock selection would have to be met. Also, Regional Planning Teams must approve any proposed actions. Planning concerns include avoiding harmful interactions with wild stocks, interceptions of existing stocks and interference with other fisheries. There are some areas for which this option is not appropriate.

How will this help recovery?

The aim of this option is to minimize additional injuries to user groups by providing alternative fishing opportunities when historical fishing areas are restricted. As an alternative to completely closing fisheries, fishing pressures could be redirected to target these new runs until injured stocks recover. This option could also be used to enhance fishing opportunities above prespill levels if new runs were continued after target species recover.

How does this relate to the policy questions?

Based on its potential effectiveness, this option may be found under alternatives 3, 4, and 5 for Commercial Fishing and Recreation. It is likely to produce substantial improvement in recovery of these services by efficiently producing large salmon runs to replace or create new fisheries.

It is found only in alternative 5 for Subsistence because it is likely to produce only some improvement in reduced or lost subsistence use. The primary damages to subsistence are due to a general loss of confidence in food safety as well as decreased opportunity to harvest species other than salmon.

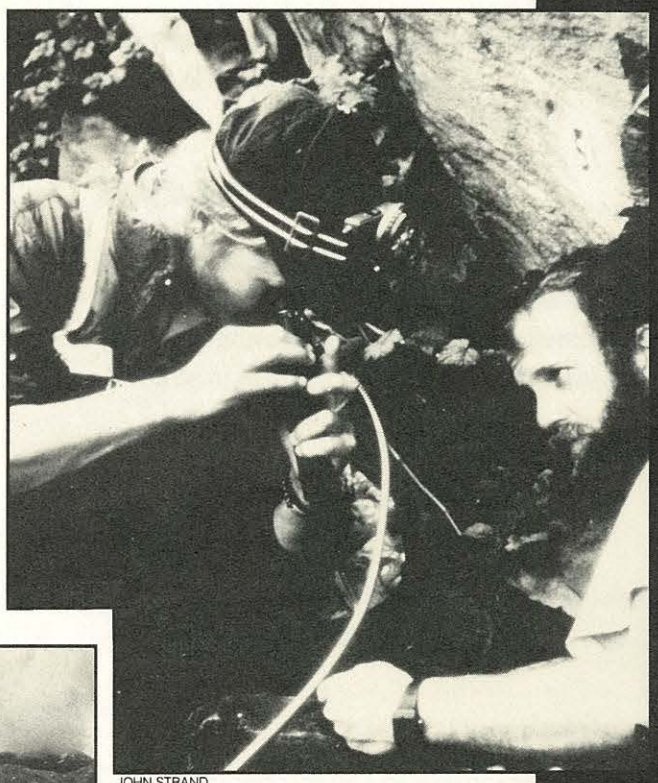
Cost and Duration:

The cost estimates for implementing this option may range from $250,000 to $1,000,000 per fish run. Implementation of this option may extend for up to 10 years depending upon the number of runs targeted. (Estimates given in 1993 dollars.)

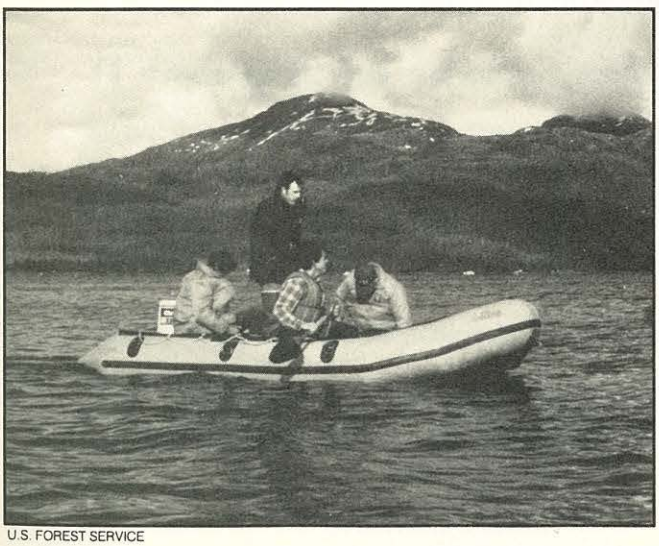
• • •

Section E

RECOVERY MONITORING AND RESEARCH PROGRAM



JOHN STRAND



U.S. FOREST SERVICE

Section E

RECOVERY MONITORING AND RESEARCH PROGRAM

Background

The *Exxon Valdez* Oil Spill Trustee Council is developing an initial (conceptual) design for monitoring and research of injured resources and reduced or lost services. With an approved conceptual design, the Trustee Council will next develop a detailed technical design for monitoring and research that will be implemented as part of the Restoration Plan.

GOAL

The goal is to design a monitoring component for the Restoration Plan. A comprehensive and integrated monitoring component is necessary to follow the progress of recovery and evaluate the effectiveness of proposed restoration activities. Monitoring also is needed to improve the information base from which future disturbances can be evaluated. When necessary, research will be to required to develop new restoration technologies and approaches.

OBJECTIVES

This program will assist the Trustee Council in developing a comprehensive, interdisciplinary and integrated approach to monitoring and research aimed at:

1) ***assessing the rate and adequacy of recovery.***

Monitoring is necessary to assess the rate and adequacy of natural recovery as well as recovery assisted by restoration. Resources and associated services that are found to be recovering at an unacceptable rate may have to be considered as candidates for restoration action. Likewise, resources that are found to be recovering faster than anticipated may allow for earlier completion of a restoration action.

2) ***developing an environmental (information) baseline.***

Monitoring of important physical, chemical, biological properties and human services (cultural and economic) can be used to improve upon or establish anew an environmental baseline. This information can be used to

document long-term trends in the quality and quantity of affected resources and services and assess the effects of future development and natural disturbance.

3) ***understanding the relationships among ecological and human components of the affected ecosystem.***

To better understand the environmental health of the affected ecosystem, it is essential to first understand the linkages among natural and human components and the causes of natural and human change. Based on measurements of the rates of important natural and human processes, understanding can be expanded to include quantitative relationships that define the dynamics of the affected ecosystem. Basic information on ecosystem dynamics can be used to assess the anticipated effects of future human development and improve our ability to manage affected resources and services over the long-term.

4) ***developing a restoration research capability.***

Research could be employed to better understand the causes of failure to recover. Research also could be used to develop new restoration technologies to restore resources not recovering or recovering at lower than expected rates.

Proposed Program Components

The Trustee Council's monitoring and research program could include one or more of the following components, although the components vary among the five alternatives of the Draft Restoration Plan:

1) RECOVERY MONITORING

would assess the rate of recovery of injured resources and reduced or lost services, and determine when recovery has occurred, or when injury is delayed;

2) RESTORATION MONITORING

would evaluate the effectiveness of individual restoration activities and identify where additional restoration activities may be appropriate;

3) ECOSYSTEM MONITORING

(including human uses) would follow long-term trends in distribution and abundance of injured resources and the quality and quantity of human uses. Monitoring of this type could also detect residual oil spill effects and provide ecological as well as human services baseline information useful in assessing the impacts of future disturbances, and;

4) RESTORATION RESEARCH

would clarify the causes of poor or slowed recovery, and design, develop, and implement new technologies and approaches to restore injured resources and reduced or lost services.

Resources and Services to be Monitored

At minimum, monitoring should follow recovery for all injured resources and reduced or lost services listed in **Table E-1**. For some of these resources, there is documentation of declines in abundance that will persist for more than one generation, decades in some cases.

While mortality and other injuries occurred to other resources, population abundance was not always affected. There also is evidence of diminished human services in the spill area including commercial fishing, commercial tourism, recreation, passive use, and subsistence.

Table E-1

Injured Resources and Reduced or Lost Services

Resources

POPULATION DECLINE	INJURED, BUT NO POPULATION DECLINE	OTHER
Black oystercatcher	Bald eagle	Archaeological resources
Common murre	Cutthroat trout	Designated wilderness areas
Harbor seal	Dolly Varden	
Harlequin duck	● Killer whale	
Intertidal organisms	Pacific herring	
Marbled murrelet	● Pink salmon	
Pigeon guillemot	River otter	
Sea otter		
Sockeye salmon		
Subtidal organisms		

● *For these species, the Trustee Council's scientists have considerable disagreement over the conclusions to be drawn from the results of the damage assessment studies.*

Services

(Human uses)

- Commercial fishing
- Commercial tourism
- Passive use
- Recreation including sport fishing, sport hunting, and other recreation use
- Subsistence

Should the Trustee Council decide to implement ecosystem monitoring, the population dynamics of other ecological components would need to be followed, for example, those species important in the food webs of injured species. To better manage injured marine birds, marine mammals, and some species of fish (salmon, halibut, rockfish) in the spill area over the long-term, it may be useful to follow the abundance and distribution of their prey species (herring, sandlance, candle fish, pollock). Changes in the patterns of prey abundance and distribution may effect changes in abundance and distribution of predator species. This kind of information will assist the Trustee Council in better understanding the dynamics of recovery of injured species, or potentially the lack thereof, but also is intended to document long-term trends in the environmental health of the affected ecosystem.

Because of the complexities of both institutional and technical issues associated with developing a meaningful monitoring program for the spill area, a phased planning approach is being undertaken. In **Phase 1**, a consultant is assisting the Trustee Council in developing a "conceptual" design for a monitoring plan. This is intended to guide more detailed, technical planning in a subsequent **Phase 2.**

PHASE 1 Conceptual Design

Key elements of the conceptual design for the Trustee Council's proposed monitoring plan include:

Conceptual Framework

In Phase 1, the objective is to develop a conceptual framework that can be used by the Trustee Council as a tool for developing and refining effective monitoring, which addresses what to monitor, where, when and how. It also establishes the relationships among those who require and those who produce monitoring information, as well as establishing how monitoring is integrated and coordinated among the various activities. This approach borrows significantly from the National Research Council's conceptual methodology for developing more effective and useful monitoring programs (National Research Council, 1990).

As with any tool, it is both how well the tool is constructed and how well the tool is used that determines its effectiveness. The Trustee Council's approach has been to construct a framework with the contributions of as many interested parties as possible. Through telephone interviews, analysis of case histories, and a technical workshop, the Trustee Council has obtained participation of a large number of individuals representing the Trustee agencies, universities, consultants, and peer reviewers.

Conceptual Model(s)

A conceptual model is the central feature of this approach and can be used to develop either monitoring or research strategies. In application, a conceptual model will identify the links among resources at risk; the physical, chemical and biological processes of the affected ecosystem; and, the human and natural causes of change. Essentially, conceptual models help define cause-and-effect relationships and permit testable hypotheses to be formulated and evaluated. By providing a framework for organizing existing scientific information, conceptual models can also identify important sources of uncertainty.

A conceptual model can be used to develop and refine effective research strategies to understand why resources and their associated services are not recovering. For example, designing and applying a conceptual model to illustrate how residual oil in mussel beds could affect harlequin ducks, juvenile sea otters, river otters, and oystercatchers, all of which are known to feed on mussels and show signs of continuing injury, could be an important first in step in understanding the recovery of these species. Mussel beds were not cleaned or removed after the spill and may be potential sources of fresh (unweathered) oil for these and other species.

Management Structure

Implementation of the proposed multifaceted program requires central coordination and management. In order to successfully implement an ambitious and wide-ranging program as contemplated, a high degree of organization is needed to create the final design, to analyze, interpret and disseminate the data generated, and to ensure that all aspects of the program are carried out as designed.

The Trustee Council is presently considering several management options. A decision on the type of management structure to implement will be made once the public has had opportunity to comment on the scope of the proposed program.

Data Dissemination

It is the intent of the Trustee Council that monitoring information be accessible and in a format that can be readily utilized by scientists, resource managers, and the general public. The final configuration of the data management system, and how and where the system can be accessed, however, have not been decided.

Avoiding Duplication of Effort

Integration and coordination with other monitoring programs in the spill area is essential to avoid duplication of effort, but also could result in benefit to each program where there is potential overlap. For example, both the Prince William Sound and Cook Inlet Regional Citizens Advisory Councils presently conduct monitoring within the spill area. Other major programs with geographic as well as potential technical overlap will soon be implemented by the Oil Spill Recovery Institute (Prince William Sound Science Center) and the Regional Marine Research Program (Coastal Regional Monitoring Act/Program). While the specific goals and objectives of these programs (including the Trustee Council's program) may be different, each program could benefit from integration such as conducting monitoring (where appropriate) at common stations, agreeing to follow standardized sampling and analytical protocols, and sharing logistics as well as data, etc. Every attempt, then, will be made to integrate and coordinate these different monitoring efforts.

PHASE 2
Detailed Design

With an approved conceptual design, the Trustee Council will next consider developing detailed technical specifications for monitoring and research that will be implemented as part of the Restoration Plan. This proposed planning effort focuses on the technical requirements of an integrated monitoring and research plan and again assumes a close working relationship among the Trustee Agencies. The Final Restoration Plan will include at least a summary of the technical design for each monitoring and research component.

This proposed final phase of planning would establish:

a) ***the locations where monitoring and research should be conducted;***

b) ***a technical design for each monitoring and research element (sediments, invertebrates, fish, birds, mammals, and services [commercial fishing, tourism, recreation, subsistence]) that specifies how, when data will be collected, analyzed, interpreted, and reported, which will be based on the design of appropriate conceptual models;***

c) ***a design for a data management system to support the needs of the Trustee Council and other decision makers, planners, researchers and the general public.***

d) ***a rigorous quality assurance program to ensure that monitoring and research data produce defensible answers to management questions and will be accepted by scientific researchers and the public;***

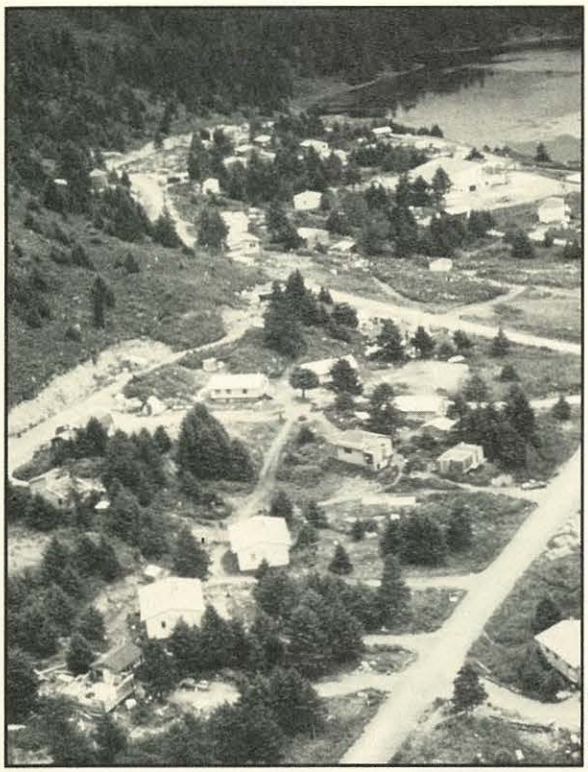
e) ***cost estimates for each monitoring and research component; and***

f) ***a strategy for review and update to ensure that the most appropriate and cost-effective monitoring and research approaches are applied.***

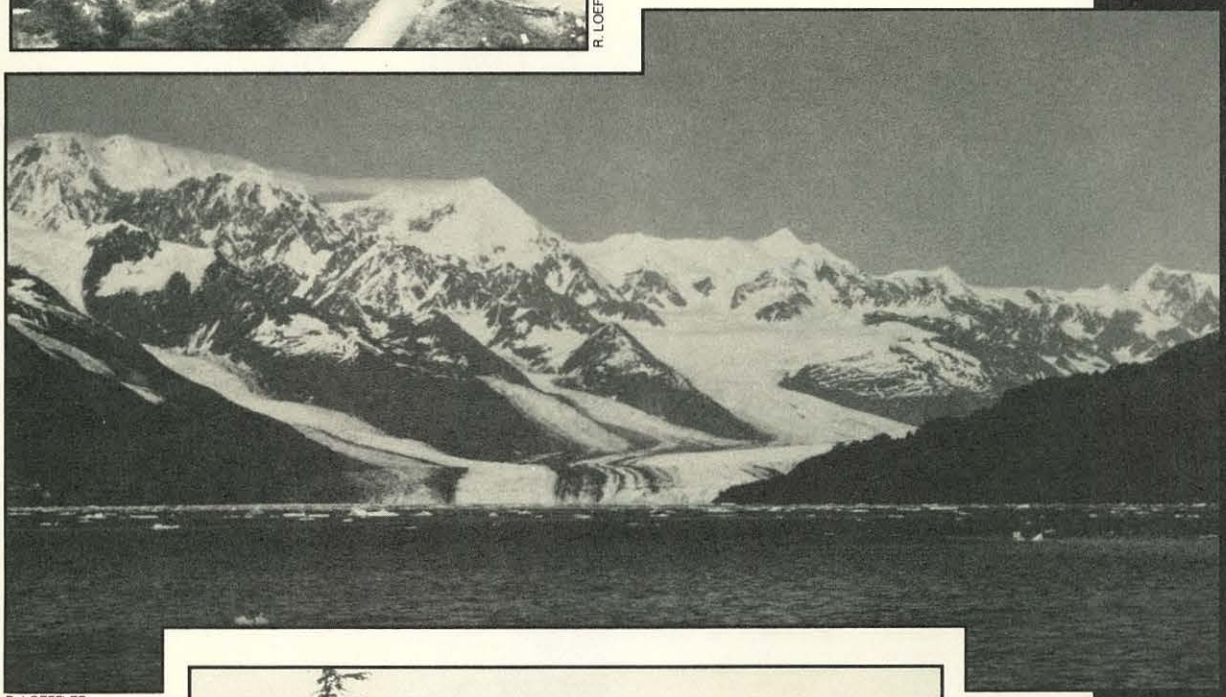
After completion of a Draft Recovery Monitoring and Research Plan, a program of peer review would be organized and implemented. Subsequently, it will be included in the final Restoration Plan.

Section F

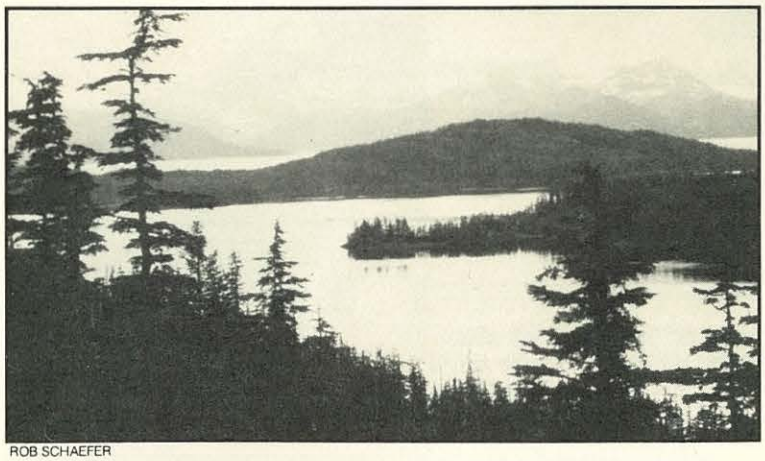
MAP OF THE *EXXON VALDEZ* OIL SPILL AREA



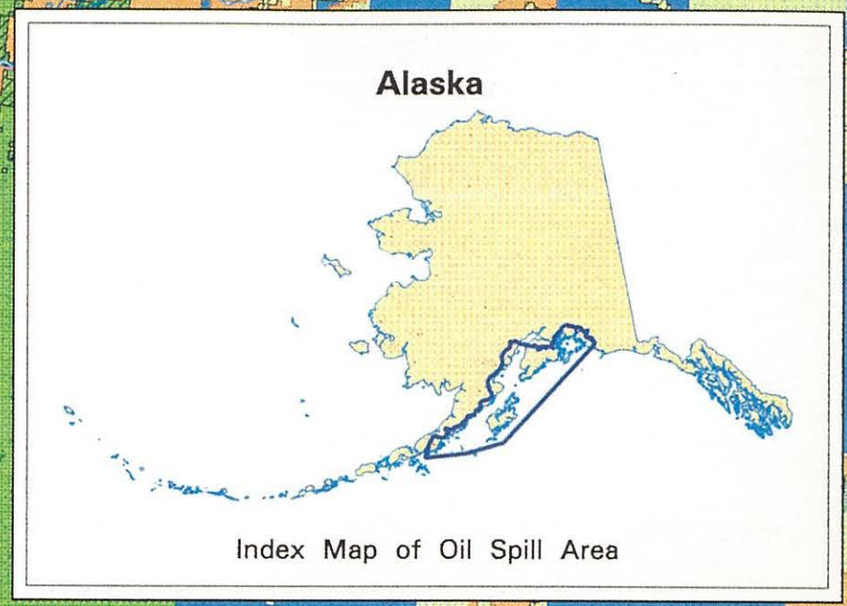
R. LOEFFLER



R. LOEFFLER



ROB SCHAEFER



Index Map of Oil Spill Area

THE *EXXON VALDEZ* OIL SPILL AREA GENERAL LAND STATUS

SOUTHCENTRAL ALASKA

0 50 miles

LEGEND

Oil Spill Area Boundary

FEDERAL LANDS

- National Forest
- National Parks, Monuments or Preserves
- National Wildlife Refuges
- Bureau of Land Management

STATE OR MUNICIPAL LANDS

- State or Municipal Lands
- State Parks, Critical Habitat Areas and Game Refuges
- Offshore State Parks and Critical Habitat Areas.
- State Marine Parks Areas

OTHER LANDS

- Native or Other Private Lands
- Native Selected

The *Exxon Valdez* Oil Spill Area includes the area enclosed by the maximum extent of oiled shorelines, severely affected communities and their immediate human-use areas, and adjacent uplands to the watershed divide.

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

Date Printed: June 08, 1993